The Historical Ecology and Social-Ecological Systems of Kona Coast Coral Reefs: Towards ‘Peopled’ Approaches to Marine Science and Management

by

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Michael K. Orbach

Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Environment, Duke University Marine Laboratory, Nicholas School of the Environment and Earth Sciences in the Graduate School of Duke University

2008
ABSTRACT

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Abstract

No corner of the world’s oceans is untouched by humans. Yet in marine science, management, and conservation, oceans are consistently treated as ‘unpeopled’, that is, human systems are divorced systematically from ecological systems, and assumptions of human/environmental relationships are oversimplified. This dissertation aims to contribute to interdisciplinary, or ‘peopled’, approaches to marine sciences and management by integrating biophysical and social sciences, specifically historical ecology and resilience thinking on social-ecological systems. Herein, I examine this theoretically (Chapter 2) and empirically by investigating the coral reefs of Hawaii Island’s Kona Coast historically, through the oral histories of ‘ocean experts’, diverse locally-living people from diverse knowledge systems. I investigate human, biophysical, and social-ecological aspects of ‘ecological change.’

Chapter 3 demonstrates that currently there are six expert ocean knowledge systems surrounding Kona’s reefs: Native Hawaiians, dive shop operators, tropical aquarium collectors, shoreline fishers, scientists, and conservationists. These are distinct in what experts know about Kona’s reefs, and how they know it. The giving and taking of authority between ocean experts, and among people and marine management, influences the condition of the biophysical, social, and management dimensions of Kona’s reef systems.
Chapter 4 examines the biophysical dimensions of change, specifically the historic abundance and distribution of 271 coral reef species. Ocean expert’s observations of ecological change are surprisingly consistent, regardless of perspective. Historically, species tend to follow one of eight trends in abundance and distribution, grouping into what I term ‘social-ecological guilds’. Analyzing these data with Western scientific frameworks (e.g., trends in apex predators, herbivores, corallivores) proved inappropriate, compared to qualitative approaches. Engaging a multiplicity of perspectives reveals historical ecology broader and richer than from any one knowledge system alone.

Chapter 5 identifies coupled aspects of marine social-ecological systems, or what I call ‘keystone social-ecological features’. I examine 8 features in detail and show how they are central to understanding ‘sea change’ through such diverse perspectives. Comparing expert’s perceptions and responses to ecological through keystone features, I show that ‘change’ differs based on sociopolitical, economic, etc. perspective. Understanding relationships between and among people, the ecosystem, and marine management institutions is critical for improved ocean management.
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Dedication

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Chapter 1. Introduction: Towards a Science and Management of Oceans as a ‘Peopled’ Landscape
1.1 The concept of oceans as ‘peopled’

No corner of the world’s oceans is untouched by humans (Halpern et al. 2008). Yet in science, management, and conservation, marine ecosystems are consistently treated as ‘unpeopled’. By ‘unpeopled’, I mean the systematic practice of divorcing human systems (individuals, their social networks and institutions) from ecological ones, and the reliance on oversimplified assumptions of human/marine environmental relationships, such as considering humans solely as external agents of change. The converse, a ‘peopled’ ocean, refers to the notion that marine ecological dynamics cannot be understood apart from the human practices and behaviors that influence ecosystems, nor can ocean ecosystems be effectively understood or managed absent some research and management of the human communities interacting with them. ‘Peopled oceans’ serves as a unifying theme to this dissertation, and is addressed theoretically and through an empirical study of historical ecology and human dimensions of a coastal social-ecological system – the coral reefs and nearshore areas of Hawaii Island’s Kona Coast. The social-ecological history of Kona’s reefs is based on interviews with ‘ocean experts’ and participant observation. By combining theory and approaches from the biophysical and social sciences, the body of work herein aims to contribute to the development of interdisciplinary, or ‘peopled’, approaches to the science and management of ocean systems.
1.2 Paradigm shifts and the crisis in the world’s oceans

The concept that oceans operate as an integrated system, comprised of human as well as ecological dimensions, has seen a recent surge in policy, research, and management. This paradigm shift, towards integrated, ecosystem-level, process-oriented, and multi-scalar approaches, stems from the heightened recognition that coastal and ocean ecosystems worldwide are in decline (Hughes et al. 2005; McLeod et al. 2005; Leslie & McLeod 2007). Key ecological interactions in coastal and ocean systems worldwide are severely degraded, as a result of species loss and reduction, destruction of key habitats, and changes in disturbance regimes (MEA 2005). Marine systems’ ability to recover from these disturbances has markedly weakened (Paine et al. 1998; Hughes et al. 2005), as have ecosystems’ capacity to adapt to change. Dramatic shifts in species composition and system function, known as phase shifts, have occurred worldwide, are often long-lasting, and are difficult to reverse (Hughes et al. 2003; Bellwood et al. 2004; Hughes et al. 2005). Conventional science and management practices – typically single species, single issue based – have failed to stem the tide of ocean decline (POC 2003; USCOP 2004; Hughes et al. 2005; Leslie & McLeod 2007).

Coral reefs, the coastal systems primarily addressed in this research, are a familiar example of habitats shifting to resilient, ecologically unproductive states (Nystrom et al. 2000; Pandolfi et al. 2003; Bellwood et al. 2004; Hughes et al. 2005). By the 1980s, in response to a multiplicity of chronic and acute disturbances (overfishing,
pollution, hurricanes, disease), entire regions began undergoing phase shifts from 3-dimensional calcareous, productive habitats to dense algal mats, as in the Caribbean (Paine et al. 1998). The global-scale of the coral reef problem became undeniable during the 1998 El Nino and Mass Bleaching Event, when coral bleaching affected every geographic coral reef realm in the world, nearly simultaneously (Hoegh-Guldberg 1999). Today, in marine ecological terms, there are likely no ‘pristine’ reefs left in the world (Pandolfi et al. 2003); as many as 20% of the world’s reefs have been destroyed within the last few decades, and 20% more are badly degraded (Wilkinson 2004). Most reefs deal with synergistic natural and anthropogenic disturbances and threats – runoff, overharvesting, climate change, invasive species, oceanographic oscillations, and others (Knowton & Jackson 2001). Threats to coral reefs, in being synergistic, acute to chronic, and local to global, therefore require science and management to address cross-scalar issues (Hughes et al. 2005).

Science and management’s movement towards integrative approaches, historical approaches, and broadening scales of research reflect the limited capacity of conventional approaches to deal with global-scale connectivity and long-operating, synergistic disturbances. Given that anthropogenic change likely occurred long before the onset of most marine ecological research, Pauly, Pitcher, and others claim there is a shifting baseline syndrome (Pauly 1995; Pitcher & Pauly 1998; Jackson et al. 2001) limiting our ability to set reasonable goals for ecosystem recovery. This is a particular
issue in coral reefs, whose ‘natural’ cycles operate on the order of 10’s to 1000’s of years (life spans of coral-building organisms, hurricane recurrence intervals, oceanographic oscillations). Extant knowledge was limited by available data, as typical coral reef ecology research lasts 1-3 years and is limited spatially (Knowlton and Jackson 2001). Furthermore, conventional approaches in marine science and management, more and more, seemed ill-suited to dealing with increasingly global, synergistic drivers of change (e.g., globalization, technological advances, climate change) (Leslie & McLeod 2007), and movement began towards techniques in science and management that, above all, focus on connectivity and broad spatio-temporal scales (including historically).

Resilience and historical ecology are two such approaches that attempt to study dynamics and connectivity across scales, and extend to historical scales, respectively (see next two sections). But ecological data limitations seem insubstantial, I argue, considering the scarcity of knowledge about human systems in oceans. In the writings of history, oceans have received little attention compared to the terrestrial earth; similarly, in the study of human systems, the oceans have been largely overlooked or oversimplified (Bolster 2006). What few historic insights into ocean ecosystems that exist derive from science/thought which has long separated humans from nature, which I contend, makes the challenge of managing interconnected human/marine environmental systems all the more formidable. We have a long way to go towards understanding, let alone managing, the connectivity of human and ecological systems in the sea.
My dissertation’s three overarching theories – marine ecosystem-based management (EBM), resilience thinking on social-ecological systems, and historical ecology – resulted from this shift in thinking. This dissertation takes steps to integrate these three fields. Though in the published literature these fields have not yet been approached in tandem, their parallels are clear. Each highlights the importance of developing a science and management that will effectively sustain healthy oceans; each realizes this has something to do with integrating the study and management of both people and the marine environment; each can fill a gap currently limiting the others. The primary contributions of this dissertation are in bridging the three: looking at the history of people and oceans together, from both historical and resilience perspectives, to forge an interdisciplinary science applicable to management. By interdisciplinary, I mean looking at human and marine ecological systems in tandem, and drawing from methodology and approach of natural (historical ecology, resilience thinking) and social sciences (human dimensions, resilience thinking, political ecology). Where these fields of science and practice converge, and where they ought to (ie, the gaps in current thinking), are the primary contributions of my doctoral work. The following sections outline several fields of research (resilience thinking and historical ecology) that when combined, I contend, offer a way to study oceans as a peopled landscape through historical insights. That is, research that fills in gaps in knowledge about historic condition and
dynamics of oceans, but doing so in a way that builds capacity to consider oceans as integrated systems.

1.3 Objectives and approach

The objectives of this dissertation cover topics in natural, social, and interdisciplinary sciences. They also are framed in the context of providing practical insights into people and oceans, relevant to the science and practice of marine ecosystem-based management. The four main objectives are:

1. To combine theory and approach from biophysical and social sciences to achieve a more ‘peopled’ approach to science (historical ecology & resilience thinking) and management (marine EBM).

2. To contribute to a deeper understanding of the dynamics of marine social-ecological systems, including biophysical dimensions (history of natural and anthropogenic disturbances) and human dimensions (how people affect, and are affected by, the oceans).

3. To give voice to a multiplicity of perspectives within a coastal community, including indigenous, local, and scientific ocean experts, on the topic of ecological change.

4. To further our understanding of the nature of ecological knowledge of ocean and coastal systems.

My dissertation research looks broadly at the historic, human dimensions of coral reefs on the Kona Coast, Big Island of Hawaii. It examines the contribution of diverse local expertise to understanding historic baseline conditions and processes on coral reefs, natural and anthropogenic disturbances, as well as dynamics of the social-
ecological system. Diverse perspectives are sought, including traditional, local, and western scientific ecological knowledge (TEK, LEK, and WSK), while giving voice to all groups and not prioritizing any one over another. Marine ecological knowledge in Hawaii stems from the millennia in which Native Hawaiians collected, fished, tended, and spiritually interacted with the coral reefs and coastal watersheds. In much more recent history a diverse admixture of actors—local people, Native Hawaiians, and marine scientists alike—have populated the Kona Coast, are generating expert knowledge, and interacting with the environment and each other in an extremely wide array of activities. Understanding these actors, their observations and perceptions of change on the reefs, and how they broadly fit into (affect and are affected by) the coral reef ecosystem is a primary goal of this research.

This research takes an interdisciplinary approach, largely drawing from resilience theory and historical ecology. It treats the oceans as coupled social-ecological systems, in which people and the oceans affect, and are affected by one another. Many processes cannot be understood outside of the context (geographic, social, cultural, political, economic, psychological, etc) in which they exist. It also assumes that all ways of knowing are legitimate, and that a multiplicity of perspectives including local,

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1 A note on structure: herein, the term ‘human dimensions’ is used in the vein of NOAA (2007), as an approach looking at the “ways humans affect, and are affected by, the oceans”. Methods and approaches in resilience and historical ecology may also be human dimensions approaches.
traditional, and western scientific knowledge all can contribute valuable insights into ocean dynamics and to managing these complex systems.

1.3.1 Objective 1: To combine theory and approach from biophysical and social sciences to achieve a more ‘peopled’ approach to science (historical ecology & resilience thinking) and management (marine EBM).

**Marine ecosystem-based management**: Where the ‘peopling’ of theory and policy have outpaced the development of ‘peopled’ management strategies

Nowhere is the movement towards integration more pronounced that in marine ecosystem-based management. Widely supported in theory and policy, marine ecosystem-based management (EBM) is young in practice. EBM practices and toolboxes are emergent, techniques are being developed, and on-the-ground examples are few and quite new (Leslie & McLeod 2007; McLeod & Leslie, *in press*). Its basic principles, however, are relatively well described and agreed upon, and are the subject of a scientific consensus statement signed by more than 100 marine ecologists (McLeod et al. 2005).

Marine EBM is, above all, focused on connectivity (Agardy 2007). In contrast to current management practices that tend to focus on the short-term provision of single ecosystem services, a key goal of EBM is to conserve the long-term potential of the ecosystem in a healthy, productive, and resilient condition in order to sustain the delivery of a broad suite of ecosystem services (Rosenberg & McLeod 2005). By consensus, ‘ecosystem-based’ strategies, theoretically: (1) protect ecosystem process and function; (2) are place-based; (3) attend to connectivity between air, land, and sea; and
(4) recognize the interdependence of economic, institutional, social, and ecological realms of the oceans (McLeod et al. 2005). The latter principle, recognizing that the ecosystem is interdependent with human dimensions, is that upon which my dissertation focuses.

The importance of human dimensions to marine EBM has become increasingly clear. This is seen in the major literature surrounding marine EBM (McLeod et al. 2005; Leslie & McLeod 2007; McLeod & Leslie, in press), which touts interdisciplinary approaches and linking stakeholders and communities with management as its overarching principles: “Marine ecosystem-based management (EBM) involves recognizing and addressing interactions among different spatial and temporal scales, within and among ecological and social systems, and among stakeholder groups and communities interested in the health and stewardship of coastal and marine areas” (Leslie & McLeod 2007, 540). At the same time, the challenge of achieving science and management of an integrated system is formidable, and successful examples rare. As is suggested in the social science strategy for marine protected areas (MPAs), although we are beginning to understand the natural ecology of oceans more fully, federal, state, and local management agencies often lack information on the cultural, social, and economic aspects of oceans (Wahle, Lyons, et al. 2003). This critical information gap severely complicates the consideration of management tools (Wahle, Lyons, et al. 2003). These
issues, and obstacles in integrating social sciences into predominantly natural science-driven oceans management, are addressed in a literature review in Chapter 2.

Moreover, one of the goals of this dissertation is to contribute to the theoretical scholarship and debates surrounding marine EBM’s integration within and among the natural and social sciences, and with local people and communities. Chapter 2 addresses the extent to which human dimensions are considered in even the most fundamental discourse of marine conservation science and management. It contends that in marine EBM, the integration needs to occur first in discourse, and the practice of science before management strategies can be considered based on current understandings of marine conservation issues. Elsewhere (Shackeroff & Campbell *in press*) we have dealt with a more specific issue: the implications of marine conservation’s enthusiasm for traditional ecological knowledge (TEK), and the problems and prospects for TEK’s engagement with (and sometimes uncritical treatment by) marine conservation. These two papers set the theoretical foundation for Chapters 3-6 herein, which describe aspects of an interdisciplinary study of the historic, human dimensions of a coral reef ecosystem. Results and discussions in my data-driven chapters help bring the ‘peopled’ approaches to life, such as (1) how to cross disciplines effectively in management-relevant research, and (2) what aspects of the ocean system are important to consider in marine EBM. Specifically, Chapter 3 discusses how marine management can be improved by considering the range of ocean knowledge systems, and their power relations within
coastal communities; Chapter 4 demonstrates that eliciting expert’s observations of ecological change provides ecosystem-level and historic trends in marine communities, trends that can be described in richer detail and more broadly than from diverse perspectives than any one alone; and Chapter 5 shows how people’s perceptions of different features of the coral reefs influences the condition of the ecosystem, social relations, as well as marine management’s success or failure.

**Marine historical ecology:** Revealing crucial insights into historic conditions, the field may realize greater potential with ‘peopled’ approaches

Science and management of ocean systems are complicated by a paucity of historic data, both in total availability of ecological data over time, as well as integrated human/ecological data (Brown 1995). In tandem with the trends towards interdisciplinary research and management, the marine sciences have sought paradigms and conceptual models to encompass larger spatial and temporal scales, including historical ones. The field of marine historical ecology, plunging into museum archives and alternative data sets to explore how humans shaped (often altered) marine ecosystems prior to the onset of much marine ecological research, influenced the greater appreciation for the role of history and non-equilibrium dynamics in the tempo and mode of ecosystem change (Brown 1995; Pauly 1995; Jackson et al. 2001; Knowlton & Jackson 2001; Hughes et al. 2005).

For example, Jackson and colleagues (2001) examined historical data from 30 to 125,000 ybp and revealed the magnitude of human alterations of coastal ecosystems.
throughout history was far greater than imagined. Human alterations, primarily from overfishing, have caused the loss of entire trophic levels in coral reefs, estuaries, kelp forests, seagrass systems and other coastal systems. Losses in the abundance of large marine animals was so “enormous” and pervasive historically that they are effectively absent from most coastal ecosystems (Jackson et al. 1997, 2001, Jackson et al. 2001). Few of these insights were known to marine ecology prior to this groundbreaking research.

Marine historical ecology is a research field largely responsible for our better appreciation of the role of history in the current status and trends in oceans; yet in this dissertation I contend that without a more ‘peopled’ approach, historical insights from marine historical ecology will remain fundamentally flawed and its contributions to marine EBM limited. While lauded for its creative use of unconventional data sources to address key conservation problems (Hughes et al. 2005; Bolster 2006), the research field is also criticized for its adherence to quantitative data (van Sittert 2003) and rather narrow assumptions about human systems and human/environmental relationships (van Sittert 2003; Bolster 2006; Campbell et al. in prep). Confining research to the examination of extant, quantitative records limits not only the analysis of the human dimensions (why impacts occurred) but also the array of possible data sources to purely quantifiable ones. The “greatest sea change in history” will remain unknowable, and potentially inexorable, unless human dimensions are better integrated into historical ecology, and marine science more generally. In Chapter 2, I concur with Bolster (2006),
who argues that divorcing humans from oceans is a systematic problem in scientific
thought as well as in the writings of history. Yet the many complexities of human
systems (relationships among people, groups of people, and oceans through race,
religion, culture, history, worldview, science, politics, economics, etc.) not only cannot
be revealed by quantitative data alone, they are best suited to qualitative approaches.

In this dissertation, by tracing the ways in which diverse ocean experts observe,
perceive, and respond to ecological change, I describe the history of a marine social-
ecological system and unravel the co-evolution between people and a marine ecosystem.
Chapters 1-2 contribute to theoretical scholarship on marine EBM, resilience, and
historical ecology. Furthermore, I look at the people, expertise, and authority in Chapter
3; Chapter 4 examines historical ecological trends across suites of organisms; in Chapter
5, I explore keystone SES features (marine species and processes) whose histories
apparently help to predict and explain ecological, social, and institutional change; and
finally in Chapter 6 I present themes in the ‘historical ecology of Kona Coast coral reefs’.
Together, chapters 3-6 describe the interplay of a marine social-ecological system over
the past 80 years. The latter chapters link theory to practice, demonstrating that unique,
historical insights into ecological dynamics can be gained through qualitative research
with local and indigenous people as well as scientists. Therefore, in this body of work, I
strive to bridge resilience thinking and historical ecology towards an interdisciplinary
science that is meaningful to marine EBM.
Resilience Thinking: An emergent theoretical framework for ‘peopled’ approaches

Resilience thinking, as a concept and research strategy for understanding, managing, and governing complex linked systems of people and nature (Folke et al. 2004), offers a way to achieve an interdisciplinary science of the oceans. The term ‘resilience’ refers to the extent to which ecosystems can absorb recurrent natural and human perturbations and continue to recuperate without slowly degrading or unexpectedly flipping into alternate states (coral reef to algal mats, as an example) (Holling 1973; Folke et al. 2004; Nystrom et al. 2000; Gunderson & Pritchard 2002; Hughes et al. 2003; Berkes et al. 2003; Hughes et al. 2005; Folke 2006). ‘Resilience thinking’ offers a way to approach oceans as a singular, integrated system of coupled human and environmental dimensions – or, a social-ecological system (SES) (Berkes & Folke 1998). My approach in this dissertation links historical ecology and resilience, by focusing on the components and nature of a regional marine SES through history. This attention to unraveling the characteristics of a SES historically is warranted, as I describe below, because the scholarship of marine SESs typically looks either at broad scales and times of perturbations (e.g., tsunami), or at alternative knowledge systems at the very local level. Herein, I focus on SESs, their components, and functioning, in referring to ‘resilience thinking’ I specifically reference it as an overarching framework for SESs.
SESs are “an integrated concept of humans in nature” (Berkes & Folke 1998, 4). A central assumption of SESs is that people and the natural world are coupled, co-evolved, and inseparable (Figure 1).

**SOCIAL-ECOLOGICAL SYSTEM**

![Diagram of a social-ecological system](image)

**Figure 1**: Diagram of a social-ecological system, emphasizing connectivity from the local to the global in both social and ecological domains. Interactions as well as drivers of change occur across scales. That the provision of ecosystem services depends upon both people and the natural world signifies how people affect, and are affected by, ecosystems in positive and negative ways. (McLeod & Leslie, in press)

SES theory assumes that humans can act in restorative and recuperative manners, instead of always effecting negative impacts, like overfishing (Berkes et al. 2003). Examining coupled SESs that appear to resilient and sustainable (typically defined as enabling the sustained production and delivery of ecosystem services, MEA 2005) is a strong theme in resilience scholarship. First, the dynamics of marine SES
typically are examined at broad scales following times of perturbations (e.g., Coral
& 1998; Robards & Greenburg 2007; Huitric 2005; Berkes et al. 2006. Natural disasters:
Adger et al. 2005). For example, regarding coral reefs, the major resilience scholarship
attempts to explain what drivers of change have caused reef phase shifts from
productive to unproductive states (e.g., synergistic overfishing, land-based pollution,
storms, climate change, and shifts from productive 3-dimensional calcareous habitats to
dense algal mats) (e.g., Pandolfi et al. 2003; Bellwood et al. 2004). Hughes et al. (2005)
applies resilience thinking to managing reefs in the face of pervasive change (per
Bellwood et al., 2004 etc.), and suggests adaptive co-management, creating institutional
frameworks matching scales of the ecosystem, and aligning the marketplace with
stewardship and conservation. Adger and colleagues (2005) examine social and
ecological vulnerability to disasters and outcomes of an extreme event (Boxing Day
Tsunami). Their examination of such measures as the level of responsiveness in
institutions, knowledge and preparation, and scales of governance, explores how a
better understanding of the linkages between society and ecosystems can help to reduce
vulnerability and enhance resilience of coastal SESs.

A second theme in marine SES relates to alternative knowledge systems, like
traditional, local, and fishers’ knowledge, can help Western science articulate how SES
behave, and learn to manage more healthy, productive marine ecosystems. Berkes et al.
(2003, 8) suggest: “Especially with social systems, it is difficult or impossible to understand a system without considering its history, as well as its social and political contexts… A complex social-ecological system cannot be captured using a single perspective.” Western scientific understandings of the natural world will remain fundamentally limited unless (1) social science is used to examine human systems and context (social, cultural, historical, political, economic, institutional, psychological, etc.), and (2) the perspectives of local people and communities (including indigenous) are sought. Ecological knowledge generated over time by people interacting with the natural world (e.g., fishing, diving, engaging in spiritual or cultural practices) is assumed to be a crucial link in a sustainable relationship between people and marine ecosystems (Berkes & Folke 1998; Folke 2004). Thus, traditional, local and fisher’s ecological knowledge are all prevalent themes (Berkes and Folke 1998; Berkes 2003; also see Folke 2004 and Ecology & Society special feature on Traditional Ecological Knowledge in Social-Ecological Systems, online at http://www.ecologyandsociety.org/viewissue.php?sf=13).

For example, maintaining the web of relationships of people and places seems to be critical to adaptive learning among the Anishinaabe people northwestern Ontario, Canada, (Davidson-Hunt and Berkes 2003). These researchers document the social memory of landscape dynamics as a combination of biogeophysical structures and processes, along with the stories about how the Anishinaabe people wrote their histories
upon the land. Elders play an essential role in the adaptive learning process. In a second example, Olsson and colleagues (2004) describe co-management and adaptive co-management of biodiversity and ecosystem dynamics in social-ecological systems, and the role that traditional knowledge may play in this context. They provide insights into how ecosystem assessment and management by local people can fulfill several important objectives (e.g., promoting participatory processes, developing indicators of change and resilience to monitor ecosystem dynamics), can inform contemporary society, but can also be influenced and supported by contemporary science and institutions. They can also develop social responses for dealing with uncertainty and change (Peterson et al. 2003).

As a new approach, resilience is just beginning unravel ocean SES dynamics by linking theory to case study (Walker et al. 2006). It thus leaves enormous potential for new contributions to be made in describing ocean systems, and in particular historical insights, which until now have not been investigated systematically by resilience thinking. Because of the pressing problems surrounding anthropogenic impacts, marine ecosystem change, and uncertainty, resilience scholarship in ocean systems looks at perturbations at the broad scale, while also looking at knowledge systems at the very local scale. But I contend that these efforts have yet to sufficiently describe the components and function of marine SES, including the fundamental nature of human/marine environmental relationships. Basic questions first posed in Berkes &
Folke (1998), later in Berkes et al. (2003), have yet to be answered: what are the components of marine SESs? The key interactions between people and ecosystems? Do different perspectives (e.g., knowledge systems from different political, economic, historical contexts) identify different components and functions? Many resilience studies look at alternative knowledge systems, but few do so looking at several perspectives in tandem.

As discussed theoretically in Chapter 2, these unanswered questions hint at the gaping hole in the understandings of marine SES’s in fleshing out particulars of SES dynamics at the local level (local people, local place, local context). In Chapters 3-6, I attempt to add detail to the somewhat vague term, “marine social-ecological system.” I take the approach of studying the SES historically, which is warranted given both the (a) historic separation of human and ecological sciences, and the (b) dearth of historic data on oceans. I justify joining these literatures – resilience and historical ecology – in Chapters 2, 3, and 5. Chapter 2 suggests that research in coastal and ocean environments is necessary to elucidate resilience theory, rather than relying on terrestrial research as has historically been done. Furthermore, Chapter 2 suggests historical ecology is an appropriate angle, given the great need for filling in data gaps in marine ecology. This chapter provides the theoretical groundwork, and reviews the pertinent literature, for latter chapters in this dissertation.
Chapters 3-5 look historically at the components of Kona’s coastal SES – in turn examining the history of (1) human, (2) biophysical, and (3) coupled social-ecological aspects of Kona’s coral reefs. Chapter 3, looking at people, describes the multiplicity of perspectives, and how the historic giving and taking of authority affect the ecosystem, social systems, and institutional systems. Chapter 4, looking at ecosystem-level processes, shows how groups of species are intimately tied to groups of people; and species ecological histories of decline and resurgence are felt differently by different groups of people. In particular, Chapter 5 unpacks the term ‘marine social-ecological system’, showing what it means across a region, and from a multiplicity of perspectives. As it traces the interplay between specific features of the ecosystem, multiple and diverse groups of people, and marine management over time, this chapter shows (1) how history helps reveal social-ecological dynamics, (2) that the social-ecological history is richer from diverse perspectives, (3) what feedback loops exist between social and ecological domains, on what levels, and how they change over time, and (3) which components of the SES have the most implications for ecosystem health, management effectiveness, and the well-being of local people. In identifying keystone social-ecological features (species and processes alike), Chapter 5 identifies influential and coupled components of a marine SES.

1.3.2 Objective 2: To contribute to a deeper understanding of the dynamics of marine social-ecological systems, including biophysical dimensions (history of natural and anthropogenic disturbances, and
evidence of resilience) and human dimensions (how people affect, and are affected by, the oceans)

Scholarship in marine social-ecological systems is aimed at understanding their components and dynamics. Theory is burgeoning, as is case study research (Walker et al. 2006; Folke 2006). There has been an increased emphasis on looking at the ability of a SES to transform, instead of remaining in the status quo, and how managers might foster movement towards restoring productive ecosystems (e.g., through adaptive governance and co-governance, Deitz et al. 2003). What has come of this work is a picture of SES as a web of relationships, such as thinking of social institutions as the webs linking the people to the ecosystem, and to an adaptive governance system (Folke 2004; Dietz et al. 2003). Diversity in the webs of social institutions is thought to be inherent to a system’s capacity to resist change (Folke 2006), for example, communities with diverse livelihoods recuperated most quickly from the Boxing Day Tsunami (Adger et al. 2005). Describing important social threads in the SES webs, Olsson and colleagues (2004) demonstrated the crucial role of leaders and leadership in providing trust, learning, vision and meaning; Berkes and others (2003) posit ecological knowledge (e.g., TEK and LEK) as a fundamental relationship between people and ecosystems, rather like a node where the web of people and ecosystems meet. From these studies, a more defined picture of the ‘SES’ is emerging.

Yet, there is much to be explored about the fundamental nature of SESs, and marine SESs in particular, as I outline in Chapter 2. Aspects of SESs that are believed to
affect ocean resilience include: the dynamic nature of social and ecological systems, diversity, disturbance regimes, feedback loops, and cross-scale and cross-domain interactions (Kinzig & Leslie, in press). In complex systems, there are many knowledge systems which affect and are affected by ecosystems; thus, these ways of knowing, and the social, political, economic, and historical context from which they come are crucial components of the SES that must be understood (Berkes et al. 2003). This is well-illustrated by a paper on “Bush tucker, bush pets, and bush threats”, in which the perspectives of Australian aborigine peoples on feral animals in Kaduku National Park showed, even though Western science considers these invasive species as necessarily bad for the park, the Jawoyn people see some as food, others as pets, and still others as pests (Robinson et al. 2005). Thus, although feral animal management is often based on the proposition that introduced species threaten ecological and conservation values, researchers found that view is not necessarily shared by all stakeholders, including those indigenous people who own and co-manage the Park (Robinson et al. 2005).

One of the primary goals of my dissertation is to advance the idea of marine SES and dynamics, by exploring marine ecological change through the experiences of diverse people within a single but heterogeneous coastal community. In line with resilience thinking which argues there is no one correct and all-encompassing perspective on a system, I discovered 6 distinct groups with different knowledge systems and perspectives in the region (see results in Chapter 3). Additionally, I ask,
historically what effect the diversity of perspectives had on the social-ecological system, that is, how it influenced human values, attitudes and behaviors connected to ocean condition.

Ecologically, in a heterogeneous region with a paucity of marine ecological data prior to 2000, I examine historic change to coral reef habitat, marine organisms, natural and anthropogenic disturbances, and biophysical processes. Marine ecology today and even resilience-oriented marine research commonly focuses on functional guilds like herbivores and apex predators (e.g., Bellwood et al. 2004), on synergies between natural and anthropogenic disturbance, and on habitat (e.g., Hughes et al. 2005). But these are largely studied through the perspective of Western science. Therefore, I examine the very ‘ecological’ question of the tempo and mode of ecosystem change through a multiplicity of perspectives. I let the data – qualitative interview texts, voices of diverse ocean experts – tell the story of change, rather than predetermined (i.e., marine ecological/Western scientific) frameworks. Chapter 4 presents results indicating strong patterns in the abundance and distribution of the 271 species outlined in these interviews. By collating all people’s observations, I found eight clear trends, and since the species with similar historic patterns appear to be related both culturally and ecologically (but not in the way scientific literature categorizes species as ecological niches or functional guilds), I present data as social-ecological guilds. Then in Chapter 5, I describe the 8 most important biophysical features (7 species, 1 process) in expert’s
stories of ecological change. In presenting these data, I demonstrate that the biophysical history of change ought not to be separated from the peopled history of change. Bringing together a multiplicity of perspectives enables me to illustrate that where people’s narratives of change converge and diverge can be strongly indicative of the potential for cooperation or conflict; management success and failure; and of changes to the ecosystem that may otherwise have been off the radar of science and management.

1.3.3 Objective 3: To give voice to a multiplicity of perspectives on the topic of ecological change within a coastal community, including indigenous, local, and scientific ocean experts.

Information on current and past ecosystem condition, ideas for management, insights into conservation problems may be gained from research with TEK, LEK, and fisher’s knowledge (Johannes 1981; Johannes et al. 2000; Berkes et al. 2000; Berkes 2003; Davis & Wagner 2003; Drew 2005; Drew & Henne 2006). Resilience literature strongly encourages drawing from a ‘multiplicity of perspectives’ (Berkes et al. 2003), and one of the most consistent lines of resilience research is based on traditional and local ecological knowledge (Folke 2004). While the marine conservation literature appears relatively responsive to the idea of TEK (and to a lesser degree LEK and fisher’s knowledge) (e.g., Davis & Wagner 2003; Drew 2005; Drew & Henne 2006), the published studies that look at alternative knowledge systems tend to prioritize TEK over others. This is despite mounting calls to complicate the idea of communities, human systems, and tragedy of the commons perspectives in the realm of marine science (e.g., see St. Martin 2001;
Kaplan & McCay 2004; Olson 2005). What’s more, within the community of scholars who conduct research with indigenous people, there is active debate with regards to political, ethical, and epistemological challenges in integrating TEK with Western science (Agrawal 1995; Nader 1996; Nadasdy 1999; Agrawal 2002). These ideas are reviewed in Chapter 2, meant for an audience of marine ecosystem-based managers – a group dominated by biophysical scientists.

Throughout my empirical research (Chapters 3-6), I draw from a multiplicity of perspectives to address the topic of historical ecological change on coral reefs. I take a critical realist approach, contending that there is a biophysical reality, but that based upon human context, various people and groups of people may interpret, experience, respond to, and affect that biophysical reality in different ways. It also suggests some elements may be unknowable. Qualitative in its approach and analysis, my research casts a broad net in seeking perspectives from the local community. Using snowball sampling and social network analysis, I let the community inform me about what the various perspectives are, and who are considered experts of, Kona’s coral reefs and their history. In Chapter 3, I demonstrate that ocean experts draw from more diverse perspectives than anticipated, and by sampling from the network of ocean experts, I conducted semi-directive interviews and participant observation with experts from each perspective (‘expertise group’). Throughout Chapters 3-5, direct quotes and qualitative data are presented to give a richness of detail of the many perspectives on the Kona
Coast. I analyze the qualitative data with interpretive grounded theory (Strauss & Corbin 1994; Baxter & Eyles 1999), to allow the many voices to speak through the data. The results are presented in Chapters 3, 4, 5, and 6, which in turn use quotations from interviews to address topics about knowledge and authority, biophysical trends, keystone species of the social-ecological system, and peopled historical ecology.

1.3.4 **Objective 4: To further understanding of the nature of marine ecological knowledge**

In marine conservation, greater appreciation is afforded to people and cultures, who as a result of engaging with oceans over time, have developed expert knowledge and practices surrounding it. There are vigorous debates surrounding whether or not, and how, alternative knowledge systems (e.g., traditional ecological knowledge, TEK, Berkes et al. 2000; local ecological knowledge, LEK, Davis & Wagner 2003; fisher’s knowledge, McGoodwin 1990) should engage with Western science (see Folke 2004). Some laud the potential of TEK and LEK to provide insights into methods to deal with rapid environmental change, and sustainable use practices (Johannes et al. 2000; Berkes & Folke 2002; Berkes 2003), while others challenge the practicality of indigenous and local knowledge in an increasingly global world (Krupnik & Jolly 2002). On political, epistemological, and ethical grounds, some strive to overcome the dualistic treatment of Western science vs. ‘other’ knowledge systems like indigenous and local ecological knowledge (Nader 1996; Nadasdy 1999; Agrawal 2002); still others try to test, code, or otherwise integrate into Western scientific frameworks (Davis et al. 2004). In the marine
sciences, TEK is lauded (Acheson 2005; Drew 2005), while other alternative knowledge systems are less well-represented in the published literature (see Campbell et al. in review).

My dissertation reflects the difficulties, but also the potential to be found in, combining knowledge from traditional and local knowledge systems with marine science and management. One of my goals is to explore, through the issue of the nature of knowledge, in what way, if at all, people’s relationships with oceans are fundamentally different to land. Chapter 2 explores this theoretically and poses questions to the broader audience of marine ecosystem-based managers. Chapter 3 looks at the nature of people’s relationships with oceans, through the generation and transmission of expert knowledge; in looking at the history of the same coral reef region, I find that while their observations of change are surprisingly consistent (Chapter 4), how they interpret and draw meaning from change differs and is partly due to the historic and cultural context of their way of knowing (Chapter 5).

Another goal of this dissertation is to get beyond the labeling of knowledge in the dualistic manner it has been enacted in conservation arenas (science vs. other; TEK vs. other alternative knowledges), and move towards recognizing that knowledge is diverse and situated, and that management can be improved by recognizing and engaging with many perspectives. My approach starts with broad questions on the nature of knowledge and by attempting to describe expert marine knowledge systems
that exist on Hawaii Island’s Kona Coast. Whereas many studies examine one knowledge system versus another (e.g., TEK vs. science), or prioritize working with one or another (TEK instead of fisher’s knowledge), this study did neither of these things. By assuming the knowledge systems in Kona likely include, but are not limited to TEK, LEK, or WSK, I sought to examine the types of expertise that exist in Kona. Results in Chapter 3 show these knowledges were indeed more complex than the three labels suggest; multiple ‘local’ knowledge systems, for example, are distinct in who these experts are, what they know, and how they know it. From examining the knowledge systems, Chapter 3 then asks to what effect convergences and divergences have on relations among people, as well as on their lines of access historically to marine management.

In doing so, Chapter 3 also examines some of the more fundamental aspects human/marine environmental relationships; because, as Berkes et al. (2003) suggest, expert knowledge and knowledge holders are some of the most fundamental and important connections between people and ecosystems. Further, Chapter 4 illustrates empirically why approaching culturally inclusive ecological knowledge with a scientific framework is not only inappropriate, but also can hide important trends in the data. I argue that the multiplicity of perspectives on ecological change can be highly diverse in a local community (Chapter 3), and therefore are critical to consider in marine management decisions. In chapters 4 and 5 I illustrate that a multiplicity of perspectives
contributes a richer, deeper, and more complex story of ecological change and social change than any one knowledge system alone. Despite surprisingly consistent observations of change (Chapter 4), people from different knowledge systems can experience, respond to, and interpret ecological change in a wide variety of ways (Chapter 5). I argue that these differences are not only culturally embedded but have serious implications for the success or failure of marine management (Chapter 4 & 5).

1.4 Case study on Hawaii Island’s Kona Coast coral reefs

1.4.1 Site description of the Kona Coast

This study was conducted Hawaii Island’s Kona Coast, an ideal context for a study of cross-cultural historical ecology for reasons of its biophysical setting, history of coral reef management, and the range of ocean-interested actors from varying cultural, social, political, and economic contexts. The research is timely because the Big Island is in a state of flux, from a rural village setting to a landscape being quickly reshaped by the onset of the construction boom. Nearshore marine resources have long provided sustenance and a venue for cultural practices for Hawaiian and non-Native local people, and in more recent decades have become a focal point for tourism industry. It is a region long considered pristine, but where contemporary accounts of change, namely, the declining abundance of reef fishes due to tropical aquarium fish collection, are evident. The collection of nearshore marine resources for live aquaria trade have a long
and complex history in Hawaii, and several decades of user-conflicts surrounding the issue on the Kona Coast resulted in the passage of legislation limiting collection activities. A network of marine protected areas, called Fisheries Replenishment Areas (FRA), was established, as was a community-based management council, the West Hawaii Fisheries Council (WHFC) to deal in perpetuity with coastal resource issues. Not only the biophysical setting but also the socio-cultural and institutional setting of Kona’s coral reefs have faced, and are facing, changes due to increasingly global and synergistic drivers of change.

I refer to the region of study herein as the “Kona Coast”, though the study region spans, more or less, two-thirds of the leeward, western coastline of the Big Island, from the Kaloko-Honokohau region to Kapua, the South Kona district boundary.
Figure 2: The study region, Hawaii Island’s Kona Coast. The six study sites are shown in yellow stars, on the natural resource inventory of the Kona Community Development Plan.

To focus the research geographically, I selected six study ‘sites’ (coral embayments and areas mauka-makai (mountainward – oceanward)) within the same coral reef region, but with varying histories reflective of the region’s diverse land uses and human dimensions. Selection of coral bays for this research was determined by (1) existence of TEK, LEK, and WSK reef experts knowledgeable about each site and (2) with varying coastal watershed influences. To account for the variety of human
influences on these reef systems, I chose sites located downstream of a variety of urban/industrial, agricultural, and rural/conservation land uses. After conducting informal interviews, completing the majority of interviewee sampling efforts, and mapping current land uses, the six study sites I chose include: Kaloko-Honokohau, Kailua Bay, Kahaluu, Kealakekua Bay, Honaunau, Ho’okena, and Miloli’i (Figure 2). Within these sites are a diverse array of land uses, land cover, histories, and uses. At least one golf course exists currently in this area, as well as upstream agriculture and residential landscaping. The north is dominated more by urban and industrial land uses and boating/marina facilities. Further south, development becomes successively sparser, as agricultural fields and animal facilities replace buildings and road infrastructure towards Kealakekua (Figure 3 & 4). Near Miloli’i and Kapua, sub-watersheds exist with almost no development at all, some of which are state parks, and others with relatively more undeveloped/rural landscapes. Additionally, southern stretches house ancient Hawaiian fishing villages and cultural practitioners. The stretch of coastline was also limited enough in scope that research could be accomplished with the time and resources available. Kona’s coastal heterogeneity is reflected in this array of sites (Figures 3 & 4).
Figure 3: Heterogeneity in the study region. A mosaic landscape, the Kona Coast boasts a patchwork of ancient and contemporary island life, black lava and verdant landscapes. Dramatic heterogeneity shifts from the (a) new industrial area encroaching on the marina and ancient sites of Kaloko, southwards through (b) urban Kailua-town. Kealakekua Bay (c), more isolated from urban bustle, sees its own kind of traffic, and (d) more traditional livelihoods and practices can be seen in the rural fishing villages in the south of the district.
Figure 4: These 1987 aerial photographs depict Kona’s heterogeneity in land cover. Top: urban, marina, industrial of Kaloko and Kailua. Middle: Agricultural, rural of Kealakekua and Honaunau. Bottom: Rural of Hoʻokena and Miloliʻi.
1.4.2 Fieldwork

Fieldwork was conducted across 4 years during February – May, 2003; June – July 2004; February, June, and October 2005; January 2006 – January 2007; and April 2007. Concurrent to this project, I was involved in a study of Hawaii’s small boat handline fishery, as well as other social-ecological research in the archipelago.

1.4.3 Identifying ocean experts

“Ocean expert” is a term used herein to describe the key informants, or interviewees, who participated in this study. The population of interest is the group of all individuals within the community, irrespective of worldview, who have historic knowledge of Kona’s coral reef ecosystems (‘ocean experts’). To identify the population of ocean experts, informal interviews were conducted with upper-level informants knowledgeable about Kona Coast coral reefs and ocean community. The purpose of informal interviews was many-fold. Informal interviews served to (1) detail the setting’s background and context (2) identify the social network of ocean experts, and (3) gather information to prepare interview materials.

Ocean experts are recognized both in holding specialized knowledge about Kona’s social-ecological history, and for their status as an ocean authority within the local community. Rather than call interviewees ‘holders of intimate environmental knowledge’ or ‘holders of TEK’, I purposely chose a vague term because Kona’s ocean
experts represent a diverse conglomeration of individuals, cultures, worldviews, histories, and user-groups.

Ocean experts were not sampled randomly from the local population because their expertise about the local marine environment, its organisms, and its history represents a level of knowledge not commonly held in the local community. Random sampling of residents is therefore inappropriate. Snowball sampling (Bernard 1988) and social network analysis (Hanneman & Riddle 2005) enabled me to identify the few individuals most knowledgeable about the coral reef ecosystems, and to prioritize and justify potential interviewees based upon the number of recommendations each individual received.

The social network of Ocean Experts is comprised of 203 individuals. Basic information about each Ocean Expert was obtained during informal interviews and participant observation. Determining basic characteristics of the Ocean Experts was necessary for descriptive and methodological purposes. The objective of formal interviews was eventually to elicit diverse perspectives of ocean change across the region. Thus, I needed to identify groups of varying perspectives within the social network. Because I wanted to let the community describe how it grouped ocean experts, I used grounded theory to identify the most common attributes by which Ocean Experts were associated by the broader community. Experts were grouped by their main activity in the ocean, and/or by their village or kuleana. Experts were primarily classified as one or more of the following expertise groups: (a) Native Hawaiian, (b) Scientist (including resource managers, resource
agency personnel, scientific outreach personnel), (c) Dive shop operator, (d) Tropical aquarium fish collector, (e) Conservationist/recreational diver.

I employed a formal process to choose potential interviewees from network. First, those individuals with the most recommendations were prioritized. The most recommendations of any expert totaled 23, followed by several in the 10-15 range. All of these individuals were top priorities. Second, I strove to sample a similar ratio of people per group in the interviewees, as was in the social network. For instance, over 40% of the people in the network were Native Hawaiian; therefore approximately 40% of in-depth interviews were with Native Hawaiian people, 30% scientists, 15% dive shop operators, and so on. Additionally, some people, while deeply knowledgeable, are not widely known by the community and may not have had many recommendations. Through participant observation and broadening in-roads into communities, I learned about these people and sought to interview them.

1.4.4 Formal interviews

Semi-directive interviews were conducted based on methods described in Bernard (1989), using techniques of critical reflexivity (Baxter & Eyles 1997; Rose 1997) and for cross-cultural research (Tuhiwai-Smith 1999; Gibbs 2001). Forty seven formal interviews with 61 participants were conducted between February 2006 and April 2007. The typical interview lasted 1.5 – 2 hours, with a range of 1 to 5.5 hours. Prior to interviewing an ocean expert, inroads were made with gatekeepers, and exploratory
contact was made with each person and the project details discussed. Potential interviewees were offered the opportunity to give their informed consent, or to decline the interview. If consent was given, the telephone often became an informal or introductory interview.

All interviews were recorded with pen and paper during the interview; with permission and when relevant, interviews were recorded with audio or video systems. Field notes were revisited and elaborated upon immediately following each interview. All interview notes were transcribed into digital format. Interviews were generally conducted one-on-one, though several sessions involved multiple Ocean Experts. When a member of the interviewee’s family was available, they were asked to be present. During seven interviews, a field assistant with Hawaii field experience and trained in anthropological research methods was present. In these events, field notes were recorded and transcribed by both researcher and research assistant and triangulated at a later time.

An interview protocol guiding the direction of each interview was used, but true to the flavor of semi-directive interviews, the depth and scope of any given topic depended upon the expertise of the individual (Box 1). Each participant was asked to describe their observations of ecological change on Kona’s
Box 1: Semi-directive interview guide

I. Personal Description
- Basic personal descriptors: approximate age, gender, ethnicity, etc.
- Tenure on Kona Coast—residency, ohana, etc.
- Education and career, as applicable to reefs
- Community involvement on reefs (e.g., West Hawaii Fisheries Council involvement)

II. Nature of Personal Relationship with Kona Coral Reefs
Activities on the Reef
- Types of activities, frequency, duration, spatio-temporal details, importance to person

Knowledge of Organisms and Environment
- Organisms, geography, years and times, seasons,

Learning about reefs
- Who or what was most instructive, frequency, geography, duration, ohana roles, community context

Context of coral reefs in participant’s life
- Role of reefs in life
- Value and meaning of oceans and coral reefs to one’s person, profession, family, community, etc.

III. Overview of Change
Observations of Change
- As applicable, to organisms (see list), habitat (coral, etc), biophysical events
- Look for change in distribution, abundance, life cycle, behavior, techniques to use, etc.
- Mapping exercises

Natural versus Anthropogenic Change

coral reefs. As shown in Table 1, over the course of interviews, I aimed to collect biophysical information on (1) reef guilds (herbivores, corallivores, piscivores, and upper level predators), (2) habitat structure (coral cover, habitat structure, coral-algal balance), and (3) natural and anthropogenic disturbances, including biophysical events.
Table 2: Ecological themes sought in interviews over the course of study

<table>
<thead>
<tr>
<th>General Topic</th>
<th>Specific Themes</th>
</tr>
</thead>
</table>
| **Habitat Structure**               | • Spatial depiction of increase or decrease of coral cover over time  
                                      • Spatial depiction of coral-algal balance over time  
                                      • Description of any species or morphological change over space and time |
| **Reef Fisheries and Guilds**        | • Population growth or decline over time of individual species (per indicators like catch success), illustrating spatial and temporal changes in relative abundance.  
                                      • Growth or decline over time of key guilds (e.g., herbivores, corallivores) or groups of target species (tropical aquarium fish collection, key food species) spatially and temporally. Sought through changes in use or collection of organisms over time.  
                                      • Indirect ecological effects of above (e.g., sea urchin playing key role of controlling algal growth as numbers of herbivores decrease). |
| **Rare Biological Events and Biophysical Processes** | • Rich description of rare biological events, specifically focusing on radical changes  
                                      • Changes in relative abundance, introduction or disappearance of species, or population explosions. Description will be text based, and displayed visually where appropriate.  
                                      • Discussion of high energy storm or wave events, El Nino, annual, seasonal variations in organisms. Life history details of organisms, spatially and response to biophysical processes. |

Specifically, interviews were used to elucidate historic change and disturbance, both natural and human-made, related to these ecological parameters. The materials used to focus the interviews along these lines included: a list of organisms of interest, as well as a book of aerial photographs of the research sites as a focusing tool along spatio-temporal topics. As illustrated by the nature and direction of the interview protocol, and expanded upon in Table 2, the semi-directive interviews aimed to capture not just
the reef expert’s personal experience with and understanding of the Hawaiian coastal areas, but their observations and perceptions of change.

1.4.5 Participant observation

Extensive participant observation was imperative to this study as a means of collecting contextual and ethnographic data, reducing the problem of reactivity, and improving understanding of local language and cultural mores (Bernard 1988; Baxter & Eyles 1997). For example, I have attended over a dozen West Hawaii Fisheries Council meetings, since 2004 and meetings where this study’s individual participants and groups have converged. The WHFC, which meets monthly, oversees in a community-based manner the decisions relating to user conflicts, coastal and marine development, outreach and education, scientific monitoring of marine protected areas. It also helps to manage the local network of fisheries replenishment areas. This and other forms of participant observation were essential to putting interview themes in context, particularly those pertaining to political and divisive issues. Hawaii has no shortage of public debates about ocean issues well-attended to by the general public as well as ocean experts; over the course of fieldwork, I observed ongoing debates in public forums, newspapers, in local communities, on the floor of the legislature, and at community-based management venues including: designing subsistence fishing area legislations, bottomfish closures, the Northwestern Hawaiian Islands status prior to being designated a monument, gillnet bans, the development of Coast Watch (now called
Makai Watch), spinner dolphins, Superferry, rural area development and planning, Hawaii County Council meetings, conservation meetings, fishing meetings, community monitoring, coral reef outreach and education events, and a variety of meetings held by state and federal natural resource agencies, among others. Through several years’ research and long field seasons on the Big Island, as well as training in social scientific methods that help increase validity and reliability in interviews (e.g., critical reflexivity, participant observation, member revisits, researcher triangulation, via Baxter & Eyles (1997) and Rose (1997). I used participant observation notes to help analyze interview texts and try to distinguish politicized from non-politicized observations of change.

1.4.6 Ethical considerations

Ethical protocol was screened and deemed exempt from review by the Duke University Institutional Review Board, Office of Research Services. Ethical protocol and procedures, as filed with and staff-reviewed by Duke University Institutional Review Board (IRB), include: a process of informed consent, member revisits, and confidentiality of participation. Further, working with ecological knowledge raises issues of intellectual property rights and perceptions of communities and cultures, and in a cross-cultural, indigenous, and small community setting it raises the threat of bringing harm to an individual’s reputation, means of sustenance, income, perception of themselves, or local environment. With this in mind during analysis and publication, there was critical reflection upon the use of research subject’s knowledge and striving to limit potential
sources of harm. Additionally, each subject signed a participation form. Knowledge of local history and cultural mores suggested that I should give each interviewee copies of their own transcripts and tapes/video, as well as offer to donate another copy to the holding or archive of their choice.

1.4.7. Data analysis

Based on the objective to understand SES dynamics through the eyes of local experts, I had a basic idea of themes that might emerge in interview texts. I therefore used adapted grounded theory and thematic coding to code qualitative data. By iterative reading of interview texts, themes emerged and codes were derived. The nature of knowledge, experts’ observations and perceptions of ecological change, and social-ecological system dynamics were the three-pronged research objectives in question. Relevant to this study’s ecosystem-level focus, I sought themes related to patterns and processes rather than single species or issues, unless otherwise an exemplar of broader dynamics. Qualitative data were coded with Microsoft Word once coding structure was finalized. In each chapter with qualitative data (3, 4, & 5), I describe, as relevant, the details of data analysis.
1.5 Structure

1.5.1 Chapters 1-2: Theory and literature review

The first two chapters of this dissertation contribute to the ‘peopling’ marine science, management, and conservation with theoretical contributions and literature reviews. Chapter 1, the Introduction, frames the overarching theory and themes seen throughout following seven chapters. It outlines the fields of marine ecosystem-based management, historical ecology and resilience literatures, as well as puts forth this dissertation’s contributions to ocean-related scholarship and management. It also provides an overview of the study site and methods.

The second chapter is a theoretical contribution to an edited volume on resilience approaches to marine EBM. From the perspective of a ‘peopled ocean’, it reconsiders one of the most fundamental questions in marine science, management, and conservation: the status and drivers of change of the world’s oceans. This chapter on ocean status and drivers of change plays the devil’s advocate: it first reviews current thinking in marine conservation on status and drivers of change in the world’s oceans. Then it asks, is current state of knowledge truly sufficient to address these questions in integrated marine social-ecological systems? It outlines why, and how, we may need to better integrate and cooperate across academic disciplines, and with local communities, ultimately forging new ‘peopled’ approaches before status and drivers of change in marine social-ecological systems can be fully articulated. Written for an international
1.5.2 Chapters 3-6: Empirical research

Chapters 3 - 6 are the empirical chapters of this dissertation, written in manuscript-style format. Together, they show in practice what is discussed theoretically in Chapters 1-2. Each looking at a different component of the peopled seascape, (1) Chapter 3 looks at the human seascape through knowledge and power relations among ocean experts; (2) Chapter 4 examines the biophysical seascape through trends in the abundance and distribution of 8 social-ecological guilds; and (3) Chapter 5 investigates the coupled social-ecological seascape through the values and meanings attached to 8 social-ecological keystone features (species and processes).

Specifically, in Chapter 3, I explore the nature of knowledge of ocean and coastal areas by looking at the diversity of ocean experts within a single coastal region. In Kona’s community today, there are 6 distinct ways of knowing – expertise groups – with very little cross-over in who its experts are, what their ecological knowledge consists of, and how that knowledge is generated. This chapter traces the giving and taking of authority within a coastal region, showing that the absence of local marine science and management catalyzed the re-claiming of authority at the local level. It complicates the idea of community-based management, which is typically seen as prioritizing indigenous peoples, by illustrating a case in which local and indigenous people together
re-claim community authority over coastal resources, but indigenous people increasingly feel disaffected. It primarily addresses my dissertation objectives 3 and 4.

Chapter 4 reflects my efforts to depart from purely quantitative approaches to answering historical questions about the biophysical system. It forges efforts towards a peopled marine historical ecology, first by complicating current approaches and then by presenting historic trends across 8 guilds of reef organisms. Highlighting the shortfalls of current approaches to marine historical ecology, I argue that resilience thinking offers potentially complimentary approaches and introduce possibilities in integrating the two fields. Then, by drawing from multiplicity of perspectives on marine ecological history, I elucidate patterns on a regional level across suites of organisms – which I have called social-ecological guilds. The data, rather than preconceived notions of what categories of organisms are related, tell the story. In allowing the data to tell the story, new insights into relationships among and between over 270 marine organisms, a cross-cultural group of ocean experts, and the Kona Coast itself, were revealed. My results show the surprising consistency in expert’s observations of change, regardless of their way of knowing. Perhaps most importantly, this chapter demonstrates that scientific analytical frameworks were not as appropriate to these culturally inclusive data as an interpretive qualitative analysis. The story of change appears to be complex: biophysical, social, historical, economic, and institutional. Management interventions, local and traditional knowledge, and the evolutionary capacity of a coral reef appear to be major characters in
Kona’s historical ecology. But the story was made richer by casting a broad net, so to speak, in the experts and knowledge systems considered to contribute to this historical ecology. The end data set is far richer because of the variety of perspectives, than any one can give alone. This chapter therefore addresses objectives 2 and 3.

Chapter 5 combines theory on marine social-ecological systems and empirical results from qualitative interviews on historic ecological change to Kona’s coral reefs. This chapter looks at the idea of a marine social-ecological system (SES) – a term widely used but not well articulated at the everyday, local-to-regional level. There is need to identify social-ecological dynamics – the features and processes that actually link humans and ocean ecosystems together, that help us better understand and predict how people and oceans affect and are affected by one another. To identify features of the SES that might be used to indicate, potentially predict, human-environmental relations, I examined the 8 ocean features (7 organisms and 1 biophysical process) most central to ocean experts’ historical narratives of ecological change. These features are of particular importance to groups of people, for various social, political, and other reasons. This paper explores a multiplicity of perspectives about each of these biophysical features – observations, perceptions, responses to, and meanings drawn from change. What these results suggest is that certain species and processes become central to people’s explanations about how people affect, and are affected by each other, by the coastal ecosystem, and by marine management strategies. Thus, I call these species and
processes *keystone features in social-ecological system*. In doing so, I meet dissertation objectives 2, 3, and 4.

Chapter 6, the Conclusions, presents themes from what will eventually become a monograph on the historical ecology of Kona Coast coral reefs. For pragmatic reasons, I made the decision to write this body of research as a manuscript-style thesis rather than a monograph, despite the fact that my findings lend well to a complete, unparsed story. As elements of my analysis undergo the peer review process, I expect the ideas to evolve and develop into several more papers. A few themes of these next stories, however, appear in the conclusions and provide the capstone to my doctoral research.
Chapter 2. Status and Drivers of Change in Marine Social-Ecological Systems: Considering Oceans as Peopled Landscapes
2.1 Introduction

To many, the status of the world’s oceans is both troubling and inspiring. Mounting evidence has documented decline across all reaches of the oceans, from the poles to the tropics, the shoreline to the deep sea. Cross-disciplinary, international efforts to synthesize global change literatures have unequivocally shown the influence of humans on the ocean’s capacity to provide essential services, like food provisioning, climate regulation, and spiritual enrichment. Natural and human factors causing changes to and often diminishing the capacity of the production of ecosystem services are increasingly global and synergistic. Yet the growing awareness of ocean condition has also propelled advancements in marine management theories, practices, and strategies. Ocean status and drivers of change, therefore, are topics at the forefront of the recent paradigm shift towards marine ecosystem-based management (EBM).

Our in writing this chapter for Karen McLeod and Heather Leslie’s text on *Ecosystem-Based Management for the Oceans: Resilience Approaches* (Island Press, *in press*), is to describe the status of the world’s oceans, as well as biophysical, social, and integrated drivers of change in the past, present, and future. Other chapters in their volume will detail why EBM is a paradigm shift and how practical tools can be built from resilience approaches. When considering questions of status and drivers of change, that the book proposes to join two highly integrative frameworks is not inconsequential. Resilience approaches to EBM recognize the connections between the land, air, and oceans, across
scales of space and time, and – most important from our perspective – human and environmental dimensions. For all the literatures we reviewed for this chapter, we were compelled to reassess some of their most fundamental assumptions about ocean complexity, connectivity, and dynamics. Ocean condition and drivers of change must be presented in the most integrative, holistic sense.

In this chapter, we begin our discussion with the field of marine conservation biology (Section II) and recap current thinking on the status and drivers of change. This literature is familiar to policy-makers, resource managers, and scientists, so we focus briefly on the history of and factors that influence marine and coastal systems (Millennium Ecosystem Assessment, MA, 2005). Then we examine the same issues from the perspective of coupled social-ecological systems (SES), an alternative way of thinking about human impacts on and interactions with the marine environment. In doing so, we emphasize a broader view of marine social-ecological systems that goes beyond thinking about humans as generating external impacts to marine ecosystems. Instead, we promote an approach where humans and their activities are fully integrated into marine EBM, or, where oceans are treated as a peopled landscape. But because of limits in our knowledge of human-environmental relationships, and more specifically human relationships with the oceans, we currently lack a complete understanding of the status and drivers of change of coupled marine social-ecological systems. This chapter thus poses more questions than it answers.
Re-conceptualizing the oceans as a peopled landscape may be the most important message of this chapter (detailed in Section III). It is an emerging concept to ocean management and science, and its ‘newness’ is the primary reason we cannot provide a discussion of the status and drivers of change of marine social-ecological systems. Therefore, in this chapter we discuss six implications of approaching status and drivers of change from the perspective of ‘peopled oceans’. In that the oceans have long been treated as un-peopled, much is yet to be learned. Basic assumptions about the relationship between social and ocean systems will need to be reconsidered, rather than continue to treat humans as largely exogenous, negative forces on the environment. Interdisciplinary cooperation and research agendas will be essential in the research and management of coupled SES’s. In designing marine management strategies, the context, history, and human dimensions at local scales will need to be kept in mind, particularly when facing global drivers of change. Finally, power relations among individuals and groups of people offer very compelling explanations for human-environmental dynamics. Underlying each of these points is the assumption that a multiplicity of environmental perspectives exist. We suggest not only recognizing the many diverse perspectives on and experiences with the environment, but also building these diverse perspectives into management strategies.

Herein, we focus on the community perspective in explaining ‘people’ and the ‘oceans.’ While human dimensions also include topics of economies, institutions, and
others, we focus primarily on communities due to limitations in space and thematic coverage of other chapters in this volume (e.g., Rosenberg et al. on governance; Klisky et al. on local knowledge). By bridging extant knowledge (Section II) with emergent peopled approaches (Section III), ocean status and drivers will be better revealed for the purposes of EBM.

2.2 Current approaches to the status and drivers of change of marine and coastal systems

2.2.1 The status of marine ecosystems

Identifying key components of marine ecosystems from a biophysical perspective and describing the status of these ecosystems is a challenging, but important topic to address before we can fully understand the effects of environmental variability and anthropogenic drivers of change. The status or condition of the marine environment can be defined in a variety of ways:

- Ecosystem level (e.g., watersheds, coral reefs, the open ocean, deep sea hydrothermal vents),

- Based on constituent parts of ecosystems, such as
  - Components (e.g., species, communities, populations),
  - Patterns (e.g., distribution, genetic variability, species richness, food webs), and
  - Processes (e.g., oceanographic linkages, dispersal of organisms, seascape connectivity).
Differentiation among the components, patterns, and processes can be made on temporal as well as geographic scales, for example coral reefs at the scales of leeward Maui, the Hawaiian Archipelago, or the Indo-Pacific across 10, 100, or 100,000 years. Moreover, the status can also be discussed in terms of condition in connectivity between systems, such as watersheds upstream of coral reefs, offshore dynamics, or the global climate. Ecosystem services (provisioning, regulating, cultural, and supporting), which are the benefits obtained from ecosystems (Millennium Ecosystem Assessment 2005, Chapter 1), also can be examined to understand both status and drivers of change.

Coastal and ocean habitats are in varying degraded states due to the increasing intensity and frequency of anthropogenic activities, coupled with natural environmental variation. Coastal ecosystems\(^2\), though more resilient to disturbance than the open ocean due to the high natural variability in coastal processes, are more proximate to and are more affected by anthropogenic effects (Lotze et al. 2006). The coastal zone occupies less than 11% of the world’s oceans but accounts for 90% of marine fisheries landings. Localized depletion of coastal fisheries occurred for thousands of years prior to ecological research (Jackson et al. 2001). These depletions have decreased the resilience of these ecosystems by reducing the diversity of organisms that can respond to disturbance. In wetlands and estuaries, though nutrient availability varies naturally,

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\(^2\) The coastal boundary zone begins 100km inland and extends to the start of the continental shelf (<50 meters in depth, Millennium Ecosystem Assessment 2003, Chapter 18).
polluted run-off from agriculture and urban areas are impacting waters and sediments both acutely and chronically. Hypoxic bottom waters have increased worldwide between the 1950s and the 1980s, but there has been no global trend towards reversal (Diaz 2001). Many species depend on estuaries for a critical portion of their life cycle (Dayton 2003), but nutrient loading, overfishing, and invasive species have compromised the resilience of these systems (Boesch et al. 2001). Mangrove forests have been lost at a rate of 2.1% per year over the past two decades – a total loss of 35% (Valiela et al. 2001). Coral reefs and atolls contain high levels of biodiversity and provide a range of ecosystem services including important nursery habitat for many species as well as ecotourism opportunities. There are likely no pristine reefs left in the world (Pandolfi et al. 2003); as many as 20% of the world’s reefs have been destroyed within the last few decades, and 20% more are badly degraded (Wilkinson 2004). Seagrass beds and kelp forests, both highly productive ecosystems, show worldwide decline from pollution (Duarte 2002) and a release of grazing predators due to overfishing (Dayton 2003). These coastal systems highlight, but by no means provide a complete list of, the ~60% of marine ecosystem services that have been degraded (Millennium Ecosystem Assessment 2005).
Compared to coastal areas, open ocean ecosystems have experienced significantly less human activity and yielded less information to science due to distance from land, rougher seas, and difficulty in assessing the deep waters. Open ocean ecosystems are known principally through fisheries landings data and patterns of fisheries’ activity. Relatively less is known about biodiversity, pollution, and many open ocean ecosystem components and human activities therein (Millennium Ecosystem Assessment 2005). Anthropogenic effects also must be understood in the context of natural environmental variation including both short- and long-term cycles in ocean climate and productivity. An increase in fishing effort offshore and in deeper waters, combined with a leveling off of global fishery landings since the mid-1980s, indicates that pelagic communities have been impacted spatially through localized depletion. A displacement of artisanal and local fisheries, which was masked for years by relatively constant landings globally (Watson and Pauly 2001), highlights the historic and contemporary changes in spatial distribution of fisheries, loss of local ecological knowledge and practice, localized changes in biomass, populations, and food webs, among others. The recent trend towards fishing at lower trophic levels suggests that humans may have already depleted many top predators (Pauly 1995; Myers and Worm 2003; Myers et al. 2007), while escalated demand has also increased fishing pressure on

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3 Open ocean systems are defined as waters greater than 50 meters in depth making them the largest habitat in the oceans by area and volume (Millennium Ecosystem Assessment 2005).
lower trophic levels (Essington et al. 2006). This results in severely impacted patterns (food web functioning, genetic variability, biodiversity) and processes (dispersal, behavior) of marine ecosystems (Worm et al. 2006). Fisheries have begun targeting the highly vulnerable deep sea. Its long-lived species that are adapted to constant environmental conditions (Thiel and Koslow 2001; Freiwald et al. 2004) are showing signs of severe impact, such as the orange roughy (Hoplestethus atlanticus) and pelagic armorhead (Pseudopentaceros wheeleri) quickly reaching overfished levels (Roberts 2002). Currently, no management structure addresses the unique ecology of deep sea environments leading to heavy harvest and rapid depletion. These conditions have led some (Devine et al. 2006) to call sustainable harvest in the deep sea a “fallacy” that policy needs to address. Moreover, the open ocean and deep sea are seen as the ‘next frontier’ for energy resources (e.g. gas, wind, and tidal), deep sea mineral extraction, and aquaculture.

2.2.2 Drivers of change in marine ecosystems

Biophysical portions of marine ecosystems and their services are continually in flux due to environmental variation and anthropogenic drivers of change. A driver of change can be defined as “any natural or human-induced factor that directly or indirectly causes a change in the ecosystem” (Millenium Ecosystem Assessment 2005). Drivers in marine ecosystems can be direct or indirect (Box 2). Direct drivers act unequivocally on a resource, such as the extraction of fish by the groundfish fishery in New England.
Indirect drivers operate more diffusely by influencing one or more direct drivers, for example a change in market demand for groundfish that leads to increased fishing activity. In management, an endogenous driver is one that can be directly influenced by a resource manager, while exogenous ones cannot. A complex relationship operates between humans, drivers of change, the ecosystem, and ecosystem services (Figure 5). Without understanding the interaction pathways that ultimately affect ecosystem services, it is impossible to effectively manage ecosystems. Direct drivers of change can affect an individual species, food webs, or entire ecosystems, and processes develop and respond at a variety of temporal and spatial scales (Figure 5). Examples include fisheries harvest, resource extraction, land use changes, climate change, invasive species, disease, and pollution (Box 2). Equally important is the issue of global climate change, which acts on a much broader spatial and temporal scale (McLean and Tsyban 2001). Anthropogenically-driven climate change overlies natural variations that can include both short-term (e.g. ENSO, or El Niño-Southern Oscillation) and long term (PDO, or Pacific Decadal Oscillation; NAO, or North Atlantic Oscillation) cycles. Fine scale drivers have a shorter feedback loop than broader processes. As spatial scales increase, effects take longer to propagate, and more time is needed to study them and to provide useful information for managers.
Box 2: Drivers of change (adapted from Millennium Ecosystem Assessment, 2005)

Many drivers that have a primary effect on coastal habitats (due to the proximity to humans) can eventually propagate to the open ocean. The impacts of invasive species primarily affect coastal habitats and can completely restructure food webs (Mack et al. 2000). Little research has focused on their potential influence on deep sea vent dispersal and recruitment. Land use changes such as the destruction of mangroves and wetlands for aquaculture can reduce critical nursery habitat, thereby effectively reducing recruitment into open ocean populations. Although climate change and eutrophication are direct drivers of change, the broad spatial scale of nutrient run-off and greenhouse...
gas emissions requires spatially and temporally extensive management strategies to be successful.

The disparity in scale between long-term drivers and that of management exacerbates the already onerous task of managing ecosystems. While endogenous drivers often act at similar spatial and temporal scales as management, the feedback effects can be delayed. While an increase in fishing rates might cause an initial decline in population abundance, long term cascading effects in ecosystems are difficult to forecast. Exogenous and often indirect drivers such as globalization affect the ecosystem in ways that are more difficult to predict. Advances in technology allow more efficient harvesting of marine resources as well as easier transport around the globe. As the
distance increases between the location of harvest and where the resource is used, the effects become more dilute and the awareness of the eventual consumer decreases. As previously mentioned, physical processes often act at multiple scales, many of which extend beyond the geographic or authoritative jurisdiction of resource management. Multiple- and cross-scalar drivers can act across a season or decade, reef or watershed. Drivers require management foresight that is difficult to achieve, and may necessitate buffers to protect against unanticipated and potential cumulative effects of drivers.
2.2.3 Examples of drivers of change

According to the MA and conservation biology literature, one of the most significant direct, endogenous drivers in biophysical ocean ecosystems is fishing (commercial, recreational, and artisanal). In addition to directly extracting a target species, non-target species are often taken as bycatch. Bottom trawling can significantly damage benthic habitat (Turner et al. 1999; Thrush and Dayton 2002), and lost gear from fisheries can lead to entanglement. Across the oceans, food webs have been significantly altered by overfishing (Christensen et al. 2003; Jackson et al. 2001) with as many as 90% of all fisheries fished at an unsustainable rate (Myers and Worm 2003); the resulting loss of biodiversity is substantial (Sala and Knowlton 2006; Worm et al. 2006) and may affect system resilience. Relatively minor disturbances in one species can catalyze dramatic regime shifts towards less productive environmental states. By steadily depleting the largest organisms in the population, fisheries may have evolutionary effects on fishes as well. Large scale fishing for Atlantic cod (*Gadus morhua*) in New England has led to the rapid evolution of reduced size at age (Law 2000; Olson et al. 2004). In heavily overfished ecosystems, population level effects can last well after fishing pressure is reduced, reduced biodiversity can ease the establishment of invasive species, and loss of keystone species can have cascading effects throughout the food web.

Decreased commercial catches have led to financial subsidies for unprofitable fisheries allowing over-saturation of the market and increasing the cost to consumers
Subsidies allow more fishers to remain during declines resulting in a ratchet effect on fishing effort; an indirect, endogenous driver, subsidies are one of the most notable causes of overfishing (Pauly et al. 2002; Millennium Ecosystem Assessment 2005). Additional indirect, exogenous drivers include changes in market demand, technological advances, and globalization (Box 2). Technological advances such as global positioning systems and fish finding sonar have made it easier for fisherman to find and extract their catch. With increasing demand for fish in rich countries, economic globalization has encouraged developing countries to export most of their catch rather than supply local markets (Alder and Sumaila 2004). Population growth amplifies the demand for fish, other foods, as well as coastal development.

Population growth in general, and along the coast in particular, results in coastal land development, increased nutrient loading, while also diminishing coastal wetlands and estuaries that can filter such pollution. Nitrogen and phosphorous run-off originates primarily from agricultural fertilizers and waste from farmed animals, but are compounded by many other non-point sources (Rabalais et al. 2002). Rivers transport the nutrients downstream directly to estuaries where eutrophication is a growing concern. Moderate levels of coastal eutrophication can act as a subsidy on the system by providing more resources for top-down regulated systems (Cloern 2001), but extreme eutrophication results in widespread bottom water hypoxia (Rabalais et al. 2001). The Gulf of Mexico along the Louisiana coast receives nutrient inputs from 42% of the
continental US and experiences bottom water hypoxia covering up to 26,000 km² (Rabalais et al. 2002).

Global temperatures have risen between 0.3 and 0.6 °C in the past century and are predicted to rise between 1.3 to 3 °C over the next century from greenhouse gases in the atmosphere (IPCC 2001). Increases in global temperatures will have a multitude of effects on marine communities and biodiversity. Increased surface ocean temperatures in the 20th century have increased the growth rates of some shallow water fish species but resultant cooler deep water temperatures have decreased the growth rates of some deep water species (Thresher et al. 2007). Natural variability in sea surface temperatures and ocean productivity (e.g. ENSO) have offered glimpses of changes in phytoplankton distributions, reduced fish catches, and a decline in seabirds in the Pacific (McGowan et al. 1998; Polovina 2005). Increased ocean temperatures are one of the causes behind bleaching coral (Knowlton 2001) and of decreased recruitment success of important forage species such as walleye pollock in Alaska (Wespestad et al. 2000), and krill in the southern ocean (Loeb et al. 1997). Higher sea levels may reduce intertidal habitat by 20-70% over the next 100 years (Harley et al. 2006). While mobile organisms (e.g. tuna) might alter their migration patterns with changes in ocean temperatures or prey distributions (Polovina 2005), long-lived community building blocks such as kelp forests and coral reefs cannot move rapidly (Steneck et al. 2002; Walther et al. 2002; Bellwood et al. 2004). Changes to circulation patterns could negatively affect the recruitment of
corals (Harley et al. 2006) resulting in a decrease in biodiversity. Most research has focused on the linear effects of climate change (e.g. sea level rise, temperature increases, Harley et al. 2006), but non-linearities such as regime shifts will be difficult to research and manage.

The increase in global ship traffic has increased the transport vectors for invasive species. Marine species are transported in the ballast water of ships that can move non-native organisms across entire ocean basins (Ruiz et al. 2000). These invaders can impact vulnerable native species leading to decreased biodiversity and often extinction (Mack et al. 2000). Because systems with reduced biodiversity have greater available niche space, strong competitors like invaders can dominate the landscape (Stachowicz et al. 1999). The Mediterranean Sea now contains over 85 species of introduced algal macrophytes including large monocultures up to 30,000 ha where substantial diversity once existed (Sala and Knowlton 2006). With increases in both potential for anthropogenic disturbances and in global shipping, the number of successful invaders will continue to rise.

### 2.2.4 Synergy among drivers of change

Most marine systems are adapted to natural levels of disturbance, but oceans are subject to increasing, cumulative, and synergistic effects of both natural and anthropogenic factors. Coastal systems are at high risk to multiple stressors due to their proximity to humans and the prolonged time scale of degradation. Synergism between
increased temperatures and high levels of eutrophication has led to toxic dinoflagellate blooms and resultant fish kills. Often coastal properties are left with tons of rotting fish, and coastal food webs are impaired (Boesch et al. 2001). Anthropogenic disasters such as the Exxon Valdez oil spill in March of 1989 can lead to massive mortalities throughout the food web (Paine et al. 1996). While some species have recovered due to diligent management, biomarkers of this disaster still remain in the tissues of top predators. Chronic long-lasting effects are still visible in the loss of kelp habitat, as well as reduced growth and physical deformities in fish with high biomarkers (Peterson et al. 2003).

Exemplifying cumulative and synergistic drivers, over-harvesting of coral reef species, sediment and nutrient pollution, disease, and global climate change have led to mass bleaching and shifts in species composition in coral reef ecosystems (Bellwood et al. 2004). The number of reefs damaged has increased exponentially since 1980 (Bellwood et al. 2004) due to the synergism of these anthropogenic disturbances (e.g. disease and overfishing in Discovery Bay, Jamaica; Knowlton 2001). The additional stressor of ocean warming could cause major changes in coral species composition, in many cases decreasing the capacity of reefs to provide social and economic services (Hughes et al. 2003). None of the aforementioned drivers act in isolation, but instead have compounded effects. Elevated global temperatures have caused increased intensity and frequency of coral bleaching; extensive nutrient loading has facilitated algal overgrowth on reefs; and fishing of predator fish has released predation pressure on
coral grazers. The compounding effects of these drivers of change need to be considered in concert to adequately manage marine ecosystems.

Synergistic effects require management strategies that deal with the entire ecosystem, multiple species and drivers of change, and account for natural environmental variability. Massive disturbances can be difficult to manage for directly, but precautionary management of controllable stressors can aid quick recovery. On an ecosystem-level and regional scale, the Great Barrier Reef Marine Park Authority has undergone rezoning to match governance scales to biological scales and to manage for resilience (Hughes et al. 2005). The global decline in marine ecosystems has stimulated expansion to new fields of inquiry, including historical ecology (Jackson et al. 2001) and resilience theory (Berkes and Folke 1998), to ensure that ecological baselines sufficiently account for historical influences, scale in space and time, multiplicity of natural and anthropogenic impacts to the environment, and the human component of marine ecosystems. New approaches focusing on ecosystems have been inspired by concerns over the status of marine ecosystems, and the recognition that conventional marine management approaches are limited in their level of attention to synergy, cross-scalar interactions, and the human dimension (Berkes 2003; Leslie & McLeod 2007). Because scales of governance are often mismatched to scales of ecosystems (Crowder et al. 2006; Young et al 2007; Guichard and Peterson in McLeod & Leslie in press), new innovative management strategies are needed. Mass movements towards new research and
management agendas highlight that we may need to push the discussion of status and drivers of change beyond the biophysical components of ecosystems.

### 2.2.5 Reflections on drivers of change

So far in this chapter, we have summarized the current thinking in status and drivers of change, as outlined in the MA and the wider marine conservation literature. In the following section, we present an alternative way of thinking about human impacts on, and interactions with, the marine environment. In doing so, we hope not to supplant the marine conservation literature, but rather to bridge it with an alternative interdisciplinary perspective of marine social-ecological systems. The following section is driven by questions about the dynamics of people and the oceans. Do different people tell different stories of ocean status and drivers of change? Is the current literature integrative and holistic enough? Will focusing on the social-ecological system reveal new drivers of change previously unknown or considered peripheral? For instance, technology, market forces, and globalization are considered important drivers of change to fisheries; however, are these factors also not intimately related to one another, as well as to worldview, human development, and power relations between groups? The MA identifies large knowledge gaps in understandings of ecosystems at regional and national levels; are there critical people/ocean complexities and dynamics that can be found at these smaller scales? For these questions and reasons explored in the following
sections, both the broad literatures reviewed in Section II and integrative approaches that will be put forth Section III are necessary foundations for ecosystem-based approaches.

2.3 Status and drivers of change in a ‘Peopled Ocean’

“How inappropriate to call this planet Earth when it is clearly Ocean.”

- Arthur C. Clark

Given this volume’s approach joining resilience and EBM, integration is central to all of our discussions. Resilience approaches integrate social and ecological systems. They offer a different way of thinking about the world, one which human systems and the environment as inextricably linked, even co-evolved (Kinzig and Leslie, in press). The term social-ecological system (SES) means “an integrated concept of humans in nature” (Berkes and Folke 1998: 4). SES is less similar to ecosystem as scientifically defined, than to holistic conceptions of environment or landscape more typically associated with indigenous worldviews (Berkes 1999). For instance, the Native Hawaiian people conceive of the `aina (land) not simply as the soil. Rather, it is a place of shared lineage, encompassing generations of physical and metaphysical beings, including rocks, streams, trees and plants, air, earth, seas, fishes, humans, ancestors and gods (Kamakau 1964). Marine EBM requires further integration of the system. Marine EBM is characterized by four key features, one of which recognizes the interdependence of economic, political, social, and ecological dimensions (McLeod et al. 2005). From the small- to large-scale, both social and ecological systems are complex and co-evolved.
Individual people, social networks, and institutions continually affect and are affected by ecological systems across local, regional, and global scales (Figure 1, in Chapter 1). A marine social-ecological system is thus multidimensional and integrative of people, their institutions, and economies as well as the biophysical system. In other words, the oceans are a peopled landscape.

The main thrust of this chapter’s discussion, ultimately, asks: why do people do what they do? What is the nature of human (cultural, social, institutional, political, economic) interactions with the oceans? These questions start at a foundational level because what is not yet known (and needed in this discussion) are the fundamental processes and linkages between Oceans and Society, across local to global scales. The challenge of forging an integrative approach to understanding this fully integrated system is formidable. Scientific intellectual traditions, until very recently, separated nature and society (many, e.g., Endter-Wada et al. 1998), posing significant intellectual obstacles to managing the two as integrated. Relatedly, conventional ways of describing status and drivers of marine ecosystems are lacking because they are unable to fully integrate the human aspects. Humans are generally seen as exogenous forces of destruction, and applications of social systems often overly simplistic. Interdisciplinary approaches are proliferating, advancing the scholarship of co-evolved systems, and beginning to offer solutions for integrative social-ecological management. It is too early to have a complete understanding of social-ecological synergy, status, and drivers in the
oceans. Thus, this chapter is more about asking questions about the linkages than
describing them in any detail, because the state of knowledge is still emergent.

2.3.1 Oceans as a peopled landscape

Though uninhabited, the oceans are not un-peopled. People make meaning of
the oceans, interact with, affect, and are affected by the oceans. Many of us can relate to
the idea of a ‘sense of place’ (Relph 1976; Tuan 1977), and we suspect that, like us, the
readers of this book can quickly conjure a mental image of a coastline, or a little stretch
of sea that holds deep personal meaning. At the level of the individual, the idea of a
sense of place helps us describe what it means for oceans to be “peopled”. People
develop a complex fabric of meanings, relationships to, and interactions with the oceans.
Consider, for instance, the different roles of the ocean in the lives of a big wave surfer, a
3rd generation Sri Lankan fishermen, a sea turtle biologist, or a seafood restaurateur in
China. These exemplify, on a micro-scale, the textured human experiences with and
relationships to the oceans; or, what is referred to as the ocean’s human dimensions. The
very richness and complexity of the oceans’ human dimensions has long been
underestimated and unwritten, yet are central to a discussion of drivers of change. For,
they relate inextricably to why people do the things they do, and by extension, the small- to
large- scale dynamics of the social-ecological system.

The implications of ‘peopled oceans’ are myriad for this chapter, as well as for
efforts towards forging an integrated approach. Below we identify six issues, which
identify knowledge gaps, discuss complexities, and elucidate the links between oceans and humans. Tending to these issues will prepare us to manage SES’s, describe their status, and identify drivers of change therein.

2.3.1.1 Oceans as a peopled landscape: overcoming an unwritten history

First, in the writing of history and generation of academic knowledge, the oceans have not been treated as peopled. Indeed, as Arthur C. Clark’s words at the beginning of this passage indicate, we are a terrestrial people, and perhaps naturally terra-centric. Many maps of the world, for instance, portray the ocean as a featureless blue space. While the ocean has a history in which people have been deeply involved, the ocean’s history has remained largely uninvestigated and unwritten (Bolster 2006). Bolster makes this case and in doing so also provides a sense of what it means for oceans to be peopled:

We need to better understand many things: how different groups of people made themselves in the context of marine environments, how race, class, fashion, and geo-politics influenced the exploitation and conservation of marine resources, how individual and community identities (and economies) changed as a function of the availability of marine resources, how technological innovation frequently masked declining catches, how fishermen’s knowledge of localized depletions accumulated in the past, how public policy debates revealed historically specific values associated with the ocean, how collaboration between (and then antagonism among) fishermen and scientists affected marine environments, how faith in the certainty of marine science waxed and waned, how different cultures perceived the ocean at specific times, and—when possible—how past marine environments looked in terms of abundance and distribution of important species. These are the constituent parts that get to a deeper historical question: the nature of the greatest sea change in human history. (Bolster 2006: 571-2)
The richness of human context in the oceans is a vast area in need of exploration. As illustrated in the marine environmental history example above, the social has historically been separated from the ecological in academia, research, management, and practice. Within Western traditions, many self-reinforcing mechanisms have fostered this divide (distinct epistemologies, departmentalization, differing expectations within literature, publishing, tenure, academic jargon; e.g., Endter-Wada et al. 1998). The social-ecological divide is less dramatic today in terrestrial research – interdisciplinary research fields have examined humans and landscapes as co-evolved for some time now. Indeed, human dimensions of marine systems recently have been identified as key knowledge gaps in many interdisciplinary literatures: political ecology (Bryant 1998), historical ecology (van Sittert 2005), marine environmental history (Bolster 2006), resilience theory (Walker et al. 2006), to name a few. However, their common goal in variously examining human/ocean linkages signals how extensive the knowledge gap really is. By long separating the social from the marine ecological, we may have oversimplified the interactions between the two. Given that interdisciplinary research is beginning long after the onset of coastal and ocean degradation, there is a great need to discover the human/ocean history. Until intellectual traditions weave together, in a sophisticated manner, the complex science of social and ecological systems, we risk making management decisions based on incomplete assumptions.
2.3.1.2 Oceans as a peopled landscape: humans as deterrents vs. humans as co-evolved

Second, and on a related point, part of understanding the human dimensions of the oceans will involve re-conceptualizing the relationship between oceans and society. According to conventional wisdom, people threaten the oceans. Human beings pollute, build in the coastal zone, use fertilizers on lawns and agricultural fields causing nonpoint source pollution, consume seafood and thereby support excessive fisheries extractions, burn fossil fuels and influence global climate change (see Sections II, the MA, and other marine global change reviews). While conventional wisdom of human impacts is not entirely misplaced (we are responsible for these things), it tends to cast humans as exogenous to the natural world. It is much harder to get at the question, “Under what historic or socio-political circumstances are fisheries sustainable?” when wisdom suggests humans are external agents, rather than part of the food web. Or, humans as stewards with power over nature, rather than also being partly shaped by and vulnerable to the oceans. The conventional wisdom also ensures human/marine environmental interactions are largely negative (negative impacts, threats, etc). Such assumptions pervade management and are often paired with a classical economic assumption of the ‘tragedy of the commons’ (many, e.g., Berkes et al. 1989; St. Martin 2001), which places people within a homogenous role as actors motivated solely by self interest, invariably overexploiting resources held in common (Hardin 1968).
Yet in social science fields, the prevailing assumptions of ocean/society relationships are being challenged and some overturned. Common pool resources literature, for instance, shows that successes and failures are found in all private, state, and communally-based property-rights regimes (e.g., McCay 1995; McCay 1996; Ostrom et al. 2002). There are many cases of self-restraint and sustainable practices in marine stakeholders. The “tragedy of the commons”, although a widely held assumption in conventional wisdom, does not always come to pass (Berkes et al. 1989). In examining these assumptions, Berkes et al. (1989) highlight the danger in explaining complex social-ecological systems with simple deterministic models. Furthermore, St. Martin’s (2001) work re-mapping fisheries in terms of fishers’ perceptions revealed landscapes different to what was assumed based on fish stock and fishing effort numerical data. Rather than behaving individually in a homologous and unbound commons, St. Martin (2001) showed that individual fishers cooperate and form communities, and can even act as the basis for more formal forms of resource management that avoid depletion and sustain their equitable distribution.

Social-ecological relationships are proving more complex than previously considered. In addition to people as culprits of ocean change, we can describe people as cooperative, recuperative, restorative agents of ocean change. People affect, and are affected by the oceans in positive, negative, and neutral ways. Moreover, humans are not exogenous, rather, are no less a part of the ocean system than the California grunion, the
San Francisco Bay estuary, or ENSO. To fully harness the complexity of marine SES’s a number of approaches are likely necessary. Several are addressed in the following sections, including interdisciplinary research agendas, cooperative interdisciplinary teams in management, and working with local communities to better address local context, diversity of perspectives, and power relations.

2.3.1.3 Oceans as a peopled landscape: a new interdisciplinary research agenda

Third, managing an integrated system will require a parallel research agenda that is sophisticated both in its treatment of human dimensions as well as marine ecology. Given their common focus on the multi-scalar relationships between Nature and Society, several interdisciplinary research fields are well poised to ask key questions about marine social-ecological systems, and by extension to describe their status and drivers of change. The purpose of this chapter is not to review all of these literatures, but to signpost key literatures for those considering managing or studying marine social-ecological systems. We highlight four approaches, and suggest review literature and marine examples (where they exist):

(1) Political ecology – multi-scalar approach examining power relationships among diverse communities and how they relate to broader ecological, political and economic events; attends to the way decisions are made and benefits shared across groups differing in levels of vulnerability and marginality. Reviews: (Bryant 1998;
(2) Resilience theory – explores the dynamics of complex systems from multidisciplinary perspective; pairs social and ecological dimensions as a co-evolved whole. Review: Kinzig and Leslie, this volume. Oceans e.g., (Berkes 1998; several in Berkes, Colding, and Folke 2003; Hughes et al. 2003; Hughes et al. 2005; Wilson 2006),

(3) Historical ecology – common name held by two fields that emerged concurrently from social sciences and marine ecology. Both are multi-disciplinary approaches to understanding the human role in global change. The former is investigates the co-evolution of human communities and (largely terrestrial) ecosystems; the latter looks to alternative data sets to reconstructing marine ecological baselines. Review of social science historical ecology: (Crumley 1994; Balée 1998). Marine historical ecology e.g.: (Jackson et al. 2001; Rosenberg et al. 2005).

(4) Common pool resource literatures – examines the links between resource management and social organization; analyzes how institutions and property-rights systems can deal with the “tragedy of the commons.” Review: (Ostrom et al. 1999; Ostrom et al. 2002). Oceans e.g., (McCay 1995; McCay 1996; St. Martin 2001).

A number of research fields could have been included in this section – ecological economics, human ecology, political economy, environmental philosophy, cultural
ecology, among others. More are likely to emerge. The four above are highlighted because as a collective whole, they explore connections between a) marine ecosystems, b) a local perspective on human dimensions, and c) broader political and economic processes, across scales of space and time. That is, they seem most attentive to particular integrative needs of a peopled oceans.

Why are findings from these fields insufficient to describe ocean status and drivers of change? While we can learn from these disciplines, we still need to be cautious because most interdisciplinary work is still terrestrial. Compared to oceans, the studies of Nature/Society are quite advanced in terrestrial environments, as are the human dimensions in land resource management (many, e.g. Zimmer and Bassett, 2003). Studying “peopled oceans” is a relatively new research activity: theory is being tested by case studies but is not yet generalizable (e.g., Walker et al. 2006 RE: resilience approaches). While it is not necessary to reinvent the wheel, we should not assume that people behave the same way towards the oceans as they do the land. We believe that the very features that define oceans (three dimensional, saline, aquatic environment) and that have contributed to its characterization as un-peopled also ensure that humans interact with the ocean in fundamentally different ways than they do with the land.

Within and across disciplines, the ocean is distinguished as unique to land consistently enough to convince us, the authors, that terrestrially derived principles should only be applied to marine environments with caution, and that marine social-
ecological science should be pursued and given time to mature. This conclusion corresponds with that of Carr et al. (2003) who consider the specific example of protected areas, and argue that terrestrial principles of protected area networks should not be applied ad hoc to marine ecosystems. We argue three reasons why terrestrial findings are not sufficient for marine applications.

First, data limitations in total availability, as well as over time, are more of an issue in marine environments. In the generation of scientific knowledge, marine ecologists are generally limited to various forms of remote sensing and underwater sampling technologies due to our land-centric physiologies. Reliance on technology has meant that the span of ecological data tends to be far shorter in duration than those on land. The origin of longest coral reef data sets, for instance, almost directly coincide with the widespread application of scuba technology in the 1960s – long after the onset of ecological change to these systems (Knowlton and Jackson 2001). Today, novel approaches to reconstructing ecological ‘baselines’ are necessary to understand relatively pristine, normal ecological conditions (e.g., Jackson 1997; Jackson 2001; Rosenberg et al. 2005; History of Marine Animal Populations project, online at http://www.hmapcoml.org/). While these novel approaches can fill some data gaps, data paucity remains a problem.

Second, what we do know about oceans suggests important differences in function, for example, ecologically (Carr et al. 2003). These authors list extensive
differences in ecological, environmental, and evolutionary processes between marine and terrestrial systems. Most significant, they suggest, is the “openness” in the ocean’s transport of nutrients, materials, organisms, and reproductive propagules, which expansively connects nearshore and open ocean ecosystems. With likely marked influence “on oceans’ spatial, genetic, and trophic structures and dynamics”, these differences also imply that humans affect ocean processes differently in the organisms most exploited and targeted for protection (Carr et al. 2003: S90).

Third and related to the former point, humans and their communities also seem to have different relationships with oceans than land. Changes to the landscape are more visible to air-breathing humans than changes to the seascape. Unable to directly observe most marine processes without assistance (pole and line, scuba, satellite imagery), human/ocean interactions are often mediated by technology. Culturally, the characteristics of fishing communities and fishermen around the globe seem to share more similarities with each other than with the cultures of the nations in which they reside (McGoodwin 2001). Historically, the oceans were un-historied, forgotten in the writings of history compared to the land (Bolster 2006). Both suggest something different about how people interact with, come to know, perceive, and respond to the oceans. Most interdisciplinary social sciences make basic theoretical assumptions regarding how humans interact with nature. For example, social scientific historical ecology assumes that there is a direct level of feedback between humans and the
environment (Balée 1998); however, much evidence, such as nonpoint source pollution, suggests ocean’s feedback is far less visible, and less direct in space and time.

Again, while it is not necessary to reinvent the wheel – Nature/Society relationships revealed in terrestrial environments may indeed be relevant to oceans – we suggest they should be applied with caution until proven otherwise. Given the complexity of human systems and marine systems alone, we suggest that we must constantly ask of a marine EBM approach: is it marine enough? Is it peopled enough?

2.3.1.4 Oceans as a peopled landscape: the case for balanced interdisciplinary engagement

*Fourth*, shifting ocean research and management into a framework of “oceans as a peopled landscape” should come, at least in part, from balanced interdisciplinary engagement. For example, the social science research strategy for marine protected area (MPA) management takes a human ecology perspective: “MPAs must be viewed holistically as they fit into the biophysical environment, as they reflect and affect past and present human users, as they relate to the prevailing policy and management framework, and as they are informed and influenced by science and stakeholder perspectives” (Wahle, Lyons, et al. 2003). Balanced interdisciplinary engagement means that biological, social, and interdisciplinary experts all participate from the earliest design and research phases of a management action. Interdisciplinary engagement should entail both cooperative teams of people trained in various disciplines and interdisciplinary research, like studies in political ecology linking behavior of local
people to broader ecological, political, and economic contexts. Without interdisciplinarity and balance across disciplines, marine management actions have been shown to fail. Christie et al. (2003) state that in most cases, MPAs involve both biological and social dimensions, goals, and indicators. However, most are examined principally on biological evaluation criteria. While an MPA may be biologically successful, it can fail on social measures – usually resulting in disappearance of biological successes in the long term unless social issues are addressed (Christie et al. 2003; Christie 2004).

Recent growth in interdisciplinary engagement is evident in many areas: (a) Interdisciplinary teams of biophysical and social scientists in marine science and management (e.g., the three-pronged approach to indicators – biophysical, socio-economic, and political – in the text, How is your MPA doing? [Pomeroy et al. 2004]); (b) Interdisciplinary research agendas of nature/society relationships focusing attention on marine systems (e.g., Maurstad 2000, Mansfield 2003, Mansfield 2004, St. Martin 2001); and (c) Individual researchers trained and/or working across disciplines (e.g., advent of marine management programs in schools of the environment).

Despite a clear trend towards interdisciplinary cooperation, the social science literature offers suggestions towards more productive engagement. Specific concerns relate to overcoming problems of simplification, of both the role of social science in marine management and the complexity of local communities. In some cases, problems
in interdisciplinary engagement relate to how issues are addressed, and in others, problems are about misunderstandings of what social science is and can do.

Complexity within local communities is extremely important but often oversimplified. Simplifying the human dimensions, such as the tendency of looking only at how management actions will affect local communities, plays down the importance of people’s histories and contexts. This is to the detriment of “more proactive senses of community that stress what communities can do rather than what is done to them, and renders less visible the multiplicities of interests, positions, and values in any given community” (Olson 2005: 249). Oversimplification is exemplified by a Gulf of Mexico MPA that measured human dimensions by the number of boats on the water, which underestimated the importance of ethnic diversity, types of fishers, and fisheries. Moreover, it may have failed to consider existing management regimes, the complexity of human relationships with the oceans, and the willingness of local fishers to participate in management (Christie et al. 2003). More broadly, Christie et al. (2003) argue that in MPA design and implementation, social science is often considered too late and can result in poor understandings of frequently contentious social interactions across local, national, international, gender, class, ethnicity levels and others. Unintended negative consequences, missed opportunities, and at times, the failure of the MPA itself have occurred.
Social science included from the outset of research and management initiatives can offer a way to better understand the people affected by management, including motivations, cultural heritage, social and economic situations, local or indigenous expert knowledge, and cooperative management. Yet, Kaplan and McCay (2004) note that too often in the fisheries council processes, co-management with local people is used as a last resort, after trust and communication has broken down. The approach and people regulated have suffered for it. If social science approaches to working with local communities are implemented from the outset, as a means rather than an end, compliance and communication should improve. The human dimension is an important part of the fishing and seafood industries (Kaplan and McCay 2004). Campbell (2005) fully supports and frequently participates in interdisciplinary marine research, particularly relating to sea turtles, and also describes challenges related to biologist colleagues’ misconceptions of the social scientific practice. In her experience, while eager to work in local communities, field biologists have given her the impression that social science was necessary to educate the local people about conservation-related values of sea turtles. They have even expected her to fix socioeconomic problems – neither of which are possible in the role of a social scientist (Campbell 2005). Cooperative or joint research with fishers (Kaplan and McCay 2004), and local ecological knowledge research (Berkes 2003 a & b) are among techniques recognizing that diverse kinds of knowledge exist within communities. Lessons-learned from the fisheries council processes indicate
that cooperative or joint research efforts with fishers, particularly those impacted by management decisions, can improve trust, communication, and good faith amongst constituencies (Kaplan and McCay 2004). Social science and interdisciplinary efforts can foster successful marine management – but only if approached in a way that respects the social scientific process as well as the communities within which social science is achieved.

2.3.1.5 Oceans as a peopled landscape: keeping sight of the ‘local’ when facing global change

Fifth, as inferred in the former discussion, the local-scale is particularly important to consider in new approaches to peopled oceans. Scale is a theme that arises throughout this volume (Guichard and Peterson in press) because cross-scale interactions within and between social-ecological systems are considered one of the more pressing marine management challenges to be dealt with. The rising prevalence of global issues such as climate change is increasingly demanding global efforts, and is reflected in the tendency to talk about broad scale processes and change in oceans. This is despite burgeoning work in marine political ecology, which tends to look at and across scales, and common pool resources’ attention to local context. Few case studies examine integrated marine systems, and even fewer at a multi-scalar approach. Yet terrestrial literatures and marine case studies that do take a multi-scalar approach find that the complexity of local communities and human experiences are extremely important in explaining broader
processes (terrestrial overviews: Leach and Mearns 1996a; Zimmerer and Bassett 2003; marine case studies: see below).

Keeping in sight of the local scale is important in any approach (Campbell 2007), and it has often been the focus of terrestrial interdisciplinary studies, to the point that scholars have begun to criticize over-emphasizing the local and ignoring multi- and cross-scalar processes (Brown and Purcell 2005). But the opposite has tended to be the case with oceans, where the local is often invisible since people are absent or transitory. Many processes cannot be understood outside of the context (geographic, social, cultural, political, economic, psychological, etc) in which they exist. Just as the fine-scale patchwork of recruitment, wave exposure, and habitats are important in designing networks of MPAs on a local level, the complexities in local communities and in the human experience are critical in explaining patterns and implementing management measures. Local scale is important because it provides the context (political, economic, social ecological, etc.) to implement scientific knowledge and management practices meaningfully.

Local knowledge is receiving increased consideration for its potential contributions to marine science and management (Davis and Wagner 2003), including new insights into marine ecosystem dynamics, human dimensions, and local context (Berkes 1999). Local ‘eyes’ on the system may provide efficient feedback and response to environmental change. Local people, knowledge, and community structure may offer
new ideas for management strategies attuned to the local social-ecological context (McGoodwin 2001; Berkes 2003a), as well as help bring attention to what local communities can do to achieve effective management (Olson 2005). When looking closely at fishing communities (McGoodwin 2001), or fishers knowledge (Berkes 2003a), complex stories of culturally evolved environmental management practices exist and can offer great insights into human dimensions and potential management strategies allowing for small scale use (St. Martin 2001). These all reflect the benefits of a mostly local-scale approach.

To give an interdisciplinary, cross-scalar research example, Mansfield (2003) traced how different people and groups make distinctions about the biophysical world. These distinctions can become important in how economies are driven. Debates surrounding which places were more appropriate than others for certain kinds of production activities – such as whether imported seafood from Vietnam could be labeled “catfish,” or whether farmed shellfish could be labeled “organic” – showed that the biophysical world, as manifest in individuals and their cultures, is related to international relations and trade (Mansfield 2003). Examining local complexities has enabled researchers to identify and describe why particular fisheries are sustainable, and how sustainability is achieved. Because of the local socio-political context and the Maine lobster’s unique biology, Acheson (1997) suggests, the Maine lobster fishery instigated
shifts towards sustainable practices following periods of decline, three separate times across a century.

Heterogeneity in local contexts must be taken into account, particularly in considering the scale of management actions. Campbell et al. (2002) examine the scalar mismatch between an international treaty and current thinking in conservation (namely, community-based conservation). In their example, the use of international instrument to eliminate the local use of marine turtles, without considering whether turtle use might be sustainable in specific communities, ultimately may undermine the treaty’s effectiveness. This international instrument failed to reflect the local emphasis in current conservation thinking, and seems to demonstrate that both international treaties and local efforts may be effective in some ways – and ineffective in others (Campbell et al. 2002). Indeed, institutional diversity is now considered as essential as biological diversity (Ostrom et al. 1999), and emergent place-based approaches emphasize the importance of local context towards overcoming mismatched scales of governance and ocean management issues (Young et al. 2007).

Of many ways that cross-scalar interactions are implicated in marine systems, the local scale is emphasized here because it is so often oversimplified or reduced to technicalities in oceans. In terrestrial interdisciplinary research, the opposite has been true, and political ecology scholars have begun to talk about the ‘local trap’, or the tendency to overemphasize the local to the detriment of scale (Brown and Purcell 2005).
But the local has not yet figured prominently in the integrated treatment of ocean systems. The small, local scale of human beings is a fundamental variable in describing drivers – why we do the things we do – and iterative relationships between ecological change and human change.

### 2.3.1.6 Oceans as a peopled landscape: a multiplicity of perspectives and power relations

*Sixth*, and the final implication of oceans as peopled landscapes, is one that underlies all of those previously discussed. Many people hold understandings of the oceans different to those ideas described in science; these represent a ‘multiplicity of perspectives’. Suggesting both practical and philosophical reasons for learning about these diverse perspectives, and applying them towards environmental management and conservation, Berkes et al. (2003) state:

> The need to use a multiplicity of perspectives follows from complex systems thinking. Because of a multiplicity of scales, there is no one ‘correct’ and all-encompassing perspective on a system... Especially with social systems, it is difficult or impossible to understand a system without considering its history, as well as its social and political contexts... A complex social-ecological system cannot be captured using a single perspective” (Berkes et al. 2003: 8).

The single “all-encompassing perspective” to which these authors refer is science. Outside of science there are many environmental perspectives that tell stories of the environment different to conventional wisdom (e.g., Leach and Mearns 1996a; Bryant 1998). Science, particularly Western science, has had more direct access to
environmental policy and management than other perspectives (Forsyth 2003; Nader 1996). Pragmatically, capturing more perspectives on environmental change will help address data gaps, as well as recognize the “social” as the complex system that it is. In addition it will better enable managers to *situate*, or contextualize, marine management strategies socially, historically, and geographically. Many other pragmatic justifications for attending to multiple perspectives are addressed elsewhere in this paper.

In addition to more practical issues, there is a philosophical argument herein relating to the need to recognize local and non-scientific knowledge as legitimate. Historically having the most direct access to environmental discourse, management and policy (Forsyth 2003), science has excluded many other perspectives and knowledge systems (Raffles 2002). Being excluded historically from the dominant discourse remains a “deeply remembered” aspect of many indigenous people’s cultural memory (Tuhiwai-Smith 1999). Efforts to re-assert their ‘contested stories’, or alternative perspectives on history, have driven political movements and, according to an indigenous scholar/advocate, influence indigenous people’s perceptions of science and researchers today (Tuhiwai-Smith 1999).

Reflecting the science-local knowledge tension, many indigenous communities have written ethical protocol that scientists must adhere to when conducting research in their communities (e.g., http://www.desertknowledgecrc.com.au/socialscience/social
Power relations between science and other perspectives not only underlie these issues, but also offer compelling explanations for human/environmental dynamics (Leach and Mearns 1996a). Due to differences in power, equity, access to political power and voice, and level of vulnerability and marginalization, people are affected differently by environmental change, leading to such different perspectives (Leach and Mearns 1996b; Bryant 1998). In Sub-Saharan Africa, conventional wisdom long considered pastoralists to be the primary agents of deforestation, despite local people contesting otherwise. This untested assumption pervaded science, policy, and public perception of peoples of Sub-Saharan Africa for many years. Examining aerial photos, geology, and interviewing local people indeed demonstrated pastoralists were agents of re-forestation (Leach and Mearns 1996b). Power and legitimation issues are very much enveloped in considerations of scale – local interests have been shown to struggle as marine management is implemented at broader scales. Regarding sea turtle conservation, Campbell (2007) shows that in local, national, and international arenas certain conservation policies are legitimized in the language of ecology, but are underlain by beliefs about people’s rights to sea turtles as a resource. Across scales, ecological arguments are employed differently to promote certain types of conservation interests – with consequences to the local rights of access to the resource (Campbell 2007). In certain
circumstances worldwide, there is evidence to suggest local knowledge is still considered less legitimate than science, suggesting there is still much progress to be made in attending to local perspectives. Campbell and Vainio-Mattila (2003) discuss that while a pharmaceutical company employed indigenous people in bio-prospecting, these people were not given intellectual property rights – suggesting that local ecological knowledge was important, but relatively less so. Thus the philosophical argument suggests a moral imperative in addition to the practical ones.

The message is that scientific knowledge of marine ecosystems, if not generated in a local, cooperative, and integrated context, will only be as powerful as it is inclusive of other ways of knowing the oceans. Poignant examples of the relationships between scientific and local knowledge, as well as the power of local situated in a context, are provided in the literature. In a case study by a Finnish researcher, despite the existence of highly sophisticated silvicultural expertise in Finland, the main reason for the relative health of Finnish forests is that conservation practices are based on traditional knowledge passed from one generation to another (Oksa 1993, as cited in Campbell and Vainio-Mattila 2003). Similarly, Berkes (2003b) speaking to community-based conservation, suggests a strong need to link cross-culturally, encompassing a broader view of the livelihood needs of local people and their knowledge and interests. Small-scale local farmers, fishers, and forest users may be the best natural allies for conservationists (Alcorn 1993, cited in Berkes 2003). In marine management, local, often
indigenous, knowledge is increasingly given consideration (Davis and Wagner 2003), for example, Native Hawaiian traditional ecological knowledge and traditional tenure practices are explicitly recognized and in recent revisions and reauthorizations of the Hawaii State Ocean Plan, and in the federal the Magnuson-Stevens Fisheries Reauthorizations (2006). Attending to local people’s perspectives has the potential to empower people. However, empowerment is not always inherent as commonly assumed; rather, it must be fostered and achieved (Davis and Wagner 2003). Others describe how to elicit diverse perspectives and why they are so important to marine management (e.g., McGoodwin 2001; Berkes 2003a & b). We simply state here that there is much to be learned and gained by an inclusive frame.

2.4 Conclusions: status and drivers of change in the management of oceans as peopled landscapes

We have been asked to discuss status and drivers of change in marine social-ecological systems. Throughout we have argued that the oceans are a peopled landscape. Being an emergent concept, coupled marine social-ecological systems are not fully understood. Thus, we have signposted several considerations that will attend to the topic of status and drivers of change marine systems. Interdisciplinary marine research and cooperation will continue to unravel the synergistic relationship between Oceans and Society. With regards to ocean status and drivers of change, substantial components of the discussion do exist. The conservation biology literature and MA, for
instance, are important pieces, and insights into the synergies between Oceans and Society will continue to emerge from multi-scalar, interdisciplinary case studies.

Solutions may lie in collaborative efforts between local people and managers to learn about, work with and within local communities. Management approaches better reflecting local communities’ diversity, multiplicity of perspectives, and power relations may be necessary. Once balanced interdisciplinary teams of practitioners, managers, and scientists are joined, trends will likely emerge. These cross-boundary approaches may be central to understanding and managing oceans as a peopled landscape.
Chapter 3: Expertise vs. Authority: The Prominent and Hidden Dimensions of Ocean Expert Knowledge in a Coastal Community
3.1 Introduction

Great attention in marine conservation and management has recently been given to the notion of “how humans affect, and are affected by, the oceans”, or the human dimensions of marine systems (e.g., NCCOS 2007; Leslie & McLeod 2007; McLeod & Leslie in press). Human dimensions approaches are increasingly regarded as fundamental to one of the more pressing issues of today: stemming the relentless tide of global ‘sea change’ (POC 2002; USCOP 2003; MEA 2005). Highlighting that integrative approaches are gaining in prominence, traditional ecological knowledge (TEK) (Berkes et al. 2000; see Ecology & Society 11-13) and local ecological knowledge (LEK) (Johannes et al. 2000; McGoodwin 2001; Berkes 2003; Davis & Wagner 2003) are significant growth areas in research, and are recognized as fundamental principles of marine conservation (Drew 2005; Norse & Crowder 2005) and ecosystem-based management (McLeod et al. 2005; Leslie & McLeod 2007).

Though young in practice, integrating human dimensions into the conventionally natural science-dominated field is showing promise (Liu et al. 2007). But the way in which human dimensions approaches are implemented in marine management has been met criticism, saying that human systems and the practice of social science have, thus far, been oversimplified. Getting at the nature of how humans affect and are affected by oceans (i.e., human/marine environmental relationships, or dynamics of integrated human/ocean systems) requires that greater complexity be
afforded to humans and social sciences, than has been systematically demonstrated thus far (Berkes et al. 1989; Endter-Wada et al. 1998; St. Martin 2001; Christie et al. 2003; Christie 2004; Kaplan & McCay 2004; Ostrom et al. 2002; Campbell 2005; Olson 2005; Campbell et al. in review). Failure to do so may prove deleterious not only to marine management strategies and their relations with coastal communities, but also to resource users themselves (Kaplan & McCay 2004; Olson 2005).

An overarching critique of how human systems are often treated in ocean science and management today relates to the lack of recognition of the array of values, attitudes, and behaviors within coastal communities. It is commonplace, for example, to type-cast fishers and other resource-users as actors in the tragedy of the commons (Hardin 1968). Fisheries anthropology, common property literature, resilience and other literatures challenge environmental discourse’s perpetuation of the ‘tragedy’, as a uni-dimensional and erroneous assessment of human behavior (Berkes et al. 1989; Ostrom et al. 1999, 2002; St. Martin 2001, 2005). This, along with the propensity in marine conservation to look at humans solely in light of negative anthropogenic impacts (i.e., humans as threats), not only belie the complexity of social systems and behaviors, but also serve to undermine what actual human behavior can teach us with regards to ocean systems and their management (e.g., conservation activities, traditional marine tenure, social organization of fishers to perpetuate fish sustainability) (e.g., Berkes et al. 1989; Endter-Wada et al. 1998; Ostrom et al. 1999; St. Martin 2001; Mascia 2003; Kaplan & McCay
While marine conservation emphasizes the examination of “how humans affect, and are affected by, the oceans”, in practice it thus still focuses on relatively few of the many aspects of human/marine environmental relationships.

It is this disconnect that I address through an empirical study of the historic, human dimensions of the coral reef ecosystems of Kona, Hawaii. In tandem with the critiques above, this paper looks at the complexity of expert ocean knowledge systems within a single coastal region, and traces how a multiplicity of perspectives affects human/marine environmental relations and the condition of coral reef ecosystems. This paper’s attention to “expert knowledge” as a human dimensions issue is warranted, given the attention TEK and LEK are receiving as marine human dimensions approaches. Furthermore, the generation and transmission of ecological knowledge is one of the most fundamental of human/environmental relationships, but is never far from power relations. One ecological knowledge system, Western science, historically has had stronger lines of access to power and marine management, with serious implications to the lives and livelihoods people (fishers, indigenous people) of other expert knowledge systems. Thus, this paper further examines how the giving and taking of authority between these groups of people has influenced the ecosystem, social relations, and management regimes – that is, the many overlapping human/marine environmental relationships at work and influencing Kona’s coral reefs.
3.2 Knowledge(s) of nature: confronting the nature of knowledge

The issue of oversimplification of human systems in marine management and conservation arises in what is both the subject of this paper, as well as one of the more popular human dimensions approaches in marine conservation: alternative ecological knowledge systems, and in particular traditional ecological knowledge (TEK, Berkes et al. 2000). The idea that outside of science, some people and cultures over time have developed knowledge and tenure practices for marine environments has been accepted, and now is viewed as an area with the strong potential to contribute to marine conservation and management. Other ways of knowing are studied for their novel insights into ecosystem condition and functioning, as well as to suggest strategies to cope with global change (Johannes 1981; Berkes et al. 2000; Berkes 2003; Folke 2004; Drew 2005; Folke 2006). Its popularity in marine conservation can be seen, for example, in its presence in texts outlining fundamental principles in marine conservation and marine ecosystem-based management (Norse & Crowder 2005; McLeod & Leslie, in press).

TEK’s popularity as enacted in marine conservation, I argue, is both encouraging and problematic. It is encouraging because it evidences movement towards interdisciplinarity, and towards recognizing human behaviors that are not deleterious ‘anthropogenic impacts’. I agree with Drew (2005) and others who say TEK stands to make substantial contributions to marine scientific practice, if sufficient attention is
given to the significant ethical, political and epistemological issues involved in TEK research (Shackeroff & Campbell *in press*). Yet the emphasis on TEK remains problematic for other reasons. First, it often overlooks other forms of knowledge, like that held by fishers, that also stands to contribute to and benefit from engagement with marine conservation and science. While there is evidence of a surge in local and fisher’s ecological knowledge research (LEK, Davis & Wagner 2003), many fewer published studies embrace fisher’s knowledge compared to TEK. Rather, fishers tend to be vilified in marine conservation. Overfishing, for example is often espoused as a primary threat to oceans today and in history (Jackson et al. 2001; MEA 2005; Worm et al. 2006). Second, the focus on TEK lends to romanticizing and essentializing it as primitive and ‘indigenous’, assumptions adamantly critiqued by indigenous and non-indigenous people alike (e.g., Nadasdy 1999; Tuhiwai-Smith 1999).

These kinds of oversimplifications set up a hierarchy of knowledge systems: e.g., science vs. other, TEK vs. other non-scientific. Science studies and political ecology actively debate these issues (Nader 1996, Forsyth 2003), and in the resilience literature scholars are working through problems with needing to engage ‘other’ knowledge systems productively and ethically with the science on global change (e.g., see Folke 2004, and Ecology & Society Special Issue on Traditional Ecological Knowledge in Social-Ecological Systems). Assumptions about TEK and LEK tend to cast ‘alternative’ knowledge as rigidly opposed to or in contrast to ‘science’. Some scholars try to codify
TEK into scientific language, or use Western science to ‘test’ the validity of indigenous or fisher’s ecological knowledge (Davis 2004); while others critique these practices philosophically (Nader 1996; Nadasdy 1999; Agrawal 2002; Folke 2004). The science vs. other dichotomy also may disregard potentially significant influences in how humans affect and are affected by oceans, such as the potentially diverse origins of and interactions between various bodies of knowledge, and the complex and uneven ways knowledge is transmitted in the contemporary world (Nader 1996; Agrawal 2002; Walley 2002). Herein I contribute to this debate, by examining the complexity of knowledges in Kona and arguing that what is found in a single coastal community not only defies this dualistic thinking (science vs. other), but also brings clarity to the dynamics of ocean systems through a richer understanding of simultaneous intra-community, community-science, and community-management, power relations.

This study ‘unpacks’ complexity in a coastal community by exploring and identifying the range of knowledges, perspectives, and experiences that exist within a coastal region. It focuses on the coral reefs of the leeward coastline of Hawaii Island. As human populations are concentrated on coastlines, coastal ecosystems are some of the most impacted and altered worldwide (POC 2002; USCOP 2003; MEA 2005). Coral reefs are some of the most threatened of marine ecosystems (Pandolfi et al. 2003; Bellwood et al. 2004; Hughes et al. 2005), and in need of historic data (Jackson et al. 2001; Knowlton & Jackson 2001; Pandolfi et al. 2003). But as sites with much human activity (e.g.,
compared to open ocean or deep sea), they are also systems where we may gain a better understanding of the linkages between marine ecosystems and human societies, via exploration of expert knowledge, because of the diversity of people and activities (fishers, divers, cultural practitioners, scientists, etc.) who use and generate knowledge about coral reefs.

Drawing from the science studies and resilience literatures, this paper assumes that science is a historically and culturally situated activity (Latour 1987; Haraway 1988) and that there is no one correct and all-encompassing perspective on a system (Berkes et al. 2003). Instead of ‘knowing’ oceans only through the scientific enterprise, a multiplicity of perspectives outside of science are required to understand social, economic, and political contexts of ocean systems and global change (Berkes et al. 2003; Folke 2006). Rather than focusing on pre-existing labels (TEK, LEK, science, etc.), I cast a broad net in exploring expert knowledges surrounding Kona’s coral reefs. This paper does not assume any one knowledge system exists, and likewise, does not prioritize any one way of knowing over another. As results herein demonstrate, at least six marine knowledge systems exist in Kona today. These ‘expertise groups’, as they are called herein, exhibit very little cross-over in who experts are, what they know of ocean systems, and how they know it.

After exploring Kona’s marine knowledge systems, this chapter then traces the giving and taking of authority between expertise groups, as a proxy for how a
multiplicity of perspectives operate synergistically, and drive changes (positive and negative) to marine systems. As the political ecology literature observes, people’s experiences with power, socio-economic development, and political voice affect their experiences with and explanations of environmental change (Bryant 1998). The marine protected area (MPA) literature has found this to be important, as noted by Christie and others (2003) who show that biological successes of MPAs (e.g., increasing species abundance and richness) may be reversed in the long term if success in social measures (e.g., community participation, compliance, conflict resolution mechanisms) is not achieved (Pollnac et al. 2001; Christie et al. 2003; Christie 2004). Therein is the link between knowledge systems and adding complexity to the question of how people affect, and are affected by, the oceans. This paper tackles the question of human/marine environmental dynamics by looking at how complexity in the community (that is, the diversity of perspectives therein) and social relations among these groups factor into ecosystem condition, human/environmental relationships, and marine management regimes.

3.3 Study site: Hawaii Island’s Kona Coast

Hawaii Island’s Kona Coast is an ideal context for a study of cross-cultural historical ecology for reasons of its biophysical setting, history of coral reef management, and the range of ocean-interested actors from varying cultural, social, political, and economic contexts. The study region encompasses approximately a 50 mile region
between Kaloko and Kapua, the southern two-thirds of the Big Island’s leeward, Western coastline called the Kona Coast. Nearshore marine resources have long provided sustenance and a venue for cultural practices for Hawaiian and non-Native local people, and in more recent decades have become a focal point for tourism industry. Along Kona’s coastline, the great diversity of ocean uses is matched, perhaps, only by that of the local populous, which is among the most diverse in the nation (US Census 2007).

The Big Island is widely considered in a state of transition (participant observation), as its rural, ‘local’ setting is being quickly reshaped by the onset of the ‘construction boom’. On O’ahu and Maui’s more developed coastlines, the construction boom has for years effected dramatic social and ecological change. Kona’s reefs are influenced by heterogenous factors in the landscape, seascape, and human dimensions (see Figures 2, 3 & 4, Chapter 1). Thus, I chose a series of study sites within the region to unravel the heterogeneity. The northernmost study sites are proximate to industrial, urban, boating and marina, and heavy development pressures. In contrast, agricultural and rural land uses dominate South Kona watersheds. A plethora of fishing, diving, surfing, cultural and religious practices, and scientific endeavors converge on the seascape of Kona’s coral reefs.

Kona’s nearshore resources are important to a wide variety of groups today, whose experiences and perspectives of environmental change cannot be understood
outside of their historic social, political, and economic contexts. From the time of the first waves of Polynesian navigators’ settling the archipelago c. 300 AD to Western Contact in 1778, the Native Hawaiian peoples developed sophisticated subsistence, governance, social, and spiritual practices related the oceans (Kamakau 1964; Kahaulelio 2006; McGregor 2007). Contemporary accounts of the ocean’s importance to the Hawaiian culture recognize many aspects linking ancient and contemporary practices, including the sophistication and mastery of diverse fishing practices (Glazier 2007). Post-contact Hawaii has been a history of diversification, Westernization, and globalization. The ocean is central to the way of life of a diverse mixture of locally-living people on the Kona Coast. The ocean is never far from view, whether from the perspective of Native Hawaiian practitioners or the locally-living people, or kama‘aina, who fish, collect, dive, surf, barbeque, and recreate along Kona’s shores.

Post-contact, political and economic forces have effected great change on the Native Hawaiian people, their access to political and economic voice, rights to land and to practice their culture, and millennia-long marine fishing and tenure practices (Churchill and Venne 2005). The Native Hawaiian people (kanaka ma`oli) or part-Hawaiians of this coast are emerging with varying degrees of success from a demonstrable history of oppression and poverty. Many of the non-Native local residents (kama`aina) whose forebears worked on the plantations and ranches of the Big Island also continue to struggle. Nearshore resources have long provided food and a venue for
socio-cultural practices for members of these groups. But agents (often haoles; that is, persons of European ancestry or other "foreigners") and consequences of our modern capitalist system continue to affect and may indeed threaten those resources and/or access to them. A key question herein is the extent to which a typical individual may realize agency to change or deflect powerful forces that precede or accompany development and associated ecological change.

Relating to the biophysical condition of Kona’s reef systems, prevailing assumptions suggest that Kona’s reefs are not only considered relatively pristine, but that steep bathymetry, high nearshore circulation, and adaptations to the high wave energy environment make Kona’s corals resistant to the affects of land-based pollution (Dollar and Grigg 2004). To locally-based ecologists, however, coral reefs elsewhere are harbingers of eminent change in Kona; synergistic affects of fisheries and land-based sources of pollution have resulted in regime shifts on many reefs globally (Jackson et al. 2001; Bellwood et al. 2003) and degradation on other Hawaiian Islands (Dollar and Grigg 2004). Surface and subsurface hydrology in Kona is not well established (USDA NRDC 2006, pers. comm.), and consequently neither is the connectivity between the hydrologic regime, freshwater flow, and potential or actual conduits for polluted runoff to coral reefs. Between 5 and 10 million visitors come annually to the Hawaiian Islands (HDBED 2007), approximately 80% of whom recreate in Hawaiian waters (Cesar et al. 2004). Thus framed, the construction boom and related growth in resident and tourist
populations, Kona’s coral reefs are considered at an impasse (Walsh 2007, pers. comm.; Beavers 2007, pers. comm.).

Removal of coral reef organisms is a complex and significant issue in coral reef ecosystem dynamics in Hawaii, replete with complex cultural, historical, economic, political, and social issues surrounding fishing and trade in live coral organisms. Since 1973, the tropical aquarium fishing industry has more than quadrupled from 90,000 fish collected that year, to over 400,000 reportedly collected in 1995 (Friedlander et al. 2005). Local people are said to have observed demonstrable change in coral reef fish abundance for several decades, due in large part to trade in live aquarium fish (Capitini et al. 2004). Tissot and Hallacher (2003) investigated the legitimacy of local people’s decades-long claims, and in the mid-1990s documented that a bay historically closed to tropical aquarium fishing had significantly higher ornamental fish abundance and diversity than open areas. However, the historical, spatial, temporal, and biophysical extent of potential decline is not systematically recorded in the scientific literature, as no scientific data spans the decades and sites described by local people.

In the mid-1990s, a diverse group of locally-living people engaged in grassroots campaigns to limit tropical aquarium fish collection (Capitini et al. 2004; DAR 2004). Assisted by Tissot and Hallacher’s (2003) findings, they pushed forth a new regime of resource management. A network of marine protected areas excluding tropical aquarium fish collection was put in place in 2000, and the community-based process that
had worked for several years to delineate and determine the protected areas, was also
instated as an official community-based management council, the West Hawaii Fisheries
Council, reportable to the state resources agency. The largely top-down and off-island
regime of marine research and management was handed over to the community to
manage nearshore resources (DAR 2004). Within the WHFC’s member-representatives
can be seen some evidence of the complexity of ocean uses and interests: Native
Hawaiian cultural and fishing practices, aquaculture, free diving, spearfishing,
commerce, science, conservation, recreational diving, professional dive shop operations,
tropical aquarium fish collection, shoreline fishing, and others. Not only the socio-
cultural setting but also the biophysical and institutional setting of Kona’s coral reefs
have faced, and are facing, changes due to increasingly global and synergistic drivers of
change, thereby warranting a study of historic, human dimensions through a
multiplicity of perspectives.

3.4 Methods

Framed in context of reefs at an impasse (land use and coastal resources in
‘transition’, construction boom, etc.), this research examines the various knowledge
systems of locally-living ocean experts through the lens of their perspectives on
historical ecological change on coral reefs. ‘Ocean experts’, or those considered by the
broader community as being experts about Kona’s coral reef systems and historic
change therein, were identified through snowball sampling (Bernard 1988) and social
network analysis (Hanneman & Riddle 2005) in more than 200 informal interviews between 2003-2006. The resultant social network of ocean experts is comprised of 203 individuals, representing an array of ocean constituencies from across the geographic bounds of the study region. Sampling from the social network, I identified potential formal interviewees by prioritizing the individuals with the most ‘recommendations’. I stratified the sample to ensure that interviewees represented the study region’s geographic range, as well as a variety of hypothesized knowledge systems (e.g., TEK, LEK, WSK).

I conducted semi-directive interviews (Bernard 1988; Huntington 2000) with 41 ocean experts; as several were interviewed multiple times, the number of formal interviews totaled 65. The length of interview ranged 1 to 5.5 hours. As multiple ocean knowledge systems became apparent, over time I tried to interview numbers of people...
from each constituency roughly corresponding to their representation in the social network (see Table 3). As Table 3 shows, local fishermen (who did not otherwise fall into another expertise group) were not interviewed as a part of this study; this is a significant issue relating to sampling methods, expertise, and authority, which I will return to in section 3.5.6 (on Kama’aina fishermen).

Allowing the depth and scope of discussion to be determined by the interviewee (Huntington 2000), I interviewed each ocean expert about their observations of the history of ecological change to Kona’s coral reef ecosystems. Member revisits, critical reflexivity, and extensive participant observation were used to ensure analytical rigor (Baxter & Eyles 1997; Rose 1997). In the vein of McGoodwin (1998), qualitative data were analyzed interpretively, drawing from grounded theory (Strauss & Corbin 1994; Baxter & Eyles 1999). On a structural note, interviews are referenced herein by unique alphanumeric symbols (e.g., 06.20A.06); while attribution is important, the symbols are not meant to be ‘traced’ to particular individuals or groups of people for ethical reasons.

### 3.5 Ocean knowledge systems of Kona, Hawaii’s coral reefs

On the Kona Coast today, there are at least 6 ‘expertise groups’ who possess distinct knowledge systems about coral reefs. These include: (1) Native Hawaiian practitioners, (2) dive shop operators, (3) Western scientists, (4) tropical aquarium fish collectors, (5) conservationists/recreational divers, and (6) local (kama’aina) fishermen. Between expertise groups, there is very little cross-over in who experts are
(demographics, uses of oceans, tenure on coast, etc.), what they know (features of the biophysical, sites, species, times, etc.), and how they know it (ontology, epistemology, knowledge generation and transmission, passive vs. active observation, etc.). While some people share characteristics of knowledge across multiple expertise groups, most do not. Though currently there are at least six, and likely more, distinct knowledge systems, they each demonstrate that knowledge is ever-evolving, and that knowledge systems have been introduced and transformed in intermittent periods over the past 35 years.

As this is a study of historical ecology, the groups’ tenure in Kona is pertinent to interpreting their stories and causes of change. The earliest first-hand accounts of change, from 1920-1970, stem exclusively from interviews with Native Hawaiian participants. While Hawaiian ocean experts describe all study sites, more of their narratives focus on South Kona, where the ‘last-remaining Native Hawaiian fishing villages’ remain. Around 1970 the uses of Kona’s coral reefs rapidly diversified; participants from each of the other expertise groups generally begin their narratives (i.e., first arrived in Kona) in the early years of this decade.
Figure 6: Timeline of the tenure and knowledge of Kona’s ocean expertise groups on Kona’s reefs from 1920-2007. Dotted lines prior to 1920 indicate that Hawaiian people’s expertise is typically multigenerational, in terms of the contribution of oral histories to their knowledge of oceans. In the scientists’ timeline, it indicates the 15-year interlude in marine ecological monitoring on the Kona Coast.

Events that opened coastal access not only enabled the proliferation of new user groups around 1970 (Figure 6), they also explain why most non-Hawaiian participant’s narratives focus on the central and northern portions of the study site, and less so on the more southerly areas surrounding the Hawaiian fishing villages. The diversification in the early 1970s appears to coincide with both the popularization in scuba technology as well as the construction of crucial infrastructure in Kona. Prior to the construction of Kona’s small boat harbor (Honokohau harbor, c. 1972) and the region’s makai (coastal) highway (Queen Ka’ahumanu Highway, c. 1972), access to any but the most central Kailua-town reefs, beaches, or waters was extremely difficult. Nearly impassable unpaved roads over a‘a lava fields, as well as, perhaps, the intimidating presence of local
people (G.05), made exploration or exploitation of Kona’s oceans difficult to all but those with close ties to Hawaiian families (JB.05). Traveling from Kailua-town to any coastline north of the airport once was an all-day affair on unpaved roads, where today it takes mere minutes. But when scuba technology, the harbor, and ‘Queen K’ highway were introduced (among other socio-political factors), tropical aquarium fish collection, dive shop operations, and scientific research programs multiplied.

Scientists’, dive shop operators’, and tropical aquarium collectors’ perspectives on historic ecological change originate around 1973. A 15-year interlude in marine scientific observations on the coast is evident because the only marine ecologist among ocean experts with first-hand accounts was off-island between the early 1980s and mid-1990s (one other current resource manager had experiences in Kona during that time, but more from a diver’s perspective rather than purely Western scientific). The absence of ecosystem-level monitoring on Kona coral reefs during this time appears to have had important implications for the status of science and management, vis-à-vis local expertise, today; this will be explored further in latter sections. Around 1990 begins the conservation/diver experts’, who participated in this study, first experiences in Kona waters, and in 2000 (the council was established in 1998 to determine FRA bounds, but factors into people’s narrative timelines in 2000) the West Hawaii Fisheries Council becomes an entity.
Who experts are in each group, what they know about ocean change, and how they know it are be explored in the following sections, with subsequent discussions about aspects in the convergence and divergence in group perspectives that are crucial to Kona’s coastal dynamics over this time.

3.5.1 “Hoʻo manaʻo nui, Take your time, do it right”: Marine knowledge systems of Native Hawaiian ocean experts

Who they are

Of the 14 Hawaiian ocean experts, most of the 3 women and 11 men are kupuna (knowledgeable revered elders) but range in age from mid-40’s to late 80’s. Kupuna from two remaining native Hawaiian fishing villages, populated predominantly by several Hawaiian families with long genealogies to this ‘aina (land, holistically), participated in formal interviews. Several dozen more participated in participant observation and informal interviews over 4 years. All but two participants are from in South Kona, a region included in this study because it retains a rural, local Hawaiian character distinct from the more commercial, tourist center of Kailua-town. It is also considered a possible cultural kipuka (pocket of cultural continuity) (McGregor 2007).

What they know

Ranging from ancient to modern, cultural to commercial practices, Hawaiian people’s interactions with the oceans vary daily, weekly, and seasonally. Collecting opihi and limu, spearfishing, diving recreationally and commercially, tending and fishing the opelu koa, palu ahi and ika shibi fishing, surfing, paddling, community-
based monitoring and management, and spiritual and ceremonial practices are some of the activities in which experts report engaging. With regards to subsistence fishing, target organisms vary across a given day, as a fisherman might fish opelu and later *poke uhu* (spear parrotfish) on the coral reefs, while women collect opihi and limu. In the summertime, a fisherman might target opelu and ahi, but catch lobster on the way out to the *koa* (fish aggregation site); while in wintertime he might fish akule, and bottomfish when the currents are calm.

Though asked specifically about historic change to coral reef systems, Hawaiian participants cast a net far broader in the biophysical topics introduced than any of the other expert groups (e.g., organisms and processes from far inland to offshore, and socio-cultural, economic, spiritual, political, and historic issues). Subsistence organisms were discussed in every interview, and ranged across the seascape from intertidal (e.g., *wana*, urchin; *opihi*, limpet; *limu*, seaweed spp; *ohua*, recruit convict tang), inner reefs (e.g., *nenue*, chub spp.; *honu*, Hawaiian green sea turtle); mid- to outer coral reefs (*manini*, convict tang; *kole*, Goldrim surgeon fish; *uhu*, parrotfish spp.; *paku’iku’i*, Achilles tang; lobster; *tako* or *he’e*, octopus); bottomfish (*u‘u*, soldierfish spp.; ‘aweoweo, Hawaiian bigeye); meso-pelagic (*akule*, bigeye scad; *opelu*, mackerel scad) to pelagic (*ahi*, yellowfin tuna; *mahimahi*).

Native Hawaiian ocean experts seem to best know the seascapes with which they link generations of their ‘*ohana* (family), in particular near to and including their
ancestral villages (ahupua’a, ancient land divisions). Their interviews wove tales of change stretching far inland (mauka) to far offshore (makai); and most concentrated in their ancestral ahupua’a, their knowledge tends to extend only limitedly up or down coast. A few people engage in more roving practices, like commercial diving and collecting, and others spent time off-island (O’ahu, Mainland US, Pacific Islands) and so know and compare to a broader geographic range of coral reefs. Had I focused on pelagic fishermen, who travel widely following highly migratory species, their knowledge likely would have encompassed a wider geographic range.

Through people’s talk of their generational ties to ahupua’a, connection to place is strong: “My grandfather fished here, his grandfather fished here. Our ʻohana farmed up mauka, and traded them fruit, breadfruit for fish” (G.04). For their ancestral ʻaina (lands, holistically), experts describe an overriding sense of kuleana (responsibility for), of belonging to, and protecting and being protected by the lands and oceans. Respecting other’s kuleana is important: “You feel funny fishing in someone else’s place… gotta ask permission” (01.04). Hawaiians expect such deference from other Hawaiians, and talk about enforcing their kuleana with non-Hawaiians.

Hawaiian practitioners know oceans holistically, as an interconnected landscape. Connections are evident upstream and offshore, within the land-air-sea. Fishermen follow signs on land as a guide for ocean activities, such as knowing wana (sea urchins) are most ‘ripe’ for picking when the lá’au shrubs blossom yellow (05.04; 07.18.06). When
the winter rains and swells blow towards the leeward coast, for instance, one believes it signifies natural, necessary renewal:

Winter rains... every year the winter swells come in. It flushes the bay allowing the seaweed to grow. Oh, the limu (seaweed) and opihi (limpets) love that! It causes all the murky water to flush. Moi (six-fingered threadfin) can spawn, and uouoa (sharpnose) mullet. It flushes the bay.

The best time to pick limu and opihi is after a high surf. It moves down the food chain for tropical fish. Flushing, the tropical fish like manini, paku‘iku‘i, the uouoa mullet feed off the reefs. I remember they would feed right up [at the shoreline] in front of my dad’s old place. A lot of fish use reefs for protection, mmhmm. [07.18.06]

In this interconnected 'aina, generations of fish move through time with generations of fishermen, which the latter talk about as if they interact within an evolved, mutually acceptable behavior (08.31B.06). According to ancient texts, Hawaiian people are responsible for maintaining the balance of the universe (Kamakau 1964). Kupuna, in particular, remembered what happens when the balance is off-kilter (paraphrased from Interviews 01.04 and 02.04):

Interconnected aspects of the 'aina are illustrated by the story of Ho‘okena’s shark rock. Waves whipped up by Hurricane Iniki (1992) swept the rock from its poise overlooking the bay, hiding it from villagers. After the storm passed, illnesses of physiological and social nature overtook the small village. Rocks are said to possess strong mana (spirit) and are revered and feared. Like akule rocks, which are said to draw akule balls into bays, this shark rock had a place in maintaining the balance of the akua (gods), kama‘aina (people), and the ‘aina (landscape, holistically, including oceans). To find the rock, problem-solving was occurring communally, when one man leapt up, apparently guided by their kupuna (revered elders, here spiritual guides). He staggered to the beach, wandered several hundred yards, smacked his hand on the sand, and said, “it’s under der.” The village found the rock six feet beneath sand and rocks; Aunty Ane, by these years a kupuna-wahine, was the only one who could lift it with ease, or so the younger
generations remembered with awe. Once restored, it left the village and its people at peace. [01.04; 02.04]

Similarly, Hawaiian ocean expert’s relationships with ‘aumakua, or protector spirits, evidence holism between spirituality, the people, and ocean beings.

To me, the ocean is everything to me. And in the ocean there, we have an ‘aumakua. It comes out, it follows me when I pick opihi. Follows my father. (What kind ‘aumakua is it?) Shark. Tiger shark… And I never get too close… But I know one thing. Me, my family, we can swim the South Kona water with no fear. No fear. But we go to North Kona, we fear. We invading somebody else place, we fear. And when we go South Kona, it’s all our ‘ohana. It’s our place. Our water. We feel at home. [02.04]

She was not alone in speaking of the oceans as a metaphysical presence in her life. Rich with metaphor, oceans are known as “icebox”, “playground,” “the mother,” as well as a powerful, sometimes violent figure. Iterative and genealogical, a family’s relationship with its ‘aumakua must be nurtured: “my auntie fed the manō (shark) milk from her breast” (03.04). Failure to care for the ‘aumakua causes the relationship to break down, though healthy ‘aumakua relationships were mentioned by many. After an interview, one participant who dives frequently ran over to his truck to show me a tall stack of underwater photographs. My field notes describe how the interviewee, through these images, revealed his ‘aumakua to me (narrative by JMS; quotes of JMS and interviewee):

He flipped through photo after photo showing himself, a wet-suited scuba diver against a bright blue backdrop, suspended over a rippled sandy ocean bottom… and nose to nose with a 15-foot (bigger?) tiger. The shark was so big, in most photos his hulking mass disappeared off the left of the frame. Its namesake stripes showed startlingly clear in the photo. Nose to nose! He was no more than a foot from the tiger shark!
“You weren’t scared,” I asked? “Nope” he said. I thought for a moment. “They’re your ‘aumakua, then, aren’t they,” I asked? “Yup,” he returned with a big grin. [04.20A.06]

Hawaiians also carry some knowledge of traditional marine tenure practices.

There is some contention about what constitutes Hawaiian marine tenure practices, the continuity of Hawaiian knowledge and culture, and whether contemporary calls to return to the ‘old ways’ constitutes a revisionist history. But this study’s most elder participants recall, in their childhood, entire villages tending to and fishing the opelu koa (aggregation site)(07.04; GK.04; 07.18.06; 08.31A.06); the tenure of the last konohiki (expert practitioner, overseer) of a village’s fish pond (02.04); making offerings of catch to shrines and kupuna; and an actively maintained and transmitted ethos of malama, kokua, ‘ohana, and aloha (to care for; to respect; family; and a spirit of welcoming/hospitality/being Hawaiian/loving/friendship; many interviews).

In talking about historic change to the coral reefs, each ocean expert talked about the history of their people, directly relating ecological change to a myriad of spiritual, historical, political, economic, and social topics. “The ocean is Hawaiian culture; the Hawaiian culture is the ocean. Cannot have the Hawaiian culture without a healthy ocean,” which was said in a small group of kupuna who described their efforts to enact positive change (ecological, social, cultural). In fact, many interviewees many talked about enacting community initiatives to preserve the ocean and sustain the culture (many, e.g., 01.04;GK.04; 03.06; 07.18.06; 08.31A.06; 08.31B.06).
Knowledge generation and transmission amongst the Hawaiian people in this study are typified by individual diversity in ocean activities, multigenerational ties, and community- and ‘ohana- transfer of knowledge. The diverse and eclectic nature of Hawaiian people’s ocean activities make describing the lens through which marine knowledge is generated rather challenging. Even subsistence practices’ target species, means of collection, and purpose differ depending if needs are for daily personal consumption, for celebrations like baby luau and weddings, or to sell commercially. In these diverse activities, people make observations both above and below water, interacting with organisms by active extraction as well as passive observation, ceremonially or spiritually, and with extensive coverage of under and above-water environments in 4-dimensions. While fishing traditionally was confined to men, and collecting a woman’s task, Hawaiian gendered roles had begun to blur by the 1920s.
Hawaiian people’s ocean knowledge is multigenerational, learned and practiced largely through the Hawaiian culture; their collective experience stems from an indigenous culture’s post-colonial experience in a highly cross-cultural island setting (see, for example Churchill and Venne 2005). As children, many Hawaiian ocean experts were raised in ‘the old ways’, learning by watching, listening to the stories of their *kupuna*. Asking questions was considered ‘niele’ (nosey) and discouraged, but with age and maturity, increasingly difficult tasks were given to children, from dropping the *palu* (chum) to hauling the *opelu* net. Once a common means of ensuring the transfer of *kupuna* knowledge and practice to children, two participants as the eldest children in their ‘*ohaha* were hanai (adopted, raised) by their grandparents.

Today, ocean knowledge tends to transmit quickly through communities. Subsistence activities, while likely not to the degree ancient times, are still community and ‘ohana endeavors particularly for events like weddings and funerals. Changes in resource abundance are thus known quickly, as exemplified by the opihi (limpet), a delicacy in great shorage today. “A [Hawaiian] wedding without opihi is like a Japanese meal without rice” (07.18.06); thus, its presence, abundance, and absence at the micro-level are felt immediately and communally. In addition, opelu, a staple protein of ancient Hawaiian villages and generally considered a prolific and impenetrable resource, seems to have experienced a prolonged period of low productivity, according to Hawaiian fishermen in 2006. One fishermen’s Uncle, who is one of the most
renowned fishermen in Kona, said it was longest mostly ‘dry’ stretch experienced by his family since 1850. Quickly, opelu’s dilemma was felt by opelu as well as Kona’s many small boat pelagic fishermen, to whom opelu is “number one bait” (many, e.g., 08.31B.06; Ika.06). Several ‘highliner’ fishermen were forced to take ‘land jobs’ in 2006.

Several Hawaiian participants cross bounds into other ocean ‘uses’ (a dive shop operator, an aquarium collector, and a resource manager.); but their ocean knowledge and narratives retain such strong elements of the Hawaiian way of knowing that they reveal something of how Hawaiian knowledge interacts with other forms of knowledge in the contemporary world. While learned and described primarily from a Hawaiian cultural perspective, Hawaiian ocean knowledge is neither rigidly separate from science nor the cosmopolitan perspectives in the region. Several Hawaiian practitioners are teachers in the public schools, one at the community college level; one kupuna for many years worked for the federal fisheries agency; and many hold post-secondary degrees. Still others engage in participatory science and management, and describe actively exchanging knowledge with marine ecologists. By no means can I say Hawaiian marine knowledge is isolated from exposure to other ways of knowing. Yet, characteristics of the Hawaiian ocean knowledge system are very distinct and carry thorough all those who identify as Hawaiian, including those who are educators in the Western schools, or who primarily engage in other activities (dive shop, collection, etc).
Moreover, Hawaiian people view oceans through a culturally embedded framework seeing people as integral, inseparable parts of the universe. Talking about learning to fish from his *kupuna*, a Hawaiian fisherman evidences the spiritual, cultural, and ecological connectivity through which oceans are known and engaged:

I felt compelled to do the reef advocacy, serving on the local resource council, help establish the FMAs... Until it’s done, you’re not complete. When you begin something, you see it through. Never leave unfinished... My *kupuna* taught me, ‘Ho’o manao nui, boy. Ho’o manao nui. Take your time, do it right.’ This *kupuna* taught me fishing, throw net. Taught me life. He used to say ‘Ho’o manao nui.’ Take your time, do it right. If do it right, comes from here. [He pounded his gut.] Come from the gut. Speak from the gut. Na’a. My dad said, ‘never start something unless you sure you go finish. If you not sure, you cannot start.’ No leave puka (hole), empty... Listen to your gut. It doesn’t mean nothing unless it comes from here. [He pounds his gut again.] [08.31B.06]

Acutely aware of the relationship between spiritual practices and environmental condition, several villagers told me how the disappearance of a village’s akule stone (shrine) was responsible for the fish’s absence in recent decades. Since the nearby village of Napo’opo’o reputedly still sees seasonal akule schooling, Ho’okena *kupuna* believe this means that Napo’opo’o villagers still actively tend their stone. People’s actions are known by the fish, the gods and others. If a people neglect their responsibility whether ceremonially or in fishing practice, for instance, the fish are not obligated to be caught, nor are aumakua responsible to protect. On a broader level, this iterative relationship between people and the oceans is seen in the fervor with which many Hawaiian people are approaching in tandem cultural preservation, ocean (environmental) protection, and community development issues. Community- and village-based initiatives are
proliferating, are often by the same leaders, and have multifaceted goals: intertidal ocean monitoring, establishing subsistence fishing areas and other village-based marine regulations, community enforcement of ocean regulations, summer programs for school-aged children, drug prevention and rehabilitation efforts, and recording kupuna knowledge.

Finally, and related to the former point, underlying experts’ experiences of ocean change is a collective socio-cultural experience. In this highly cross-cultural, post-colonial setting Hawaiian ocean experts’ knowledge and experiences with environmental change cannot be explained apart from the sociopolitical, economic, and negotiations of power since Captain Cook ‘discovered’ the Hawaiian Islands in 1778. Talkingstory with kupuna on their lanai (porches), I find conversation inevitably leads to talk about The Pilgrims (non-Hawaiian, non-kama‘aina) invading the coast, driving property values beyond what is financially feasible to many Hawaiian people, and of people being displaced from their ‘aina. It speaks to the Hawaiian people’s well-documented and inequitable experiences with economic development, from the time of the Great Mahele of 1859, in which Westerners in local control supplanted many Hawaiian people from their lands (participant observation 2004, 2005, 2006). Maintaining cultural and spiritual connections, such as enacting kapu, and tending ‘aumakua and opelu koa, became harder to accomplish as the local populous became more diversified, economic production more centralized, and governance enacted off-
Cultural subversion was a reality of childhood to many of these kupuna (c. 1920-30), who recall being punished by religious figures and school teachers for practicing hula or chants, reading or speaking the Hawaiian language. Yet, they also remember their kupuna forcing Hawaiian language books back in their grandchildren’s hands once safely at home. Socio-economically, Hawaiian villages tend to suffer from poverty and other human development concerns. Often the most ‘traditional’ Hawaiian villages are far from centers of commerce, and living in such remote areas is increasingly difficult financially with the cost of gasoline, with traffic congestion, for children who have long commutes to school, and many others. Such topics arise repeatedly in discussions about oceans and change.

3.5.2 Triggerfish at the barracuda’s vitamin shoppe: Marine knowledge systems of dive shop operator experts

Who they are

Expert knowledge from dive shop operators enters into Kona’s history in the early 1970s. Within a few years surrounding 1972, Kona’s most prominent and long-standing businesses were all established. Operators of Kona’s oldest dive shops, along with longtime divers, comprise 10% of the ocean expert network. Three men and three women, ranging in age from 40’s to 60’s, and including one Native Hawaiian, one O’ahu-born individual, and several mainland-born but longtime Hawaii residents,
participated in this study. How I deal with the few individuals who cross boundaries is explored in the discussion of authority.

*What they know*

Given dive shop’s characteristic use of coral reefs in space and time, they provide a near-continuous record of their dive sites over the past 35 years. Dive shops typically lead small groups of divers at regular intervals, 2 to 3 times a day, 7 days a week, and a dive shop operator may herself dive 3-5 or days a week professionally. Most dive companies embark from the Kailua Pier in downtown Kailua-Kona or the nearby Honokohau Harbor, and tend to utilize the network of day-use mooring buoys and sites accessible to launch points (see Figure 8). Spatially, they are most familiar with the northern two-thirds of my study sites, though discussing the southern study sites from intermittent recreational experience was not atypical.

![Figure 8: Map showing one dive shop’s dive sites near Kaloko-Honokohau (left), and the fleet of zodiacs at Captain Cook’s Monument, Kealakekua Bay.](image)
Over the course of decades logging daily to weekly dives, dive shop operators honed expert knowledge ranging from ecosystem-level processes and community ecology, to tracking the behavior of individual species (see Table 4).

Table 4: Ranging from ecosystem-level observations to the behavior of individual critters, dive shop operators discussed coral reef ecology across many scales.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Topic &amp; example</th>
</tr>
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<tbody>
<tr>
<td>Ecosystem</td>
<td>a) Habitat structure—Growth, stability, and disturbance in finger coral (<em>Porites compressa</em>) near Kaloko Honokohau.</td>
</tr>
<tr>
<td></td>
<td>b) Disturbance dynamics—hurricanes, storm events, and seasonal winter swells’ impacts on coral reef ecosystems; specifically, the patchwork recovery from 1981, 1992, &amp; 2002-03 storm events.</td>
</tr>
<tr>
<td>Community</td>
<td>a) Predator-prey interactions—triggerfish (Family <em>Balistidae</em>) preying upon long-spined urchins (<em>Diadema paucispinum</em>) during urchin disease epidemic.</td>
</tr>
<tr>
<td></td>
<td>b) Commensialism—cooperative hunting behavior between goatfish (Family <em>Mullidae</em>) and octopus (<em>Octopus cyanea</em>).</td>
</tr>
<tr>
<td></td>
<td>b) Cycles of population abundance—timing of population explosions of fire dartfish (<em>Nemateleotris magnifica</em>).</td>
</tr>
<tr>
<td>Organism</td>
<td>a) Behavior—observations of several ‘pet’ yellow-marginned moray eels (<em>Gymnothorax flavimarginatus</em>) over several decades.</td>
</tr>
<tr>
<td></td>
<td>b) Life cycle—molting, feeding, and death of Triton trumpet snail</td>
</tr>
</tbody>
</table>

Typically they focus on ornamental organisms, including a wide array of colorful and/or gregarious vertebrates (e.g., butterflyfish, angelfish, wrasses, eels); rare organisms (e.g., lionfish, leaffish, scorpionfish, flame angelfish); and invertebrates (e.g.,
urchins, triton’s trumpet snails, crown of thorns seastar). Subsistence organisms were also discussed, primarily reef-associated (e.g., Achilles tang, paku’iku’i; parrotfish; Hawaiian green sea turtle; and octopus), as well as apex predators (various sharks, e.g., tiger shark; *uluva* and other jacks).

Knowledge differs from individual to individual, and relates partly to the niche dive markets they have developed. The bread-and-butter dive tours, which all operators have led at one time, rely on overall visual experiences of a colorful, three-dimensional coral reef teeming with marine life. Several of the ocean expert-dive shop operators diversified and developed ‘critter dives,’ or unique specialty dives focusing on rare, thrilling, or charismatic organisms; and unusual aggregations or behaviors.

As their businesses rely upon leading customers through an underwater experience, all dive shop operators to some degree attend to elements of the aesthetic and adventurous reef-diving experience. How dive shop operators organize and relay their ocean knowledge seems to be structured by how this aesthetic is achieved three-dimensionally at each dive site. Dive operators tend to describe coral reefs condition and change by giving, for each dive site: (1) general assessment of coral composition and condition, (2) abundance and diversity of ornamental fishes, and (3) key characteristics (species, schools, behaviors).

Kealakekua Bay is really interesting area because it’s not a nursery, as prime nurseries appear to be drop offs with plenty of lobe corals for shelter. But Kealakekua Bay is a mecca for rare fish. We had 3 to 4 Tinker’s [butterflyfish] before the black coral died,
because they like to eat black coral. We watched one pair of flame angels for 14 years.
Kealakekua Bay has the largest population of black longnosed butterflyfish color morphs
on the coast. If I saw 6 to 8 in a dive at Kealakekua Bay, then there were probably 12 total
in the bay at that time, about half of which were right off the monument.

An area near the airport, called Sand Chute, is the only other place to see multiples [of
color morphs]. Sand Chute dive site is more like Kealakekua Bay than anywhere else on
the coast. It has somewhat similar coral composition, but not as well developed as
Kealakekua Bay. I associate Sand Chute with Kealakekua Bay. They have similar species
and coral cover. Sand Chute, however, does have deep plate coral, but it is not as well
developed as Kealakekua. [She used her hands to depict the similarities between
Kealakekua, Sand Chute, and “everywhere else.”] If Kealakekua is up here [she held her
hand 2 feet above our lunch table], Sand Chute is here [she held her other hand a few
inches below her ‘Kealakekua’ hand], and everywhere else is down here [she waved a
hand across the surface of the table.] [05.17.06; 05.22.06]

In following dive sites over time, they have gained insights into biophysical
processes, their relative magnitude across the coast, and their changes over time.
Processes also help dive shop operators characterize the seascape: Ho’okena is a “high
recruitment area” with “fat fish” (01.04; 05.18B.06); Kaiwi while a low recruitment area is
“prime adult fish habitat” (05.05A.06; 05.22.06); and although being protected from wave
exposure gives the Captain Cook monument “spectacular plate coral formations”
(05.17.06), it has so few of the gregarious schooling fishes that multiple experts noted:
“I’d bang my head against a wall if I had to dive there every day” (05.05C.06). What dive
shop operators know of coral reefs, and in particular their condition over time, also
couples inextricably with human activities, watershed influences, and marine
management (or lack thereof).

I don’t like to lead tours in Kealakekua; there are so many people! I’ll go north of the
main bay to avoid the million kayaks and the zodiacs! There are 4 zodiacs, 3-4 Sea Quest
boats; 3 Dolphin Discovery. The impact at expense of our resources… It has a good thing – to make money for our people – but…. [07.13A.06]

Today, dive shop operators also compare ‘open’ versus ‘closed’ sites, referencing the network of FRAs limiting aquarium collection; and they take particular note of trends in collected species’ richness and abundance over time.

*How they know it*

Dive shop operators are focused on providing an aesthetic, sometimes adventurous, and often educational experience to an increasingly savvy clientele. Scuba diving is highly visual, though it is also sensory and aural. The seascape is seen through an opaque mask, heard through distortion in the water, sensed in three directions. Decades ago, when many of the dive shop operators opened their businesses in Kona, diving was considered “extremely adventurous” (05.05A.06; 05.17A.06). This peculiar underwater experience of human (air-breathing) beings navigating undersea characterizes how they learn about the reefs, as well as the products they sell.

Part of how they know coral reefs is through decades underwater applied to building a business based on the clients’ gaze on the aesthetic and nature. Coral reefs’ vibrancy of color, otherworldly textures, and gregarious and at times dangerous creatures lend to a sense of wilderness, and a pristine, unspoiled aesthetic. A recreational diver provides insights into how aesthetics (in this case, the color yellow) can be both a product as well as the seed for generating knowledge of change. Yellow is an important color, as “You can see yellow forever. Fish lose color as you go deeper
underwater. First red is gone, then blue. Bright yellow fish don’t lose their intensity as you get deeper. That’s why yellow fins have big visibility” (07.13B.06). Over a decade, she thought she was noticing declines in abundance. But it was the yellow fish that proved declines had been occurring: “I counted three yellow fish! Not yellow tang, yellow fish” (07.13B.06). In this vein, sounds and people infringing upon the aesthetic experience, as well as ecosystem decline known through the loss of the visual qualities of the pristine, are important considerations.

Dive shop operators (and many others) experienced the impacts of tropical aquarium fish collection on ornamental fish abundance (see Chapters 4 & 5) between the 1970s-2000; multiple experts mentioned being “embarrassed” to take clients to dive sites that had been particularly hard hit by collection (05.05A.06; 05.22.06). Over time, dive shop operators convey how they increasingly viewed and generated knowledge through a conservationist, and more recently a participatory management perspective. For instance, one dive shop operator believes the presence of divers affords reefs de-facto protection, as collectors may be unwilling to net fish when visible to dive shop operators and their clientele (05.17.06). But there is variation in their attitudes about conservation, from the more ardent (“collectors don’t reap; they rape!” 05.17.06) to the more tempered (e.g., one who suggests conservation to a degree is important for business, but not at the expense of the collection industry, 05.05C.06). In coming from a strong conservation standpoint, the question arises whether knowledge shared with me is politicized for
conservation purposes. While people’s perceptions of ecological change contain strong conservation themes, their observations repeatedly evidence not being politicized. For instance, as a follow-up question to a dive operator explaining that she is more aware of algae now, as she has learned about algal overgrowth on corals due to land-based pollution. I asked if she had seen evidence of pollution on the coral reefs, to which she replied, “No. I wish I could, but I can’t” (05.22.06). In addition, the consistency of experts’ observations of change, regardless of topic and regardless of expertise group (see Chapter 4), also underscores that observations tend not to be politicized, even though what they look for may be shaped by conservation or other purposes.

Although dive shop operators participating in this study are ‘first-generation’ scuba divers, social transmission of knowledge has occurred for decades within the diving community, as well as to and from scientists and resource management. In example, a peculiar triggerfish behavior long puzzled an expert, until she noodled it over with another diver and a renowned marine ecologist:

The feces eaters! “Holly” [pseudonym] finally figured out this interaction! Near schools of Heller’s barracuda, you often see black triggerfish. Holly pointed out when barracudas poop, the triggers race up and eat the poop! Sometimes, you can see the triggers ram the barracuda. They are the only fish so impatient; they literally scare the shit out of the barracuda.

[Marine ecologist, Dr.] Jack Randall’s theory is that the feces eaters are mostly plankton eaters, and need to obtain either nitrogen or nitrates from the feces. I think it could be both, like taking a multivitamin. They’re going to the vitamin shop. Other feces eaters, like the ta`ape (bluestripe snapper), don’t ram the fish. Most have manners. The only one we’ve seen lacking manners is the [Hawaiian] black triggerfish. [06.29.06]
The bounds dive shop operators draw around the coral reef ecosystems are more categorically similar to the concept of ‘ecosystem’ in coral reef ecology and conservation science, than any other group outside of Western science. Drawing parallels between dive shop operators’ observations of change and coral reef textbooks’ topics in ecology is strikingly easy, as at any site they might talk about habitat, abundant species, rare species, processes, and fish behavior. Their patterns of visitation to dive sites tightly control the diurnal observations, but these are made over decades; and observations of change are recorded meticulously in memory, underwater photography, videography, the names of dive sites, and the history of the use and abandonment of dive sites.

Despite scientific-like distinctions made about reefs, dive shop operators’ knowledge is decidedly local and derived in a Western (but not scientific) framework. Being un-rigorous statistically is a concern, rather a source of pride. Their emotional ties to coral reefs are strong, building attachments to ‘pet’ organisms, anthropomorphizing others.

Roi (Peacock groupers) interact with eels, primarily the white mouths, although I believe they hunt with others. The roi whack eels on the cheek, saying ‘come out and hunt!’ and the eel will say, ‘OK’ or ‘No’ and that conversation will go on for a while until the eel comes out or decides not to. [She wiggled her hand, wrist, and forearm, undulating them parallel to the table.] The eel would swim and the roi would be on top. The eels chase out the prey, and the roi, who are very lazy, get what’s chased out. Meanwhile the eel gets to hunt in the daytime under the protection of the roi. This interaction happens almost exclusively with young eels. [5.22.06]

At Kaiwi, we had a ringtailed wrasse with buck teeth. ‘Bucky’. If we were looking at him, he’d bite me in the hand! Not a one time behavior! He’d deliberately turn and come on
me. He’d look around like, ‘Me? I didn’t do that!’ I know I anthropomorphize a lot. But it’s so akin to human behavior! [5.22.06]

While many identified their own anthropomorphizing and exploring reefs through perceptions as signs of lacking ‘scientific objectivity’, some laughed about it, and others scoffed at scientists for not recognizing their decades of experience.

Their Western framework is evident in describing humans as stewards and agents of change; through direct impacts (fishing, anchor damage, restoration activities, etc.) and indirect impacts (land use change in watersheds, management activities, education, etc.). Watershed impacts to coral reefs are of deep concern, and experts acknowledge volunteering in land use planning efforts. While ocean expertise derives largely from their underwater experience as dive shop operators, their knowledge generation and transmission is not separate from the eclectic other activities in which they engage (e.g., undergraduate studies in marine biology, conservation activism, intertidal and reef monitoring, volunteer educating, participants in community-based management) and from social transmission. Many are well-read in coral reef biology, or at the very least taxonomy; several hold ongoing educational dive programs like kid’s summer scuba camps.

3.5.3 “Pollution will get it before we could”: Marine knowledge systems of tropical aquarium fish collector ocean experts

Who they are
Kona’s first known tropical aquarium collector (“collector”) reportedly established operations in 1969, though the collectors who participated in my study arrived in the early 1970s, having abandoned collection sites on O‘ahu for Kona’s more plentiful waters, or fleeing political instability in international waters. An influx arrived in Kona after Hurricane Iniki caused the demise of the O‘ahu fishery, and the most recent transplant, a particularly friendly ‘tropical fisherman’, as he calls himself, started in the early 1990s (05.18A.06). Of the four male and one female aquarium collectors interviewed, only one, a Hawaiian, was born in Hawaii. All are middle-aged.

**What they know**

Collecting tropical aquarium species for trade in some respects is well-described elsewhere (e.g., Tissot & Hallacher 2003; Capitini et al. 2004; Tissot 2005; the Marine Aquarium Council, [http://www.aquariumcouncil.org/](http://www.aquariumcouncil.org/)). In this study, collection provides an example of an ocean knowledge system (a) generated through roving, regional activities that are highly species- and processes-oriented, and (b) remarkably unique but overlapping in a few critical ways with other knowledge systems. Aquarium collectors follow recruitment, or ‘The Drop’ up the coast each year. In Kona, reef fish recruitment occurs in annual waves, which typically land in Kau (South Point, Big Island) and move northwards up the coast over the course of weeks to months. Because their trade is largely in juvenile fish, collectors follow the drop, and stagger their timing several weeks to months behind settlement. Because fish behavior is markedly nervous and flighty
when a site recently “has been worked” (05.18A.06), collectors disperse themselves spatially to ensure sufficient catch and to avoid overworking a site (05.04).

Generally, a collector’s return to any particular site occurs no more frequently than a few days at a time, once or twice a year. Over time, an individual might work the whole coastline, from 30 to 240 feet depth, focusing on spatial distribution of abundant species or habitat niches for rare critters. I asked a participant how he chose his collecting sites:

After I learned all the reefs on the water, I got really good at it. I could pinpoint where I wanted to go…Like if I started here [he put his finger on the table], then I would take a mark [he looked up, triangulating his position based on something on the horizon]. If I was 50 feet [depth], I would go all the way at 50 feet… And tomorrow, same place at 70 feet. If I was 70 feet, all the way 70 feet. Depends upon how far the current takes me. [05.04]

He thus learned to follow a bathymetric contour line each day within a given bay, never repeating a contour and searching for the prime habitat for the critter the market demanded. What collectors talk about with regards to ecological change is highly processes- and regionally-oriented. They describe how to read environmental conditions (depth, tide, currents, water temperature, season), habitat features (benthic cover, coral species, rugosity, 3-dimensionality), and others to be able to identify probable habitat for target species. To be able to apply one’s knowledge of species, habitat preferences, and environmental conditions in unfamiliar conditions is critical. During one interview, a collector described being in unfamiliar waters in 1975:
You can put me in the water now, in any place where I’ve never dived. I did that in 1975. I came to Hilo. I had this guy shipping me Achilles tangs. I wanted to teach him. He bragged, and he wasn’t a good diver. He had one 50 gallon tank with about 35 fish in it, and I’m going ‘Wrong, wrong, wrong.’

He took me into an area. I didn’t know nothing about this area. We’re looking for paku’iku’i. [Quoting himself] ‘Oh, I know where get hundreds of ’em.’ And he goes, ‘I don’t see too much.’ So we’re sitting on the boat. I say, ‘You know what? You know what finger coral is?’ The diver goes, ‘Yeah. Why?’ [I said to him.] ‘That’s where the babies are born. That’s their protective area.’ I go look where the big guys [adult fish] are, and then I find out which way the currents going all the time. They won’t travel more than a mile down. Then I look for the rubble. Then I find the rubble. Then I find the babies [recruits]. I say, ‘oh, give me a tank. So come over here and throw anchor.’ And we got 22 boxes, and the guy couldn’t believe it. He couldn’t believe it. [05.04]

Processes-level knowledge is exemplified by one collector’s descriptions, in embayment-specific detail, of variation in Tinker’s butterflyfish recruitment across the Kona Coast over the past 35 years (06.08B.06). Multiple fishermen independently described the (more-or-less) 12-year cycles in recruitment since the 1970s, recalling the high and low periods and magnitude difference to the ‘norm’ (05.18A.06; 06.08B.06; 07.06.06).

Though knowledge about ornamental and rare organisms varies, tropical fishermen all discuss: (a) recruitment and juvenile fish, (b) the three most collected ornamental species (yellow tang, paku‘iku’i (Achilles tang), and yellow-eyed kole (Goldring surgeonfish)); (c) coral; (d) sharks; (e) Nahakey’s angelfish (named for a Kona collector who first identified it); and (f) the predatory, invasive fish roi, which the collectors implicate in ornamental fish declines. Collectors who focus on rare fishes
tended to describe a much wider range of ecological topics, such as the individual who shared substantive historical ecological knowledge about more than 60 species, each differentiated by site, decade, and season (06.08B.06). Those attentive to rare organisms display an impressive harness of taxonomy.

Further explaining collectors’ focus on the region and processes (more so than sites and species), two collectors independently contrasted their practices’ fluidity with the inflexibility and challenges of Hawaiian handline tuna fishing. When describing my ethical agreements with a collector, I expressed concern for protecting expert fishing knowledge for tropical fishermen, just as in with my work with local small boat tuna fishermen. To this, he said, “Well, for tuna fishermen, they have skills. To do what I do, there are no secrets. It takes no skill, it is simple” (07.06.06).

Notwithstanding this fisherman’s humility, I took this to reference how reef fish are diverse, and spatially bound. If one target species is unavailable, there are hundreds of other possibilities from which to choose. In contrast is handline tuna fishing, which on the Big Island is a small-boat (McGoodwin 1990) fleet depending upon a few highly migratory, and rather temperamental, pelagic species. Said another aquarium fisherman: “Tropical fishing is one of neat industries because no matter what you do, when you go out, make money. May not make $200, or $500, but you’ll make something. Ahi (yellowfin tuna) fishing is different. If you don’t take care of your truck [in Kona the small boats are largely trailered], or miss the bite, you don’t make money that year.
Tropical fishing is like opelu (mackerel scad), maybe. If the catch is down, you don’t go to the movies as much, but you can still keep fishing to survive” (06.08B.06).

Compared to other groups, collectors’ focus is uniquely regional and ecosystem-focused (e.g., processes). The aquarium collector’s knowledge is top-down in scale (accumulating knowledge about the entire coastline, and over time learning intricacies of each site therein), while the marine knowledge of some other groups is bottom-up (accumulating knowledge site by site, and over time drawing comparisons across the region). Though for years tropical fishermen roamed up and down Kona’s coastline each year, their spatial use-patterns changed markedly in 2000, when collection was excluded from the FRA network, or 35% of West Hawaii waters. At that time, what these fishermen know of coral reefs became inextricably linked to Kona’s social and political dynamics, state and federal resource management, and from the standpoint of the people vilified in coral reef ecosystem declines: “I spent more time on O’ahu [lobbying, at legislative hearings] that year [1999, 2000] than in the water. But you don’t want to hear about the politics, do you?” (06.08B.06).

For this group in particular, having been so vilified in local conservation politics and practice, what they shared in interviews – as opposed to what they know – may have been tempered by their recent experiences with politics and power. I do not suggest that any individual purposely gave duplicitous information; rather, some may have only talked about the bread-and-butter fish (whose populations are naturally large, and
rebounding since being protected) and consciously not talked about rare fishes (less noticeable improvement), or any other potentially contentious topics, which might have been used against them. That being said, multiple collectors expressed genuine enthusiasm and relief in being offered the opportunity to share their knowledge, particularly about recruitment (05.18A.06; 06.08B.06). While none debated that aquarium collection can have an impact on reef fish populations, they universally believed that Kona’s widespread discourse demonizing aquarium collection, and lauding the marine protected areas, fails to account for natural recruitment cycles that accentuated reef fishes’ lows and highs (many 05.18S.06; 06.08A.06; 06.08B.06; 07.06.06).

How they know it

As is true with many types of fishermen worldwide (McGoodwin 1990; 2001), tropical aquarium fishermen seem to be quite independent, adhering to the sentiment “loose lips sink ships”. Yet in talking about forming and disbanding loose huis (partnerships), working for/with other fisherman for short periods of time, the generation and transfer of knowledge thus is achieved secondarily through social transmission. Since scuba technology is relatively new, none of their expertise is multigenerational. Aquarium collector’s ocean expertise is experiential, comparative, and Western. Because all of these fishermen collected aquarium fishes elsewhere (O’ahu and internationally), individuals frequently compare Kona’s coral reef condition to ecosystems elsewhere. They organize their ocean knowledge in ways that see ecosystem-
level connections, and place humans as external but influential to the ecosystem; for, oceans are described with regards to patterns and processes, and natural and anthropogenic disturbances. The relationship between ecosystem condition, disturbance, and socio-political conditions is very clear to these experts, because many emigrated from O’ahu after hurricanes, pollution, and fishing decimated reef systems. Further, several were forced to abandon fishing grounds elsewhere due to political instability; and recently, their industry has been excluded from over a third of Kona’s waters under FRAs.

While it may be easy to presume that tropical fishermen are motivated by money, in contrast to “science for the purity of knowledge” or “diving solely for the aesthetic”, most of these fishermen are also motivated by a curiosity about their surroundings, such as in discovering new species. Many envisage themselves as taking part in an adventurous, independent, and at times dangerous trade (04.06; 06.08A.06; 06.08B.06; 07.06.06). The wife of one collector mentioned she is happy her husband, in his old age, has slowed down in his chase of adventure – diving in hurricanes, or near new lava flows. A few also talk of being driven by doing “the right thing” with regards to participating in cooperative management (04.06; 05.18A.06). Speaking about his fellow fisherman, a collector notes how longtime Kona-based collectors have experienced highs and lows in all aspects of the fishery, and that some have a different mentality of cooperative management:
I talk to them, and they say, ‘It’s the same old story. They’ve [conservationists, managers] tried to close us down for 20 years. The fishery sees good times and bad times.’ Their take is that they’ve seen it all. Fishermen come and go. A few—the good fishermen—last the while if their knowledge is keen and they can wait through the dry cycles. They haven’t seen any reason to be shut down. I take a different take. With user conflicts, one has the responsibility to address the situation…

Of course it’s [collection] going to have an impact on the reefs. What stops the next person from taking everything? The question is, how much activity can occur to ensure that a good recruitment happens next year and the following year? In the last five years, with studies in open areas we are gaining a better understanding of the levels of allowable activities. And regardless, the greatest single threat to the longevity of the coral reefs is development. It’s all development. Pollution will get it before we [collectors] could. All of the other things combined – fishing, invasive species – the pollution will get it before we could. [05.18A.06]

Describing how collectors know Kona’s reefs thus cannot be complete without mentioning that their experiences are likely colored by recent user conflicts, grassroots activism, and legislative actions to limit their trade.

3.5.4 “We hang our hat on MPAs”: Marine knowledge systems of scientist/resource manager ocean experts

Who they are

Participants considered scientists/resource managers are those trained in the Western scientific tradition and who primarily engage with and develop knowledge about coral reefs through the scientific practice; herein referred to as ‘scientists’, most of these individuals have worked in both academic and resource management settings. Though representing more than one-third of the ocean experts recommended (n=63), very few Western scientists and resource managers in the experts network have historic (> 10 years) expertise about coral reef ecosystems within the study region. Over the
course of this study, 13 scientists and resource managers participated in semi-structured interviews. While all possesses scientific expertise about coral reef ecology and/or management, it became apparent from in-depth interviews that only a few have first-hand and historic expertise of the reef ecology in the study region, while a few more had historic, first-hand experience with reef management and more recent in-water experience in the study region. Generally decades into their careers, none of the scientists described ancestral ties to Kona nor were raised there, though a few were born elsewhere in the state.

What they know

In the following paragraphs, scientific expertise will be characterized, to a large extent, from the analysis of in-depth interviews with a few ocean experts with historic in-water expertise, and with socio-political/resource management expertise in Kona. Characterizing the knowledge system from interviews versus the published literature is an important distinction, because science, unlike the other knowledge systems makes (at least some) knowledge public through scientific talks, papers, white papers, etc. Additionally, coral reef ecological research in the Main Hawaiian Islands has largely been conducted elsewhere (e.g., O‘ahu, Maui). In Kona, the production of science on the coral reefs has gone through multiple ‘eras’: (1) intense marine ecological research of short duration (late 1970s - early 1980s); (2) inactivity for 15 years; (3) re-establishment then proliferation of coral reef (mostly fish) ecology (1996-present); and (4) currently, an
apparent heightening of habitat monitoring and land use planning activity with an applied focus on marine protected areas (MPA) and land-sea connectivity. Aside from the knowledge systems conveyed through interviews with scientist ocean experts, the general issue of the presence/absence of scientific activity has important ramifications for the relations between local and scientific authorities in Kona, for management, and for the condition of the ecosystem – all of which will be explored in latter sections.

The first era of coral reef ecology, in the late-1970s to early-1980s, constitutes part of the published record (e.g., 1983; 1984; 1987), as well as some of the only historic ecosystem-level baseline data available to managers today⁴ (pers. comm., 2007, W.J. Walsh, HDAR). In Kona, professors, graduate students, and resource management professionals conducted an intensive effort in marine ecology for a short period of years prior to 1982. This type of research was highly typical until recently (Knowton & Jackson 2001), but by today’s standards was narrow in geographic scope, having been conducted mostly in the Ke‘ei and Honaunau Bay areas (05.18B.06). Biological topics discussed include: coral reef fishes (including what are now considered ornamentals, some subsistence organisms, like yellow tang, surgeonfishes, butterflyfishes, wrasses, parrotfish, and paku‘iku‘i), basic habitat condition, as well as ecological functioning and processes (recruitment, storm events). Additionally, in the 1970s some scientists were

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⁴ The exception to the assessment that the Kona Coast is largely lacking in historic baseline data is Puako Bay in Kohala. Outside of the study region, this small bay has seen intermittent but relatively consistent research activity for some ~30 years.
involved in collection efforts for rare organisms (Hawaiian lionfish, leaffish, Tinker’s butterflyfish, bandit angelfish), which were present in Kona but no longer readily available on O’ahu reefs (04.14.06). But by 1983, individuals accruing historic ocean expertise from the scientific perspective had moved off-island and/or were no longer involved in research in Kona.

Local, ecosystem-level ecology in the study region was virtually absent from the early 1980s through mid-1990s (the second era); coral reef research was primarily conducted elsewhere (O’ahu, Maui, e.g.). During this time, locally-living people noticed dramatic declines in reef fish abundance coast-wide. Despite their urgent concerns voiced to O’ahu-based resource managers, scientific research on these issues only returned in mid-1990s when local people partnered with University of Hawaii-Hilo marine biologists to examine the issue. By this time, Kona’s coral reef fishes populations, including abundant schooling fishes as well as rare species, were dramatically reduced from the decades prior (see Chapter 6 and 7).

Thus, after a 15-year hiatus, coral reef ecology in Kona was reenergized in the mid-1990s with the first “small, but in retrospect powerfully designed” (04.03B.06) studies. Ecosystem-level scientific activity soon proliferated in scale, scope, and people involved (the third era). Initially, a few studies were established to assess “local anecdotes” of reef fish decline due to tropical aquarium fish collection (04.03A.06; 04.03B.06). Upon finding evidence supporting these claims, the scientific effort began
growing “with Al Gore’s funny money” (04.03A.06) for purposes of both coral reef ecology and conservation. Eventually efforts proliferated into an intensive and extensive effort across most of the leeward coastline of Hawaii Island. Asking mainly applied questions, scientific research in the 1990s helped support grassroots activism towards enacting a network of MPAs and zoning ocean uses. Currently the much-expanded research happening in Kona assesses the action’s effectiveness: “We hang our hat on MPAs”, as one ecologist said. They log over 200 in-water research days each year (12.04.06). These efforts also primed the region for research by scientists new to Kona.

While the first era of marine ecology might be characterized as intensive, short duration, ecology-driven studies in a few concentrated areas, the current era of research is characterized as more intensive, extensive, and applied (management and conservation issues). With regards to this shift, one ecologist noted:

[It] has changed a lot now since ‘98, since we’ve been doing this research. I knew a lot about my dissertation research sites, but I would say that I know more about more areas now than the few areas I did my Ph.D. work in. Now, we’re so intensely involved in research all over the island. [12.04.06]

Coral reef species studied and monitored today number in the hundreds, and over the course of interviews with scientists it became very apparent that scientists both talk about, as well as develop research programs surrounding, species and issues representative of the many cultural interests on the coast. Unique to each expertise
group is an array of biophysical topics (species/processes) each group tends to discuss (e.g., Hawaiian experts talk about an array of subsistence species unique to those dive operators discuss.). But what scientists talk about is best described as being a balanced treatment of topics importance to each of the other expertise groups. In interviews, scientist experts discuss ornamental species (yellow tang, butterflyfishes), rare species (lionfish, leaffish, Potter’s angelfish), subsistence species (uhu, manini, pakuʻikuʻi, kole, uʻu, wana, tako), as well as processes like recruitment, storms, and habitat change.

Moreover, there is somewhat of a disconnect between what these experts know versus what they have had the resources (time, personnel) to process, publish, and therefore bring back to the public. This discrepancy seems to be worrying to resource managers, who are concerned about addressing the diverse interests within Kona’s highly cross-cultural community (12.04.06; 01.A.07). Given the intensity of their data collection efforts, scientists hope to ensure sufficient time to analyze and publish data on topics of importance to Kona’s many constituencies (e.g., pakuʻikuʻi, an important subsistence and collected species whose populations are not responding to protections, see Chapters 4 & 5), but feel to some degree constrained by what is demanded of them politically (12.04.06).

Scientists/resource managers spoke extensively about their concerns about reef ecosystem sustainability, and their future visions for science and management meeting the conservation needs. While this concerns knowledge yet to be generated, I argue this
constitutes a fourth era in what scientists know about Kona’s coral reef ecosystems, and their science and management. Extensive efforts to establish baseline habitat (coral cover, structure, algal cover and change) have been initiated in the past few years (06.29B.06; 02.InfM.06; 03.07), because few baseline data on habitat (coral cover, etc.) exist, and what does exist come from studies where they cannot detect statistically significant change to today (06.07B.06; 06.29B.06). Habitat condition is especially important because Kona is widely considered in a ‘construction boom’ and rapid state of transition from rural to developed; the Kona Coast has much open space but few parcels without pending development plans (06.29A.06; 06.29B.06). Despite a global body of scientific literature showing coastal development as a critical threat to coral reef resilience, Kona’s scientists have been stymied in efforts to improve land use management practices (from the development to policy level) because they are asked to show locally-derived data demonstrating development poses a threat to Kona’s coral reefs. In light of this, scientists and resource managers are actively establishing monitoring programs; participating in land use planning activities as advocates for downstream ecosystems; and persistently expressing concerns about land use planning, regulations, and the vitality of coastal and marine ecosystems. Finally, what scientists know of coral reefs is also increasingly tied to conservation practice, community-based management, and through ecosystem-based management perspectives (see sections below).
The extent to which scientists refer to published research in their interviews is somewhat limited due to what I was asking them, as well as the fact that historic research on Kona’s coral reefs is rather limited as compared to elsewhere in the MHI. First, the participants were aware that I asked specifically for their observations of change on the coral reefs, historically. Yet, only one participant had historic research experience in the study region; this individual and other scientists referred to that work as the only data sets where historic change could be elicited by site-revisits (e.g., Walsh 1982; 1984; 1987). Multiple individuals referenced the recent research investigating the impacts of tropical aquarium fish collection and the assessment of the FRA network (e.g., Tissot & Hallacher 2003; DAR 2004; Tissot et al. 2004; see also Hawaii Coral Reef Initiative, Research program results for Hawaii Island, available online at: http://www.hawaii.edu/ssri/hcri/research/reports/interim/pi/tissot.shtml). Some research conducted elsewhere in the MHI is referenced, such as Williams and colleagues (2006) assessment of MPAs on O‘ahu, as well as Dollar’s and Grigg’s research on zonation and structure of coral reefs (e.g., Dollar 1982; Grigg 1998; Dollar & Grigg 2004). When scientists speak of their concerns about land-based pollution and synergistic effects with over-collecting, scientists infer the plethora of research globally showing the deleterious impacts on coral reef ecosystem condition and function (e.g., Pandolfi et al. 2003; Bellwood et al. 2004; Hughes et al. 2005). But the universality of science and its generalizability as an authority seems limited in local land-ocean planning issues,
because in local land use planning scientists are required to demonstrate *locally-derived* evidence of such synergies (06.29.06; 12.04.06).

*How they know it*

In the science studies literature (e.g., Nader 1996) the nature of scientific knowledge is well described. As a historically and culturally-situated activity (Latour 1987), Western science’s generation and transmission of knowledge tends to stem from a logical positivist perspective. It is often posited in contrast to indigenous and local forms of knowledge. Notwithstanding evidence that ‘science’ is becoming more inclusive epistemologically (Robertson & Hull 2001), and that some are challenging the dualistic perspective on science vs. TEK/LEK (Agrawal 2002; Walley 2002), how science is enacted in the oceans, as compared to on land, has yet to be explored. These questions are warranted, I contend, because the physiological limitations of human powers of observation underwater (e.g., limited by available technology, like scuba) have the potential to fundamentally alter how the ocean is observed, and thus how marine knowledge is generated.

In general, the knowledge generated by these experts occurred through Western scientific, ecosystem-level research. Across all research endeavors, these individual’s knowledge generation is dictated by research design and protocol, which determines the sites and species known, timing and duration in-water, frequency of return, and coverage across daily, lunar, seasonal, and annual, etc. cycles. Knowledge generation
through the typical marine scientific process involves passive observation often in-water (e.g., swimming/diving fish transects unobtrusively to count fish abundance).

Observations of sometimes extensive arrays of organisms are recorded in-water, but processing of information occurs later outside of the water via statistical analyses. Some common methodologies and environmental conditions tend to assess reef-associated species more accurately than others, for example, apex predators (e.g., jacks, sharks), who might (or might not) dart in and out of transects when they are being conducted (04.05.06), or parrotfish who may have shifted spatially to wave-exposed habitats, an avoidance behavior due to high human presence of nearshore reefs (05.07).

Scientists are trained observers, learned in recording complex information in challenging field situation, and also in relying upon statistics to derive meaning. Statistical significance can often be surprising relative to what one ‘thought’ while collecting data in the field. Reliance on the quantitative nature of scientific data, rather than visual observation, was evident in some scientists’ hesitancy to share qualitative observations. One participant, for example, only discussed statistical findings about organisms he had studied, but gave qualitative observations about those he had not.

Generally, scientist and resource managers spoke quantitatively (often referencing publications) when observations were made via the scientific practice, and qualitatively when observations were made during recreational activities. But the vast majority of their experiences (that were shared in interviews) were made in scientific research.
Hesitancy about sharing qualitative observations (“visual observations” as one scientist called it) may relate to the development of knowledge from passive (scientific observation) vs. active (extraction) ocean activities, and perhaps from the delayed vs. in-water processing of information. One scientist, talking about returning after 15 years away to his PhD research site, a reef he “lived on” for years, shared an experience in which he confronted his ideas about scientists as trained observers, and being able to detect change qualitatively. Knowing aquarium fish collection was thought to have left reef fishes “in terrible shape”, he tried to detect any changes visually, at first. Then he looked at the data:

I looked around trying to ask myself if there were no fish, or lots of fish, compared to the 70s and 80s. I thought, ‘I am a trained observer. I know this place like the back of my hand. I was separated for 15 years, so maybe I’d be able to see changes.’ I couldn’t. The abundance looked the same to me… and after 1 year back in Kona, I … compared data to my [earlier] studies, and the density was fully half of what it was in the old days. Had I been there continuously, and there had been a gradual decline, I might not have noticed the change. But coming back after 15 years, I thought I would notice such a dramatic change. And I was a trained observer!

So when you ask, between the 1978 and 1979 study, and out there now [2006], what changes have you seen? If I was harvesting, sure, you’d be able to see changes over time because you’d get less money or less food to eat. It’s not complex. … But the visual thing, I am very skeptical that people can detect that without actively harvesting the resources to have some tangible—sustenance or financial—depiction of change. It unsettled me. It tested the resolving power of a trained observer. Look at this paper [he showed me a 20-year ‘retrospectus’ study]. I couldn’t tell you this by personal experience. In light of, under the harsh light of scientific analysis, we have found that even aquarium species in protected areas were still lower [than population levels from decades prior]. [05.18B.06]
In light of this experience, this individual thinks there is a threshold – 50% change – above which scientists may be able to detect changes visually, but below which this individual is doubtful. However, he says, people who fish for subsistence or their livelihood may be able to detect minor changes in abundance.

Scientific expertise about Kona’s reefs also appears to be influenced by marine scientists’ perspective being ‘downstream’ of watersheds, terrestrial ecosystem management, and land use planning decisions. “We go begging to Department of Health people who have water quality data…” but the watershed-reef connectivities, and implications of land use decisions on ocean and coastal systems are much less tangible to terrestrial scientists, one participant, a marine ecologist and resource manager said in reference to his concerns about rapid development and land use change impacts to coral reefs (05.07). As this indicates, an explicit conservation narrative threads through the scientist’s interviews, as well as one concerned about recognizing the diverse constituencies and interests in Kona. “The shift towards community-based management is something I support wholeheartedly but I’m still waiting to hear how it affects the local people – recreational divers, shoreline fishermen, those who currently are not part of the [community-based management] process” (05.07). Mentioning the apparent recent influx of new immigrant groups from Micronesia, another resource manager asked for my advice about how to outreach to new fishing constituencies who
might not be well acquainted with the English language, marine regulations, or Hawaiian/local fishing customs (02.07).

As to the question of what scientific ocean experts know, this tri-partite history of scientific activity forms a critical explanatory construct, as its recent endeavors appear to be highly responsive to the local community’s diverse needs. Movement towards applied questions shows responsiveness to conservation-issues, as well as the concerns of locally-living people who first voiced the concerns; towards research topics of interest to subsistence, diving, collection, and conservation community illustrates equal responsiveness to the host of interests throughout; and, towards coast-wide, intensive, and extensive research programs shows reflects responsiveness of the need for locally-based science and resource management as a partner to local people. Finally several of these people are highly active professionally in the WHFC, and speak of social transmission of knowledge from myriad local and indigenous peoples. As suggested by each of these points, scientist and resource manager’s marine knowledge is a motivated by a drive for knowledge, but not any less by a conservation ethic, and by a desire to ‘do good’ by (or, meet the interests of) the community.

3.5.5 “I saw three yellow fish... Three fish!”: Marine knowledge systems of conservationist/diver ocean experts

Who they are

Several experts are unified by their participation in community-based conservation efforts. Five men and women among a larger group formally interviewed
have historic expertise about the Kona Coast. None were raised in Kona; two are
decades-long residents; three arrived within the last 15 years. Aged 30-something to 60-
something, their ocean activities are myriad: recreational divers, free divers, community
volunteers, photographers, community activists, and participants in community-based
management efforts. Several characteristics seem to unify this conglomerate group: first,
that they do not otherwise fit into the other sub-groups of ocean experts; second, that
only local people and scientists ‘recommended’ these experts during my sampling; third,
that all are recreational divers or have worked for dive shops; and fourth, that they all
have, in some way, been affiliated with the West Hawaii Fisheries Council. Finally, their
narratives of change and characteristics of how they know Kona’s reefs show strikingly
similarity.

*What they know*

Corresponding to the group’s mish-mash characteristics, expertise among the
conservation/dive sub-group is difficult to characterize. While all have at least 15 years
of in-water experience on Kona’s reefs, some of these experts are more knowledgeable
about the human and institutional dimensions rather than biophysical history.
Therefore, in the following paragraphs I will be explicit in following the in-water
(ecological) expertise versus the out of water (social/institutional) expertise held by
members of this group.
Biophysical topics of interviews of the conservation/dive group were more markedly focused on ornamental species, butterflyfish, and the bread-and-butter aquarium-collected species than any other expertise group. All conservationists discussed yellow tang, pakuʻikuʻi, kole, flame angelfish, uhu (parrotfish), coral, as well as a variety of butterflyfish (e.g., Tinker’s, lined, raccoon, and reticulated). Their interviews consistently followed themes of the historic decline, and recent resurgence of ornamental and collected organisms, as well as color and abundance in reef ecosystems.

Similar to all other study participants, key subsistence organisms and invasive fishes were discussed (honu, pakuʻikuʻi, roi and ta`ape), but were extremely minor in their narratives than any other group.

Spatially, conservation/divers know the region between the northern bounds of my study region through Kealakekua Bay. One woman swims several times a week in Kailua Bay, and recalls changes over time from her near-daily excursions. Most participants from this group distinguished their observations between protected and non-protected areas (FRAs), such as the way in which an expert introduced each study site by whether or not it is “protected”. “Honaunau... collectors didn’t often go there during the day. I understand they’d go there at night, especially looking for eels. Eel collecting at night is just too easy.... And Puako – it is protected and has been for a long time.... Au‘au, not protected. I have noticed the rare long-handled lobsters disappearing. They’re not great eating. But I used to see them in every puka (hole). Now
I look all over, and don’t see them. It’s the only place I ever see longhandleds” (07.13B.06).

In line with this reference, every person in this group structured their narratives on the before-and-after story of collection, ecological change, and the FRAs and the West Hawaii Fisheries Council. “Historic change to coral reefs”, according to their interviews, has been to the ecosystem, management regimes, as well as the social relations among Kona’s constituencies, many of whom were embroiled in conflict surrounding the establishment of the FRAs. Conservation/divers experts talked about being surprised at how positive relations among previously antagonistic groups have become: “It [the WHFC process] ought to be a model for the universe, on how to sit down with your enemies and work things out” (07.05A.06). The Hawaii legislative process, grassroots activism and community organizing were consistently described. In addition, they also have expertise about the democratic process, particularly surrounding conservation interests.

How they know it

Not unlike dive shop operator experts, the conservation/divers also generate knowledge as people seeking the underwater aesthetic and adventure, though from a recreational rather than professional standpoint. Aspects of the color, texture, and aesthetic experience similar to operators are evident in their narratives, and over time discussed increasingly through a conservation lens. In this case, conservation refers to
ardency against extraction for tropical aquarium fish collection, but not against subsistence, cultural, or ceremonial extractive uses; it also refers to enthusiasm for MPAs as a conservation strategy. Their early recollections of Kona’s reefs are portrayed in colorful, descriptive language: “When we first came to Kona, at least one time per year [as tourists before his/her family moved permanently to Kona], I remember clouds of fish. So many that I never, ever thought they would be impacted like they were” (07.05A.06). Though they recognize, “At that time I wasn’t well trained in counting or identifying fish, but all I know is that there were lots of fish, and over the years, there were not as many. ‘Where are all the yellow tangs?’” (07.05A.06). Conservation/ divers’ more recent observations are much more quantitative:

Actual instances of disappearances are hard for me to remember; it is so cumulative. I do have stories of increase, particularly around Kailua-Kona [she previously mentioned swimming in Kailua Bay almost daily]. There were 80 lined butterflies right outside of Kailua I just saw them within the last few months. [HDAR marine ecologist Dr.] Bill Walsh didn’t believe me at first. Finally I snapped some shots [photos]! And he believed me! I have seen big schools of 400-500 yellow tang… Raccoon butterflies … some pretty good schools of about 50 fish. This area has just become amazing. [07.13B.06]

In coming from a conservationist standpoint today, and as regular participants in the WHFC, they have reason to purposefully acquire quantitative information in being part of the fleet of local “eyes” on the coral reefs, reporting on ecosystem change “since protections”. In contrast, dive operators consistently made ‘quantitative assessment’-oriented observations, from their earliest accounts of Kona’s reefs through today; I contend this group had financial incentive (building business, satisfying clientele) to
account for dive site condition in their early years, even when conditions were considered “good” (06.08A.06). But like conservation/divers, the dive shop operators’ observations also became more conservation-oriented over time, such as learning to look for algal overgrowth, as an indicator of the synergistic impacts fishing of herbivores and nonpoint source pollution (05.17.06). Many people, divers or otherwise, note instances when the kinds of cues they looked for changed, as they became more knowledgeable about coral reef ecology and conservation (04.20A.06; 05.05C.06; 05.20.06).

How conservation/dive experts know Kona’s reefs today, more than any other group, come from a rigid conservation perspective. Several moved to Kona “for the diving,” and quickly saw “it being impacted” (07.05A.06). They started asking questions, trying to count the number of boxes shipped out of the airport (“every day… stacks and stacks of coolers. Hundreds of them. Every day (07.05A.06)). “We formed the Lost Fish Coalition because we were seeing fewer and fewer fish. I went to a lot of the residents on Alii Drive [the frontage road on Kailua Bay]. It was very easy because a lot of them got excited about the changes they’d seen; we hears lots of trouble stories” (07.05A.06).

Finally, they called a state fisheries manager to learn 250,000 tropical fish were reported as catch in Kona each year. “But we had spies at the airport, counting boxes shipped. I estimated that only about 1/6 of all the fish got reported, and therefore the amount being taken out amounted to several million. Hurricane Iniki put the coup de gras to the O’ahu reefs…. [more] collectors moved here, to Kona, after 1991. People started to get
alarmed. Just the number of a quarter-million was shocking. It was a nasty number unto itself. But is that just the number that are put in boxes and sent to the mainland? What about all the ones that die along the way?” (07.13.06). While denouncing overextraction by tropical aquarium fish collection, several experts carefully explained fishing “to eat”, for subsistence or cultural purposes is a natural part of life in Hawaii and *not* objectionable.

How these experts generate and transmit knowledge today comes as much from participating in the WHFC (“democratic, community-based management” (07.06A.06)) as it does from in-water experience (diving, photography, etc.). Illustrating that this group’s knowledge may come as much or more from social transmission than individually acquired in-water knowledge, experts often referenced other expert’s observations of change, especially with regards to open and closed areas (07.13B.06). Knowledge transfer between these three groups, as they describe in interviews, has come through the 1990s activism, the process of determining the FRA boundaries, likely primarily through the frequent, time-intensive WHFC activities (monthly meetings, sub-committee meetings, scientific lectures, hearings, etc.).

### 3.5.6 Local, kamaʻaina fishermen: the hidden dimension

Longtime local, or kamaʻaina, fishermen are a regular presence on Kona’s coastline. During my stay on the Big Island, it was a rare visit to the shoreline when I did not see a shoreline fisherman throwing net, or spearfishermen popping their heads
above water, or a father and son peering over a bucket. Other ocean experts apparently see the same shoreline fishers walking the coast like clockwork, and indicate some sociocultural organization to the times when different groups will fish (e.g., Micronesians fish Mondays mornings; Japanese on Wednesdays and Thursdays). Yet kama‘aina fishermen represent those who were excluded from this sampling of ‘experts’, why dimensions may remain hidden in social network analysis, and to what effect this has on investigating the relations of knowledge and ocean dynamics. Some kama‘aina fishermen were recommended in the ocean expert network; and I know this because people recommended them as such “Talk to the D--- boy. He’s been fishing, longtime” (05.05C.06). But few (if any) received 4 or more recommendations, and none were among the top 25 of experts recommended. A number of experts I interviewed do cast-net and spearfish in Kona, but as Native Hawaiian people and tropical aquarium fish collectors, their ocean knowledges were not distinct from the other ways of knowing that emerged from the data. Thus, I believe kama‘aina fishermen are a dimension hidden by my methods and ought to be examined in future research.

Kama‘aina fishermen signify the discrepancy between having expertise versus authority. One of the shortfalls of this methodology is that, especially for shoreline fishers, some people may have TEK, LEK, or WSK but not be known or recognized by other people (thus not receive sufficient recommendations to be sampled from the population of experts). Where there is an expertise/authority disconnect may serve to
indicate a level of marginalization, limited access to political power or voice. A state resource agency manager emphasized this may be the case with kama’aina fishermen, as he gave thoughtful consideration to why his agency repeatedly is met with angry masses at public hearings. As illustrated by the case of proposals to restrict gill nets (which was more an issue statewide than in Kona):

Agencies look at coral reefs in the short term. Our problem is not understanding the human component. We have... always fallen into traps because we don’t know anything about the people. We focus on herbivores and their ecological services... gillnets target [threaten] ecosystem services. But we get a big wake up call when go to public hearings. The gillnet is case in point [he referenced public hearings on a proposal to ban gillnets, a few months prior, where the agency was met with large public outcry]. The gist of that lesson had nothing to do with resource decline, but impinging on people’s uses and values. They [fishermen] believe they have a right to use that gear. It’s like the painter Norman Rockwell who painted the American life, the farmers and agricultural land. Here, the kupuna take their sons and grandsons out fishing. Like giving their sons their first shotguns to go hunting, here it’s the gillnets and fishing, right of passage to maturity or something. I think there’s an argument to be made about each fish’s role in this world. Look at each animal: What is its role to people? And different people? There’s a role here, and it’s part of a system, more than whether its good to eat or not....

Local fishermen thus seem to illustrate a case of a loosely affiliated group marginalized (unknown, lacking political voice and power) by resource management (see Bryant 1998 for review). Bryant (1998) in reviewing the literature on political ecology notes that marginalized groups may be more vulnerable to environmental change (e.g., declines in nearshore fisheries), and derive fewer positive benefits from, and sometimes are deleteriously affected by, management actions. Evidence of kama’aina fishermen being marginalized is plentiful: in not being recognized as authorities, in taking management officials by surprise at public hearings, and perhaps in shying from venues
(e.g., WHFC, public seminars in Kona), where they would be more ‘known’ and can participate. Furthermore, several resource managers expressed the desire to reach out to fishermen, including some new immigrant groups from Micronesia, but were unsure how. All of this suggests that kama‘aina fishermen, whether comprised of one group or many, may be elusive or unknown to marine management; and for cultural or other reasons may require different modes of outreach and venues for participation in management.

3.6 Giving and taking of authority among ocean experts

The question remains, how do these expert’s knowledge systems, and their experiences of and interpretations of ecological change, influence their relations with one another, the oceans, and ocean management? Tracing the giving and taking of authority between these ocean expertise groups illustrates that their power dynamics strongly influence how people affect, and are affected by, the oceans. During my stay in Kona between 2003-2007 it quickly became apparent that the locally-living community recognizes not one, but multiple and diverse authorities on oceans. Neither do people adhere to the idea of science as a monolithic authority, nor view ocean experts as a homogenous, unified, or one-minded group. Among ocean experts in particular, ‘local knowledge’ and ‘indigenous knowledge’ are afforded legitimacy vis-à-vis science. But with greater distance from Kona-based ocean constituencies, non-scientist ocean experts continue to negotiate power both with the more local terrestrial and land use
constituencies, as well as with non-local political and bureaucratic entities – the non-local levels that seem less willing to grant legitimacy to ‘non-scientific knowledge’ than at the local-level.

Often in my first conversations with prospective interviewees, ocean experts expressed appreciation for opportunity to record what they have learned over time about Kona’s reefs. Ocean experts convey a strong sense of legitimacy in their own expertise, authority which individuals usually give themselves and, to a degree each other, on the local level. As a Hawaiian participant said to me:

I tell you, I’m proud that people like you are taking an interest, finally. Because you can only learn so much from school. When you’re out there everyday, you see things. You learn things. Like Uncle Robert Leslie [renowned Hawaiian fisherman]. Have you met with him? You learn from people like that. They have this big book of knowledge, it’s a big thing. [04.20A.06]

As readily, they also express that securing legitimacy has been hard-won, and while strong among ocean management community in Kona, legitimacy and recognition remains a struggle politically and in ocean governance outside the local community.

One longtime dive shop operator expressed deep appreciation for being asked about her observations of change on Kona’s reefs:

I don’t have much schooling. I started at UH Manoa… I’ve taken classes here and there, but I’m glad that somebody finally realizes what you can learn from life experience. It’s like when you talk with these scientists with all their degrees, and they say, for example, ‘Dolphins don’t play.’ I’ve sat out there for 2 hours a day, every day for years watching them, and you sit in meetings and the scientists say, ‘They don’t play.’ Excuse me? Just because I don’t have all the degrees doesn’t mean I haven’t learned about the ocean. [05.05A.06]
Locally-based marine scientists and a few key individuals for years have asked local people for insights into fish distribution. While these few key individuals long since granted divers, Hawaiians, and collectors authority, it is far less easily given among science and management who work outside of ocean issues, and off-island.

Kona residents also recognize ocean expertise and authority in non-scientists. This was apparent as I identified the population of ‘ocean experts’ and analyzed the social network. The number of recommendations an individual ocean expert receives is a proxy for the level of ‘authority’, or being widely known as an expert. Not only were each of the six expertise groups (Hawaiian, dive shop operators, etc.) well-represented in the upper 20% of those recommended (4 or more recommendations), five of these groups were represented in the ten people with the most recommendations. These five individuals, the ‘figurehead’ of each group, often received the nod from many groups and from off-island upper-level informants. Thus, experts and upper-level informants in locally-living communities as well as the more informed members of the broader ocean community evidently recognize authority in many different kinds of expertise. Yet as indicated in above sections, this does not apply to kamaʻaina fishermen, few of whom received 4 or more recommendations and none of whom were among the top 25 of experts recommended.

Table 5: Each of the expertise groups was represented among the top ten most-nominated individuals within the 203 Ocean Experts. All but one sub-group was
ranked in the top 5. The exception is the group of kama‘aina fishermen, none of whom had more than 4 recommendations. Basic knowledge categorization (traditional, local, and Western scientific knowledge) of upper level informants is listed; a more specific group x group cannot be given because many recommendations came from upper-level informants who do not necessarily affiliate with, nor did I collect as much information on, Kona’s ocean expertise groups.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Expertise Group</th>
<th>Number of Recommendations</th>
<th>Recommended by</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>TEK</td>
</tr>
<tr>
<td>1st</td>
<td>Science</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>2nd</td>
<td>Science/mgt</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>2nd</td>
<td>Native Hawaiian</td>
<td>11</td>
<td>6</td>
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<tr>
<td>3rd</td>
<td>Dive operator</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>4th</td>
<td>Dive operator</td>
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<td>--</td>
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<tr>
<td>5th</td>
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The giving and taking of authority proves to be dynamic over time, shaped by access to power, interpersonal power relations, as well as more forgiving on the locally-living level, as evidenced in the following section on the ocean experts’ own giving and taking among themselves, and latter sections on the historical events transforming power relations between ocean experts and coastal resource management institutions.
3.6.1 “I can make them cry”: How and when ocean experts cede authority to one another

Ocean experts believe their own perspective, and to a degree the perspectives of Kona’s other ocean experts and groups, ought to be considered in making management decisions. Generally people are willing to consider giving authority to an individual, regardless of knowledge perspective, so long as the individual has proven expertise. I was frequently cautioned that some may claim expertise for ulterior motives; for example, those who claim “the fish taste like sunscreen” when aiming to quell the heavy, wearisome tourist traffic at village beaches (04.04.06). There is explicit recognition of authority between and among all expertise groups, albeit hesitancy in some groups to cede authority outside of their own (see Table 5).

In Kona, there is a primacy placed on locally-derived, non-scientific knowledge. Said a dive shop operator, “No scientists have been out on the reefs as much as the divers and fishermen. They simply do not have the day-to-day observations” (05.17.06). The perspective of locally-living experts outside of Western science has proven helpful in fighting development plans, such as a proposal to “blast a new marina north of Kaloko Pond” in which a dive shop operator organized community groups, “barraged a County Council meeting and halted development plans” (05.22.06). From outside of science, she feels the power to use her marine expertise and persuade people emotionally:
Our community groups organized a series of testimonies to alternately give the facts, and then have everybody in tears. So ‘Bob’ [a dive shop operator] brought video of the coral reefs near the proposed development site, and the other community members brought in the facts and figures. And then I got up. I can get a bunch of people crying over a poor homeless turtle. If you give a string of numbers, you won’t get anybody behind you. But, I can make them cry. [05.22.06]

Scientists also give weight to certain people with indigenous or local knowledge. As detailed in the above ‘Scientist/resource manager knowledge’ section (see above), one scientist nods to those who depend upon numbers (fish caught) for sustenance or livelihood, believing this gives fishermen a more astute ability to detect visually small changes in resource condition (05.18B.06). Another scientist with longtime local experience, and a clear memory for 30-year old details of fish presence and absence, assured me repeatedly that there are many kupuna, divers, dive shop operators, and collectors with better knowledge of Kona’s history than herself; no scientists had been around so long, so continuously, or depended so much on the oceans, as locally-living people (6.14.06). Generally, scientists/resource managers who were interviewed for this study were very willing to recommend individuals, regardless of knowledge system, who had proven to them the soundness of their observational capability and integrity of purpose (that their observations are a-political, or explicit in their politics).

Ceding authority to one another, or not, is shaped by people’s interpersonal relationships, political histories with one another - particularly with dive shop operators and conservation/recreational divers (who tend to align together), and aquarium collectors (who do not). This is strongly evident in people’s narratives about one
another, and regarding the decade-past user-conflict, and whether or not individuals have come to resolution through the WHFC. Living in a small place like Kona “is like a large high school; everyone knows everyone else” (G.05). Dive operators and conservationists tended to align together, against collection; and when recommending one another, these alliances seemed to underlie the rather colorful language used in referring one another as experts. Across historic lines of user-conflicts, experts recognize others with great expertise, if not begrudgingly: “C--- really knows his stuff. I can’t vouch for his character, but...”, or “…knows every fish by name. Real knowledgeable. Despite his politics…”, or “You should talk to him/her to get an idea of ‘the other side,’” (Fieldnotes, informal interviews February – May 2006). But even over the course of my research, I saw evidence of historically acrimonious relationships between experts reaching conflict resolution, building trusting relationships, and vouching for one another’s character. Several “sworn enemies” and adversaries have developed mutual friendships that they call “surprising” and “respectful”, through their years of volunteering with the WHFC (05.22.06; 07.05A.06; 07.13B.06).

3.6.2 “The younger generation get more modern”: Authority of Native Hawaiian ocean experts

Although many non-Hawaiians expressed interest in Native Hawaiian ocean expertise, the Native Hawaiian experts were more hesitant than others to recognize experts outside of their community. Typically, Hawaiian experts defer first to their
**Kupuna**, then people from their village or ‘ohana, and with less frequency the members of nearby Hawaiian villages.

But that generation [kupuna of the 1920s], they had so much knowledge, and they didn’t pass it down... Well, the younger generation, they get more modern, and they figure all the old ways are too slow, or you know, just too, too many things you gotta do. Shortcut... they kinda lost a lot of it. [I asked him if there are many kupuna/expert fishermen still alive.] Not the old ones... a fair few of them left over. And we [he, his family, and community organization] try to talk to them... record their knowledge... [Saying he will serve as a gatekeeper for me to interview kupuna] That’s who we’re going to talk to later. [01.04; 03.06]

Mainly, the Hawaiians who have participated cross-culturally in ocean management activities are the few who make exceptions, and have nodded to a few scientists and tropical aquarium fishermen as experts: “‘Dave’... you can talk to him. He’s a good guy. Despite being a haole (Caucasian)” (G.05). Of note, these scientists and fishermen are also the ‘most recommended’ from their own expertise groups. Hesitancy to give deference outside of the Hawaiian community may speak to their trust in me, an outsider and haole, and probably to a large degree the Hawaiian people’s collective and ongoing fight for legitimacy in a post-colonial setting (See Churchill and Venne 2005). We will look at this issue with greater complexity at the end of this paper, though a few points are relevant here. Since the 1970s, the Hawaiian Renaissance has re-imbued the voice and authority of the Hawaiian people. But having long been disenfranchised and subject to cultural subversion, it is not surprising that Hawaiian people are protective of
their authority. It seems a constant battle not to “be watered down,” as illustrated by a Hawaiian expert’s comment:

There’s been a big influx of money. But think how it affects Hawaiians and Hawaii in the long term. Like this past New Years, there were 66 private jets at the Kona airport, so many that some had to drop off their passengers in Kona and fly to Hilo to store the plane. The 30,000 square foot homes… local people can never afford that. Local people, where are they going to go? How can they afford to live here? I hope the cultural things remain intact and do not become watered down. It’s one of the reasons why I started my own business, to run it in the old ways, the way I want to dive the reefs. [04.20A.06]

It also seems that Hawaiians may be less likely to cede authority to others, if they feel others have interests contrary to, or motivations which might undermine the Hawaiians’. Giving deference to longtime local (i.e., non-scientist, non-Hawaiian) ocean experts who serve tourist clientele may threaten Hawaiian people’s interests. This is according to one Hawaiian small-business owner, who mentions how powerful ‘outside’ interests are because of the local economy’s dependency on tourism (80% of Hawaii’s economy stems from tourism (HDBED 2008), and 80% of tourists engage in ocean activities while in Kona (Caesar 2003)). Other ocean experts’ interests may prioritize the interests of outsiders (haole, mainlander, American consumerism were terms he used) over the interests of the Hawaiian people. “[Hawaiian] people here have a sense of place. I know you… I’ve got haole blood in me too… but I don’t mean to pick on these folks” he motions to a family of tourists walking on the Kailua sidewalk. “But it’s them [tourists, haole mentality, American consumerism]. It’s this attitude. All these charter boats here, what happens if the marlin [catch] slows down? What the heck, there are a
lotta sharks out there,” he said, raising question as to what would stop the transformation of Kona’s active charter boat fishing fleet to shark fishing, if the billfish populations declined.

On the other hand, scientists and local people willingly and frequently recommend Native Hawaiian people as ocean experts, particularly those individuals with whom they have interacted and can vouch for their expertise. Enthusiastically, they gave many names of Hawaiian practitioners and *kupuna* as experts. At the same time, while emphasizing their support for Hawaiian ocean experts, it was not uncommon for these people to note frustration with feeling obliged to recognize all people of Hawaiian ancestry as ocean experts, just because they are Hawaiian. Said an elder kama‘aina: “*Kupuna* … age does not make you a wise person. Some are wise, but age does not necessarily make you so. It’s not politically correct to say this in public. But what, some percent Hawaiian blood gives you more authority than someone else?” (05.07). While rather blunt, this small act of resistance was said with regards to the claims of unconditional authority of Hawaiian people. To be clear, there are individuals with profound knowledge and authority; but as is the case with all cultures and peoples, wisdom and expert knowledge is not held by everyone in a group with common ancestry.
3.6.3 Science, its one-time absence, and a tempering of its social authority

There is a tension between, on one hand, the historical and bureaucratic framework that prioritizes scientific data, and on the other hand, the locally-living people aware that not only few scientific data exist about coral reefs but also that there are other means of ‘knowing’ coral reefs. Prioritizing science as a means of generating knowledge is seen in the authority that the broader community and resource management institutions vest in coral reef ecologists, regardless of their experience in Kona. Fully 1/3 of the ocean expert social network is comprised of scientists who were recommended to me as having expertise about the history of Kona’s coral reef ecosystems; thus suggesting something of the wider perception of science as an authority, only a few scientists actually possess historic, locally-based expertise of Kona’s reef systems (see sections above). Two scientists with local expertise not only received the most recommendations in the ocean expert network, they are also some of the few scientists to whom the other participants in this study are willing to cede authority. Charismatic leaders, outspoken and positively engaged with each of the surrounding communities and stakeholder groups, these two have historic and contemporary experience in Kona. Ocean experts describe these individuals in positive terms: “he’s a superb scientist;” “very personable;” “really know the politics;” “such hard worker, I don’t know how she does it” (05.05A.06; 05.22.05; 05.07). About other scientists, locally-living experts are rather reticent to say they have historic expertise, in all likelihood
because of the length of time that science was absent and management of Kona’s coastal resources was conducted from afar.

This ‘absence’ of local marine science and management between the early 1980s – mid 1990s is a critical element in the history of ocean expertise and authority, as it catalyzed the reclaiming of authority at the local level. During the 15-year hiatus, many local people and Native Hawaiians watched reef fish populations fall dramatically. Affecting the entire region’s fishes and hundreds of species, the declines also caused spatial shifts in resource use (see Chapters 6 and 7) and eventually incited user-conflicts between tropical aquarium fish collectors and many other constituency groups (many interviews; Capitini et al. 2004). Hawaiian practitioners and kama’aina fishermen, and increasingly joined by dive shop operators and recreational divers, voiced their concerns to off-island scientists and resource managers. But without local scientific evidence of declines, and without a local presence in management, ‘local anecdotes’ met resistance and were ignored.

Hawaiian practitioners and kama’aina fishermen forged a Gentleman’s Agreement with tropical aquarium collectors to create areas closed to collection, but the ‘handshake’ agreement achieved poor compliance. In the early 1990s the ecological and social conditions had deteriorated, and driven now by the diving community, the movement to limit collection swelled. This was met by resistance among off-island resource managers who “sabotaged” local and Hawaiian peoples’ claims (05.18B.06;
So, Hawaiian and local people, through their grassroots campaigns, garnered the support of a few academic marine ecologists, who were as one conservation/diver said, “the savior of the Lost Fish Coalition [one of the grassroots organizations]. [Their] science legitimized our claims to the state legislature and DLNR (Hawaii State Department of Land and Natural Resources)” (07.05A.06). Now backed by scientific data, ocean experts took their environmental concerns to the state legislature and passed conservation legislation known as ‘Act 306’, which established the FRA network zoning aquarium collection (this history is described in Capitini et al. 2004; DAR 2004; Tissot 2005). What would later remain in perpetuity as the West Hawaii Fisheries Council, a community-based council delineated the FRA boundaries through a democratic, multi-stakeholder representative process. Reflecting upon the status of local knowledge vis-à-vis science and the resource management bureaucracy, a dive shop operator and longtime, active member of the WHFC, noted:

Now it’s state law to consult local environmental experts, but for years we were not heard by politicos in Honolulu, nor by managers… Eventually the scientists began to understand what they might learn from us divers. We took them diving and they saw what we’d observed and learned, what we could identify. They started calling us up to ask questions about this or that. [But] the politicos and the managers never did [seek local knowledge] until they were forced to a few years ago. State management thinks they can just keep taking and taking and taking from the reefs! [05.17.06]

Despite resistance in distant bureaucracy to ‘local knowledge’ (or what are often called ‘local anecdotes’, and is inclusive of all locally-living people’s observations, including Native Hawaiian, local dive, local conservation, etc.), the dive operator/expert...
in the above quote recognizes that several scientists have a long history of listening to, learning from, and supporting the locally-living experts. A few scientists took positions in locally-based resource management and help oversee the WHFC. According to local people, the leadership of these locally-based scientists, who reinforced the importance of local participation in management and knowledge sharing against the grain of state agency, helped secure the authority of local people both initially and in the ongoing running of the council. Today, the WHFC is a voluntary, democratic council that meets on a monthly basis to address coastal management issues; it is meant to be representative of all stakeholder groups in the region, and key leaders make efforts to reach the (largely Hawaiian) constituencies at West Hawaii’s far northern and southern bounds. Thus, due to the absence of science and management, critical changes in resource condition, and perceived lack of voice in resource management, the FRAs and WHFC came into effect, helping to secure authority over coastal resources in the hands of locally-living people. In the end, it seems, local authority is strong in Kona because of a prior vacuum; but there is also evidence that today, local authority is underlain by, or perhaps in strong partnership with, science.

3.6.4 The West Hawaii Fisheries Council: Examining measures of social success

The WHFC itself appears to have garnered a great deal of authority, both in attracting and maintaining active members who are also considered long-time local ‘experts’ but also in making more recent Kona residents known as ‘experts’. Active
volunteer participation with the WHFC is one of the most consistent characteristics shared by study participants, regardless of knowledge system. Most people in the ocean expert social network, who have >4 recommendations, are affiliates with the WHFC. As an authoritative entity, the WHFC seems to overcome bounds between many groups (science, dive, conservation, collection), though Native Hawaiians are an exception as discussed further below. As I interviewed study participants and upper level informants to construct the social network, it became apparent that both the council and its members appear to be known and considered authorities internally and externally. At several community meetings I witnessed people from Kau, East Hawaii Island, and Maui ask WHFC leaders if their communities can be incorporated into the WHFC bounds, or ask for advice on how to a similar council in their community. Several ocean experts (04.20B.06; 07.13B.06; 12.04.06) talked about being recruited to assist other communities: “Maui’s trying hard. They asked me to come help them. But this [Kona] is my community, my reefs. One is enough” (07.13B.06).

This raises the question of whether the source of authority is vested in the WHFC itself, or is transferred to the WHFC by the experts who populate it. In all likelihood it is both, but the important issue is that ocean experts’ ongoing association with the council evidences broad stakeholder participation. Prolific language surrounds the WHFC as “participatory” and “community-based” – from the WHFC’s mission statement, to many of its participants and upper-level informants (many, e.g., 05.18A.06; 05.18B.06;
As an organic bottom-up process driven by locally-living people (also many participants in this study), one resource manager says, the WHFC is made by the volunteers who poured “blood, sweat and tears” into forming and establishing the council. It gives them a vested interest in the WHFC’s continuity, as well as exemplifies why enveloping other communities into WHFC would undermine their potential for success. Today, the WHFC works because its participants have found success in their process of bringing coastal management issues to state authorities:

This is the whole process. [To introduce a new coastal issue] if you go through the process, you build a base of very well informed people around the issue, more informed than anyone else in the state. It’s a way to get the government really excited about the issue. Take it through the WHFC, you will come out with an all-inclusive and very well-focused set of recommendations to take to the state. They [WHFC members, in a strategic planning meeting] painted a picture, of ‘This is how we do it.’ These are all battle scars, from the aquarium collectors, the lay net, spear fishing, Pebble Beach [the major issues they have worked through the process].

There’s a belief in the process… at the highest level. It was not always so. Hostility, skepticism, sabotage from DAR [Hawaii-Division of Aquatic Resources] and others. Part of the success of this group of people – people change. And change becomes institutionalized if it exists long enough to keep it going. But that’s the hardest thing to do, to keep it going. Amazing, 8 years later, and it’s still vibrant, tackling issues. People can bring conflict of use issue, get a fair hearing, and get resolution. They may not like it, but they’ll get a resolution. At least it’s a vested interest. The credit goes to all the 50 or more people who put time into the council. There are still agents of pronounced hostility. A minority, but they are here.

Broad stakeholder participation is considered a standard criterion of management strategy success along social measures (Christie 2004), thus indicating evidence of potential social success of the WHFC’s management approach in meeting the needs of the many locally-living experts.
3.6.5 The West Hawaii Fisheries Council vis-à-vis Native Hawaiian ocean experts’ efforts to protect coastal resources

Native Hawaiian ocean experts participated in the precursors to and early years of the WHFC, but no longer actively participate (G.05; 03.06; 04.20A.06), despite very active efforts by the leaders of the WHFC to engage Hawaiian communities, such as holding meetings at the geographic edges of the West Hawaii boundaries, where many of the Hawaiian people live. In talking with these experts, I sense a level of disinterest, rather than deep disenfranchisement. For instance, one said to me when I mentioned attending a meeting, “Let me know what they say. Good to keep an eye on them” (G.06). Some are more vocal against the WHFC being “not-Hawaiian” (04.20A.06), while others indicate more disinterest as if there are more pertinent issues to deal with first.

Some level of disengagement from the WHFC does not imply disengagement overall. Many Hawaiian ocean experts remain actively in community-based management of coastal issues. Instead of the WHFC, however, their efforts are focused at the village level and typically deal with environmental and social issues jointly (e.g., community centers offering, in tandem, after-school and summer kid’s programs, reestablishment of Hawaiian environmental practices, recording and archiving kupuna knowledge, housing non-profit organizations geared towards re-establishing marine tenure practices) (01.04; G.05; 03.06). An elder kama’aina resource manager, who is not directly involved in but is supportive of the WHFC, shared insights into why the WHFC may not be entirely satisfactory for people in the Hawaiian community. This person says
the WHFC broke new ground in establishing community-based management programs, but by the time it was established, the ecosystem and social conditions were at a critical point. This left few options for how to devise the community-based management, and limited the potential for it to represent everyone’s interests:

Primary example of an existing community-based management program is the West Hawaii Fisheries Council. It’s good, but it doesn’t quite capture the cultural patchwork. [When management interventions occurred it] is too late in the game. It’s got 2 strikes against it already, you know, so its choices are limited. It is populated by ‘California expats’, very smart about politics. Bring mainland knowledge to Kona. They’ve gone to a Western system in the WHFC. They know how to operate, through a formal democratic process. Is this the only way it will work? It’s possible. But it’s not Hawaiian. [05.07]

Though the WHFC may be seen as “island style” by its participants (07.05A.06), it is not necessarily “Hawaiian style” (04.20A.06). Relations between Native Hawaiian ocean experts and the WHFC thus add to debates which complicate how the idea of community-based management is portrayed in the literature. In the community-based conservation literature, in particular, there are underlying assumptions that ‘community-based’ often means outreach to indigenous peoples (e.g., Agrawal & Gibson 1999). While there are substantive efforts by WHFC leaders to include Native Hawaiian people in the WHFC, that their efforts have been increasingly ineffectual may be indicative of tendencies to, or in this case more likely the constraints (e.g., political, bureaucratic, etc.) leading to, an oversimplification of ‘community’ in conservation strategies (Agrawal & Gibson 1999) and in marine conservation, particularly (Christie et al. 2003; Olson 2005). In Chapters 4 & 5, I explore further signs of effectiveness, and
some areas for improvement, in the WHFC and FRA strategies, which are themes that emerged organically from (i.e., was not elicited nor sought) interviews with a variety of ocean experts. Specifically, Chapter 4 deals with suites of organisms that have rebounded, and to what degree, since the FRAs and WHFC were implemented, as well as suites of organisms that have not responded to protections. Chapter 5 discusses how the FRAs have not led to the recovery of subsistence organisms (some of which were, and others were not, meant to respond to protections). It also shows how the continued declines in subsistence organisms reinforces the disenfranchisement from ‘community-based management’ but may have caused a re-enfranchisement of traditional management tenure.

3.7 Conclusions

This paper examines how, at once, expertise is constant, but authority partly hinges upon people’s perceptions of ocean ecosystems, social systems, marine management, and one another. Six distinct ocean expert knowledge systems are evident in Kona today, though kama’aina fishers may not be on the radar of the broader community. Resource managers are also concerned about, and still struggling to, effectively engage this group. Systematically identifying ‘ocean experts’ may be a useful tool for identifying a key group of stakeholders with whom to engage.

Tracing the giving and taking of authority shows that the absence of local marine science, and the resistance of marine management bureaucracy to indigenous and local
ocean experts’ observations of change, catalyzed the re-claiming of authority at the local level. The giving and taking of authority is dynamic within this region. It seems to depend both on the people’s perceptions of resource and social conditions, as well as on the convergence and divergence of people’s ‘place’ within the SES. This paper also complicates the idea of community-based management, by illustrating a case in which local and indigenous people together re-claim community authority over coastal resources but indigenous people increasingly feel disaffected.

As demonstrated by findings herein, even when MPAs and community-based management (CBM) are successful on some biological and social measures, they may require further strategies to deal with all of the ocean resource management issues at hand. Other species and peoples (e.g., subsistence, Hawaiian people, kama’aina fishermen) may not be served by MPAs and CBM. Trade-offs are expected in making any management decision, but through a multiplicity of perspectives approach, those making management decisions may be better informed about what impact management strategies are having, and will have, on various groups of people, and the aspects of the marine ecosystem they value. In Kona’s case, scientists and managers seem aware that the FRAs are a fix for one suite of important issues (i.e., collection), but not all issues; they are now working through more challenging conservation problems (e.g., pakuikui, see above and Chapter 5; e.g., engagement of all groups of people). More generally, the conservation problems faced by ocean and coastal managers today are extremely
complex (POC 2002; USCOP 2003; MEA 2005; Norse & Crowder 2005). MPAs are an approach considered to be integral to managing oceans today (Lubchenco et al. 2003), but this case shows (and as Kona-based scientists noted), a multifaceted marine management approach is necessary, where MPAs may be one of several tools used.

Likewise, CBM, while seemingly extremely successful biologically and rather successful socially, may not be entirely so. The WHFC has been designed to be a conduit for stakeholders to introduce new coastal issues to policy- and decision-makers at the state level. It appears to be experiencing success on some biological measures (Tissot et al. 2004; Chapters 4 & 5), and some social measures (e.g., see above on WHFC as an authority aggregating many local ocean experts); however, it may need to be joined by other strategies, if its mechanisms for participation are not synergizing with all of the diverse stakeholders in Kona. At least one, if not two or more, groups of people are not as well-served by this approach as others.
4.1 Introduction

Historical ecology of ocean and coastal systems\(^5\), or marine historical ecology, responds to the recent and rapid global change seen throughout ocean ecosystems (Pauly 1995; Jackson 1997; Jackson et al. 2001). Historic insights into ocean condition and dynamics are crucial to an effective response to the declining health and resilience in marine ecosystems, but are often absent. Profound anthropogenic impacts on marine ecosystems, largely from fishing (Jackson et al. 2001), are thought to have occurred long before the onset of marine research, thus limiting our ability to evaluate fully ocean condition and dynamics, and the tempo and mode of marine ecosystem change (Pauly 1995; Jackson 1997; Pitcher & Pauly 1998; Jackson et al. 2001; Knowlton & Jackson 2001; Pandolfi et al. 2003). Lack of historical data can lead to what Pauly (1995) labeled the ‘shifting baseline syndrome’, where managers set inappropriate recovery goals based on a short-term view of what past ecosystems looked like. A longer-term historical perspective is thus needed to envision what a more pristine ocean might have produced and how it operated, to assess the synergies between natural and anthropogenic disturbances, and to set achievable goals for management and conservation that ‘could not even be contemplated based on the limited perspective of recent observations alone’

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\(^5\) Herein referred to as marine historical ecology to distinguish it from a field of research also called ‘historical ecology’ that emerged separately and concurrently in the social sciences.)

In order to envision what past marine ecosystems looked like, marine historical ecology has turned to non-traditional data sources, e.g. historical archives where tax records, ship logs, and even restaurant menus can be found. The field recognizes the value of ‘traditional’ or ‘indigenous’ knowledge holders and the contributions they can make to describing past systems. While we recognize its many contributions to date, we share concerns of van Sittert (2003), Bolster (2006), and Campbell et al. (in review) about marine historical ecology’s reliance on quantitative data, its detachment from historical context, and its characterization of humans as primarily ‘the problem’. We argue that marine historical ecology stands to benefit from a more ‘peopled’ approach, or one more balanced in its treatment of coupled human/environmental interactions.

As marine historical ecology often focuses on the long-term past, a peopled approach would involve placing historic marine ecological ‘data’ in the context of history, (how race, class, technology, globalization, trade, science, relates to ‘sea change’, i.e., why humans behaved in the way they did to effect change). In other words, ‘replacing’ humans in ocean systems, likely, will involve cooperative research between marine ecologists and historians, archaeologists, and geologists, and others trained in the research of historical human context (van Sittert 2003; Bolster 2006).
Yet there are many places in need of a contemporary marine historical ecology, where for example there are reports of recent ecological change, or where a dearth of recent historic baseline data is limiting management efforts. One example is this project’s study region, the coral reefs of Hawaii Island’s Kona Coast. In such cases, contemporary historical ecologies can be elicited from locally-living people, such as indigenous, local, and fisher’s ecological knowledge holders. We believe that this kind approach provides the opportunity to get beyond the ‘archives’ to the people, and in doing so helps unravel the human context and different value systems, behaviors, and practices affecting oceans and coastal areas.

To illustrate our argument, we present results from a study of historical ecology and human dimensions of Kona’s coral reefs systems, which we explored through formal interviews with ‘ocean experts’ (see methods). One purpose of this paper is to describe trends in the historic ecological change they describe, specifically the abundance and distribution of over 270 coral reef organisms, over 80 years, and a 50-mile coastal region. In particular, eight groups of species, which we call ‘social-ecological guilds’, follow very distinct patterns in abundance and distribution, which we detail herein. A second objective of this paper, applicable beyond the specific history of a Hawaiian reef region, is the bridging of marine historical ecology and research with holders of indigenous and local knowledge. To elicit historic trends, we worked with ‘ocean experts’, or people who hold expert and historic ecological knowledge about
Kona’s coral reefs and coastal areas, and explored their observations and perceptions of ecological change. Those who participated in this study represent diverse backgrounds, including holders of traditional ecological knowledge (TEK), local ecological knowledge (LEK), and Western scientific knowledge (WSK).

Our study approaches historical ecology of a coral reef region by engaging various forms of ocean expert knowledge without legitimizing any one knowledge system over another. Our intention in talking to a variety of peoples is to get beyond the attention to single species and to talk about broader trends in the ecosystem, which is more feasible by working with people with a variety of expertise and experiences. Engaging people from diverse knowledge systems also reflects current thinking about dynamics of complex systems comprised of interlinked social and ecological domains (Johannes et al. 2000; Berkes 2003; Berkes et al. 2003; Folke 2006). As we will explore throughout, our data shows the importance of human context (social, political, ecological, historical, etc.) to the history of marine ecological change, because people talk about the organisms, processes, and events they value. Finally, and in conjunction with this idea, this culturally-inclusive approach provides a far richer history than any one perspective, including science, may have garnered alone.

**4.1.1 Joining TEK, LEK, and Western scientific frameworks**

TEK is commonly defined “as a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by
cultural transmission, about the relationship of living beings (including humans) with one another and with their environment” (Berkes et al. 2000: 1252). Indigenous peoples are holders of TEK, while the knowledge of locally-living people (non-scientist, non-indigenous) is known collectively as LEK. As described in Davis and Wagner (2003: 477), LEK “is presumed here to constitute a ‘body’ and a ‘system’ of understandings and know-how that arise through time from a variety of individual and shared experiences and observations, mediated by culture, with regard to environmental factors, behavioral attributes, and ecological dynamics.” Marine-relevant LEK also research includes a body of work on fisher’s knowledge (Neis 1999; Marustad 2001; McGoodwin 2001), and participatory approaches (e.g., Johannes et al. 2000; Berkes et al. 2000; Berkes 2004).

By engaging with TEK/LEK for the purposes of historical ecology, we broach debates surrounding the political, epistemological, and ethical implications of joining alternative ways of knowing into Western science. A fundamental objective of this research is to give voice to indigenous, local, and scientific people on a level platform, while remaining true to each of their voices. But to date, similar efforts have been limited by problems associated with crossing several long-standing divides between natural and social sciences, and the qualitative and quantitative (Endter-Wada et al. 1998). Additionally, approaches that bridge knowledge systems (Western scientific, indigenous, and local) have raised questions relate to: (1) attempts to fit qualitative data to quantitative needs (Nader 1996; Agrawal 2002), (2) the legitimacy, validity and
reliability of codifying indigenous or local knowledge systems into scientific frameworks (Agrawal 1995; Nadasdy 1999; Gadgil 2003), and (3) ethical issues surrounding the ‘use’ of another’s knowledge for purposes they may, or may not, support such as conservation (Agrawal 2002; Shackeroff and Campbell, in press). As TEK/LEK research, as a social science, requires the use of social scientific methods of rigor, validity, and reliability (Baxter and Eyles 1997). It introduces issues relating to cross-cultural and indigenous research (Tuhiwai-Smith 1999; Gibbs 2001), such as intellectual property rights (Gibbs 2001) and other ethical considerations in conducting TEK-research for ecological science and/or conservation purposes (Shackeroff and Campbell, in press). Finally, as some argue that human systems and the social sciences have been largely over-simplified in marine research (Christie et al. 2003; Mascia 2003; Kaplan and McCay 2004; Olson 2005; Campbell 2005), such approaches also have to ensure that they address ecological and social systems with sufficient complexity (Endter-Wada et al. 1998). The point here is not to dissuade the potentially valuable partnership of TEK/LEK research with marine historical ecology. Rather, we believe being explicit about potential challenges will improve the possibility that benefits are achieved.

4.1.2 Approach and objectives

This research attempts to integrate methods and approach from the biophysical and social sciences, towards the social-ecological history of Kona’s coral reef systems.
Giving voice to the diverse ocean experts in the local community, our approach examines marine historical ecology at the ecosystem-level, based on qualitative data from interviews with local experts, and without privileging any knowledge system over another. Its approach is at once peopled, historic, and ecosystem-level. First, without privileging any knowledge system over another, we elicited ocean experts’ observations, perceptions, responses, and narratives of marine ecological change. We take a critical realist approach, believing that there is a biophysical reality, which is revealed through experts’ observations. But peoples’ interpretations of the natural world differ, depending upon how their knowledge is situated (socially, politically, historically, etc.) (Haraway 1988; Nader 1996; Berkes et al. 2003). Complex systems theory suggests we cannot know the ocean without understanding the many ways ecosystems and ecological change are interpreted and experienced (Berkes et al 2003). Second, we approach historical ecology at the ecosystem-level. We sought experts across a coral reef region – the leeward, western coastline of Hawaii Island – to learn about ecological patterns and processes over time. Though the depth and scope of ocean expert knowledge interviews is determined by the individual’s knowledge, over the course of all interviews, we aimed to amass insights into historic (a) habitat condition, (b) coral reef functional groups (initially assumed to be herbivores, corallivores, piscivores, apex predators, etc.), and (c) natural and anthropogenic disturbance and synergies.
In this paper, we examine patterns in historic abundance and distribution of coral reef organisms, and guilds thereof. But as we explore in latter sections, we confront questions about joining ecological insights from distinct knowledge systems. Our initial attempts to apply ecological frameworks (e.g., the previously defined ecological functional groups) to the analysis of cross-cultural and multi-cultural qualitative data was problematic. It quickly became apparent that looking for trends across herbivores, corallivores, apex predators and other ecological functional groups was not only inappropriate for these non-traditional data sets, but not as fruitful as other analytical schema. Our results demonstrate how preconceived Western scientific analytical frameworks are not as rewarding to these cross-cultural data as an interpretive, more flexible approach.

How we reconciled different types of knowledge (local, indigenous, scientific), and the implications for inter-disciplinary research and management, is revisited in our discussion. In doing so, we discovered clear patterns in abundance and distribution shared across groups of species. In that species within these groups shared both ecological and cultural characteristics, we call the groups ‘social-ecological guilds.’
4.2 Methods

4.2.1 Research site: Hawaii Island’s Kona Coast

We conducted this research on the Kona Coast, the leeward, western coastline of the Island of Hawaii. Six watershed-reef-pelagic complexes between Keahole Point and Kapua were selected as research sites, because they are representative of the diversity in people, seascape, landscape, and historic context on this coastline. The Kona Coast is a post-colonial, cross-cultural, island setting, with a rapidly growing resident population and large tourist population. Still considered rural, the landscape is undergoing rapid development and land use change, which are raising concerns about ecological and cultural change. Oceans are a way of life in rural Hawaii; many people nurture deep ties to and knowledge of the kai (ocean).

Kona Coast coral reefs suffer from a dearth of historical data (qualitative and quantitative), despite a proliferation in the last decade of marine ecology research and on-island management. Though Hawaiian coral reef ecosystems are considered to be relatively pristine, low-level, cumulative impacts over decades to centuries are thought to have occurred (Jokiel et al. 2004). Environmental and anthropogenic stressors in Kona may include fishing down apex predators, tropical aquarium collection, and water quality declines associated with rapid growth in coastal watersheds (Friedlander et al. 2005). Locally-based marine managers and ecologists have little ‘baseline’ ecological data on habitat (coral cover) or on many reef species. As of 2006, coral monitoring
programs were being initiated bay-by-bay and geared to assess impacts of land use change and nonpoint source pollution (Sallie Beavers, National Park Service, pers. comm., 2006 & 2007). Reef fish monitoring programs began region-wide in 2000 (WHAP), and have drawn upon one ‘historic’ study of reef fish in Ke`ei Bay from the late 1970’s-early 80’s (Walsh 1983; 1984; 1987).

In Kona, there is need for a better understanding of past habitat and reef fish conditions. From the early 1980s through late 1990s, little science and management was conducted in Kona. Over the course of these two decades, both Hawaiian and local people began voicing complaints, claiming tropical aquarium fish collection was causing dramatic declines in colorful coral reef fishes and organisms (Capitini et al. 2004; Tissot et al. 2004). These people engaged in grassroots activism to limit collection, a growing movement which eventually resulted in the establishment of a marine protected area (MPA) network limiting aquarium fish collection (Fisheries Replenishment Areas, or FRAs) as well as the inception of a community-based management council (West Hawaii Fisheries Council, or WHFC) (Capitini et al. 2004; DAR 2004). Questions remain about historic reef fish abundance, levels of historic decline, and whether and to what extent other aspects of Kona’s reef systems have changed in recent history.

4.2.2 Eliciting expert ecological knowledge

Historic ecological knowledge was derived from semi-formal interviews and participant observation. Ocean experts (n=203) were identified in informal interviews
(n>200) by snowball sampling (Bernard 1988) and social network analysis (Hanneman & Riddle 2005). Following Davis and Wagner (2003), ocean experts were selected based on the criteria of being considered those with the greatest expertise about the history of Kona Coast coral reef ecosystems, between Keahole Point and Kapua. The sample selected for interviews was stratified, non-random, to ensure we worked with TEK, LEK, and WSK experts in each of the study sites. Experts with the highest number of recommendations were prioritized. Considering that six expert marine knowledge systems were identified (Chapter 3), we interviewed people from each expert knowledge system.

In the vein of Huntington (2000) and McGoodwin (1990, 2001), 61 semi-directive interviews were conducted with 41 experts in one-on-one and group interviews (Bernard 1988; Holstein & Gubrium 1997; Dowling 2000; Dunn 2000; Gibbs 2001; Maurstad 2001). Each participant was asked to discuss their observations of ecological change on Kona’s coral reefs. Across all interviews, we aimed to collect data on the historic dynamics of: (1) habitat condition (coral cover, coral-algal balance, etc.), (2) reef organism guilds (herbivores, corallivores, carnivores, apex predators, etc.), and (3) processes (e.g., recruitment, storms), and (4) natural and anthropogenic disturbances.

Herein, we distinguish between experts’ observations vs. their perceptions of ecological change. Observations of ecological change assume that there is a biophysical reality that exists, and that a person in this context, regardless of his/her epistemology,
has the ability to generate similar knowledge about that reality. That is, all participants in the context of this study can detect change to marine ecological resources and report it in somewhat similar manners (e.g., that there are fewer or more numerous ‘fish abc’ than in the past). *Perceptions* relate to how a person interprets and explains what they have observed – such as what caused changes. An underlying assumption is that people may share similar observations but different perceptions about the same ecological phenomenon. Differences in perceptions may relate to a wide variety of factors: cultural, historic, socio-political, economic, or the nature of knowledge and expertise. Perceptions provide insights into natural and anthropogenic disturbance on reefs, as well as tap into the human dimensions of change. Between 2003-2007, two full years of fieldwork including extensive participant observation was conducted by JMS (Bernard 1988).

### 4.2.3 Qualitative data analysis

Qualitative data totaled over 1,000 pages of text from informal interviews, semi-directive expert interviews, participant observation field notes, and a field diary. Substantive historical ecological knowledge was shared for more than 270 organisms. The number of organisms discussed per interviewee ranged from 13 to 147. I analyzed qualitative data with an iterative approach to grounded theory (Strauss and Cobin 1994; Baxter and Eyles 1999; Charmaz 2005), which allows themes to emerge from the text rather than asking pre-determined questions. Qualitative data were coded by (a) ecological topic (species, process, change vs. stability over time and sites, accounts of
change), and (b) knowledge group (participant, within and across groups, comparing what the observed and perceived by species, site, and time).

In this paper, we sought trends in organisms’ abundance and distribution over time and space; we also examined if groups of organisms shared similarities in trends. The criteria for determining trends are multiple. First, a trend may come from one individual’s observations over time; or from two individuals who observe an organism at different times. In the example of *paku’iku’i* (Achilles tang, *Acanthurus achilles*): (1) “Charlie” recalls schools of 100’s in Kaloko in 1960s, but for the last decade (1996-2006) has counted no more than a dozen at any given time; or, (2) “Elaine” recalls schools of 100’s *paku’iku’i* in Kaloko in 1960s, while “Barry” counts no more than one dozen of the fish in the same area today (2006). Critical reflexivity (Dowling 2000) was used throughout research, and some interview analyses were triangulated between researchers, to assess the validity and reliability of interview and research processes (Baxter & Eyles 1997; Miller & Glassner 1997; Mullings 1999).

Second, all trends in abundance and distribution were included in analysis, even if the trend was observed by only one participant. Most organisms were observed by two or more people, such as the *honu* (Hawaiian green sea turtle), which over 75% of participants discussed. However, for a few organisms, like the “leaffish” (Leaf scorpionfish), only one expert shared observations of change, despite that multiple people raised the topic of leaffish in conjunction with Hawaiian lionfish and Decoy
scorpionfish. On both methodological and epistemological grounds, we justify including in our analyses the observations made by only one participant. Different people have different interests and values in different species and processes, different scales of space and time. In addition to what they know, people differ in how they know the ecosystem. But given the methodological rigor in identifying and selecting expert interviewees, as well as in critically examining their interview data (Baxter and Eyles 1997; 1999), we consider the data to be expert knowledge and thus justifiable. Additionally, as in Goodwin (1998), an objective of this research is to identify cultural phenomena. It is less important to quantify how many people share the same observation, simply that it exists.

<table>
<thead>
<tr>
<th>Abundance</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑ ↓ ≈</td>
<td>↑ ↓ ≈</td>
</tr>
<tr>
<td>↑ ↓ ≈</td>
<td>↑ ↓ ≈</td>
</tr>
</tbody>
</table>

**Figure 9: Schema used to code qualitative data for individual species, then groups of species. Symbols indicate increases, decreases, or relative constancy.**

Third, to determine a species’ abundance and distribution over space and time, we used the schema illustrated in Figure 9. Observations of increases, decreases, or constancy in abundance and distribution, over space and time, were coded for each
species. Changes in abundance in space and time were determined by having at least two observations of abundance of any organism. Observations of abundance were both quantitative and more relative. Relative observations of abundance were also made in terms of changes in catch per unit effort (See Table 6). Trends in abundance, theoretically, could come from joining observations from two people’s texts; however, there was broad concurrence in changes in abundance, and this never was necessary.

Distribution relates to the organism’s inhabitance of ecologically suitable habitat and conditions. Distribution is only relative to the observations collected over the course of this study.\(^6\)

Fourth, we looked for patterns in abundance and distribution shared by groups of organisms. We found that most species fell into one of 8 patterns that we found. We examined counter examples to the 8 patterns that emerged, to ensure analytical rigor (Baxter and Eyles 1997). Because the species in each pattern share several commonalities: (1) patterns in historic abundance and distribution; (2) ecological characteristics; and (3) cultural or human dimensions characteristics, we refer to these suites of organisms as social-ecological guilds. In choosing this term, we signify that these trends derive from the ecological histories of a multiplicity of expertise groups, and that species in each guild

\(^6\) Separating the changes in distribution versus abundance may be difficult to do, since declines in abundance are often correlated with declines in range (MacCall 1990). As populations decline in overall abundance, fish converge on the best habitats, thus dropping residency in more marginal areas (MacCall 1990). Fishermen may detect reductions in range before they detect changes in abundance because they fish where the fish are most abundant; divers, since their observations are of organisms within dive sites may have different means of detecting changes. Thus, where these two issues have been distinguished in the minds of the ocean experts, we have presented the results as such; conclusions can be drawn accordingly.
share both ecological and cultural characteristics. The reasons for not calling or analyzing groups of organisms by scientific frameworks, like ecological guilds, will be addressed in our discussion. We summarized the guilds’ trends in bubble diagrams (Figures 10, 11, & 12).

Table 6: Examples of interview text indicating changes in abundance

<table>
<thead>
<tr>
<th>Quantitative abundance</th>
<th>“For decades we would see between 10 and 13 lionfish on any given dive in that area. Then, they all disappeared, and we haven’t seen one since.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative abundance</td>
<td>a) “Yellow tang schools were like rivers of yellow, or beds of yellow tulips until the 1980s, then noticeably in decline until the late 1990s when you might see 2 or 4 fish in any area”</td>
</tr>
<tr>
<td>Relative abundance</td>
<td>b) “We used to go spearfishing and all would choose a fish and only take that one kind of fish. I’d take <em>manini</em>, my friend would take <em>uhu</em>... There used to be so many fish, I would have to push them out of the way to get the one I wanted. After an hour, our lines would be full. Now a couple of hours, and you get only a couple fish, different kinds. Last week, I got in the water, and I was excited to see <em>one fish</em>. Just <em>one</em> fish!”</td>
</tr>
<tr>
<td>Distribution</td>
<td>Tinker’s butterflyfish have been observed historically (1930’s) from 5 – 180 feet depth. But for some decades adult Tinker’s have not seen shallower than 100 feet. This is an indication of a relative decline in distribution over space (shallow depth range) and time (recent decades).</td>
</tr>
</tbody>
</table>

The 8 social-ecological guilds presented in this paper include: (1) Subsistence organisms; (2) Ornamental organisms, including two special cases of ornamentals, the (3) Butterflyfish and (4) Rare Fishes; and 4 guilds of predators, including (5) *Ulua* and native piscivores, (6) Tiger Sharks, (7) Eels/Reef Sharks, and (8) Invasives. The 4 patterns we describe as predators relate to the counter-analyses, as well as exemplify some
interesting findings about joining knowledge systems, which we attend to in the
discussion. A subset of the organisms included in each guild is listed in Appendix A.

In addition, although this research addressed coral reef ecosystems, there are
some organisms included herein which in the scientific literature would not typically be
associated strictly with coral reefs, such as yellowfin tuna, big eye tuna, and opelu
(mackerel scad). But in the Native Hawaiian worldview and way of knowing the
environment, different connections are made and meanings drawn about coral reefs
than in the Western science view of ‘ecosystem’. To do honor to these experts’ ecological
knowledges, thus, we have all included organisms participants discussed, even though
the organisms do not necessarily meet conventional definitions of ‘coral reef organisms.’

4.3 Results

4.3.1 Social-ecological guilds: Population dynamics and historical ecology

When looking at biophysical change across organisms, certain patterns arise that
are shared by groups of organisms. First, we define each social-ecological guild, by
listing the organisms therein, and describing their shared ecological and cultural
characteristics. Second, the guilds’ historic ecological dynamics are summarized in
Figures 10, 11, & 12, which change over time in abundance and distribution.
Surprisingly, there was very little disagreement between participants about the trends
Table 7: Patterns observed across suites of organisms

<table>
<thead>
<tr>
<th>Guild</th>
<th>Trend in abundance and distribution</th>
</tr>
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<tbody>
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observed, regardless of the person’s way of knowing or socio-political context. Very similar patterns of historic change in coral reef organisms were triangulated by multiple experts, and sometimes across diverse expert groups. Even though there was little disagreement about biophysical trends, experts did not always talk about the same topics, even within a single guild. What people and their groups talked about varied rather widely; as in Subsistence Organisms, Hawaiian people tended to talk about...
certain kinds of Subsistence organisms (e.g., ahi, aku, opelu, umaumalei) that were not common organisms among the subsistence organisms discussed by other people. We attempt to keep the issue of attribution (who talked about what) at the forefront. The 8 patterns in abundance and distribution in space and time, labeled by taxonomic or cultural characteristics, are summarized (Table 7).

Second, in our results, after explaining the trends, we will begin to explore possible factors underlying change in Kona’s social-ecological guilds. To do so, we draw from interview texts, namely people’s perceptions (explanations) of ecological change, as well as available published information. We also compare and contrast how experts perceive and interpret the changes they observed in the ecosystem. While there was surprising concurrence in experts’ observations, their explanations of ecological change varied far more widely. Given the rather complex biophysical and human factors (social, economic, historical, institutional, political) involved in people’s perceptions of ecological change, the topic is beyond the scope of this paper. Herein, we present a few key themes, and then explore them in more detail elsewhere (Chapters 3, 5, & 6).

4.3.2 Subsistence organisms (1920-2006, with detail from 1960-2006)

Subsistence organisms are characterized by decrease in abundance and distribution over time, with reductions accelerating from the 1960s to today. This guild represents a broad class of organisms including many species from the intertidal, coral reef, meso-pelagic and pelagic systems. In addition, it includes a suite of organisms
more taxonomically and functionally diverse than any other guild described in this paper – invertebrates, algae, crustaceans, highly migratory species. We refer to this guild as ‘subsistence’ for several reasons. In everyday conversations and interviews, organisms in this guild are commonly referred to by their Hawaiian names, rather than English or scientific. Many of the organisms herein are considered to be Native Hawaiian cultural resources in texts of historic fishing and ocean use (e.g., Kahaulelio 2006). Furthermore, the guild is called subsistence because Hawaiian ocean experts spend proportionally more time talking about these organisms than any other expertise group does, and proportionally less time talking about any of the other guilds (see also Chapter 3 and 5).

First-hand observations of subsistence organisms date to the early 1920s; observations shared from c. 1920 – 1970 come solely from Native Hawaiian ocean experts, and from that time to the present from a diverse admixture of ocean experts. Subsistence organisms, according to ocean experts, experienced gradual decline between 1920 and 1960 (Figure 10). In this study, experts’ first reports of declines in subsistence organisms occur in the 1960s when many experts returned to Kona after prolonged absences (returning from military service, or from working off-island) (04.04; 07.18.06). What experts describe of subsistence organisms prior to 1960 generally relates to their relationships with these organisms through cultural, marine tenure, and subsistence practices and how these practices were affected over time. Though ocean experts did not
say they had observed signs of decline prior to 1960, some indication of earlier temporal changes is provided in early twentieth century documentation of commercial landings data (e.g., Cobb Report of 1902) compared to contemporary ones. But making inferences

Figure 10: The guild of Subsistence Organisms is shown: (a) spanning the 1920s-2006, as well as (b) detail from 1960-2006. Regarding this, and other ‘bubble diagrams in Figures 10-12): scales of abundance on the bubble diagram are exact numbers – 1 being observations are made of single fishes, 10 being around 10 to 10’s of fishes, 100 being 100 to 100’s of fishes, and so on. Relative changes to distribution are represented by different sized bubbles. Different sizes of the bubbles indicate changes relative to the species in the group, from the first observation of that group to present day. Thus, a constant size of bubble indicates that these data indicated no evidence of change in distribution (sites inhabited, or range within the habitat). Different sized bubbles within a guild indicate a shrinkage or expansion in sites or space within a site.
about trends would be inappropriate because they were not accompanied by rigorous measures of effort (Dye & Graham 2004). According to Dye and Graham (2004), the landings data were accompanied by a few accounts that looked specifically at temporal changes, based on the first reports of commercial landings in the Cobb Report (1902). The following account does not specifically address Kona, which are some of the more rural, isolated reefs in Hawaii, but provides important context to the archipelago as a whole:

The fauna of the reefs is much less abundant than in the period of the first extensive explorations, those of Dr. Oliver P. Jenkins, in 1898, and of Jordan and Evermann in 1901. Probably no species had been exterminated by overfishing, but many once common have not become rare (Jordan et al. 1927, as cited in Dye & Graham (2004, 51-52)).

In our study, participants report dramatic declines across most subsistence species from 1960 to the present time (2007), and those with longer tenure (e.g., Native Hawaiian people) report more dramatic change than those with shorter tenure in Kona. Similar to the observations of many experts, one fishermen commented, “When I was a boy, my friends and I go poke fish [spearfish]. We each chose one fish, and only get that fish. He take manini, I take uhu, my friend take kole. Take one spear, one line, and fill ‘em up real quick. There used to be so many big fish...” he said, waving his hand in front of his face, “I used have to push fish out of the way to poke the one I want. I don’t dive much anymore, I getting old. But my son took me fishing just a couple months ago. And I was excited to see one fish. Just one fish! Not like when I was a boy. Only place

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still get [large fish and large abundances] is Kapua...South Kona.” (7.10.07). With the exception of a few fishes who cross-cut categories (mostly with ornamental guilds), most subsistence fishes show a steady downward trend with no sign of upswing. This is consistent across all ocean experts’ interviews, from 1920-present.

Organisms from pelagic through intertidal zones are locally depleted, though not entirely absent across Kona. Respondents report pelagic species, including various tuna, are many fewer, further offshore, and less predictable than two decades ago (many, e.g., 01.05; 07.18.06; 08.31B.06). Slightly nearer to shore, meso-pelagic species such as the staple subsistence fishes akule (big eye scad), opelu (mackerel scad), and o’io (bonefish) are far fewer in numbers than decades ago. Though nearly every bay used to have seasonal schooling of akule, the fish now are locally absent in most but not all of Kona’s bays. “Now only place get (akule) is Napo’opo’o [a nearby village]” (06B.04). Said a resource manager, “if akule is gone, you hold your breath” (12.04.06), indicating the species’ low capacity to repopulate once ‘fished-out’. In Kealakekua Bay according to a revered, multigenerational fisherman, the seasonal o’io (bonefish) were totally absent for some 10 years but appeared again in small numbers in 2005 (07.16.06).

Offshore fishermen expressed surprise about very recent declines in opelu, which has long been considered an inexhaustible resource. At the start of this research project (2004), a kupuna and internationally renowned fisherman described opelu as “an impenetrable resource. We fish opelu for thousands of years, and they always come by
the ton. We maybe fish 1%, 2%, or less of the opelu any year” (07A.04). In 2006, opelu, which is a ‘staple fish’ of ancient and 20th century Hawaiian peoples’ diet and ‘Number One Bait’, showed signs of degradation. According to multigenerational fishermen (08.31B.06), numbers of opelu seem to fluctuate on a seven-to-ten year cycle, over which time there may be slightly high and low periods, which seem to coincide with good and bad years for mangoes. However, by 2006 opelu had been “marginal” for several years (8.31B.06), and slower than anytime in the past six generations of a renowned fishing family. Many of Kona’s few remaining, full-time, small-boat fishermen (who target opelu, as well as supplement with tuna, and diversified methods), were forced to find ‘land jobs’ due to the unusual and prolonged dearth of opelu (8.30.06).

On coral reefs and intertidal areas, important subsistence organisms (some of which are also important organisms for aquarium collection) are low in abundance, smaller sized than some years ago, and showing no signs of rebound. Paku’iku’i is targeted both as a subsistence fish (adult fish), as well as by the aquarium collection industry (young of the year). Its populations are present but diminished from 30 or more years ago.

In the 1970s... in one 15 minute swim across maybe 150 yards, I counted 35-40 pairs of paku’iku’i at the Old Airport, or about 80 fish. [05.05C.06]

The yellow tang, paku’iku’i, and naso tang (orangespine surgeonfish) were very prominent in the 1980s. Paku’iku’i schools were all up along the shoreline, numbering 30 to 40 fish per school. By the 90s, you might only see 5 or 6, and then the juveniles were scattered along the drop-off a little farther offshore. [04.20A.06]
The Achilles tang (paku’iku’i) have not rebounded, though other tangs collected in the aquarium trade, like the yellow tang and naso tang, have increased in recent years (and thus fall under the Ornamental Organisms guild, see below). The paku’iku’i are cause for concern of the ocean expert scientists who participated in this research:

Paku’iku’i—my feeling is that they’re having a tough time of it. The bay isn’t their primary habitat. We’ve been doing jet boat surveys – you “fly” underwater and cover big distances, 1 mile per tank. When we focus on Achilles (paku’iku’i), we can go big distances and do not see a single individual in their primary habitat… It’s the third-most caught aquarium species. It peaked in the 90s and went way down, and has stayed down, even though 1 to 2 years ago we started seeing an increase, generally, in [other] aquarium fishes’ recruitment. (06.12B.06)

Achilles tang are also showing little to no response; one scientist speculates that it is a fish hit from both ends, collected as a juvenile and fished for subsistence as an adult:

Paku’iku’i adults tend to be close to shore, and squeezed in two directions [in space and time]. Little ones [collected] by the aquarium collectors. Big ones [caught] by fishermen. They have no refuge in space and no refuge in time because juveniles and adults are desired. One end of it [juvenile] is now protected [by the FRAs]. But no real ‘tic up’ in them in the past few years. [12.04.06]

Like many subsistence delicacies, opihi (limpets) are extremely scarce – as are paku’iku’i and ohua (new recruit of the convict tang, manini). Except, as an elder fisherman and Hawaiian practitioner noted, opihi are still found “in front of my dad’s house [the house of the region’s most renowned Hawaiian fisherman and patriarch of a large fishing family]. You still get opihi there. Folks know not to take from in front of
our house” (07.16.06). A kupuna-wahini (revered elder Hawaiian woman) remembered 30 years ago picking 15 gallons of opihis for a wedding near their village; a younger Hawaiian from the same village returned, “now, lucky if get one gallon!” (02.04). Honu (Hawaiian green sea turtle) are an exception to the subsistence organisms’ decline, as its populations have steadily expanded and behavior around humans noticeably more calm in the past 3 decades.

4.3.2.1 Explaining patterns in subsistence organisms

The Subsistence Guild is unique from other guilds in that (a) many organisms are not conventionally considered ‘coral reef organisms’ in the scientific literature, and (b) there does not appear to be a single factor which has influenced the declines in all of these organisms; many of stories are unique to each species. Commonalities in each subsistence organism can be outlined from ocean expert’s perceptions and narratives of change. It is less straightforward to name factors causing decline in Subsistence Organisms compared to the other guilds (below), in part because each subsistence organism, whether intertidal, reef, or pelagic, has its own history that is shared by ocean experts. Species by species, site by site, respondents report a wide array of historic, social, economic, institutional, and biophysical factors causing declines in abundance and distribution across a wide variety of Subsistence Organisms over the 20th century.

A number of organisms appear to have been subject to fishing pressure by residents and tourists growing in numbers and diversity, and in the fishing techniques.
used. Related to this is the loss of cultural practices mitigating, tempering, or otherwise controlling extraction. Respondents note that historically, Native Hawaiian marine tenure practices (offerings, *aumakua*) have abated over time, which may be influencing changes in both abundance and behavior of marine species. Hawaiian expert fishermen once controlled access to fisheries based on resource condition at the village and *ahupua'a* level (pie-shaped land divisions from mountains to pelagic fisheries), and moderated subsistence and spiritual practices regarding marine resources. Such governance was a part of the childhoods of all kupuna who participated in this study (e.g., 01.04; 02.04; 06.04; 04.07); one kupuna’s auntie, for instance, was the last “keeper of the fish pond” in their village (01.04). But due to a continual process of Westernization, shifting resource control away from *ahupua'a*, centralizing governance on O’ahu, and the increasing prevalence of externalities (like purse seine fleets targeting highly migratory *ahi*) the Kona Coast’s subsistence organisms appear to have been dramatically and increasingly affected over the latter half of the 20th century.

Proximate to the nearshore and in heavily-used coastal areas, marine life exhibits signs of behavioral change and abandonment of preferred habitat (08.31B.06) due to in-water traffic, and possibly subsurface runoff and freshwater intrusion in some areas (01.04; 03.04; 08.31A.06). To fishermen, the fish (e.g., nenue, chubs) are becoming increasingly unpredictable and erratic, for instance in nenue’s timing and placement of feeding activities. The fishing practices passed down through generations of fishermen,
reportedly in some areas no longer is applicable (08.31B.06). People explain these changes variously. With increasing use of the reefs, with rising local population and visitors, some attribute behavioral changes to the proliferation of people in and uses of nearshore waters (04.20A.06). Concurrent changes in hydrologic regimes, particularly the perception of increased freshwater runoff due to irrigation of gardens, may have influenced these changes. No observations of nonpoint source pollution have been made by local experts, though many speculate fishes would feel NPS impacts to the reefs (e.g., algal overgrowth of coral) before they would notice visual signs (05.22.06).

In general regarding the subsistence guild and all other guilds described herein, ocean experts blame anthropogenic impacts, not biophysical disturbance, for declines in abundance and distribution. ‘Natural’ (biophysical) disturbance – and renewal – are ever-present in people’s talk Kona’s reef systems (e.g., storms, recruitment, El Nino Southern Oscillation, and community dynamics like cycles of disease, predator-prey dynamics, and fecundity). But in Kona, even after the most catastrophic storm events, such as the winter 2003 swell in which 40% of coral in some places was decimated, the system has always recuperated given sufficient time (05.05A.06; 05.05C.06; 05.17.06; 07.18.06, see chapter 5). Instead, human factors (aquarium collection, fishing, and introduction of invasive predators, declines in cultural and tenure practices) are blamed for the declines of many species and communities. Synergistic natural-anthropogenic disturbances do not appear to have occurred in Kona, although many of Kona’s ocean
experts report that O‘ahu’s reefs are considerably more degraded due synergistic
disturbance. Multiple ocean experts once lived on O‘ahu and recall the confluence of
pollution, overfishing, and rapid succession of Hurricanes Eva (1982) and Iniki (1992)
‘broke the back’ of O‘ahu’s reefs (04.20A.06; 06.08B.06; 06.29.06). Kona’s ocean experts
widely view O‘ahu as a harbinger for Kona’s reefs.

4.3.3 Ornamental organisms: reverse J-shaped curves

The ornamental organism guild envelops a wide suite of generally colorful,
aesthetic, coral-reef specific organisms including wrasses, angelfish, surgeonfish, tang,
butterflyfish, gobies, boxfish, and invertebrates. Ornamental organisms tend to be
referred to as ‘ornamentals’, or ‘collected species’, in everyday language in Kona, as they
tend to be the ‘colorful and gregarious’ reef fishes or the ‘cryptic, rare’ critters important
aesthetically to the dive industry and as species collected by the tropical aquarium fish
trade. Ornamentals (Figure 11c) are characterized by a “reverse J-shaped curve”, in
which the abundance of adult organisms decreased dramatically and consistently
between 1970 and 2000, and a “blip up” (12.04.06) or resource improvement in the past 5
years. People’s observations did not relay a change in the guild’s relative spatial
distribution over time. Though numbers declined, species were generally present in the
same locations, 1960-present, simply at lower abundances. Butterflyfish (Figure 11b) and
Rare Fishes (Figure 11a) are two specific cases of Ornamentals, whose historic
abundance and distribution loosely follow the reverse J-shaped curve pattern but with
distinctly different histories of both relative distribution and abundance following 2000. They have thus been cited as special cases to the ornamentals and given names reflective of (a) how local people refer to them (Rare Fishes), and (b) that all fish in one guild come from the family *Chaetodonidae*, (or, Butterflyfishes). Additionally, there are several cross-cutting organisms between Subsistence and Ornamental guilds. They are cross-cutting because they share cultural characteristics with Ornamentals (collected species, protected by MPAs), but due to their lack of, or very minimal, rebounds since 2000, they are categorized as subsistence. These include some of the most common interview topics: paku‘iku‘i, uhu (parrotfish), and manini (convict tang).

Though Ornamentals are topics of importance to all expertise groups, they featured more prominently in dive shop operators’, conservationists’, and scientists’ narratives of ecological change. Given their diverse tenures on the Kona Coast, and scientific studies were intermittent prior to the late 1990s, dive shop operators provide most of the first-hand observations from 1970 through 2000. Hawaiian cultural practitioners and fishermen note the declines and resurgence of ornamentals but spend relatively less time focusing on them than, for instance, subsistence fishes, predators, and pelagic species. Tropical aquarium collectors generally concur with declines and recent increases in abundance, but again predominantly focus on recruitment cycles, abundance of new recruits, and species-specific population cycles.
Yellow tang exemplify the characteristic “reverse J-shaped curve” of ornamental organisms. Prior to the 1960s, yellow tang were so abundant, they constituted a “band of gold around the coastline,” visible from airplanes (07.05.06), the shore (07.3.04; 05.07), and through the 1970s in the crests of waves (06.14.06). In-water yellow tang abundance...
through 1980 looked like “rivers, literally rivers, of yellow tang” in some areas and “large streams” in other areas. Monotypic schools of adults grazed on reefs, and recruitment areas looked like “beds of yellow tulips” (05.22.06). Coincident with observations of decline in a host of other ornamental species, by the mid-1980s divers and Hawaiian people recall realizing that there appeared to be fewer yellow tang on the reefs. Resource depletions grew more and more apparent to these peoples, until “on one dive I counted three yellow fish. Not three yellow tang. Three yellow fish, total!” (07.05B.06). Today, however, increases in yellow tang are apparent. In most sites, experts notice small aggregations of yellow tang again, rather than scattered individuals.

Despite distinct increases in fishes, the overall abundance of ornamental organisms on Kona’s reefs remains substantially depleted, and reef fish communities overall quite different from 30 years ago. While improvements are noticeable and consistently upwards: “There are elements missing, like there are not schools of Achilles tang. We do have one small school of yellow tang, but it’s not the wilderness of kole, manini, yellow tangs like we used to have. Now, instead, we have schools of the white striped tangs, giant schools of them, and we never used to have those before. No lions. No dragon morays. A very few flames, and teetering at that. But Lead City [a dive site] is rebounding in other ways. Tinkers, bandits are all coming back. The bluehead butterfly, which we used to call mud-faced because it looks like the face has been dipped and is all muddied, is a new character” (5.17.06).
Exceptions to the ornamentals’ upwards trend since 2000 are evident in a few significant species. Some fishes which might otherwise be considered ornamental appear to exhibit distinctly different trends to the Ornamental’s reverse J-shaped curve: either a muted-to-no rebound, or an exaggerated rebound, in abundance and distribution since 2000. Thus, they were given a separate social-ecological guild – rare organisms and butterflyfishes, respectively – and are described below.

4.3.3.1 Butterflyfishes: Ornamentals with an amplified rebound

Kona’s coral reefs are populated by “spectacular displays” of butterflyfish, including the some 17 species of the Family Chaetodonidae that were detailed by this study’s experts. Their colorful appeal helped to draw both the dive and tropical aquarium collecting industries to Kona. These organisms are not thought of as naturally pervasive like the rivers of yellow tang, kole, and manini (05.22.06). Rather, these more site-specific species aggregate in pairs to small schools (∼50 individuals), depending on the species, in a patchwork of habitats. Local experts seem to associate dive sites and bays with one or a few butterflyfish: Pyramid Pinnacles is named for its Pyramid butterflyfish schools; Kaiwi, known for steady abundance but particularly raccoon and pyramid butterflyfishes; the teardrop butterflies of Teardrop Ridge (05.05A.06; 06.27.06). Native Hawaiian experts tend not to focus on butterflyfish at all, while conservationists and recreational divers almost exclusively talk about butterflyfish. Chaetodonidae take on a minor role in scientists’ and aquarium collectors’ stories.
Butterflyfishes, a special case of ornamental organisms, experienced a reverse J-shaped curve in abundance, and some shrinkage in distribution with depth. Increases in abundance are more consistently high across butterflyfishes than ornamentals in general. Teardrop butterflies inhabiting Kealakekua Bay exemplify the stories about the 17 butterflyfish species examined in this study:

In the 1970s on any given day, divers might see 20-30 teardrop butterflyfish on any given dive. About five or six years ago [1999-2000], I saw one and got excited. Then I thought, ‘What’s the big deal? I used to see these all the time!’ Things have recently gotten better. Generally, that is the case with all the butterflies. So, for example, teardrops [teardrop butterflyfish] had virtually disappeared from so many dive sites, and are finally increasing in Kealakekua Bay. Today [2006], I might see 6 to 8 in any given dive, which I believe means there are a couple of dozen, en total. [07.05A.06]

Though improvements vary site-to-site, the Kealakekua Bay teardrop’s story is not atypical of butterflyfishes since the establishment of protected areas. In Lead City near Kaloko-Honokohau, while abundances of Ornamentals generally appear to be improving, Rare Fishes remain mostly absent and butterflyfish prolific:

There are elements missing, like there are not schools of Achilles tang. We do have one small school of yellow tang, but it’s not the wilderness of kole, manini, yellow tangs like we used to have. Now, instead, we have schools of the white striped tangs, giant schools of them, and we never used to have those before. I’d never seen them [these kind of schools] until recently. No lions. No dragon morays. A very few flames, and teetering at that. But Lead City is rebounding in other ways. Tinkers, bandits are all coming back. The bluehead butterfly, which we used to call mud-faced because it looks like the face has been dipped and is all muddied, is a new character. In nearby “Aquarium”, we used to have only a reasonable population of that bluehead butterflyfish. But in 2003 it exploded! Babies by the 100’s! We’d never seen this before! They [bluehead butterfly] spread from Aquarium all the way to Lead City and to Turtle Towers, just outside the mouth of the harbor. [05.17.06]
Pyramid and raccoon butterflies have rebounded more strongly than most, with “huge (50 or more fish) schools” now occupying specific habitats on the Kona Coast (05.051.06, 07.051.06). Lined butterflies, “formerly listed as ‘rare’ on dive identification cards are improving nicely, although milletseed and teardrop butterflies general appear slowest to respond” to management interventions (6.13.06).

4.3.2.2 Rare fishes: Ornamentals with a muted-to-negligible rebound

Rare fishes are a special case of Ornamentals, showing declines in abundance and local disappearances prior to 2000, and a muted to negligible rebound since that time. This guild includes several coral reef organisms that occur sparsely around the coast, and whose presence or absence are prized by divers, collectors, scientists, and ocean enthusiasts. The rare fish guild includes lionfish, leaffish, various scorpionfish, flame angelfish, fire goby, Potter’s angelfish, and Tinker’s butterflyfish (the latter is a cross-cutting fish with the ‘Butterflyfishes’ guild). Ocean experts report declines in invertebrates (e.g., tiger cowries, reticulated cowries, slipper lobster) along the same time period as many ornamental fishes; however, it is unclear if invertebrates have experienced rebounds like fishes. Rare fishes, like ornamentals, are important topics among dive shop operators, resource managers, recreational divers, and tropical aquarium fish collectors. These organisms were rarely mentioned by Native Hawaiian experts.
Drops in abundance and distribution in Rare Fishes occurred with increasing rapidity from 1970-2000 (Figure 11a). Their reverse-J-shaped curve response is more muted than Ornamentals or Butterflyfishes. The first substantive observations of rare fish abundances by study participants begin in the early 1970s. Rare fishes were abundant and pervasive across the Kona Coast at that time. Although not naturally occurring in large aggregations, lionfish, leaffish, and scorpionfish could be found readily in suitable habitats across the Kona Coast. In example: 1) 36 lionfish was largest aggregation seen on coast; observed at “Golden Arches” near Kaloko (05.22.06); 2) between 8-13 resident fishes inhabited the Lion’s Den dive site near Kaloko, from 1972 to the late 1980s (05.12.06, 05.05.06); 3) approximately six pairs of scorpionfish were observed regularly near the monument at Kealakekua Bay, and persisted “longer than anywhere else on the Coast, until numbers declined in the early 1990s” (07.12.06).

In comparison, by the early 1970s these fishes’ populations were so depleted, even absent, on O’ahu’s reefs that Waikiki Aquarium employees came to Kona to collect specimens for exhibits.

In 1975-77 when I worked at the Waikiki Aquarium. We came here [to Kona] to collect species that we could no longer find on O’ahu. I remember huge schools of yellow tang, huge schools of paku’iku’i. Huge schools of many things, but those were the ones that stood out to me. I also remember reticulated butterflyfish, C. tinker’s, Desmo holocanthus the banded angelfish all here. And lionfish! You could see them anytime, anywhere you wanted to here! Oh, I remember longnosed hawks in nice long black bushy coral trees! Not only were these species present, they inhabited shallow areas of the reefs. The sphex [Hawaiian lionfish] and longnosed hawk and Desmo holocanthus and tinker were in much shallower areas of the reefs. I mean, today, tinkers can be seen deep, at 300 feet and probably deeper than that; but in those days, we saw them regularly in 70 feet of water
instead of having to go to 140 feet or more. And I haven’t even seen a lionfish in 7 or 8 years. [4.14.06]

Another respondent remembers a variety of rare fishes:

Lizardfish—couple dozen per dive, now only a handful. Leaf scorpions, 1 or 2 per dive site in a good year, but there might have been 7 near turtle towers in 1998-2000. Now, the leafs don’t come into adulthood. Decoy scorpions—not common fish at all. She remembers six at a certain dive, and none today. Turtle towers never was heavy with lionfish, but it might have had half a dozen. Now, there are none. Lions really, really like arch formations. [05.17.06]

The years between 1980 and 2000 were characterized by declines in abundance and location sighted across all rare fish species. By the 1990s, many organisms had not been seen for several years. Trends differ from Ornamentals in showing evidence of localized disappearances in dive sites and bays. Several dive shops renamed, and some abandoned, Lion’s Den, a dive site named for its resident population of Lionfish. Later known as “No Lions Den” and “Lead City”, the site’s history exemplifies that Rare Fishes appear to show, at best, muted signs of rebound in the past 5 years. Since 2000, a few rare species (scorpionfish) have in small numbers begun repopulating bays and habitats where they were known to exist historically. Others species (lionfish, leaffish) and sites (several dive sites within Kaloko area; Kealakekua Bay) have not been observed as having substantial improvements since 2000. Some but not all rare species are showing improvements in abundance and distribution – either repopulating or
expanding in adult numbers over what was seen for the previous 20 years. Others remain highly cryptic, if not locally absent to the general expert observer.

4.3.3.3 Explaining patterns in ornamentals, butterflyfishes, and rare fishes

Tropical aquarium collection is considered the primary, but certainly not the only, culprit in the slow, then rapid, declines in Ornamentals, Rare, and Butterflyfishes between 1970 and 2000. Management interventions – broadly defined – are one but certainly not the only mechanism resulting in the rebounds seen in these organisms.

According to dive shop operators, conservationists, and scientists, aquarium collection is implicated because of the concurrence of declines across many collected species and in many sites. In particular, that stable populations of rare organisms ‘disappeared’ over the course of a few days to a week in some cases further supports their hand in declines (05.17.06; 07.13B.06). This guild was also affected by predation by the introduced, invasive roi, and other forms of fishing (subsistence, shoreline, gill net, spearfishing, etc.) (05.17.06; 05.05B.06; 06.08B.06). Collectors and scientists share that recruitment cycles play a strong role in the magnitude of declines, as well as upswings, as described further below. Nonpoint source pollution (NPS) appears to have had minimal to no effect historically on Ornamental, Rare Fish, or Butterflyfish guilds. All of the ocean experts regard NPS and land use change as of foremost concern to the future of Kona’s reefs.
Upswings in species since 2000 are attributed to the protections enacted in the FRAs, which prohibit tropical aquarium fish collection in ~35% of West Hawaii waters. All experts regardless of political affiliation acknowledged that management interventions played a role in elevated abundances. Some discrepancy remains, however, in the relative primacy of management intervention (MPAs and zoning) versus other mechanisms of change. For instance, tropical aquarium collectors insist that management interventions coincided with the high-point in the ‘natural’ 10 to 12 year recruitment cycle, thereby accentuating the perceived role of MPAs in resource improvements (05.18A.06; 6.08B.06). Ocean experts from the scientific community partly concur with this explanation, suggesting that rebounds appear to have occurred ‘too early’ to be attributable to FRAs, and thus may not attributable to the FRAs alone (12.04.06).

In addition, a local, representative democratic process of community-based management seems to have played a central role in bettering social relations, which has had a trickle-down positive impact on ecological conditions as well. This speaks to the literature demonstrating that biological successes from marine management (e.g., increase in populations due to MPAs) are positively correlated with social successes (e.g., elevated compliance with regulations); likewise, where social failures occur (e.g., marginalization of a local group), they typically cause biological successes to quickly reversed (Pollnac et al. 2001; Christie et al. 2003; Christie 2004). Interviewees
consistently, and without being asked by the interviewer, brought up the topics relating to what can be considered social successes of management interventions. Historically, many ocean experts were in user conflicts and antagonistic relations with one another (particularly all groups against the tropical aquarium fish collectors), and between the local community against those (mostly off-island) people responsible for managing the coral reefs and coastal waters. All ocean experts commented on the history of antagonism among them. But even though they did not always specify this as a reason for the rebounds in aquarium species, given the extent to which people talked about improvements in social relationships surrounding the management interventions, it appears this has had a positive effect on the willingness to cooperate with the new regulations and on reef fishes protected by them.

In particular, experts talk about the West Hawaii Fisheries Council (WHFC), and ‘The Process’ of community-based management involved in the WHFC, as a source of positive change in the Kona Coast community. Relatively coincident with FRA establishment, the WHFC was put into effect as a democratic, representative process of local resource management intended to link local resource users and local knowledge into state resource management. Common themes suggest that ‘The WHFC Process’ is considered a source of trust-building among historically factious groups; and a venue for fair decision-making, education, a means of linking local knowledge of resources and conservation issues to governance and decision-makers. Many are participants and
expressed pride in describing how neighboring communities and islands have been asking for assistance to establish their own local coastal resources council modeled after the WHFC.

The distinction between the low- (Rare Fishes), moderate- (Ornamentals), and high-level (Butterflyfishes) rebounds was one we made in the analysis, upon seeing trends across many people’s descriptions of the extreme case responses to management interventions. Biological, ecological or cultural characteristics may cause a species muted or non-response to protections. Butterflyfishes appear to be more resilient than many other coral reef organisms; their rebounds since 2000 are more visible to experts than any other suite of organisms. Rare organisms are described as showing little or lesser response to protections; explanations expressed by respondents include (i) breeding stocks were too depleted by the onset of protections to readily respond, (ii) remaining populations too isolated, (iii) habitats critical to particular life stages were not protected, and (iv) they are biologically slow to respond. Several species collected for the aquarium trade do not appear to have improved, such as the Achilles tang, which is also categorized as Subsistence. Species like the Achilles tang facing multiple impacts may be slower to respond to, may have physiological limitations to, or may require different or multifaceted management strategies than those implemented. Many subsistence fishes like pelagic tuna, opelu, and akule are unaffected by the FRAs, for example, because they are not species collected for the aquarium trade.
4.3.4 Predators, broadly defined

Predators described by ocean experts appear to follow several patterns in abundance and distribution, thus are described in four ways: (1) Ulua/Native Piscivores, (2) Eels/Reef Sharks, (3) Tiger Sharks, and (4) Invasives. ‘Predators’ is an ecological term used very loosely here to track trends in organisms with primarily piscivorous diets.

Historic and current data on many species described herein (particularly ulua and native piscivores) is limited, compared to available data on many reef fishes, as typical underwater survey methods in coral reef ecology do not easily account for fast-moving, roving predators that sweep in and out of survey transects.

Figure 12: Various patterns were seen across predators on the coral reefs. Four of the more consistent patterns are illustrated by (a) the “Invasives”, roi and ta’aape, (b) Tiger Sharks, (c) Eels/Reef Sharks, and (d) Ulua/ Native Piscivores.
4.3.4.1 Ulua & native piscivores: Predators with a reversed J-shaped curve

The Ulua/Native Piscivores guild (Figure 12d) appears to have been in a period of decline on coral reefs for several decades, yet seems to be on the rise in recent years. It exhibits a reverse J-shaped curve pattern like the ornamental guilds. Ulua and native carnivorous fishes (jacks, ulua, moana, uo`oua, and kahala) observations principally stem from Native Hawaiian people and dive shop operators. Noting that “visual sightings of jacks are rare” (05.18.06) in coral reef research and surveys, scientists who participated in this research typically mention the importance of ulua, etc., but generally defer to fishermen and local experts’ knowledge of their ecological history on Kona’s reefs.

On Kona’s coral reefs, those who scuba or freedive recognize the presence of ulua, kahala, and other jacks before visually sighting them: “It’s startling; the fish are suddenly gone. Then the jacks appear. The fish don’t do that with sharks, just jacks” (07.13A.06). While diving, these predators were formerly seen with schools of akule “so big they look like oil spots. There would be huge ulua and kahala keeping akule herded. They were always there, but you don’t see ulua or kahala anymore either. I remember 6-foot barracudas, 5-foot uluas.” Many akule have been fished out of the coast (05.05A.06, 07.13.06, 07.16.06), and “we [divers] never see them [ulua and kahala] anymore now that the akule are gone” (05.05A.06). In addition, the ulua, kahala, and amberjacks would rove up and down the coast’s reefs, hunting “in packs dominated by adults who are
usually accompanied by a few juveniles.” Packs of 10 were not unusual, “one time I counted 50” (05.17.06). For years, the Ulua Guild’s fishes were seen very infrequently compared to the decades prior, until the last 3-4 years when sightings have been slightly rebounding towards ‘normal’ conditions. This rebound is slightly delayed behind ornamental organisms’ rebounds.

In bays and offshore, fishermen recognize ulua, kahala, and other jacks during their predatory activities, like with akule: “Akule bring the predators in close to shore, 3 to 4 fathoms. They come under attack [by predators]. In the summertime, opelu bring in the tuna, baby skipjack, mahimahi, marlin, larger tuna, then ulua and amberjacks” (07.16.06). Further offshore, ulua and kahala are known to be associated with ahi koa (or, yellowfin tuna aggregation sites) (06A.04). At ahi koa and in nearshore areas, fishermen believe catch in general is moderately lower than some decades ago but their observations in this research seem less conclusive regarding whether sightings differ because of substantial declines in abundance or that aggregations are more sporadic. Ulua are fished traditionally from surge-swept cliffs (participant observation), but these geographic features are not well covered by this research design and thus cannot be described well herein.

4.3.4.2 Eels & reef sharks: Catch-all category of predators characterized by constancy

Several predators on coral reefs show little change in abundance or distribution, according to ocean experts (Figure 12c). This pattern, named the Eels, Reef Sharks, and
Fishes, is a catch-all category. All ocean experts share some knowledge of non-changing organisms. The organisms included in this category include non-collectible eels (white mouthed, yellow margin, not dragon morays nor garden eels), white- and black-tipped reef sharks, and weke (goatfish). Both eels and reef sharks are long-lived species important to the dive industry (critter dives, feeding, 'pets') and cultural practitioners (fishing, myth, subsistence). They do not appear to have seen dramatic increases or decreases in abundance, nor shifts in spatial occurrence. Eels, though not typically discussed alongside jacks, sharks, and apex predators, have been included as examples herein because they are some of the few reef-specific predators local people discussed.

4.3.4.3 Tiger sharks: Variations on apex predators

Sharks, along with jacks (e.g., ulua), are commonly described in scientific literature as ‘apex predators’ (e.g., Friedlander & DeMartini 2002; Friedlander et al. 2005). Respondent’s observations of shark abundance and distribution on the Kona Coast, however, tell a very different story to the dynamics of jacks (Ulua, described above). According to fishermen, dive shop operators, scientists, resource managers, conservationists, and Native Hawaiian people, tiger sharks appear to have increased in nearshore waters near Kailua-town since 2004 or 2005. South Kona is known, by most of the ocean experts, for its dense aggregations of hammerhead sharks, while areas near Kailua-town and northwards are more tiger shark grounds (04.20A.06). Grey-tip reef sharks inhabit North Kona and Kohala, while the study sites are more commonly white-
tip reef shark habitat (05.17.06). Discussions of change in shark populations revealed a single pattern: no detection in change in incidence, habitat use, over many decades until a very recent and noticeable increase in tiger sharks nearshore and proximate to the harbor (Figure 12b):

There's been a major increase of tiger sharks, especially off of Kaloko in the last year. One of them is around so much, we've been calling it LaVerne. It's a 15-16 footer, and sometimes it'll bask on the surface with the dolphins. It's inside the harbor and out there almost everyday. Extremely non-aggressive, but once it came into someone's face. The turtle population has dived drastically. We used to see 17 at each dive, and now there are only 1 or 2. Is it LaVerne? Does she make them scatter? Or the numbers of boats around the moorings all the time make the turtles scatter? Or do they go into the little bays? One of our dive instructors saw the shark swimming with a turtle in its mouth. [05.05A.06]

No other sharks mentioned (white-tipped reef sharks, hammerheads) seem to have changed in abundance (Figure 12c) beyond the typical seasonal aggregations. Nor have abundances of non-collectible eels changed. However, there is a great deal of talk about sharks by ocean experts, and much of it involves ancient cultural significance rather than change in abundance or distribution. Sharks, or manō, feature in legends, are often described as aʻumakua (protector spirits, ancestral spirits), and are held in deep reverence for various reasons by diverse experts (Chapter 5).

During an interview, one of my participants asked me if I had heard of the “visitor at the Kailua Pier yesterday” (07.12A.06). He was referring to a 15-foot tiger shark seen in a popular swimming and paddling area. This Hawaiian practitioner and dive shop owner (“Eddie”) said: “No worries, tigers [tiger sharks] are gorgeous. They’re just
doing their job.” (07.13A.06). My field notes following the mention of the ‘visitor’ said the following: “I recalled the last time I interviewed ‘Eddie’, when he showed me underwater photographs of himself nose-to-nose with a tiger shark. The photographer was so close that I could see the stripes on the magnificent creature; and “Eddie” was but an arm’s length away from the creature. “You’re not scared,” I had asked? He shook his head and grinned. “It’s you’re ‘aumakua, then?” thinking the only explanation to their peaceful connection was a spiritual one. “Yup,” he nodded, still grinning (07.13A.06).

4.3.4.4 Invasives, roi, and ta’ape: prolific predators

Ocean experts report that invasive predatory fishes (roi and ta’ape) have proliferated in abundance and depth distribution for several decades (Figure 12a). Roi and ta’ape are introduced, invasive fishes with generalist, carnivorous diets. Other than the Hawaiian green sea turtle, honu, these fishes are the only species which have consistently proliferated across the Kona Coast in the historic period of study. Roi and ta’ape’s spatial distribution, and the potential impact of their predation on native marine species, are topics of considerable interest to the scientist and management officials who participated in this study (Friedlander et al. 2005; Walsh, pers. comm), Scientists commonly asked me about local and indigenous people’s observations of roi and ta’ape; in part because ta’ape populations, particularly, are thought to have exploded in areas just outside of science’s reach (e.g., too deep for scuba surveys, too shallow for deep sea
submersibles). It may also relate to concerns that local fishermen (aquarium collectors, shoreline, and other) may be implicated in resource decline when invasive species are the actual culprits (12.04.06).

According to fishermen and divers, roi and ta‘ape fishes have proliferated both in numbers and extent on the Kona Coast since their introduction, particularly the roi since ciguatera outbreak in North Kona placed restrictions on fishing (06.04). A long-time dive shop operator and one-time commercial aquarium fish collector noted roi populations’ change over time:

The roi—there are so many more now than in the early 1980s. I would get my dive people (the passengers on his dive boats) to all crowd around and wait 3 or 4 minutes for a roi to pop his head up. Now, we see 50 to 75 (roi) on a dive (their dives are usually from 30 to 70 foot depth). They’re not shallower than 30 feet, and I rarely dive deeper than 70 feet anymore with guests, so I can’t speak to them being elsewhere. But everywhere I go, the roi populations have really grown. I see all sorts of behaviors today that you wouldn’t see before because the roi weren’t concentrated enough to do these things. I’ve seen males standing off, dominant males pushing others around. Periodically, I’ll watch a roi eat a longnose butterflyfish, and a couple of times I saw a roi with a juvenile lobster sticking out of its mouth. [05.05C.06]

Comparing roi to ta‘ape, the same respondent mentioned:

You don’t run into the ta‘ape as much on the reef (compared to roi). They like the 80 to 100 foot range more, and they like to hang in archways. They’re not as evident in the 30-70 foot depth range as roi. I’ve seen them hang 6 to 8 inches off the bottom, so many of them that the ground is yellow with them. Thousands of them hanging there. In the 90’s at Red Hill, there was a huge massive school of them there. I’ve been back recently and the school was not as big, but it was still huge. They’ve proliferated more quickly than the roi, and they’re a problem because every one of them has to eat! [05.05C.06]
A diver reported, “huge schools (of ta‘ape) at 130 feet, and lots at depths greater than 100 feet in Kailua Bay” (05.05A.06). Another respondent, a successful commercial fisherman who supported a family of eight by commercial spearfishing on Kona Coast, collected on average over 400 lbs/day of roi (07.05B.06). This species appears to be found in shallower waters than ta‘ape, which has been seen to blanket waters around 130 feet.

Respondents expressed concerns about roi and ta‘ape’s impacts on their prey fish populations, and roi in particular regards to struggling coral reef fish populations:

Roi explosions near the harbor at Turtle Towers and Pinnacles (Kaloko) are destroying these fish populations. The roi populations gradually rose since the late 1990s ciguatera outbreak, but have really exploded in the last 5 or 6 years. (She swept her hand upwards in an exponential curve.) In any one dive, there might be hundreds of roi, whereas there might have been a handful 30 years ago, when they would have hidden shyly beneath ledges. (05.17.06)

The impact of their predation is a concern; regarding the voracity of roi appetite, a dive shop operator said, “I’ve even seen roi eat juvenile lionfish!” (05.22.06).

4.3.4.2 Explaining patterns in predators

Resource declines in the predators “Ulua and Native Piscivores” appear to relate in part to declines in their prey items on reefs. Respondents, particularly those who are frequent scuba divers, believe that with fewer prey items due to collection, ulua, kalaha, and other jacks spend less time in predatory roving behaviors on the coral reefs. Furthermore, the disappearance of akule in many of Kona’s bays means that they no longer “bring the predators (ulua, kahala) in” (07.17.06). Fewer sightings by fishermen in
offshore area (ahi koa), and fewer ‘big fish’, may indicate the fish has also been subject to increased fishing pressure, as ulua are a widely popular fish culturally and recreationally. Increased sightings on coral reefs, though in levels lower than some 30 years ago, are thought to relate to moderate rebounds in prey items “since protections” (06.27.06; 07.13A.06).

Other predators (tiger shark, reef shark, eels) appear to have been rather consistent in abundance and distribution over the past 40+ years. A strong increase in sightings of seems to indicate that tiger shark presence has shifted nearshore, in the study site’s northern reaches (Kaloko, Kailua Bay). Respondents attribute this to tigers following their turtles, a prey item, to the nearshore (05.05A.06; 7.13A.06). Since turtles’ have shown a consistent increase in abundance over the past several decades, the very recent incidence of tiger sharks nearshore is thought to also be due to the open ocean aquaculture facilities, which opened recently (031.06).

Respondents in a very general sense attribute prolific increases in abundance and distribution of roi and ta’ape to (i) the fishes biological advantage as invasive species with generalist, piscivorous diets and apparent lack of limitations (predators) on their populations, as well as (ii) that that roi fishing has greatly abated since ciguatera outbreaks and fishing restrictions in recent decades (01.04; 04.04; 04.20A.06; 07.05B.06). Fishing for ta’ape does occur, but is apparently not limiting to population numbers. Historical ecological change in social-ecological guilds thus appears to relate to a
complex array of biophysical, human, and institutional factors, singly and synergistically, which are relayed partially by the ocean experts of this place.

4.4 Discussion

4.4.1 Marrying traditional, local, and scientific knowledge

Of late there has been a very active appropriation of TEK, and to a lesser degree LEK and fisher’s knowledge, in natural resource management and conservation (Klisky in McLeod & Leslie, in press; Davis and Wagner 2003; Drew 2005; Drew and Henne 2006). Working with indigenous and local peoples is now commonly encouraged and increasingly sought towards scientific, resource management, conservation purposes (e.g., Drew 2005). For instance, proponents of marine ecosystem-based management are strongly encouraging human dimensions approaches, including working with local people and communities (Leslie & McLeod 2007). Codifying, marrying, or joining TEK into Western science is often critiqued politically, philosophically, and ethically (Nadasdy 1999; Agrawal 2002; Brooks and McLaughlan 2006). In the case of conservation-oriented research, which has increasingly and uncritically calling for the ‘use’ of TEK, problems may be amplified (Shackeroff & Campbell in press). But while there is widespread philosophical, etc. treatment of the issue, rarely have the problems with codification of TEK LEK been shown empirically, as this study does.
Originally, this study aimed to amass ecological histories across a broad suite of organisms, and then collectively analyze broader trends in terms pertinent to the scientific literature. It is common practice, in Hawaii and more generally in marine ecology, to discuss marine ecology in terms of patterns and processes: habitat condition, ecological functional guilds (e.g., in coral reefs, herbivores, corallivores, apex predators), processes (e.g., recruitment), and synergistic natural and anthropogenic disturbance (Pandolfi et al. 2003; Bellwood et al. 2004; Jokiel et al. 2004; Friedlander et al. 2005; Hughes et al. 2005; Waddell 2005). Marine ecosystems-based management exemplifies the strong emphasis in studying and managing patterns and processes, over single species and single issues (McLeod et al. 2005; Leslie & McLeod 2007). In Hawaii, habitat condition, status of functional guilds (herbivores as maintenance of coral-algal balance), and biodiversity are important aspects in a debate surrounding the health of near-shore reefs in the Main Hawaiian Islands. Hawaii-based ecologists are concerned about the cumulative impacts of low-levels of decline Hawaii’s rapidly growing population, urbanization (Friedlander et al. 2005), contrary to the scientific community’s “consensus” that the health of near-shore reefs around the MHI remains good relative to other reefs in the global tropics (Turgeon et al. 2002). Furthermore, the status of functional guilds, particularly apex predators and herbivores in Hawaii, are considered important indicators of reef status and resilience in the scientific literature. In Hawaii, apex predators comprise ~54% of the biomass of Northwestern Hawaiian Islands’ coral
reef ecosystems, but less than 3% of the MHI, where reef communities are characterized by herbivores (>50% of biomass) and significantly smaller adults of target species (Friedlander and DeMartini 2002). These differences are thought to indicate extirpation of apex predators and heavy fishing down the food web, and are contextual basis for marine management decisions.

In light of this, looking for ways to describe trends in our qualitative data (271 organisms, 6 sites, 80 years, 6 expertise groups), we first attempted to examine patterns across ecological functional guilds (herbivores, apex predators, etc.). This quickly proved not only inappropriate, but left trends in our data hidden, as exemplified by the 4 distinct patterns in predators, and the Butterflyfish Guild. Instead of a single pattern in apex predators, there are at least 3 patterns in apex predators, 4 patterns overall, as revealed by Figure 12. Categorically assessing apex predators, a category derived from the scientific literature, was less revealing than ‘eels’, ‘jacks and free swimming carnivores’, ‘sharks’ and invasive fishes’ separately. Yet letting patterns emerge from the interview texts (analyzing patterns one species at a time, then examining which species appeared to share common histories) allowed the data and ultimately the voices of all expert’s perspectives, to tell the story. Social-ecological guilds emerged because they encapsulated trends in the data. Butterflyfish, for instance, were united by a clear

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7 While experts sometimes grouped organisms together to emphasize a point of discussion, such as to describe how communities of species interact, people generally talked about one species or site at a time. That is, few people talked about guilds, per say; the ‘guilds’ derived from our finding broader trends across interview data.
pattern – an accentuated reverse J-shaped curve seen across all 17 butterflyfish species discussed by interviewees. Ecologically, however, these butterflyfish species would be categorized separately as generalist feeders, corallivores, or planktivores, which would have hidden or been irrelevant to our data because Chaetodonidae were distinguishable social-ecologically, and not strictly by their ecological function.

This study thus demonstrates that analyzing TEK and LEK with Western scientific framework may not only be inappropriate, but may also hide patterns that emerge when we let the data tell its own story. In doing so, while this study confronts problems with codifying or applying scientific framework to ecological insights from other knowledge systems, it also offers a solution towards bringing various knowledge systems together, as well as illustrates the beneficial products that can come from qualitative historical ecology research with multi-cultural participants. Furthermore, it indicates the potential for marginalizing particular people who value particular organisms, if the change in organisms important to a group of people goes unnoticed, if people’s observations of this change go unnoticed, or if management actions repeatedly benefit organisms valued by some groups of people and not others (e.g., subsistence organisms, see Chapter 5).

Our biases in being trained in the Western scientific tradition, and the shortcomings of approaching culturally-inclusive ecological knowledge from a single cultural perspective (Western science), became immediately apparent in the analysis of
these data. While historical ecological knowledge could have been traced by ‘ecological
functional groups, these categories were not as beneficial to describing patterns as the
categories suggested by peoples’ talk. Ocean expert’s knowledge from TEK and LEK is
learned, processed, transmitted and categorized in different ways than Western science.
Understandings of historical ecological change were made meaningful in different
knowledge frameworks entirely. This is not simply a matter of the fishermen, collectors,
divers, and others’ knowledge depends upon their ‘use’ of the system (fish to eat, to
collect, to view), versus ecologists “trying” to understand how the biophysical system
works independent of use. Rather, in referring to alternative ways of knowing (also,
multiplicity of perspectives, knowledge systems, TEK/LEK/WSK) we mean that all
knowledge, including scientific data, is situated in a particular framework (Haraway
1988; Nader 1996). They differ in assumptions about the way the world works, in how
knowledge is generated and transmitted, and in their own particular context (Chapter
3). From this critical realist approach, we can only understand complex systems through
a multiplicity of perspectives – which will shed light on how the many different kinds of
people (even within one community) variously affect, and are affected by, the oceans.
That is, in the context of this study, how different people over time observe, perceive,
and make sense of marine ecological change.
4.4.2 Historical ecology, revisited

By exploring marine ecological history through multiplicity of perspectives, we cast a broad net in possible contributions to and implications of this field and interdisciplinary marine science. Through the integration of the qualitative and the quantitative, or the people and the oceans, we learn about the historic dynamics of a coupled marine social-ecological system.

First, on an ecological note, we found surprising consistency across people’s observations of change to Kona’s coral reefs, over 80 years, 271 organisms, and multiple sites within a larger region. Qualitative data lend nicely to ideas about change over time, and people’s observations were surprisingly consistent regardless of knowledge system. This lends credibility to the idea that qualitative data – through interviews with experts of the ocean, regardless of their knowledge system – can make substantive contributions to the field of historical ecology. The striking consistency also answers a persistent question of the validity and reliability of interview data to explore ecological history – relating to determining whether or not an interviewee’s observations are not politically or financially motivated, are not skewed by the fallacies of memory, or otherwise misconstrued. In addition to, or perhaps because of, methodological rigor in choosing and conducting interviews (e.g., social network analysis, snowball sampling for experts, critical reflexivity, and participant observation), the extent of consistency in
people’s observations lends weight to the validity and reliability of the historic trends in social-ecological guilds.

Second and ecologically, ocean expert knowledge (indigenous, local, and scientific in all its complexities) enables unique insights into past ecosystem dynamics more expansive than any single knowledge system alone could have offered. We see this in the array of organisms explored, at different times, places, and scales, as well as the suites of species which tend to be better known by one expertise group or another. For instance, predators on the coral reef are particularly challenging to measure by conventional coral reef fish survey techniques; yet with Native Hawaiian fishermen, dive shop operators, and aquarium collectors watching above and below water, over many years, these species dynamics become known. Moreover, each group of people tend to know and value different species within the general term ‘predator’, thus each group contributes to the richness of detail herein.

Third, ecologically and locally, the story of ornamental organism decline, and recent resurgence, is not altogether new or unknown. Many different people in the local community (Native Hawaiians, dive shop operators, fishers, conservationists) noticed aquarium fish declines throughout the 1980s and 1990s, attributed it to tropical aquarium fish collection, and eventually inspired grassroots movements to manage and zone these issues (DAR 2004). These “local anecdotes” as they have been called inspired a mid-1990’s scientific study examining the issue of aquarium fish collection (Tissot &
Hallacher 2003), and eventually the recent renaissance and proliferation of coral reef ecology on the West Hawaii coastline (e.g., WHAP). But people’s observations of change have never been systematically collected, nor explored to see if and what other ecological changes occurred. Despite mounting scientific evidence since the research program’s start in 2000 of the biological improvements in many aquarium species due to the MPA network, local management efforts are encumbered by a dearth of historic scientific data. When trying to enact changes to marine management approaches, as many participants to noted, like this one: “When you don’t have the ‘before story’ [to justify a management strategy], you realize how important it is” (04.20B.06). Through qualitative data, our study’s approach helps to fill in these historic data gaps and more completely through a multiplicity of perspectives.

Fourth, the social relevance of peopled approaches is that marine historical ecology then broadens in scope and examines historic human dimensions, along with ecological ones. Although local communities are highly complex, they tend to be oversimplified in the context of marine management (St. Martin 2001; Christie et al. 2003; Olson 2005). In any local community, there are diverse values, attitudes, perspectives and experiences of ecological change and marine management. In this research, we saw how ecological declines to local people meant more than increase or decreases in marine species and communities. Rather, changes were felt as decreases in ‘catchability’ to expert fishermen, ‘visibility’ to divers, and ‘continuity’ in ancient
Hawaiian knowledge, all of which are important indications of change in the social-ecological system. Moreover, in examining ‘who’ talks about ‘what’, we begin to see the complexities in what people value, are concerned about, and how they experience ecological change. For instance, we included people’s stories about various species that in ecosystem science would not be categorized as coral reef species – like several highly migratory tuna species. Yet they are included herein and are highly relevant to a people’s historical ecology because of what they indicate about the human/environmental connections. The different ways people define, or draw bounds around, ‘coral reef ecosystems’ (such as including tuna in their stories of coral reef historical change) help to unravel peoples’ values and connections to parts of the oceans, connections between the biophysical systems perhaps not otherwise known to science, among others.

If we make these connections further (who talks about what), we can see how status or condition of suites of organisms might indicate how people experience different aspects of ecological change. Hawaiian people disproportionately focus on subsistence organisms, and a range of them stretching far up and downstream from coral reefs. Furthermore, they continue to experience subsistence species declines, while dive shop operators, collectors, and conservationists are more positively affected by ornamental improvements, which raises questions about different people’s vulnerabilities to ecological change and that they may experience management
interventions (e.g., zoning to protect ornamental fishes) differently than other people. These may be, perhaps, indicated in the wide variations in people’s perceptions and explanations of change.

4.5 Conclusions: Insights into the dynamics of social-ecological systems

By drawing from multiplicity of perspectives on marine ecological history, we were able to elucidate patterns on a regional level across guilds of organisms. The data, rather than preconceived notions of what categories of organisms were related, told the story. In allowing the data to tell the story, new insights into relationships among and between over 270 marine organisms, a cross-cultural group of ocean experts, and the Kona Coast itself, were revealed. The story of change appears to be complex: biophysical, social, historical, economic, and institutional. Management interventions, local and traditional knowledge, and the evolutionary capacity of a coral reef appear to be major characters in Kona’s historical ecology. But the story was made richer by casting a broad net, so to speak, in the experts and knowledge systems considered to contribute to this historical ecology. The end data set is far richer because of the variety of perspectives, than any one can give alone. Furthermore, given the diversity within local and regional coastal communities, the human dimensions were not oversimplified.

This study demonstrates the potential for qualitative data to make substantial contributions to historical ecology. We have shown that a predetermined ecological
framework was inappropriate for these data; rather, these data suggested a logical framework itself that enabled insights into past ecosystem dynamics to arise. Not do insights from ocean experts from a multiplicity of perspectives broaden the array of potential sources for garnering historical perspective on marine ecosystems, qualitative data offers unique insights into marine systems not afforded by quantitative approaches alone. Namely, the richness of the lived experience, the new lenses and insights offered by cross-cultural perspectives and experience, as well as linking into the now-recognized benefits to science and management of co-management and participatory research with indigenous and local communities. It also suggests what people value, how they are affected by ecological and management changes, as well as whether all people’s interests are being met or are off management. The potential for marrying indigenous, local, and scientific ecological knowledge in historical ecological studies will help unravel dynamics of marine social-ecological systems – and perhaps manage them more effectively.
5.1 Introduction

In this paper, we examine key features of a coastal system that, when explored historically through a multiplicity of perspectives, spotlight broader interactions between humans, ecosystems, and institutions. Our exploration of these features, or what we label social-ecological keystone features, stems from research on the history of ecological change in a coral reef region little studied historically by Western science, and through the oral histories of locally-living ocean experts. Based on research conducted by JMS on the coral reefs of Hawaii Island’s Kona Coast, we:

(1) Identify what we label social-ecological keystone features, i.e. the marine species and processes of particular value to groups of people for a variety of reasons;

(2) Through keystone features, describe current and past abundance and ecological change, various people’s perceptions of the causes of ecological change, and the various socio-cultural, political, and other values attached to keystone features;

(3) Show that different user groups and knowledge holders identify different SE keystone features. We consider how a few features become central to the some people’s history of change, and not others; how meanings attached to features are dynamic; how certain features are representative of ecological change, others of social dynamics, and still others of marine management. By engaging a variety of groups of people in this research, we provide a more comprehensive
description of current and past social-ecological systems than could have been
gleaned from any one group;

(4) Discuss the various relationships evident between people and oceans, between
different groups of people engaged with oceans, and between people and ocean
managers, and examine how these are tied to particular keystone features. We
argue that understanding such relationships is critical for improved ocean
management. For example, it can help us to understand conflicts that have
resulted around species use and management, as well as identify issues of
concern to specific groups of people that have remained off of management’s
radar.

The need for this research arises from widespread concern for the status and
resilience of ocean and coastal systems (POC 2002; USCOP 2003; MEA 2005), and related
concerns about the failure of conventional oceans management approaches to counter
global declines in ecosystem condition and resilience (McLeod et al. 2005; Leslie &
McLeod 2007). Two areas of research that have been promoted as potential means for
confronting global ‘sea change’ include historical ecology, which considers the role of
history (Pauly 1995; Jackson 1997; Pitcher and Pauly 1998; Jackson et al. 2001; Pandolfi
2003; Pitcher 2005), and social-ecological systems (resilience theory), which looks at re-
placing people in the ocean system (Holling 1973; Berkes & Folke 1998; Gunderson &
Pritchard 2002; Berkes et al. 2003; Hughes et al. 2005; Folke 2006; Leslie & McLeod 2007;
Liu et al. 2007). This paper draws upon these two research approaches, and in describing
the marine social-ecological history of Kona’s coral reefs, we aim to contribute to an
improved understanding of conditions in and management of a specific area, and to
expand our understanding of these research fields in general.

5.1.1 Linking historical ecology and social-ecological systems

Mounting evidence suggests marine systems operate in tandem with and
inextricably from human systems (review: Folke 2006), or as social-ecological systems
(SES). As the science of marine SESs is emergent, many details remain about the
fundamental nature of coupled ocean systems: key components in human/environmental
relationships, key interactions, synergistic drivers of change, and forces of resilience.
Regarding oceans as SES responds to the tendency to treat the oceans as unpeopled, i.e.
the systematic treatment of oceans as separate from human systems, and the relates
oversimplification of human/environmental relationships (Endter-Wada et al. 1998; St.
Martin 2001; Christie et al. 2003; van Sittert 2003; Christie 2004; Bolster 2006, Campbell et
al. in prep). The idea of SES gets us to move past assuming human relationships with
oceans as anthropogenic impacts, and instead considers that coupled to an ecosystem
are a myriad of interwoven dimensions of human systems across the levels of
individuals, social networks, communities, and institutions. Given the various social,
political, and economic contexts from which human systems derive, means there are
complexities in the ways humans affect, and are affected by, the oceans. Marginalized
groups of people, for instance, are often more vulnerable to environmental change, and may be less positively served by environmental management actions than those groups with stronger political voice (Bryant 1998).

Profound anthropogenic impacts on marine ecosystems, which some say is largely from overfishing (Jackson et al. 2001), are thought to have occurred long before the onset of marine research, thus limiting our ability to evaluate fully ocean condition and dynamics, and the tempo and mode of ecosystem change (Knowlton & Jackson 2001; Pandolfi et al. 2003; Hughes et al. 2005). Historic insights into ocean condition and dynamics, while integral to an effective response to the declining health and resilience in marine ecosystems, are often absent (Pauly 1995; Jackson 1997; Pitcher & Pauly 1998; Jackson et al. 2001; Knowlton & Jackson 2001; Pandolfi et al. 2003). Marine historical ecology (HE) and shifting baselines recently have brought attention to the influential role of history in today’s context of global sea change, instigating the broadening the scales of marine research and the seeking of historical insights (Pauly 1995; Jackson et al. 2001; Pandolfi et al. 2003). This is considered particularly important in understanding coral reef ecosystems, whose natural processes and cycles of disturbance operate on extremely long time scales compared to other coastal systems and to the short duration of much reef ecology research (Knowlton & Jackson 2001). They also must overcome the paucity of historic insights into ocean ecosystems, and marine scientific gaps and uncertainty more generally (Pauly 1995; Jackson 1997; Pitcher & Pauly 1998; Jackson et
Both HE and SES theory recognize the need for marine sciences to draw from a multiplicity of perspectives (e.g., indigenous, local, fishers), along with inter-disciplinary approaches. For example, HE calls for “recognition of data that does not meet the usual standards” and specifically draws on traditional ecological knowledge and historical records (Pitcher & Pauly 1998; Jackson et al. 2001). Likewise, Berkes et al. (2003) argue that to fully articulate, and manage, the dynamics of marine SESs requires the engagement of diverse perspectives about ecosystems. In describing the historical ecology of the Kona Coast and its social-ecological systems, we use information provided in interviews with and through observations of ‘ocean experts’. We connect with traditional, several forms of local, and western scientific knowledge without legitimizing any one knowledge or perspective over another. By engaging with those in the local community with expertise about marine and coastal areas, we can explore historic insights into ecosystems; the diverse values, attitudes, and behaviors of people within a coastal community; and how people and oceans affect, and are affected by, one another. In recognizing diverse knowledge holders, we produce both a richer historical ecology and a better understanding of the social-ecological system.

Building on other work, we look at a coastal community in which at least 6 different marine knowledge systems exist (Chapter 3). Elsewhere, we have shown that
Despite differences in these expertise groups’ socio-cultural, political, and economic contexts, their observations of ecological change, across a wide suite of marine species and processes, are surprisingly consistent (Chapter 4). In this paper, we explore the myriad perspectives on ecological change, paying particular attention to the differences in how people perceive, interpret, and ultimately respond to ecological change. Results in this paper demonstrate that the convergence and divergence in people’s interpretations of change have important implications for human behavior surrounding ocean social-ecological systems.

This paper’s overarching objective is to explore these ‘keystone features’ and their role in the social-ecological system and in human/marine environmental relationships. By examining where diverse people converge and diverge in their knowledge of, and the meanings they attach to, these keystone features, I trace the dynamics of the SESs through a multiplicity of perspectives. I suggest that the existence of keystone features is not unique to this system, rather may be a means to examine in any SES how people affect, and are affected by, the oceans.

5.2 Methods

5.2.1 Approach and case study on the Kona Coast

As a ‘peopled’ approach to historical ecology, this study has dual objectives. It first seeks to unravel the history of ecological change in a coral reef region little studied
historically by Western science. It also aims to explore the convergence and divergence of a multiplicity of ‘ocean expert’s’ perspectives on ecological change. That is, it looks at historical ecology through the oral histories of local people who are considered holders of expert ecological knowledge (‘ocean experts’). For the purposes of this paper, we push the envelope on the idea of a multiplicity of perspectives. Critical discussions surround research on traditional ecological knowledge (TEK, Berkes et al. 2000) and local ecological knowledge (LEK, Davis & Wagner 2003), which have debated the political, epistemological, ethical, and practical issues in integrating alternative knowledge systems with Western science (Agrawal 1995; Nader 1996; Nadasdy 1999; Tuhiwai-Smith 1999; Agrawal 2002) and for conservation purposes (Shackeroff & Campbell 2008). In marine science and conservation, most published research prioritizes one knowledge system over another, either in codifying TEK/LEK into Western science, or in eliciting one alternative knowledge system (typically indigenous) and not others. Aside from the challenges and debates in integrating knowledge systems (Chapter 3), this paper departs from common practice in resilience thinking by examining the history of marine social-ecological systems, and in marine science by approaching marine historical ecology from a multiplicity of perspectives and without legitimizing one over another.
Our research took place on the Kona Coast, the leeward coast of the Big Island of Hawaii. As will be explored further, Kona is an ideal setting for a culturally-inclusive historical ecology because of the array of people with long-term knowledge of the oceans. In this highly cross-cultural, island setting, the oceans are central to the way of life of many people, cultures, and social contexts. Parts of the Kona Coast are considered cultural kipuka (McGregor 2007), or pockets of cultural continuity, where ancient Native Hawaiian culture is lived and practiced. In addition to housing several of the ‘last remaining’ Native Hawaiian villages, many Hawaiian kupuna (revered elders) and practitioners, the Kona Coast is home to kama’aina (non-Hawaiian local) fishers of many types, divers, surfers, scientists and other ocean enthusiasts from many cultural, socio-political, economic backgrounds.

Given that many of these people have long histories with Kona’s oceans, it was assumed that expert ecological knowledge of the history of coastal areas can be found in a variety of knowledge systems. This may include, at least, the knowledge systems referred to as TEK, LEK, and Western scientific knowledge (WSK, Nader 1996). In fact, it was determined that 6 or more distinct expertise groups are evident of all ocean experts in Kona (Chapter 3). These groups, loosely based on either cultural affiliation or primary ocean-borne activity practiced, include Native Hawaiian people, scientists and resource managers, dive shop operators, tropical aquarium fish collectors, local fishers,

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8 This research does not encompass the entire Kona Coast; instead, looks at six study regions in the lower two-thirds of the coast, between Keahole Point and Kapua.
and conservationists/recreational divers. Although a few individuals cross-cut groups, generally they fall into very distinct groups, distinguishable by: (a) who its experts are, (b) what they know about the marine ecosystem, and (c) how they know it (see Chapter 3 of this dissertation).

The Big Island, spanning an area larger than all of the other islands combined, is predominantly rural. However, the ‘construction boom’ and its associated environmental, economic, and cultural transformations, long since arrived on other Hawaiian islands, are now well underway. Until the late 1990s, Kona’s coral reef ecosystems were less-studied than the more impaired reefs of O’ahu and Maui, and are considered relatively pristine in the scientific literature (Jokiel et al. 2004; Friedlander et al. 2005). But surface and sub-surface hydrologic regimes are not well-agreed upon; few/no historic data on habitat condition exist (Beavers, pers. comm.; Walsh, pers. comm.); and low-level impacts from land-based pollution as well as wear and tear from over-use (diving, snorkeling, etc. in high-use areas) are a concern (Friedlander et al. 2005).

Kona’s reefs have experienced impacts due to tropical aquarium fish collection (Tissot & Hallacher 2003). For decades (early 1980s-mid 1990s) local people voiced concerns about declines in ornamental reef fishes to scientists and resource managers, most of whom were located off-island (O’ahu). Feeling their concerns went unheard by resource agencies, local people (Hawaiian practitioners and kama‘aina (local) fishermen
first, and later joined en-masse by divers and conservationists) engaged in decades of grassroots activism to limit tropical aquarium fish collection and ensure marine management was conducted from a local rather than largely off-island setting (Capitini et al. 2004; DAR 2004). Eventually a legislative bill established a network of marine protected areas, called Fisheries Replenishment Areas (FRA), where aquarium collection was to be excluded. The sites were chosen by a community council process, and in 2000 were established in approximately 35% of waters on the Big Island’s leeward coastline, or Kona Coast. Furthermore, around that time it was determined that the community-based council (West Hawaii Fisheries Council, WHFC), which determined the FRA siting and boundaries, would remain in perpetuity, meet on a monthly basis, and seek representative council membership from all marine stakeholder groups on the coast (DAR 2004).

Recent coral reef fish research (1996-8; 2000-present) has partly confirmed what local people long voiced. Substituting space for time by comparing historically open to historically closed areas, these studies show collection has the potential to diminish adult fish populations (Tissot and Hallacher 2003). Since FRA establishment, an intense biological monitoring program was established to study the biological effectiveness of protected areas (WHAP; DAR 2004; abundance, richness, recruitment inside/outside FRAs etc.).
But the question remains, to what extent did the abundance of ornamental organisms decline, and over what species and which areas? Moreover, what other ecological changes have locally-living people observed but which may not be on the radar of science or management? Like many coastal regions, many in Kona expressed feeling encumbered in management by the lack of historical data (especially on regional coral reef condition, hydrology, and reef fish parameters), and baseline data. Thus far, biological assessments of the management strategies are being conducted, but social measures of success, in the vein of Christie (2004), have not been measured systematically. In this research we attempt to answer these questions.

Beyond the context of the Kona Coast, this study is applicable to coastal social-ecological systems. The dearth of historical baseline data is a common obstacle in coastal settings, but this research may open up the qualitative data sources. Also like many coastal settings, Kona’s shoreline is in transition from a rural to urbanized setting. Marine resource management faces serious challenges in light of the many externalities facing coral reefs, in Kona and globally: land use planning, coastal management, and balancing tourism and local needs in the face of increasingly global, synergistic pressures on coral reefs. In working with a multiplicity of perspectives, it addresses what may be possible in integrating multiple knowledge systems in general, whether or not the specific ones seen here are present.
5.2.2 Study sites and scale

This study is designed to be cross-scalar in looking at multiple small coral reef embayments within a broader coastal region. Within the Kona Coast region, six study sites were chosen from within the southern two-thirds of the coast, Keahole Point (near the Kona International Airport) and Kapua (the southern boundary of the South Kona district). These sites represent the coast’s heterogeneity in three measures: (1) biophysical, in the coral reef ecosystem, (2) geographical, in the array of land uses on the coast, and (3) social, so as to ensure TEK, LEK, and WSK coverage in each site. From north to south, the sites studied named at the outset of the study were Kaloko, Kailua Bay, Kealakekua Bay, Honaunau, Ho’okena, and Miloli’i (Figure 2, Chapter 1). In reality, knowledge varies person-to-person, and while these sites were the focus of many discussions, they were not inclusive of all places discussed.

5.2.3 Methods in historical ecology

Fieldwork was conducted by JMS over the course of 4 years: February-May 2003; June-July 2004; several weeks each in February, June, and October 2005; January-December 2006; and April 2007. In-depth, semi-structured interviews were conducted with ocean experts, or those people considered by the broader community to have expertise about historic conditions on Kona’s coral reefs. No knowledge system was legitimized over another; thus, all people considered experts, regardless of their worldview or way of knowing, were potential research subjects. Ocean experts were
identified by informal interviews with upper level informants in which snowball sampling (Bernard 1988) and social network analysis (Hanneman & Riddle 2005) were conducted. In a series of over 200 informal interviews conducted over 3.5 years, sampling was stratified to ensure that ocean experts from TEK, LEK, and WSK were identified. Those most widely considered to be ‘experts’ have more ‘recommendations’ than those with fewer. Ocean expert identification was conducted until no new names are recommended, and the sample was considered ‘closed.’

Kona’s social network of ocean experts consists of 203 individuals, approximately 41% of whom are Native Hawaiian people, 33% scientists or resource agency personnel, 9% local fishers, 6% tropical aquarium fish collectors, 6% dive shop operators, and 5% conservationists/recreational divers (Chapter 3). From this group, interviewees were sampled by prioritizing those from each group with the most recommendations, and to ensure coverage of the array of knowledges at all six sites. All ocean experts with 4 or more recommendations were asked to participate, with the exception of a few people who seemed to have substantial overlap (e.g., were siblings, spouses, or co-workers) with higher-recommended individuals.

Sixty-one semi-structured interviews (Bernard 1988; Huntington 2000; McGoodwin 2001) were conducted with 41 people in individual and group settings. Semi-structured interviews allows the breadth, depth, and scope of conversation to follow the expertise of each individual (Bernard 1988), considered particularly important
in ecological knowledge interviews where expert knowledge may not be ‘known’ to science (Huntington 2000). Each interviewee was given the same prompt: to describe their observations of change to Kona’s coral reef ecosystems over time. When relevant to the interview at hand (i.e., recognizing that each expert might know different aspects of the ecosystem) I asked about three primary themes of change: a) habitat, b) reef organisms, and c) natural processes and natural versus anthropogenic disturbances. Topics outside of ‘ecological change’, such as social conditions and processes, were never introduced by the interviewer; but if participants introduced the topics, follow up questions were pursued. Over the course of 2.5 years between 2003 and 2007, extensive participant observation was conducted with individuals, groups, and in settings where groups came together. Fieldnotes from participant observations, a field diary, and interview transcripts constitute over one thousand pages of qualitative data amassed in this research.

5.2.3 Qualitative data analysis

This paper focuses on 8 marine organisms and biophysical processes that serve as some of the most important topics discussed in the broader story of Kona’s historical ecology. The criteria for identifying these ‘keystone features’, among the nearly 300 from my data, were several-fold, but all based on the centrality of a particular topic to the ocean experts’, and various expertise groups’, narratives of ecological change. Only topics discussed with substantive clues into historical ecology were considered. At first
Table 8: Criteria for including a biophysical feature in this paper

<table>
<thead>
<tr>
<th>Species/process</th>
<th>Criteria &amp; affiliation with expertise groups</th>
</tr>
</thead>
</table>
| **YELLOW TANG** | • Cultural importance to dive, science, and conservation experts  
                     • Authority of local knowledge, vis-à-vis scientific  
                     • Rallying symbol in anti-collection grassroots activism, & later, conflict resolution |
| **Paku’iku’i**  | • Native Hawaiians and scientists, experiences with challenging ocean issues  
                     • No reversal to declines in abundance, despite management actions  
                     • Hawaiian people feeling marginalized by management actions |
| **NENUE**       | • Shoreline fishers, Hawaiian and non-Hawaiian alike; some divers  
                     • Behavioral change, rather than abundance  
                     • Co-evolution between fish and fishermen |
| **LIMU**        | • Hawaiian cultural significance, little known by other groups of experts  
                     • Demise of cultural practices |
| **RECRUITMENT** | • Narrative of tropical aquarium fish collectors  
                     • Challenges conventional wisdom about declines and rebounds |
| **CORAL**       | • Major element of scientists’ and resource managers’ narratives  
                     • Consistently good condition, despite regular storm disturbance  
                     • Site of concerns for the future of reefs |
| **HAWAIIAN LIONFISH** | • Dive, science and resource managers  
                           • Spatial displacement of diving on coral reefs  
                           • Extreme trends in ornamental fishes |
| **HONU**        | • Common topic of all groups, but not a keystone feature  
                     • Marked increase in populations and behavioral changes  
                     • Suggests that features are dynamic (wax and wane) with SES dynamics |

pass, I looked at the topics consistently brought up within expertise groups, as well as across expertise groups. I then used interpretive qualitative analysis based on grounded theory (Baxter & Eyles 1999) and in the vein of Goodwin (1998) to open and explore themes in people’s understandings of and experiences with ecological change.
Grounded theory allows themes to emerge from the text (Strauss & Corbin 1994; Baxter & Eyles 1999), and the methodology herein does not seek to quantify how many people hold these categories assumptions, simply that they exist (Goodwin 1998).

For each organism, I compiled all narratives about it and coded for the following themes: a) which experts talked about the organism, which did not, and why; b) observations of biophysical change over time; c) perceptions of change; d) meanings people draw from change; and e) symbolism in groups’ overall narratives of change. To assess the array of expert’s understandings of and meanings drawn from each organism, I looked for convergence and divergence in people’s narratives about each organism, individual-to-individual, within expertise groups, and between expertise groups. One of the themes that emerged from the analysis, and which is the foundation for this paper, is that some features of the seascape appear to spotlight broader trends in Kona’s coastal social-ecological system – exemplifying change within and between the biophysical, human, and institutional dimensions. Of the nearly 300 possible topics, in this case I found approximately 15 strong examples of features that spotlight trends in the social-ecological system. Table 8 shows what these features signify to the social-ecological system, hence, why these features were included in this paper. These eight were chosen to represent the array of issues spotlighted; others that we might have chosen include manō (sharks), uhu (parrotfish), storms, butterflyfish, opelu (mackerel scad), akule (bigeye scad), roi (invasive Peacock grouper), and manini/ohua (convict tang adult &
<table>
<thead>
<tr>
<th>Hawaiian name</th>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahi</td>
<td>Yellowfin tuna</td>
<td><em>Thunnus albacares</em></td>
</tr>
<tr>
<td>Akule</td>
<td>Bigeye scad</td>
<td><em>Selar crumenophthalmus</em></td>
</tr>
<tr>
<td>Bandit angelfish</td>
<td>Boltynose parrotfish</td>
<td></td>
</tr>
<tr>
<td>Cleaner wrasse</td>
<td>Crown of Thorns seastar</td>
<td><em>Acanthaster planci</em></td>
</tr>
<tr>
<td>Damselfish</td>
<td>Dragon Morays</td>
<td></td>
</tr>
<tr>
<td>Eels</td>
<td>Dragon wrasse</td>
<td><em>Novaculichthys taeniourus</em></td>
</tr>
<tr>
<td>Flame angelfish</td>
<td>He`e / Tako (Japanese)</td>
<td><em>Octopus</em></td>
</tr>
<tr>
<td>Wrasses</td>
<td>Hinalea</td>
<td><em>Tbaassoma sp.</em></td>
</tr>
<tr>
<td>Brown unicornfish</td>
<td>Kala</td>
<td><em>Naso unicornis</em></td>
</tr>
<tr>
<td>Goldring surgeonfish</td>
<td>Kole</td>
<td><em>Ctenochaetus strigosus</em></td>
</tr>
<tr>
<td>Blue Heart crabs</td>
<td>Leafish</td>
<td><em>Taenianotus triacanthus</em></td>
</tr>
<tr>
<td>Lined butterflyfish</td>
<td>Lizardfish</td>
<td><em>Saurida</em></td>
</tr>
<tr>
<td><em>Ma<code>i</code>i`i</em></td>
<td>Brown surgeonfish</td>
<td><em>Acanthurus nigrofuscus</em></td>
</tr>
<tr>
<td><em>Maiko</em></td>
<td>Blueline surgeonfish</td>
<td><em>Acanthurus nigrofuscus</em></td>
</tr>
<tr>
<td>Convict tang</td>
<td>Manini</td>
<td><em>Acanthurus sanddviensis</em></td>
</tr>
<tr>
<td>Manybar goatfish</td>
<td>Moano</td>
<td><em>Parrpenes multifasciatus</em></td>
</tr>
<tr>
<td>Six-fingered threadfin</td>
<td>Moi</td>
<td><em>Polydactylus sessilis</em></td>
</tr>
<tr>
<td>Orangespot tang or Orangeband surgeonfish</td>
<td>Na<code>ena</code>e</td>
<td><em>Acanthurus olivaceus</em></td>
</tr>
<tr>
<td>Limpets (Yellow-foot &amp; Black-foot)</td>
<td>Opili</td>
<td><em>Cellana sanddviensis</em> &amp; <em>C. excrata</em></td>
</tr>
<tr>
<td>Palenose parrotfish</td>
<td>Pyramid butterflyfish</td>
<td><em>Scarus psittacus</em> &amp; <em>Hemitaurichthys polymis</em></td>
</tr>
<tr>
<td>Racecoon butterflyfish</td>
<td>Roi</td>
<td><em>Chaetodon lunula</em></td>
</tr>
<tr>
<td>Peacock grouper</td>
<td>Saddleback butterflyfish</td>
<td><em>Chaetodon ephippium</em></td>
</tr>
<tr>
<td>Scorpionfish (decoy)</td>
<td>Scorpionfish (lowfin)</td>
<td><em>Iriusus signifer</em> &amp; <em>Scorpaenodes parvipinnis</em></td>
</tr>
<tr>
<td>Slipper lobster</td>
<td>Tinker’s butterflyfish</td>
<td>e.g., <em>Scyllarides squammosus</em>, <em>Scyllarides baani</em></td>
</tr>
<tr>
<td>Scorpionfish</td>
<td>Trumpetfish</td>
<td><em>Chaetodon tinkerii</em></td>
</tr>
<tr>
<td>Slipper lobster</td>
<td>Trumpetfish</td>
<td><em>Aulostomus sp.</em></td>
</tr>
<tr>
<td>Uluu</td>
<td>Parrotfish</td>
<td><em>Scarus sp.</em></td>
</tr>
<tr>
<td>Uluu</td>
<td>Jacks</td>
<td><em>Carangoides sp.</em> &amp; <em>Caranx sp.</em></td>
</tr>
<tr>
<td>Uouoa</td>
<td>Sharpnose mullet</td>
<td><em>Neomyscus chaptali</em></td>
</tr>
</tbody>
</table>
recruits). Keystone features primarily derive from peoples and groups of people’s narratives of change. In presenting results, for each of the 8 features I will: a) describe current scientific thinking; b) outline which ocean experts do and do not talk about the feature, and why; c) compare and contrast experts’ observations and perceptions of change about this feature; and d) compare and contrast the meaning experts draw from the change. Throughout, I refer to marine species by the name (Common, Hawaiian, Scientific, or Japanese) most commonly employed by ocean experts. Table 9 provides the suite of names for all species discussed herein.

5.3 Results

5.3.1 Yellow tang (Lau‘ipala, Zebrasoma flavescens)

5.3.1.1 Scientific description

Yellow tang (Bennett 1828), a fish distinctive in its solid, bright yellow coloration, inhabits coral-rich areas of lagoon and seaward reefs from below the surge zone to about 46 meters (Lieske and Myers 1994). Across its biogeographic range, yellow tang are thought to occur singly or in loose groups and browse on filamentous algae (Myers 1991), though in Kona they are thought to occur in large groups (participant observation 2006). Yellow tang are a popular aquarium fish and the top marine fish export from Hawaii (Myers 1991), representing the largest single species taken from Kona waters.
The fish represented ~84% of reported catch in 2003, amounting to more than 400,000 reported take (DAR 2004).

5.3.1.2 Ocean experts who talk about yellow tang

In interviews, respondents frequently introduced the topic of yellow tang, which is one of the most common topics in the narratives of dive shop operators, scientists, collectors, and conservation/divers narratives regarding Kona’s coral reefs’ ecological history. Yellow tang are the namesake of the Kona Coast, also known as the “Gold Coast” because the yellow tang were once so prolific that a ring of yellow circled the coastline, visible both from the shore and air. The Gold Coast and its namesake fish are important symbolic elements of Kona as a tourist destination, as well as the local community’s identity. Both the fish, and the region’s moniker, are featured in tourist literature and advertisements in Kona: cruise ship shuttle boats in Kona all fly a single flag, showing a bright yellow tang on a blue background (Figure 13, participant observation, July 2006). As tourism represents an estimated 80% of the state’s economy, and over 80% of tourists recreate in ocean waters while in Hawaii (HDBED 2007), the presence – or absence – of yellow tang is not insignificant. To local residents, yellow tang’s former abundance was a source of pride: “You fly in on one airplane, and from the air you see one yellow band along the coast. Da yellow tang, welcoming you home” (Inverv. 07.05B.06).
Figure 13: Images of brightly colored yellow tang (inset, photo by E.L. Hazen) abound on its namesake coastline, the Gold Coast (Kona Coast): a) on the roadside to Kealakekua Bay, visitors and users of coral reefs are encouraged to be good stewards; b) a scientific slide (by Dr. B. Tissot et al. 2005, University of Washington, Vancouver, available online at http://www.hawaii.edu/ssri/hcri/images/res/reports/tissot/2005_qtr_1/15.shtml) shows results of monitoring of efficacy of the MPAs on a wide array of species across West Hawaii conducted by the West Hawaii Aquarium Project; c) the Lost Fish Coalition’s late-90’s photograph of yellow tang, discarded in a trashcan by tropical aquarium fish collectors, was used in grassroots efforts to ban collection; and d) a flag flying over the busy cruise ship shuttles sports a yellow tang on a blue background.

Dive shop operators relate to yellow tang, partly, through the aesthetic experience of diving for personal and professional purposes (Chapter 3). The ideal aesthetic experience includes some visual or experiential indication of overall reef health.
(colorful, textured coral; habitat quality; overall abundance of colorful marine life), and key critters in each dive site (rare, endemic, unique aggregations, individual critters named like pets). Kona’s reefs are reputedly some of the most vibrant in North America, and when many of the dive shops opened in the 1970s, operators’ and customers’ remember a highly visual experience. In terms of overall health, three issues are of importance: abundance of diverse and colorful reef fishes, existence of rare critters, and vibrant reef habitat (see Chapter 3). Of the abundance of colorful reef fishes, yellow tang was perhaps the most prominent of them, along with manini (convict tang), and kole (goldring surgeonfish).

Recreational divers talk extensively about ‘yellow fish’, including yellow tang and others of that color. An underwater photographer (07.13B.06) explained the importance of this color fish. The coral reef experience in Kona is unique in the United States for the relative health of the reefs, diversity and abundance of fish, and endemic species. Yellow, being the most visible color underwater, is an important feature of this experience, as it does not fade or become less vibrant with depth, like reds, greens, and other colors (07.13B.06). The yellow tang’s solid coloration, naturally abundance makes it a figurehead of Kona’s ‘yellow’ critters (07.05A.06; 07.13B.06). To the tropical aquarium fish trade, yellow tang represents 84% of tropical aquarium fishes collected each year in Western Hawaii (Kona Coast) (DAR 2004). Over 400,000+ yellow tang individuals reported sold in 2003; state resource managers estimate the value of
aquarium fish trade in Kona in 2003, $1.2 million, is underreported by $2 million (DAR 2004).

Hawaiian people long considered it a ‘trash fish’, not a delicacy like paku‘iku‘i, kale, tako, or other reef organisms. Jokingly, some note the resemblance in its Hawaiian name, lau‘ipala, to the word ōpala (trash). Yellow tang’s absence from historical writings of food fishes (e.g., Kahaulelio 2006; participant observation 2007), whose themes cover several hundred marine organisms of cultural importance, is not inconsequential. But Hawaiian and local people now speak in interviews about lau‘ipala as a food fish (07.18.06; 08.31A.06; 08.31B.06), which may be indirect evidence of elevated importance of secondary preference fishes due to the extent of depletion across many subsistence fishes.

5.3.1.3 Observations and perceptions of Yellow tang

There is little discrepancy in ocean expert’s observations of yellow tang from the 1960s through the present: yellow tang once blanketed the Kona Coast. Populations declined significantly between 1970 and 2000, though low levels of decline may have occurred in earlier decades. Since 2000, their populations have rebounded across the coastline (see trends in Ornamental Organisms guild, Chapter 4). According to ocean experts, yellow tang in Kona used to form relatively monotypic schools of 100’s or more fish, schooling in such abundance that most participants recall standing anywhere on the shoreline in Kona and ‘seeing yellow’ (c. 1970s). Their schools were also visible from
airplanes, as one Hawaiian ocean expert recalls seeing in the 1960s (07.05B.06). Ocean experts take literary agency in describing exactly how abundant the schools of yellow were through the early 1970s. “Rivers of yellow tang” once swept far across the coral reefs (05.17.06), with schools numbering “in the hundreds” (06.29.06). Like “beds of yellow tulips,” yellow tang recruits once blanketed reef fish nursery areas (05.17.06). Spearfishermen, remembering many of the fishes were abundant enough to school only with their own species, until the 1960s could each choose a different fish to target, one with a string of yellow tang, one with a string of kole, one with a string of manini or uhu (6.04). In cresting waves, frequently, were bright yellow splashes of color from the abundance of yellow tang. But this level of abundance hasn’t been seen in waves for years (04.14.06; 6.04).

Low levels of decline were noted in the 1960s by Hawaiian people, many of whom returned to Kona at this time after prolonged absences in the services, or for schooling or work. But like divers whose first indications of decline registered in the late 1970s, some 8-10 years after first diving in Kona, at first experts recognized declines but struggled to articulate how much fish abundance had changed. Yellow tang depletion was pervasive, gradual at first, and then very dramatic through the 1980s and 1990s. By the mid-1990s, one recreational diver recalls a dive in which she “counted 3 yellow fish. Not just 3 yellow tang—three yellow fish, total ” (07.05A.06). The tang were so depleted that several dive shop operators report the fish were not abundant enough to school in
some areas (05.17.06; 05.05A.06; 05.05C.06). One scientist recalls that in the mid-1990s, after a 15 year absence from a research site in Keʻei, he visually scanned the site and thought there seemed to be no difference, though his data showed a reduction by 50% of tang biomass had occurred. He relays this story noting that a change greater than 50% is probably a good benchmark for scientists to be able to notice change; although he notes that others who rely upon these and other fishes for subsistence or financial purposes likely have a much more sensitive detection level (05.18B.06).

By 1999, the largest aggregations of YT that divers observed were pairs or quads. Yellow tang during this time engaged in “no social behavior to speak of because abundance in any given area were present as individuals”, one dive shop operator reported (05.22.06). Since 1970, according to aquarium fish collectors, regular cycles in recruitment affect population numbers at any given time, but recruitment “never [has varied] more than 20% greater or lesser than normal” (06.08B.06). Aquarium fishermen relying predominantly on yellow tang catch reportedly have, averaged over the course of any year, sent out consistent numbers of boxes or shipments (07.06.06); or at least have never been limited by overall numbers of recruits available to catch. Some report slow years, and shifting target species depending on annual differences in abundance/availability. None of the collectors who participated in this study, considered the ‘highliners’ of the tropical aquarium fish trade, went out of business. Despite the continuity of collectors’ operations, many dive shop operators altered theirs’ – some
shifted dive sites spatially, abandoned dive sites due to declined condition, while others found new ‘critters’ on which to focus.

Dive shop operators, scientists, conservation/divers, and Hawaiian ocean experts implicate tropical aquarium fish collection in the decline of yellow tang, from ~1970-1999. Tropical aquarium fish collectors do not disagree that their efforts led to some declines, but argue that the others’ assessments do not take into account the natural variations in recruitment, which regularly affect adult fish availability and may have heightened unfairly people’s concerns about fish collection (see Section on Recruitment).

But in the early 2000’s, yellow tang populations began to rebound, and have since steadily increased. By 2004, yellow tang aggregations were again being seen, and fish are “beginning to think about schooling again” (07.13B.06) and “exhibit[ing] behaviors like they realize there is something they should be doing with each other but they’re not quite sure what” (05.22.06). Scientists are finding increased abundances every year (WHAP 2007; 05.18.06) including an aggregation of 90 yellow tang in 2007 (02.07). Experts largely attribute rebounding yellow tang populations to the establishment of the FRA network, the MPAs prohibiting aquarium collection in ~35% of Kona’s waters. Prohibiting aquarium collection in these areas created a refuge both for adult breeders as well as new recruits to develop into adulthood. Both tropical aquarium fish collectors and some scientists attribute early rebounds (c. 2003), at least in part, to an unanticipated and coincidental period of high recruitment.
5.3.1.4 Yellow tang as symbols in environmental change narratives

In environmental change narratives, yellow tang are frequently used symbolically. Their meanings have metamorphosed over time as conditions on Kona’s reef systems have changed. Regarding the reefs history from 1970-1999, ocean experts from Hawaiian, dive shop, and conservationist groups suggest that yellow tang declines exemplify “unchecked commercialization” of marine resources. They implicate aquarium collection specifically, but also draw generalizations about extractive uses of marine species and communities for commercial gain. However, they do not implicate extraction (fishing, collection, etc.) for personal, family, village or subsistence purposes (many, e.g., 01.04; 07.16.06). For Hawaiian ocean experts, the issue of commercial extractive uses, exemplified by the yellow tang, relate to the demise of ahupua’a (ancient land division from mountains to pelagic fisheries) and village-based controls over fishing and collection. Traditionally, village elders and expert fishermen controlled fishing in each ahupua’a, opening and closing seasons, regulating spiritual practices, and setting and enforcing kapu (taboo, system of fisheries governance). Especially relevant to the yellow tang, collection activities rarely occurred outside of one’s village of origin, unless specific permission was obtained (many, e.g., 01.04; 02.04), which is contrary to the roving nature of aquarium collection where a collector ‘works’ an entire coastline across each year. For instance, many kupuna (knowledgeable, revered elders) mentioned something like: “[I] like bring back the old ways, kapu. We learn to respect
our *kuleana* [responsibility, place of origin]. Feel funny if fish in someone else’s without asking permission” (01.04, 02.04). Additional issues particular to the Hawaiian ocean experts, though not exemplified best by yellow tang, are discussed in the nenue and paku’iku’i sections. For divers and conservationists, the issue of extractive use symbolized by yellow tang relate to complex (social, psychological, epistemological, political, economic, etc) conflicts between extractive and non-extractive uses (Capitini et al. 2004; Tissot 2005; see Chapter 3).

Above all, though, yellow tang was employed dynamically as a symbol of social relations surrounding user groups on Kona’s reefs – from the once antagonistic, and now rather cooperative, relations within and among collectors and many other user groups, and with marine management authorities. The yellow tang, being the most-collected aquarium fish species in Kona, was a prominent symbol in efforts to limit collection (Figure 13). Advocacy groups comprised initially of Hawaiian and local fishermen, and later increasingly dive shop operators and recreational divers, sought to limit collection in specific areas on the coastline. An early “Gentleman’s Agreement” to limit collection, largely around Hawaiian villages, was based on good faith amongst people in the local community, not legally enforced, and achieved little compliance by collectors (01.04; 08.31.06; Inf.Int. 03, 04, 06). Tensions within the community mounted. Later, advocacy groups launched campaigns in the state legislature, eventually effecting the establishment of the FRAs and the West Hawaii Fisheries Council (DAR 2004).
Yellow tang were a poster child of the campaign (07.05A.06), as exemplified by the photo of yellow tang in the trash can (Figure 13.c), which was used in brochures supporting the Lost Fish Coalition. Some of this history is explored in Tissot (2005) and Capitini et al. (2004), and in scientific reports to the Hawaii state legislature regarding the effectiveness of the FRAs (DAR 2004).

Within a few years of the establishment of the FRAs, YT populations began to rebound. Their still-rebounding populations now symbolize many marine conservation issues. They are called by scientists a “conservation success. Easy target, easy to identify the problem, easy to fix” (04.03B.06). To many ocean experts, the fish exemplify how effective MPAs can be as a conservation tool: “Why can’t we be like Fiji, who is setting MPAs in 30% of the entire nation’s waters? We’re only like 2% of the state?” (05.10.06). Others, mainly tropical aquarium collectors, argue that dynamics of oceans are more synergistic and complex; rebounds are at once due to MPAs, which they a bit begrudgingly admit, and due to high recruitment periods. Thus, they believe extractive and non-extractive uses can co-exist as seen by the yellow tang, which is symbolic of the many fishes improving ‘since protections’ (many, e.g., 05.10.06; 07.05A.06; 07.13B.06).

Today, yellow tang seems to have morphed to spotlight how social conditions among previously antagonistic local groups have improved. Repeatedly, and unsolicited by the interviewer, participants would follow up talk about improvements in populations of ornamental fishes (often but not always including examples of yellow
tang) with talk about improved social relationships among previously factious user-groups. Through the “terribly fair” (07.05A.05) process of determining the boundaries of FRAs, and because of continuity in “The Process” (many, e.g., 04.20A.06; 05.22.06; 05.18.06; 07.13B.06) of marine resource management with the WHFC, relations are much improved. Previously antagonistic parties talk about trust, friendship, and conflict resolution in their relationships due to this ‘process’; there are a few exceptions, namely with some level of ambivalence to this process that is arising out of the Native Hawaiian experts. This issue will be explored in more depth in Chapter 8.

Finally, yellow tang are somewhat symbolic of the return of marine ecology research to this coast and the infusion of locally-living people in the process. Since locally-living experts a) first recognized ornamental fish declines, and b) were reportedly stifled, undermined, and/or ignored when they voiced their concerns to some marine management personnel (05.10.06; 04.20B.06; 03.07), the yellow tang are also demonstrative of the authority in local and traditional ecological knowledge and powers of observation. Further, many local experts also used these examples to justify to me the need for a process like the WHFC, the democratic community-based management council, which keeps much decision-making power over coastal resources in the hands of locally-living people. The inception of many scientific research programs occurred just prior to (Tissot & Hallacher 2003) or at the time of the FRA establishment. Scientists claim to ‘hang their hat’ (05.18B.06) on research surrounding the MPA network &
aquarium fish issues (04.04.06). Also according to interviews with scientists, the data are so prolific, only a small fraction has been processed due to time and resource limitations. But dictated by state and local politics, their first priority has had to be looking at yellow tang numbers. It was very clear in interviews with resource ecologists that they were concerned about addressing issues of importance to the many stakeholder groups in Kona, but were hampered by limited resources and addressing political requests first.

5.3.2 Pakuʻikuʻi (Achilles tang, *Acanthurus achilles*)

![Figure 14: Photo of the Achilles tang, pakuʻikuʻi.](image)

5.3.2.1 Scientific description

Occurring on clear seaward reefs, usually in groups (Lieske and Myers 1994), the Achilles tang (pakuʻikuʻi) (Figure 14) lives between 0-10 meters depth and feeds on filamentous and small fleshy algae (Randall 1956). This surgeonfish is dark brown, nearly black in color, with an erectile spine (sharp and forward-pointing) on each side of caudal peduncle and distinctive large orange spot on the caudal area. Its distribution
stretches from the Western to Eastern Central Pacific (Randall 1956). It is an ancient Hawaiian subsistence fish, a favorite among shoreline fishers, as well as highly valued in the aquarium trade.

5.3.2.2 Ocean experts who talk about paku’iku’i

Only four ocean experts did not discuss paku’iku’i as a major example of ecological change in Kona. An important subsistence fish to Hawaiian people and kama’aina (non-Hawaiian longtime local people), paku’iku’i is considered a delicacy, or ono (tasty, delicious), and traditionally is a regular part of the Hawaiian diet. Fishers and collectors target the fish with cross nets, throw nets, spearfishing, among other diverse fishing techniques employed in the Hawaiian Islands. It is highly prized in the aquarium trade, representing the third-most collected fish in Kona. Local dive shop operators came to see large roving schools of paku’iku’i as a significant component of healthy reef conditions (c. 1970s) (05.05C.06; 05.22.06). Many scientists recognize it as an interesting species scientifically as well as an important conservation problem (12.04.06).

5.3.2.3 Observations and perceptions of paku’iku’i

Populations of adult paku’iku’i are strikingly diminished compared to 30-70 ybp. A small peak in recruitment in the past two years is evident in scientific data (12.04.06), but does not appear to be increasing the numbers of adult fish, as neither fishermen nor scientists perceive the adult fish to be rebounding substantially. This story
is consistent across expertise groups, and all six study sites from Kaloko to Miloli’i.
Paku’iku’i were prolific in nearshore waters decades ago: “I remember jumping in the water, and always seeing paku’iku’i and o’ama (juvenile goat fish, Mullidae sp.). Came in one spot, always for certain” (08.31A.06). Consistently, long-time Kona fishermen cite paku’iku’i among their most important target fish, swarming nearshore areas. Whereas today, diverse fishermen, divers, collectors, and scientists concur: “you don’t see too much paku’iku’i” (Many, e.g., 07.18.06). They are fewer and more difficult to catch. The contrast in paku’iku’i abundance across generations was obvious in an interview with a kupuna, who in decades past would regularly spearfish for subsistence. While standing on the shoreline in the 1920s-40s, the women could ‘poke’ (spear) paku’iku’i swimming and foraging on limu at the waterline:

A: They had paku’iku’i, we call it Japan tang. We used to walk along the shoreline. I had a hand spear. And they come up, and you just poke them. They used to have that, but now cannot find. Before we used to have. Now you cannot find.

B: Pick one up, find them [today], paku’iku’i, but they hard to catch.

A: They used to go right up and eat the limu. So we just hit ‘em in the head with a spear. Throw net. Ono [delicious], it’s good! [02.04]

In response to his Auntie’s memory of the abundance and ‘catch-ability’ of paku’iku’i, the younger Hawaiian fisherman, “B”, notes that the fish are present today but much harder to come by. They also seem more skittish, harder to land, despite better spearfishing technology (01.04; 02.04). In concurrence with these observations, another
shoreline fisherman remembers prolific, monotypic schools of fish which occupied specific regions on the reef. In the 1940s-1960s in Ho‘okena, the same South Kona fishing village about which the previous interviewees were discussing, he recalls paku‘iku‘i schools, manini schools, maiko schools, as well as schools of uhu, na‘ena‘e, kala, kole, hinalea: “they have their own koa (fish aggregation site, or house). Get one school of manini, one school uhu, get maiko…” occupying a constrained section of reef or nearshore area. Fishermen following a school with a cross net knew no school would travel far from its koa, and could count on the school turning around, heading back to its koa (and into the net) within 400 yards. Young boys learning to fish with a cross net were taught that each type of fish “belonged” somewhere on each reef. “Before, they all in schools by them self. Not today. Today they all mixed up, no schools because they don’t have enough fish to [school]” (05.04).

Other people also indicate declines in numbers and distribution of the fish. Very prominent through the 1980s, paku‘iku‘i schools were all up along the shoreline of Miloli‘i, numbering 30 to 40 fish per school. By the 1990s, “you might only see 5 or 6, and then the juveniles were scattered along the drop-off a little farther offshore… more scattered around” (04.20A.06). A dive shop operator and aquarium collector remembers through the 1970s, the “prime sites for the Achilles tang (paku‘iku‘i) were anywhere in front of town, from Kailua Bay to Keauhou.” They also were prolific at Pine Trees [Kaloko area] some decades ago, “in one 15 minute swim across maybe 150 yards, I
counted 35-40 pairs of pakuʻikuʻi at the Old Airport, or about 80 fish” (05.05C.06). A woman who swims in Kailua Bay every day notes that “you don’t see a lot of Achilles tang. But you are starting to see quite a few kole and brown tangs. Last Tuesday, I saw a school of 1,000 brown tang!” (07.13B.06). Conducting extensive surveys, scientists can travel a mile underwater “and not see a single individual in their primary habitat” (05.18B.06). Aquarium catch of this species peaked in the 1990s and “went way down, even though 2 years ago (~2004) we started seeing an increase, generally in aquarium fish recruitment” (05.18B.06). Aquarium collectors concur, the late 1990s was a weak period for pakuʻikuʻi recruitment, but it seems to have rebounded in the past few years (06.08B.06). In each study site, a ten-fold or more decline in pakuʻikuʻi since 1970 was noted qualitatively by at least one ocean expert.

Several factors appear to account for pakuʻikuʻi’s history, according to ocean experts. Pakuʻikuʻi, says a local ecologist, “appear to be having a tough time of it” because they tend to be close to shore, and have long been squeezed in two directions – juveniles are targeted by aquarium collectors, while adults are targeted by fishermen. With no refuge in space (shoreline or reefs) or time (juvenile or adult life stages), these fish are desired by many people with a variety of gears, their populations are having a rough time despite some protections at the juvenile stage (05.18B.06). Recent protections against collection have had little effect on pakuʻikuʻi populations. Although scientific data has shown a “tic up” in pakuʻikuʻi recruitment in the last few years, possibly
because juveniles are protected by the FRAs, its “response to protections” is less evident than many other species (05.18B.06). Other impacts are still an issue to the population as a whole. Scientists are “using a backdoor” approach to test if its biology accounts for low response to protections. But populations of a non-collected species of the same family and similar ecological niche, Acanthurus nigricans, appear to be flourishing, potentially indicating biological factors are not the factor limiting population rebounds (05.18B.06).

Declines in some subsistence fishes (as told through the specific case of paku’iku’i) is perceived by Hawaiian and kama’aina ocean experts to be a result of more people fishing without personal, cultural, or institutional restraints on numbers caught. Lack of enforcement is also a pervasive concern. Again, the transition in these rural pockets from the Hawaiian community- and ‘ohana- (family) oriented subsistence economy, towards a Westernized economy is implicated in subsistence fish decline. Here, Westernization is symbolized as ‘commercialization’, as described by a Hawaiian practitioner and fishermen, who relates current, small population levels of paku’iku’i to another important subsistence food, opihi (limpets):

You are always able to get as much as you needed. When I was a boy, we only took what we needed. We didn’t see any depletion. Manini, paku’iku’i were all over the reefs...very abundant. When I grew up, more fish were taken out of the bay than for home use. Opihi became used commercially. People take it and sell it on open market for $200 per gallon. When I was in high school, it was $50 per gallon. And at times it was up as much as $400 a gallon. Very high priced shell fish. But a luau just isn’t a luau without opihi! They were sold to every wedding and luau. A wedding without opihi is like Japanese having a meal without rice! Now there’s something imported instead. Around the monument it’s quite depleted. But around the houses there are plenty. Very few scavengers come and try to rip us off [right in front of their houses!]. [07.18.06]
Over-collection and over-fishing of pakuʻikuʻi (and opīhi) spotlight the impacts of commercialization on Kona’s traditionally community- and ohana-oriented subsistence fishing practices. Commercialization undermines, or signifies the undermining of, the long-standing traditional regulations on fishing – the ethos of ‘only take what you need’, kapu (taboo), and treating the oceans as kuleana. The participant notes a few extant and informal means of resource protection: the few places where opīhi are still found are in close proximity to the homes of widely known Hawaiian fishermen. Whether people fear consequences of collecting in front of a revered fishing family’s home, or are showing deference and respect to the family, the effect is an informal means of regulating the opīhi fishery.

5.3.2.4 Pakuʻikuʻi as symbols in environmental change narratives

In contrast to the many ornamental fishes rebounding since protections, pakuʻikuʻi’s persistently depleted status spotlights poignantly how not all organisms, nor groups of people, are equally affected the management interventions. For different reasons, this issue appears to be of deep concern to Native Hawaiian participants and scientists/resource managers. To Native Hawaiian practitioners, the condition of pakuʻikuʻi contributes to the relatively common perception that “Scientists never know what we eat” (02.PB.06). The focus on science and management seems to be on species important to other people, whether the scientific enterprise or other user groups. Pakuʻikuʻi both signifies the continued depleted condition across a broad range of
subsistence organisms and spotlights that some people feel they are marginalized by management priorities in Kona, and that other people’s interests are prioritized over their own. This is supported in interviews by repeated instances of Hawaiian participants noting with a passing comment on the improvements in reef fishes, while focusing on the persistence of declines across broad suites of subsistence organisms from the intertidal areas through pelagic fisheries. While some non-Hawaiian participants (conservationists) talked about Kona’s “island style” of marine management (07.05A.06), other participants criticized it as dissatisfyingly “not Hawaiian” (04.20A.06; 05.IAI.06).

Hawaiian participants perceive past management actions have had less positive affect on Hawaiian subsistence species, as on those species (e.g., ornamentals) important to other people. Conversely, the narratives of divers and conservationists are replete with examples about the positive changes “since protections”, or the biological success of the protected areas for species important to them (e.g., yellow tang, ornamentals in general, see Chapters 3 & 4). Most organisms that dive shop operators and conservationists focus on are doing better, while the species Hawaiian people discuss are not (Chapters 3 & 4).

Participants from the scientific perspective express deep concern about the current status pakuʻikuʻi for both ecological and social reasons. To scientists, resource managers, and others involved in management, pakuʻikuʻi symbolizes a marine resource negatively impacted by several anthropogenic sources and with no obvious management solution. Aquarium collection “was an easy industry to single out and
make substantive changes… in many fish populations” thereby abating a long-standing user-conflict between dive operators and aquarium collectors (04.03B.06). But unlike many coral reef fishes without other substantial impacts, paku‘iku‘i has not responded well to these protections. Because it is so valued by so many people for so many different uses, the fish’s management solutions are not necessarily obvious, easy to imagine, or easy to implement. Quickly establishing research programs specifically examining the factors affecting paku‘iku‘i (12.04.06), evidences that they are deeply concerned with meeting the needs of the Hawaiian people and shoreline fishers in the community. Their concerns stem from being hampered by long-standing bureaucratic agendas (05.IAI.06) as well as being driven politically to deal with certain issues at the expense of others (many, e.g., 01.04; 08.31B.06; 07.13A.06; 05.IAI.07). Today, this is a reference to prioritizing ornamental fish issues over subsistence, and people who value them; but ornamental fish were once an issue in itself which proved a decades-long fight against “politicos and the bureaucracy” (05.10.06). Said one of several resource managers about the resistance of the bureaucracy to ‘human dimensions’, despite the good faith efforts of individual scientists/resource managers (particularly those in Kona) trying to provide for the many values within the local community:

Agencies look at coral reefs in the short term. Our problem is not understanding the human component. Most who work here in DAR [Hawaii Department of Land and Natural Resources, Division of Aquatic Resources] are ‘fish heads.’ They look at increases or decreases, p-values, numbers of fish.
But we get a big wake up call when go to public hearings. The gill net is case in point [referring to 2006 public hearings on the issue of limiting the use of lay gill nets, in which the state met considerable anger and outcry at public hearings]. The gist of that lesson had nothing to do with resource decline, he says, rather, impinging on people’s uses and values. They believe they have a right to use that gear. It’s like the painter Norman Rockwell who painted the American life, the farmers and agricultural land. Here [in Hawaii], the kupuna take their sons and grandsons out. Like giving their sons their first shotguns to go hunting, here it’s the gillnets and fishing, right of passage to maturity or something. The agencies had walked into traps in public hearings with the gillnet fish regulations because they knew little about public perceptions, uses, values, and the roles of fish in that culture. We had missed that. Always fallen into traps because we don’t know anything about the people.

I think there’s an argument to be made about each fish’s role in this world. Look at each animal. What is its role to people? And different people? There’s a role here, and it’s part of a system, more than whether it’s good to eat or not. [05.IAI.07]

This participant took pains to note that local resource managers in Kona are both superb scientists, as well as deeply concerned about meeting the needs of all stakeholders. In addition, they tend to fight the grain, work to change institutional culture and bring it towards understanding the human dimensions. Yet, the general trend of state agency management suggests there is much to be learned agency-wide. Thus, the paku’iku‘i has come to symbolize to resource managers the challenge of linking biology and diverse community interests to resource management; while to Hawaiian people and fishers the paku’iku‘i symbolizes that their valued resources are not being protected. Thus, it spotlights how relations between diverse local interests, and agency actions and culture, can be explored surrounding the history of a single fish.

In addition, as a delicacy to many Hawaiian families in Kona, paku’iku‘i comes to symbolize the old way of life, and the loss of it. In addition to the example above of
opihi commercialization symbolizing the Westernization of Hawaii, a kupuna mentioned that paku‘iku‘i eyeballs are a favorite treat. “Oh yeah, those are good fish. Some people call them rubbish fish. Paku‘iku‘i and yellow eyed kole. When you fry them you get the yellow oil. Real unhealthy stuff, but ono (delicious), yeah?” (01.04). Many of the older experts said people who have not been raised in the islands, or raised eating the fish, do not like the taste of paku‘iku‘i. They invoke an insider/outsider dynamic, where the ‘other’ or ‘outsider’ does not understand paku‘iku‘i to be so ono. There is an understood, underlying, and complex social hierarchy placing Hawaiian above non-Hawaiian, kama‘aina above new-comer, new-comer above makahiki (tourist) (Glazier 2007), and typically non-haole above haole (Caucasian). Calling attention to those not raised on the taste of paku‘iku‘i also calls attention to the ‘McDonald’s generation’ (02.04), or younger generations of Hawaiian people and kama‘aina losing touch with traditional tastes in food. But here, ‘food’, or ‘paku‘iku‘i, represents more than simply a means of nourishment. Rather, food links to ocean links to life, and a way of life (cultural, political, spiritual, etc). It relates to the culture of fishing for subsistence, with family and community-oriented enterprises, where respect for kupuna (knowledgeable, revered elders) (e.g., offering first of the catch to elders, abiding by kapu) and the ‘aina (land) (e.g., taking only what need, ethic of malama, or caring for the land, interconnectedness of people and the ‘aina) was evident.
5.3.3 Nenue (Chubs, *Kyphosidae*)

5.3.3.1 Scientific description

Several fish of the Family Kyphosidae (chubs) are known as *nenue* in the Hawaiian language, a name fairly widely employed by ocean experts and other enthusiasts. Native species found in Kona include the grey sea chub (*Kyphosus bigibbus*), highfin chub (*Kyphosus cinerascens*), gray chub (*Kyphosus sandyicensis*), brassy chub (*Kyphosus vaigiensis*), and lowfin chub (*Kyphosus sp. 1*). The gray chub, for instance, is a reef-associated species found on seaward reefs (Myers 1991) and the brassy chub aggregates over hard, algal coated bottoms of exposed surf-swept outer reef flats, lagoons, and seaward reefs to a depth of at least 24 meters, found in exposed areas around rocky reefs (Sakai and Nakabo 1995). Recent biological surveys at Kaloko-Honokohau National Historic Park found all five of species present but in rare abundance (http://www.botany.hawaii.edu/basch/uhnpscesu/htms/kahofish/family/Kyphosid.htm, accessed November 30, 2007).

5.3.3.2 Ocean experts who talk about nenue

Hawaiian and kama‘aina (local) fishermen alike value nenue for shoreline fishing (e.g., cast net). Given nenue’s proximity to shore, and appeal to the palate, many of the Islands’ youngsters first learn to fish on nenue (Inf.Int.02). Professional and recreational divers, seeking interactive experiences with underwater creatures, hand-fed gregarious...
fish and other marine organisms (e.g., various moray eels, Triton’s trumpets) for many years (05.05A.06). Nenue were among the fish quite responsive to the practice of ‘fish feeding’ at dive sites, thus widely remembered by many kinds of divers. To a lesser extent, ocean experts who are scientists and resource managers talk about these fish, but not as a primary feature in their narratives.

5.3.3.3 Observations and perceptions of nenue

Striking changes have occurred in nenue aggregating, foraging, and movement behaviors. Since divers stopped fish feeding over a decade ago, gregarious nenue aggregations around people with scuba gear (primarily in heavily used dive sites) have abated (05.05B.06; 05.22.06). Fishermen note different changes in behavior:

Me, personally, I use the old ways. I throw net mostly. Watch the moon, moon phase, the tide change. Certain species of fish feed at certain moon phase, tide height… in the old ways, on the rising tide and half moon the fish come in to feed. Even that is changed, [in] Honaunau. They’re not there like they used to [be], the way I was taught as a boy… Nenue, manini, ouoia mullet. Where used to find ‘em like clockwork. Look at the moon. Moon is ½. At 5pm, tide is half. Tide is half. Like the first person who showed you, now 20 years later, they move [have moved to a different location or timing]. And even if they do come to that area where they did for generations, they don’t stay. They just move.

Where the fish used to go for generations, certain time, tide, the whole timing cycle, now they’re not feeding in that area where they would go for generations. Maybe a few feet or a few hundred feet away. But they’re in another area. (08.31B.06)

Though nenue abundance is believed to be rather lower today than decades ago, their behavioral changes seem to obscure many of the ocean expert’s abilities to describe in detail how and to what extent it has changed. As a diver noted, “Nenue, they’re
everywhere. Don’t seem to be seen as often, but that might be due to changes in behavior rather than sheer numbers. Because, in the 1980s, they would follow you everywhere and get in your face because people would feed them. It’s hard to tell if there are more or less of them since we’re not into feeding them anymore” (04.20A.06).

This is very similar to how many experts describe the first decade in which they realized ornamental organisms declines were occurring: they know it has changed but struggle to say how much so. A few experts are rather more specific about changes in abundance and distribution, for example, a Hawaiian fisherman and diver remembers in north Kealakekua Bay two resident schools of nenue numbering 150 to 200 fish, some of which reached 1.5 pounds or larger. One species’ school was deeper than the other. In addition, in nearby Honaunau:

There’s a reef in front of the checker board [of Pu‘uonoa o’ Honaunau National Historic Park]. The reef there, I called that the ‘nenue reef’. Just as sun touches the horizon, the whole thing is covered in nenue. All you see is tails [as nenue forage on seaweed on very shallow reefs]. Now, two weeks ago, never see one nenue. Been pretty much the norm for a couple years now. [08.31B.06]

What accounts for change, even according to a single interviewee, is thought to be a multitude of social, demographic, institutional, technological, and biological factors. Nenue, like other ‘throw net’ fishes such as manini, surgeonfishes, and ououa (mullet), are affected by increasingly heavy use of nearshore areas. The in-water presence of snorkelers, tourists, fishers, indeed humans in general has increased, likely displacing the fishes and disrupting the timing of their feeding patterns and movement with the
tides. In Honaunau, for instance, an informal visual count showed nearly 2,000 snorkelers and divers near “Two Steps” in two weeks during the winter travel season. Nenue, and other reef fishes like uhu (parrotfish), now visibly avoid humans in the water. Uhu, for instance, reacts to “a spear, or anything long resembling a spear. They dart away, stay at a distance. They’re thinking creatures” (08.31B.06). These behaviors were not historically known, and are thought to indicate an increase spearfishing effort (Inf.Int.02.06), perhaps also a loss of fishing expertise (catching without disrupting schooling, aggregating behavior) (Ika.06.06). With nenue, the worry is higher resident populations means more throw net fishermen; one who sews throw nets for extra income says demand for nets seems higher and higher. Technologically, with more fishermen using more efficient technology, “you are bound to incur depletion” (08.31B.06). Attributing nenue resource depletions to fishermen exercising little restraint as much to the lack of enforcement, one Hawaiian noted with humor: “People exercise their [collecting] rights. They say they get kaukau fish. Just hope they’re not in need of luau fish—they take 400-500 fish. Not to pick on them, but it could be possible! There’s a need for better enforcement, but there is no presence [enforcement] here in Kealakekua Bay!” (07.13A.06).

Urbanization and proliferation of agriculture upstream of Honaunau may have altered the subsurface hydrologic regime. A brackish water spring, once the source of water for the bayside village, is pumping more freshwater into immediate nearshore
areas, according to several fisherman who were raised and work in the bay (08.31A.06; 08.31B.06). Finally, cascading biological effects from federal listings of Hawaiian green sea turtle are thought to be one – of many – factors causing behavioral changes to nenue. In Honaunau, both honu and nenue appear to overlap spatially on the reefs on which they feed: nenue in the morning and turtles all day (05.18.06; 08.31B.06). Scientists report having been told by fishermen that large turtle populations impinge on fish landings. Feeding preferences and habits of such large abundances of turtles are not well described in scientific literature (Walsh, W.J. Hawaii DLNR-DAR, pers. comm., 2006), and some fishermen argue that honu compete with nearshore fishes (e.g., nenue) for food (seaweeds, *limu*) (08.31.06). Rebounding turtle populations put more pressure on *limu* resources, and some say the seaweed-eating fish are consequently displaced outside of known fishing grounds. Scientists are skeptical that *honu* impact fish feeding areas. Fishermen note that the timing is skew in turtle-nenue-limu causality (turtle population increases, which have been ongoing for some years, do not coincide with more recent behavioral shifts in nenue), but algae upon which they both forage is regularly a half-inch to several inches shorter than previously (08.31B.06). Nenue no longer follow patterns in feeding and use of space on the coral reefs that were observed at least for the previous 4 generations; they are lesser in numbers, and do not follow diurnal or tidal patterns in feeding and aggregation that they once did (08.31B.06). Nenue have been displaced, but the fisherman thought it was due to many factors – changing freshwater
inputs, potentially different quality of freshwater, increased in-water traffic of snorkelers and divers, as well as turtles’ consumption of limu.

5.3.3.4 Nenue as symbols in environmental change narratives

Generations of fish have evolved with generations of fishermen, so Hawaiian ocean experts suggest. The dynamic fish-fisherman relationship takes two forms, as symbolized by nenue in the narratives of Kona’s ocean experts, and stem primarily from Hawaiian practitioners and shoreline fishermen’s narratives. On the one hand, nenue come to exemplify the fish and fisherman’s struggles to outwit another (humans maintaining expert fishing knowledge in dynamic conditions vs. fishes behavioral adaptations to avoid being fished). “Fish are getting smarter”, one says (08.31.06) mirroring what several others voiced (15.05.06; 07.13A.06; 07.16.06). Nenue may be conditioned to human behavior and outpacing generations-old fishing knowledge. As technology advanced, on the one hand, fish learned to adapt. This is despite fishermen stalking most areas of the surrounding coastline, and fishing technology that to some kama‘aina fishermen impinges on the spirit of fair play: “fish can barely see the line” and “will jump on the line” the minute it touches the water (08.31.06). If nenue are indeed as abundant as in generations past but have altered distribution or aggregation patterns, then this allows for the possibility that the dynamic balance, or the co-evolution between fish and fishermen knowledge has tipped.
On the other hand, the kanaka maoli also had a responsibility (*kuleana*) to care for, or *malama*, the environment for fear of disrupting the natural order of things (*pono*).

Similarly described with the important subsistence fish, akule (big eye scad), some Hawaiian practitioners young and old believe part of the changes in nenue behavior, timing, and abundance relate to decline in ancient tenure practices. Humans disregarding the responsibility to maintain the balance of the universe have resulted in some fish, in turn, disregarding their responsibility to ‘be fished’. This parallels several people’s narratives about akule, whose distribution is so limited today compared to even 20 years ago. One kupuna assumed the *akule* only frequent the few bays where rock shrines, to which Hawaiians engage in fishing tenure practices, are still kept and maintained (*A.04; B.04*). Nenue, like the akule, somehow ‘know’ when tenure practices have declined, *kupuna* (ancestors, elders) are not being respected, balance not maintained, shrines unkempt – which might explain changes in nenue behavior. It is thus not surprising that the fish are disregarding their responsibility to *be fished*. So long as fishermen, and kanaka maoli, uphold their responsibility to the fish and universe, they achieve a dynamic balance. The nenue and fishermen continue to co-evolve.
5.3.4 Limu (Seaweed)

Figure 155: Collecting limu at Honaunau Bay. Lower right, limu is used in poke, a delicacy in contemporary Hawaii. Upper left, a) Limu kohu (Asparagopsis taxiformis), from “Edible Limu of Hawaii: Our gifts from the sea” poster, © University of Hawaii, Botany Department 2002, Poster by Linda Preskitt, http://www.hawaii.edu/reefalgae/publications/ediblelimu/index.htm

5.3.4.1 Scientific description

Several authoritative sources (e.g., Abbott 1984; Abbott 1999, Abbott and Huisman 2004) describe the taxonomy and cultural uses of the more than 500 seaweeds found in Hawaiian waters (Abbott and Huisman 2004). Seaweeds, called limu in Hawaiian, include a wide variety of multicellular marine algae spanning the three basic groups of red, brown, and green algae. A primary producer on Hawaiian reefs and rocky shores, limu are found in many marine environments from tidepools to deep reef slopes. Some are found as deep as 600 feet, and while most limu need a hard surface of rock or coral on which to grow, a few are found in sandy environments. The factors that affect their growth, like benthic cover, water movement, light availability, and herbivory
determine each limu species habitat and seasonality (WAED 2007). Hawaiians are unique among Polynesians in their regular use of limu, which was a common part of the traditional diet and used ceremonially (Abbott 1984; UH Botany 2002). It is widely eaten and collected today and is sold in many grocery stores.

Table 10: Limu species discussed in interviews

<table>
<thead>
<tr>
<th>Hawaiian name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limu</td>
<td>Seaweed, generally</td>
</tr>
<tr>
<td>Limu kohu</td>
<td>Asparagopsis taxiformis</td>
</tr>
<tr>
<td>Limu kala</td>
<td>Sargassum echinocarpum</td>
</tr>
<tr>
<td>Limu 'ele'ele</td>
<td>Enteromorpha prolifera</td>
</tr>
<tr>
<td>Limu wawae'ole</td>
<td>Codium edule</td>
</tr>
<tr>
<td>Limu pahi'e</td>
<td>Porphyra sp.</td>
</tr>
<tr>
<td>Limu manaana</td>
<td>Gracilariar coronoopilolia</td>
</tr>
<tr>
<td>Limu 'aki'aki</td>
<td>Ahnfeltiopsis concinna</td>
</tr>
<tr>
<td>Limu 'ipe'ipe'p (ipe'e)</td>
<td>Laurencia obtusa</td>
</tr>
</tbody>
</table>

5.3.4.2 Ocean experts who talk about limu

Both the general term limu and 18 species-specific references (e.g., limu pahe'e) were used in interviews (Figure 15, Table 10). Limu seems to be a far more important feature of Hawaiian people’s discourse than others, although multiple non-Hawaiian ocean experts who fish, collect, or monitor the intertidal or nearshore areas are also aware of the historic and current condition of limu. Hawaiian seaweeds are perhaps the most striking example in this research of an organism playing a prominent role in the discourse of a single group, while garnering little more than a passing mention by other groups.
5.3.4.3 Observations, perceptions, and use of limu in environmental change narratives

Limu was generally not discussed with respect to historical ecological change in this study, with a few exceptions. Instead, experts talk about limu as representative of the ‘old way of life’ (and at times the loss of it for various socio-political reasons) in Hawaii, evidencing pockets of Hawaiian cultural continuity. The few data of ecological change are not substantive enough to be generalizable of region-wide change, but in some instances can describe very basic condition of limu near particular places (e.g., fishing villages). For instance, in Hoʻokena, “limu wawaeʻiole, they [still] got plenty because sand over here, that green spongy one. Heʻe was only on the rough side, not by the sand, but you find that by the cliff side. But the fish, maiko, manini, uhu, eat the limu kala. And limu manauea, is like ogo [Japanese term for seaweed]; it’s a kinda brownish-red color, and has stems. I think you see it in the market. They grow that now. But they don’t have [kala or manauea] over here anymore. Used to have plenty” (05.04). A Native Hawaiian and shoreline fisherman, this respondent believed that shoreline subsidence and possibly associated changes in freshwater input have negatively affected the historically stable populations of seaweed, and fish populations that consume them.

Another long-time Hoʻokena resident believes a purple limu, now amassing 10 feet across, has newly colonized Hoʻokena Bay (01.04); worrisome to participants because of alien algae problems on other Hawaiian Islands.

Nearby in Honaunau in 2006, there is:
Not as much of the brown, real short stubby limu, look like the ‘aki’aki…. The turtles eat that all day long. Nenue only eat in the morning. The wāwae‘iole limu, look like rat feet. They sell that in the KTA seafood section [local grocery story]. Round and stubby. Don’t grow here anymore. On the north end of the pond at the temple, there is a shelf and brackish water. The limu used to grow right there. For 10 years, I wouldn’t be able to tell you why, never saw turtle eat that one. Limu not there, but it used to be there. Limu kohu, shorter, right on point off the administration building of the park. Now it’s ½ inch, and it used to be 3 to 4 inches long. National park divers, who said in 60 foot water there’s a patch of long limu kohu off the southern point in Honaunau. Why doesn’t it grow on the reef? Cannot tell you. I never knew it to be growing in the deep. Limu kala, another thing not too much now. Grows all leafy, goes up and down or like a little ball. It grows like a carpet At one time, it was like a carpet. Whole reef on the headlands off the admin buildings [of the Pu‘uohonua o’ Honaunau National Historic Park]. Not too much now. [08.31B.06]

With many Hawaiian participants, thinking about the oceans invariably led to thoughts about food, and ultimately to limu. Instead of using limu to exemplify ecological change, participants usually talked about where and when to pick limu, how to prepare it in recipes, or use it in fishing. It is a both a staple and delicacy in the Hawaiian diet. “Hawaiians love to talk about food,” a research participant stated (02.04), encapsulating a primary thread of limu in narratives herein. “Eh – I getting hungry now!” (01.04; 02.04). Limu has many ceremonial purposes in addition to its importance to subsistence (Abbott 1984); however these themes were not revealed in this study.

Participants of this research mainly recalled cooking recipes (02.04); picking limu kala to keep fish fresh in buckets (08.31.06); and in talking about tastier, and less delicious, wild crops of limu on this coast and elsewhere in the MHI (06.04). Traditionally, women picked limu and collected ophihi, crab, and other subsistence resources in the intertidal.
One Hawaiian gentleman sat with me to interview his Auntie, a *kupuna-wahine* (female revered elder), about her knowledge of limu in their village of Ho‘okena. She recalled (with my questions in brackets as [J: … ], and another Hawaiian interviewee’s comments in parentheses as (B: … )):

a) *Limu ‘ele’ele* is the popular one, the green one. Right below the wharf. But I don’t know if still growing. (B: Still get.) We used to keep them clean, never let the kids go around. When the tide’s high, that’s when you pick. The ‘ele’ele, it grows just when it rains, I think.

b) I pick *epe’e*, (*limu lipe’epe’e*) I think that’s the best. They look like a fern. [J: Where does it grow down there?] More down below the wharf, in cracks. And they shape like a fern. And the most crunchy, and good taste. [J: Around the wharf?] In the cracks. And we don’t pull, we pluck! We don’t pluck the whole thing. Because if you pull it all, you wouldn’t have anything.

c) And they have another *limu* that we used to pick. And right now in front of Ho‘okena beach, further out, they have a *limu* they call *paoheleka*. And it looks like a mango tree under water. It grows red, and when you see it, it sways back and forth. [J: That one good?] Good eat! (B: That one you see people pull the whole thing, today. How deep the water?) Can dive, maybe 5, 10 feet the most. High tide is hard, yeah? Low tide is better. (B: And how much would you take?) I only take what I need for eat for the week. [J: How much was there?] It was plentiful. Around that spot. (B: By the sand…) Just by the sand. Other than that, no other places. And I see it anytime, but they get less and less because people go there. I see them put it in baskets. Oh! I wish they didn’t know about it! [J: So when you picked…?] You just snap it off. It looks like a tree in the water. The shape of a mango tree.

d) The other one they call *wawae‘iole*. It look like greens. Get by one reef [in Ho‘okena Bay]. Sometimes the sand covers it. But maybe sometime have clean water, maybe have. That *limu*, you don’t put in an icebox. You just put it on a shelf on the side. It’s soft in the ice box.
e) *Limu pahe’e.* *Nori,* the Japanese call it. They come about January, February when it’s rough. And plenty, you look at the rocks. Anytime they here, they’re rocks. Just when the time comes, they cover this brown *limu* they call *pahe’e.* Sometimes it melts. Get all shaggy. (B: Like one shag carpet.) It break off, and the fishes eat it. It goes back to the ocean. That *limu* good dry. [Also] eat it with the raw fish. Put in soup. It’s good in soup. Lots time we boil the fish head and tail and put in soup. Any kine fish – paku‘iku‘i .... (02.04).

The two Hawaiian people finished their conversation about *limu,* mentioning many of the fishes that eat seaweed: maiko, ma‘i‘i‘i, mamo, uhu, manini, paku‘iku‘i, moano, and kala fish (02.04; 08.31B.06). Thus, it signifies in this research not only its importance culturally, but also its connection to subsistence fishes and practices.

Plentiful evidence suggests *limu* envelopes the interconnectedness of people and the land, and of mauka-makai (mountains-to-oceans) is plentiful. In the *‘aina’s* (land) natural cycles of rejuvenation, *limu* comes with winter storms, fattening the fish for people to eat. *Limu pahe’e,* a favorite food of Hawaiian people and others, is widely known to grow in wintertime, with fresh water runoff and rain from the land. “Every year the winter swells come in. It [the rain] flushes the bay allowing the seaweed to grow. Oh, the *limu* and opihi (limpets) love that! It flushes the bay. It causes all the murky water to flush. It moves down the food chain for tropical fish. Flushing... good for the tropical fish like manini, paku‘iku‘i, the uouoa mullet, feed off the reefs. Moi can spawn. Uouoa mullet... I remember they would feed right up in front of dad’s old place. A lot of fish use reefs for protection, mmhmm” (07.18.06). But “when it gets rough [during a particularly large storm, or winter swell], the fish get skinny. They cannot go
feed on the limu… until the limu grow back. Not good to go fishing just after the rough” (01.04).

Discussions of limu spotlight experts’ (particularly Hawaiian people’s) experience with social and cultural change. In a poignant example, a kupuna and another adult from a fishing village discussed what they called the McDonald’s generation. Auntie, an 82-year old kupuna-wahine, described a number of her favorite recipes with wana, gravy, limu, crab, and reef fish:

About younger generations in her fishing village, she said, “They don’t do that down there. I made some stuff, the kids, ‘Eeehh…’ [mimicking the kids, as if looking at limu in distaste].”

Uncle said, “They don’t like.”

She concurred, “They don’t eat that kine. I say, it’s a… I was raised on it! Oh! They don’t eat! Now, they too fast… too much fast food. I say, ‘don’t eat that [fast food], that’s no good.’ Before this, we eat the fruit of the land, the ocean. It’s life, the ocean. If you eat that, you never get sick!” [02.06]

Limu has long been considered, and still remains in Kona, a very important resource to the Hawaiian culture, practices, and subsistence. The isolated fishing villages of South Kona are pockets of cultural continuity (McGregor 2007), where subsistence economies lingered long after having dissipated elsewhere in the Islands. While some people (Linnekin 1983; 1991; 1992) contest Hawaiian culture as revisionist, the living memory of Hawaiian cultural practices was strongly evident in the interviews. But the experts’ comments about fast food also signified, at least in part, to the well-documented
health problems (obesity, diabetes) and related experiences with economic development afflicting the Hawaiian community.

5.3.5 Recruitment

5.3.5.1 Scientific description

Many species of coral reef organisms are characterized by having a pelagic larval stage followed by a post-settlement and relatively sedentary life stage. Recruitment, or the process by which larvae settle into shallow water habitats (in this case, coral reefs), is seasonal and variable in space and time. How biological, environmental, and synergistic forces influence recruitment are important, relatively unresolved questions in the scientific literature. In Kona, with variability among species, overall recruitment is highly seasonal with a major peak in June and July, and a generally smaller, secondary peak in February and March. “Recruitment was minimal during early winter (October–December) and a review of other studies similarly indicates minimal recruitment in Hawaii during this period” (Walsh 1987, 257). The questions of how far the larvae of marine organisms disperse, and how and when they recruit to coastal habitats, are fundamental to understanding their population dynamics, the management of exploited species, and the conservation of marine biodiversity. In Kona, a plethora of research has been established recently (~1999-present) to look at recruitment, young-of-the-year, and
adult biomass and species richness vis-à-vis open and closed areas within the network of FRAs limiting aquarium fish collection.

5.3.5.2 Ocean experts who talk about recruitment

Qualitative observations of recruitment come from tropical aquarium fish collectors, dive shop operators, and scientists. Each group describes a different aspect of recruitment, which seems to depend upon the ecological focus of their ocean activities and/or knowledge. Collectors attend to ‘The Drop’, or the wave of recruitment that passes up the Kona Coast each year. Because their trade is largely in juvenile fish, collectors follow the drop, staggering their timing several weeks to months behind settlement. Collectors tend not to return to any particular site more than a few times a season, until recruitment passes over the site again: “At any site, I wouldn’t return for a couple of months. It makes sense to go to new sites because it lessens the possibility of working a site too hard” (05.18A.06). When they can fish in a year, how much they collect, where they collect depends to a large degree on timing, levels, and spatial heterogeneity of recruitment. Recruitment as a process, and its intricacies, form a substantial part of collector’s narratives, who seem to be most aware of more fine-scale patterns and detail of recruitment cycles across several decades. Just as collectors focus on ‘The Drop’, divers and dive shop operators for professional and other reasons tend to approach different reef sites with holistic and aesthetic perspective. One component of this aesthetic is recruitment, which dive shop operators tend to compare dive site by
dive site. Their focus on recruitment stems from attention to the aesthetics of the masses of baby fish each year, as well as it being the process which provides the colorful and gregarious adult fishes so critical to the dive experience. Scientists focus on recruitment as an essential ecosystem process, for its role in restoring impacted adult fish populations, and as an indicator of the impact of aquarium collection. The intensive and extensive coral reef research being conducted today focuses in part on recruitment (young of the year), the role of the MPAs in protecting breeders and new recruits, and sends scientists on research dives more days than not. As a result, scientists “know more detail about more sites across the whole coast” (12.04.06) than ever before.

5.3.5.3 Observations and perceptions of recruitment

In Kona, overall reef fish recruitment occurs seasonally, where recruits (post-settlement fishes) settle on the coast in waves. Typically landing first in Kau (South Point), the “wave” of settlement over the course of several months moves northwards up the coast towards the North Kona and Kohala Districts (05.18A.06; 06.08A.06; 06.08B.06; 07.06.06). Species differentiation is evident especially with “rare” organisms, but recruitment has tended to be highly seasonal, with it being the lowest in the wintertime (06.08B.06). The main onset of recruitment each year generally happens in the summer months, though its timing is unpredictable. In addition, recruitment last several years (2003-early 2006) seemed unusually prolific and continuous to aquarium collectors, who report that recruitment was “going off”, that is, recruitment happened
“almost continuously” with little downtime between 2003-2005. It seemed to have abated by 2006 (06.08A.06; 06.08B.06).

According to Kona’s ocean experts, the magnitude of recruitment vacillates on a (more or less) decadal cycle. Over the past 35 years, “banner years” (06.08B.06) of recruitment seem to have occurred every 10 to 12 years. The years throughout the 1970s, 1985-90, 1995-96, and 2003-04 were periods of high recruitment. Lower periods of recruitment occurred in the early 1980s, early 1990s, and late 1990s according to a diverse array of local experts. “Longtime tropical aquarium fishermen recognize cycles of dry years, from their longevity of fishing this coast. Their take is that they’ve seen it all. Fishermen come and go. A few—the good fishermen—last the while if their knowledge is keen and they can wait through the dry cycles”, said a Kona Coast collector (05.18A.06). As for himself, “in the last 12 years of fishing, I have only seen one bad dry cycle. Seven years ago, where some people worried, and others said, ‘Good. Get rid of the excess fishermen’” (05.18A.06).

Cycles of high and low recruitment seem to range no more than 20% higher or lower than the ‘normal’ magnitude.

A normal year might be 80% of total production. If you consider that year after year, recruitment is at 80% of what it possibly ever could be, then a bad year is 10-15% drop from what production is at a normal, and a good year might be 20% better than normal. What we get [what species of fish are collected] might not be the same. Tropical fishing is one of neat industries because no matter what you do, when you go out, make money. May not make $200, nor $500, but you’ll make something. Ahi (yellowfin tuna) fishing is different. If you don’t take care of your truck, or miss ‘the bite’, you don’t make money that year. Tropical fishing is like…if the catch is down, you don’t go to the movies as
much, but you can still keep fishing to survive. There’s always something to catch. At
80%, I might make $400 per day. If it drops to 65 or 70% of possible recruitment levels, I
notice little drops, so I don’t spend ten grand on a vacation. [06.08B.06]

This participant indicates how tropical aquarium fishing operations may
specialize on one target species (e.g., yellow tang) or a suite of species (rare critters), but
in times of poor recruitment and population dynamics, collectors can shift to target
organisms in high abundance or demand on the market, or away from species in low
abundance. Collection activities have never seemed to be limited by numbers of recruits;
if fishing seems to be slow at times, collectors say, “but even surprising to me, the
number of boxes I send out every year is the same, over 12 months averaged” (07.06.06).
Since zoning has taken effect and prohibiting collection in 35% of Kona’s waters, the
‘highliners’ of the collector industry still remain active.

The magnitude of recruitment any given year is unpredictable and the ecological
and environmental causes of variability unknown to ocean experts. Whether
oceanographic processes, temperature, productivity, fish species population dynamics,
or another factor, most ocean experts suggest all of these as causes but wonder
themselves what of these is more important than others. “The cycles—I think the
temperature, the gyres in currents in particular are important. But you know all that,”
one said kindly, giving deference to my role as a researcher (05.18A.06). Said another
collector: “The winds bring them in… timing is everything. That the fish will spawn, the
larvae go pelagic, and if the winds do come in, Praise the Lord! Clearly, the angle of the
trade winds is important. I just see the end result [whether they’re there or not]. You’ll just see them all of a sudden – the post-larval stages… I find them by exploration, getting in the water” (07.06.06). He, and another diversified techniques fisherman, mentioned particular characteristics in coral reefs (finger coral, certain depths, certain zones in the rubble, certain exposure) to find recruits in new areas (06.04; 07.06.06).

There is also debate about the natal source of larvae, whether local, elsewhere in the MHI, or the Northwestern Hawaiian Islands (08.04). Native Hawaiian people have long talked about the connectivity between MHI and NWHI, giving examples such as how the seasonality of traditional fishing practices differs island to island, region to region.

Some dive shop operator participants note strong correlation between water temperature, recruitment magnitude, and daytime breeding behavior of reef fishes. According to one expert, during the last decade or more, the banner years of high recruitment magnitude (1996 and 2003) correlated with periods in which water temperatures were sustained at 82 degrees. Interim years (1997-2002) of moderate to low recruitment were also El Nino (cold water) years (05.22.06). In cooler water years, breeding behavior is observed, but without successful spawning.

Colder years…. I’d see breeding behavior, but no spawning. Like the domino damsels. The male leaps and chirps, and the female comes in and start a little bit, and no! She’ll stop. And he’s like, ‘what did I do? Was it something I said?’ You see it a lot during cold years. [06.07.06]
In warm water years, which are also high recruitment years, bullet parrotfish and palenose parrotfish engage in unusually active breeding behaviors, at all times of day. Divers witnessed “larger than average breeding schools” of lined butterflyfishes (30+ in a school), as well as saddleback and raccoon butterflyfishes. Also during warm water years, a diver’s probability of observing breeding behaviors seems exceptionally high, or every 6-7 dives out of 10 (06.07.06).

Across the Kona Coast, recruitment variation occurs spatially and by species. Certain sites are considered high recruitment areas (e.g., Ho‘okena, Ke‘ei, Kaiwi) (06.07.06; 06.08B.06), while others are considered relatively low (e.g., monument area of Kealakekua Bay) (05.17.06; 07.13A.06). Prime adult fish habitat is also distinguished from high recruitment areas. Within the Kaloko area, the northernmost study site of this research, there is a patchwork of nursery and adult habitat. Several dive sites north of the harbor are “rich nursery areas” for ornamental fishes, particularly off slopes and between 40 and 80 feet. Nearby Kaiwi, located south of the harbor, is a rich adult habitat area but poor for recruits (05.17.06). There seems to be consensus across all participants of the patterns in spatial variation.

Species do not always follow general patterns of recruitment. Population cycles appear to be superimposed on the overall cycle in ‘the drop’. Rare fishes seem to exhibit more variability from recruitment patterns than more common fishes, as demonstrated by this aquarium collector’s discussion of Tinker’s butterflyfish recruitment:
In early 70s to almost 1980, fish were overly plentiful: no cycles, no down time. In those years, I could make one run in the deeps, catch a pair of Tinker’s or 4 Tinker’s, day-in and day-out. Then for a couple years, during some dips in recruitment in the 80s, I could make a whole dive without catching a single Tinker… One exceptional year, 1998-99. The Tinker’s butterfly, especially in those two years, we could land 10 per dive in 100 feet of water. Because no decompression is required at that depth, I could do 3 dives and land 30 fish each day. Really exceptional. Since 2000 there has been good recruitment – though fishing was slightly more sporadic due to ‘political upheaval’.

[06.08B.06]

Several other species (e.g., Chevron tang, flame angelfish, & fire gobies/dartfish) were described as ‘special cases’ with patterns of recruitment different to the norm.

5.3.5.4 Recruitment as symbols in environmental change narratives

Recruitment has become enveloped in narratives about the FRA network, as well as the impacts of aquarium fish collection on the Kona Coast. Tropical aquarium collectors, who focus on recruitment, employ their knowledge of the process to complicate, or add reasonable complexities, to the conventional wisdom about the effectiveness of FRAs. That is, recruitment is used to challenge the conventional wisdom which at once blames collectors for ornamental reef fish declines (primarily, with much lesser secondary blame on roi predation), and celebrates the FRAs for widespread rebounds. Scientists concur with the idea that the management actions (emplacing a network of areas closed to tropical aquarium fishing) are not solely responsible for conditions improving so quickly after the management was enacted.
Beginning around 2003, reef fish recruitment jumped across most species. Scientists say such early signs of such high recruitment are not likely traceable to the FRAs but instead have something to do with annual variations in recruitment. But continued years of high recruitment, along with increasing adult fish populations, seems to have much to do with the FRAs protecting both breeders and overall populations in ‘closed’ areas (05.18B.06). Says another scientist:

There has been a gradual increase in ornamental fishes all along the coast… and a large increase in the yellow tang recruitment since the FRAs were established. Three solid years of recruitment occurred once the sites were set aside [in 2000]. But we should only just [this year] be seeing an increase of recruitment if the numbers [of adults protected by the FRAs] have increased. So it’s not clear if the recruitment is a result of the FRAs or not. The evidence is sketchy about recruitment, as it suggests that there has not been enough time since closures to see new recruits in these numbers that are directly attributable to the FRAs. [04.05.06]

Reef monitoring programs have proliferated since FRA inception and look extensively at recruitment across species, the region, open and closed sites, and years. Ensuring these complexities on recruitment enter the debate about collection, reef fish abundance, and FRA effectiveness is important to collectors for a variety of reasons, not the least of which is the longevity of their industry. A collector who has worked closely with the management process says, “Of course it’s [tropical aquarium fish collection] going to have an impact on the reefs. What stops the next person from taking everything? The question is, how much activity can occur to ensure that a good recruitment happens next year and the following year. In the last five years [since FRA
closures, with studies in open areas [reference to the West Hawaii Aquarium Project studies and findings relating to open and closed areas in the FRAs] we are gaining a better understanding of the levels of allowable activities” (05.18A.06).

But recruitment cycles add complexity to the situation in unraveling the ecological puzzle (what happened and is happening to ornamental fishes) and the human-ecological-institutional relations on the Kona Coast. Since the FRA closures, one collector surmises, “the tropical fishermen have all been able to survive as businessmen in more limited fishing areas because there have been three good recruitment years. [After the FRA closures], the first year was not so bad… one or two years of a not-so-good drop, and by the fourth year, thank god, there was a good drop” (05.18A.06). They are thankful both for sufficient fish to collect in ‘open areas’ as well as sufficient fish to satisfy other user groups (and thus avoid further limitations to their industry). Despite several years of peaceful co-existence of collection and other uses of the reef, tropical aquarium fishermen are worried about the onset of the next low point in the cycle of recruitment. Collectors suggest that they as a group were lucky that the FRA establishment happened to coincide with a high recruitment cycle; otherwise, they might have been subject to further spatial regulations. Recruitment since 2002-03 has deposited “Lots of everything! [Other people] say it is because of the management plan. But I think that the cycle [high recruitment] just happened to hit at that time. Maybe fish were in a slump in the 90’s. It’s good because they would’ve closed us down [the
collection industry] if all the fish hadn’t come back at this time” (06.08B.06). But as a collector said, emphasizing the importance of ensuring the complexities of recruitment enter the dialogue surrounding collection and the FRA effectiveness: “The fish drop happens in cycles. So what if next year, or the next two years, we have dry recruitment? Red flags go up all over the place” (05.18A.06).

Relations are not always contentious, however, as illustrated by a tropical aquarium collector: “I talk to [other longtime fishermen], and they say, ‘It’s the same old story. They’ve [divers, Hawaiians, conservationists, managers] tried to close us [the tropical aquarium fishery] down for 20 years. The fishery sees good times and bad times. Good years… Dry years [in recruitment]. Political pressure. They [other fishermen] haven’t seen any reason to be shut down [ie, no reason to support MPAs or other limitations on their fisheries]. I take a different take. With user conflicts, political and public pressure, one [speaking as a tropical fisherman] has the responsibility to address the situation. Anyways, even in dry years since closure, my income has gone up. Even in dry years” (05.18A.06). In his active participation in what many in Kona call “The Process” of their representative form of community-based management. He shared an emotional story about conservationists vouching for his character in the face of public (and malevolent) attacks, something somewhat unimaginable some years ago when user conflicts were so contentious.
5.3.6 Corals

Figure 16: Kona’s coral seascape (photos by E. L. Hazen)

5.3.6.1 Scientific description

Coral reef ecosystems are defined by the presence of three-dimensional reef building corals, according to the marine ecology literature (Knowlton and Jackson 2001). Situated in the middle of the Pacific Ocean and over 2400 miles from the nearest continent, the coral reefs of the Hawaiian Islands are isolated and consequently exhibit some of the highest marine endemism in the world (Friedlander et al. 2005). Home to the youngest reefs of the Main Hawaiian Islands, the corals on the Kona Coast form narrow fringing reefs, ranging from 100 – 400,000 years old (Grigg 1988). Hawaiian coral reef communities are dominated by reef-building corals of the genus *Porites* (lobe and finger coral, *P. lobata* and *P. compressa*), which “contribute the majority of biomass and biodiversity to Hawaiian reef ecosystems” (Hunter 2005). Pocilloporids (e.g., cauliflower coral, lace coral) are also present (Figure 16).

Corals of the Main Hawaiian Islands (MHI) are considered relatively pristine in the scientific literature (Friedlaender et al. 2005) and Kona’s are some of the most pristine in the archipelago (Jokiel et al. 2004). Hawaii’s coral reefs exhibit zonation where the abundance
and composition of the coral community varies according to distance and depth from shore. Wave exposure is the primary factor causing zonation but gradients in sedimentation, salinity, and temperature are also important (Dollar 1982). Puako, in North Kona/Kohala, the only long-term study site of its kind on the leeward coastline of Hawaii Island (Jokiel et al. 2004), has shown no significant change in coral cover over the past 35 years (Jokiel et al. 2004). Scientific baseline of coral condition is just being established, for example, in Kaloko-Honokohau for the purposes of long-term monitoring of impacts due to coastal development and other factors (Beavers, pers. comm.).

5.3.6.2 Ocean experts who talk about corals

Because of its fundamental importance to the coral reef ecosystem, I asked all ocean experts to share their observations of coral. To scientists and resource managers, corals represent one of the primary spotlight features in their narratives of ecological change. They ‘know’ coral as the habitat-forming and literally the foundational feature of coral reef ecosystems. Corals represent a vital research subject ecologically, as well as for conservation and management purposes, because aspects of coral condition, cover, and community structure are important indications of human impacts (e.g., land use change, nonpoint source pollution). Correspondingly, to scientists and resource managers in Kona, these aspects of coral represent a critical data gap, that is, a gap in historic data which limits their ability to scientifically evaluate or detect anthropogenic impacts. Coral represents a prominent feature in their narratives, less because of actual
changes observed (see observations of change discussion below), than because of concerns about the future of the system vis-à-vis the rapid transition in coastal development and land uses affecting the Kona Coast at present.

In general, experts who focus almost entirely on fishing had little to share about the reef-building organisms, while those who dive for recreational, commercial (dive tours as well as collection), and/or scientific purposes tended to have accrued more expertise about corals. To fishers and many Hawaiian ocean experts, those people least attentive to coral, these calcareous organisms are relatively a-symbolic features of the seascape around which other activities occur (e.g., spearfishing, fish aggregation). Many offered no specific observations about coral, with the exception of those people who worked across wide regions collecting (often diving for) rare organisms, where understanding nuances in habitat (coral species, morphology, structure, condition, current exposure, seasonality, etc.) proves important in locating target organisms. For example, a collector noted rare fish habitat and the spatial tension of collectors and divers: “Certain fish like certain terrain. Flames [flame angelfish, rare, highly prized collected fish] like very nondescript rubble, which is good because no charter dives like those areas” (06.20B.06).

To commercial and recreational divers, corals and reef structures are an important component of a diver’s aesthetic encounter with the seascape, directly as a visual feature and indirectly as habitat for reef organisms; and coral as the foundation of
the reef ecosystem is also important re: conservation of the systems. More pristine corals are more colorful, clean of algal overgrowth, exhibit texture and unusual morphology in three dimensions. Coral formations alone do not create the underwater aesthetic, as even the most spectacular coral formations, like in Kealakekua Bay, are “boring” compared to mobile, colorful reef fishes and rare critters. Multiple (but not all) dive shop operators indicated they would rather “hit their head against a wall” (05.05A.06) than have to dive every day in Kealakekua Bay, with its unsurpassed plate coral formations but rather mundane fish displays. Yet, when wave energy events devastate coral formations, dive sites have been abandoned for decades at a time while corals recuperate.

5.3.6.3 Observations and perceptions of corals

In the long term, Kona’s coral reefs appear to be in relatively good condition, with no evident change in overall coral cover and condition compared to 35 ybp, according to the region’s ocean experts. In the short term (0-15 years), corals are regularly changing because they are constantly subjected to (but until now have relatively quickly recuperated from) storm disturbance. Across all interviews, storm impacts to corals (three-dimensional structure, live coral cover) are one of the most common topics of ‘change’; and with coral, other natural disturbances discussed include crown of thorns (COT) outbreaks, anchor damage, diver/snorkeler impacts, and population dynamics. Until now, the corals have demonstrated to ocean experts their ability to recover from even the most dramatic of disturbance events. A few site-specific cases of small expansions of a coral species, and a
few of narrow coral declines were mentioned, but were minor in scope (+/– 10’s meters) and very atypical. However, due to rapid development land use change currently happening in Kona, there is an overwhelming concern among nearly all of this study’s participants that the region’s corals are reaching, or have reached, the point at which anthropogenic impacts are beginning to test the coral’s resilience.

Storms as a force of ‘change’ to coral cover and condition were one of the most common topics throughout the entire study introduced by study participants. But although storms (here, defined loosely as tsunamis, hurricanes, and storms events like Kona Lows) can effect rapid and dramatic changes to live coral cover, composition, and structure, corals have always “normalized” (05.05A.06) or “recovered” (05.22.06) within 15 years of the event. Such observations are extremely consistent across interviews with all expertise groups.

Extensive re-working of coral has occured every decade or so since 1960 including: a) the 1960 tsunami (02.04; 07.18.06), b) winter storms of 1979-1980 (many, e.g., 05.05A.06; 05.05C.06; 05.22.06; 05.18B.06), c) Hurricane Iniki in 1992 (many), and the storm surge event in January 2003 (many). Certain sites (e.g., Kaiwi near Kaloko), due to exposure, historically are more affected by wave energy events than others (e.g., Captain Cook monument area, Kealakekua Bay), but this also depends upon the storm’s swell direction.

Storm and wave energy is transmitted to great depths. “You can see where the waves have scoured the bottom, but also the effects are all the way down the slope where coral has been broken off and rolled down” (05.05C.06). In the most catastrophic
of events effects are transmitted through habitat structure and reef communities, evidencing impacts to great depths underwater and at times deposited onshore. The 1960 tsunami not only reworked underwater 3-dimensional habitat but also deposited massive boulders, coral heads, and hundreds of reef fishes on the shoreline (07.18.06). But, said this participant, “coral regrows. It always does.” According to a diver, “after the 1979-1980 winter storm, you could see complex ripple patterns on the bottom [he waved his hand back and forth as if running it over the seafloor] – ripples of broken corals the storm had broken off” (05.05C.06). Hurricane Iniki “completely changed the topography of Kailua Bay. Vast areas of finger coral interspersed by canyons were filled and re-worked. Rubble filled in some canyons, others were carved anew” (05.21B.06). Many recalled the 2002-2003 winter storm event as one of the most catastrophic in Kona in recent memory. Up to “40% of corals [in some sites] were devastated” in “long strips all the way down the slopes” (05.22.06). Massive coral boulders uprooted in shallower waters tumbled to great depths and smashed corals in their path. “Corals took out entire areas off the drop off… obliterated the drop-offs in strips. The coral structure was reworked up to 80 feet depth.” The interviewee estimated that 30 to 40% of the coral structure was gone, but noone noticed declines in fish populations (05.10.06). After the storms, “big seas of finger corals looked like the trees on Mount Saint Helens. I vividly remember thinking that those areas would never come back, but they did come back” (05.05A.06).
Recovery of the ecosystem following each storm event begins immediately. Many in the aquarium collection, commercial, and recreational dive community note that some coral heads, once settled on a stable surface, regrow quickly (many, e.g., 06.20A.06; 06.20B.06). Regarding coral cover and 3-dimensional structure, after 2-3 years little regrowth has occurred. Substrate appears in 5-7 years; regrowth visible after 10 years (many). The cauliflower corals are thought to come back quickly. “After regular winter storms, polyps grow again within the month. Larger storm events tend to break off the entire structure and leave only stumps remaining” (05.22.06). Finger corals take longer; in the largest of storms, “nobs of finger corals began to grow there about 5 years later” (05.05A.06). Within 15 years, to many people’s “surprise,” coral cover and percent structure are “mostly back to normal” despite the fact that divers needed to learn to navigate the new structural ‘seascape’.

Recovery of the ecosystem surrounding corals begins immediately, too. Rubble provides surfaces for the recruitment of new corals, contributing to recovery over longer periods of time. Within days to weeks, grasses and algae grow in rubble zones and provide immediate three-dimensional habitat for reef organisms. These grasses, according to the interviewee, “provide emergency shelter underwater”. It only grows on the shattered corals. Areas of grasses will last a short time until the corals regrow or the fish find other shelter.” For instance, in the 1980s, the grasses stayed for a couple of months; after Iniki it only lasted 3 to 4 weeks, “but by that time everybody had found
new homes and places to live.” (05.17B.06) Wispy grasses colonized rubble after the 1980s storms and remained for several months. Following the 2003 winter storms, this grass was not present, although a different “more clumpy” algae colonized rubble “almost immediately;” it appeared to be highly suitable habitat for juvenile yellow tang (05.17B.06).

Populations of fishes and other coral reef organisms generally do not appear to be affected much by storms, say ocean experts. “Before storms, they will group together, go down on the reef (to a greater depth)” (05.18A.06). In the days to week following catastrophic storms, fishes appear ‘confused’, ‘dazed’ and ‘out of it’ (05.17B.06; 06.20B.06; 05.05C.06). Although a few of the “softer fish appear battered” (07.06.06) and are not ideal for collection purposes, most fishes “go deep” before storms. “Only in tsunamis will you find many fish washed inland; though in some storm events there are always a few idiot fish lying on the road,” one expert said (06.08B.06).

At Kaiwi, near Honokohau harbor, following a 20-foot swells event, “The water was very murky from it all. All big coral heads were over-turned. Huge coral heads had fallen right down to the base. We saw exposed blue rock and chunks of white and yellow sponges. Fishes were really freaking out, jittery, skittish. Clouds of fish huddled over the corals. When it’s really ‘surfy’, the fish rise up off the reef to avoid being knocked into coral in the swell. After the storm, their homes were gone. They can’t find refuge, and they were all just up over the corals, like lost, not acting normal, confused”
Collectors report being able to land dozens of Potter’s angelfish following storms, which typically are highly difficult to land because of quick, effective shelter-seeking behaviors. According to a dive shop operator:

What’s interesting is the busiest places after storms are the cleaning stations… Mostly the cleaner wrasses are really, really, really busy. Last winter after the 2 or 3 day storm, I was looking for storm-related behavior… Fish of all sorts are lined up, dozens deep. They’ve gone 3 maybe 5 days without being cleaned. Imagine what you would feel like if you hadn’t showered for 5 days! “And peace reigns,” in this time. None of the usual predation occurs. Trumpetfish and damselfish and butterflies are all lined up together; they just wait their turn. The pyramid butterflies look out of it. Dazed. Their actions were all out of whack, not the usual eating [the participant pursed his/her lips and kiss, kiss, kiss, like a pyramid butterfly eating with its tiny mouth]. The cleaning stations were insane with everyone lined up. It was like gas stations in a gas crisis. Only the roi, trumpetfish and jacks were having a really good time [preying on the dazed fish]. But even the predators can only do so much damage. [05.17.06]

Eels and tako (octopus) “are like FEMA”, and physically clear holes in the rubble (05.17.06). As for the regularity of human presence on reefs following storms, several divers and dive shop operators recall dive sites that were abandoned for over a decade after a storm. Many of these people recall being “surprised” (05.05C.06) that corals were so “hardy”, recovering and eventually supporting impressive fish populations again. Thus, observations of change to coral include storm impacts to coral-building organisms as well as the ecosystem-level influences of changes in coral structure.

In addition to storms, some of the regular disturbance events to corals include bleaching events, COT outbreaks, isolated anchor damage, and chronic wear and tear of people who “love the reefs to death” (04.20A.06). Firstly, bleaching events have been
observed by ocean experts in 1987-1988, 1996-1997, and 2005, even though the first-recorded bleaching event in the MHI was in 1996 (Friedlander et al. 2005). During the typical bleaching event, the onset of bleaching occurs in September during periods of prolonged water temperatures 81.5°F or warmer. At times 15% of all coral, and 80% of some species of coral bleach, with ~5% overall mortality (05.22A.06). Secondly, crown of thorns (COT) outbreaks occur cyclically, though with little long-term affects on coral reefs. COTs populations increase several-fold (from ‘normal’ 1-2 individuals to over 6 visible, with several dozen more unobserved, in ~100 m²). COT outbreaks are followed quickly by population surges of the predatory snail, Triton’s trumpet. Peak population events last approximately for one year, and COTs remain high for several years until the predatory snails manage to cull the outbreak. Then for 2-3 years, neither is seen in abundance (05.22A.06). Thirdly, anchor damage has substantially improved since large vessel anchorages were banned from Kealakekua Bay in 1969 (07.18.06), and since the recent implementation of a network of mooring buoys (though all examples given were regarding Puako in North Kona, not any sites in particular in the study region). Finally, corals suffer chronic wear and tear particularly in shallow-entry snorkel and heavily-used dive sites, such as “Two Steps” in Honaunau, Kahaluʻu Beach Park, and the mooring pins in Kaloko-Honokohau National Historic Park (04.05.06; 05.05C.06; 08.31A.06; 08.31B.06; 06.A.07). Evidence of ‘wear and tear’ at these sites also may compounded (or observations
confounded) by increased freshwater input from recent upstream development (08.31A.06; 08.31B.06).

Observations of polluted runoff affecting Kona’s corals are scant historically, but may be on the rise. In a conversation about nonpoint source pollution, in which the interviewee described always being attentive to the synergies of coral health, algal overgrowth, and herbivores, I asked: “Do you see any pollution impacts at all?” To which she replied, “No,” she said, “I wish I could. But, no” (05.17.06). The few concrete cause-effect incidents of polluted runoff came from scientists. Several note that following a sedimentation event from a large construction site near Kealakekua Bay in the winter of 2000, over 15% mortality in coralline algae and other ecosystem affects occurred, even though an unusual wave energy event washed the silt off the reefs several days later. Conventional wisdom, locally and statewide, actually suggests no mortality occurred, but these understandings are incorrect (05A.07). The lava tubes downstream of the development are still “running dirty” (discharging sediment-laden waters), as are several in North Kona and Kohala (north and outside of the study region). In a similar sedimentation event in surface runoff during a large rainstorm event in October 2006, sediment was deposited on Kohala reefs where it sat for at least 8 months. Biologists (as of May 2007) had not assessed damage as sediment had not yet washed away. Otherwise, a few local people related observations of what they think relate to pollution. In Kailua Bay, one fisherman has observed the substrate becoming unusually “silty” within the past 15 years, causing “clouds
of silt [to bloom] when I poke my hand in *he’e* (octopus) holes” (07.05B.06). This individual believes this is caused by pollution from cesspools (an estimated 80% of Kailua-Kona is on cesspool), fertilizer and other polluted runoff from the Kailua-Kona urban area.

Additionally, a tropical aquarium fish collector sees parallels in Kona’s reefs today to the early signs of pollution on O’ahu’s reefs: algal growth is (newly) evident to 40 foot depth in Kaloko; and there is a higher incidence of siltation (06.20B.06). Several thought Kailua Bay’s corals, downstream of the coastline’s only ‘town’ or urban area, appeared to be in worse shape for a variety of reasons related to heavy use and location near the coast’s population center (05.17.06).

### 5.3.6.4 Corals as symbols in environmental change narratives

With surprising frequency, ocean experts employed coral as a challenge, to contradict what – if any – assumptions I, the researcher, had about the condition of Kona’s coral reef ecosystems. “You are *expecting* me to tell you everything is different, bad. Part of what I know comes from growing up on O’ahu. I spent a lot of time there, like there have been drastic changes in the reefs. I’ve been here [Kona] for 24 years now, and seen a lot of changes. Most of them for the better! I mean the corals. The fish haven’t gotten better.” (05.05A.06). Likely, these discussions had something to do with my positionality as the researcher (young, haole, female mainlander) and their expectations of me being a conservation-minded scientist. “You might think I am going to talk about long-term
degradation. But I’m going to surprise you. In the long run, even to my surprise, Kona’s coral recovers” (05.05C.06).

But most importantly, corals encapsulate the most pervasive concern amongst all ocean expert groups about the future of Kona’s reefs. Corals spotlight the threats of land use change and coastal development to the resilience and longevity of the coral reef ecosystem. Even though coral condition appears to be resilient following the many biophysical disturbances that regularly affecting it, experts talk about coral with deep concern because of the rapid transition in development and land uses (from undeveloped, rural, or agricultural lands to urban, residential and industrial development) occurring at present. Scientists and non-scientists alike talk about ‘signs’ of reef degradation – numbers of herbivores, algal overgrowth, changes in substrate composition. Many non-scientist ocean experts, for example, note how they have “become more aware of these issues lately… now I always look for algae on coral [as an indication of NPS pollution] when I go diving” (05.22.06). Another mentioned thinking about how many herbivores were removed from reefs in the aquarium trade, and trying to calculate how much algae growing on corals is thus not eaten or controlled (05.10.06).

There is also an explicit awareness of the synergy of storms, pollution, and resource mis-use, as evidenced by O’ahu reefs in the 1990s. O’ahu, where nearly 90% of the state’s residents live, serves as a harbinger for Kona’s corals, because many of Kona’s ocean experts experienced first-hand as O’ahu’s reefs declined. After quickly successive Hurricanes Iwa
(November 1982) and Iniki (September 1992), combined with nonpoint source pollution, and fishing activities of nearly million residents, the corals and reef fishes on O‘ahu failed to rebound. Many of Kona’s ocean experts experienced decades of declines, and relocated to the Big Island where coral reef ecosystems were much more ‘pristine’, between the 1970s and 1990s. A wave of O‘ahu-based tropical aquarium fish collectors immigrated to the Big Island when their operations plummeted with reef conditions after Iniki (07.06.06; 05.18.C.06). According to a marine resource manager, “I’ve seen it decline here [Kona]. But the declines I saw on O‘ahu... I think it [such extensive declines] will happen here, though it hasn’t yet” (04.14.06). Said another participant: “Kaloko, I compare this area to the Haleiwa Trench [North Shore, O‘ahu]. High, hard rolling surf with healthy coral to silted-out coral. I recognize the precursors at Kaloko from what I saw on O‘ahu. It’s the beginnings of the loss of the reef ecosystem from pollution. By coral, you see poof! Dust, silt, and it’s not getting better. You see algae to 40 feet. And siltation at 70, 80, 90 feet” (06.20B.06). In light of O‘ahu’s experience with land use change challenging coral reef resilience, many of Kona’s ocean experts are working on various levels to prevent land use change and the ‘construction boom’ from impacting Kona’s reefs.

But it is an uphill battle, against (1) the conventional wisdom which says, due to environmental factors, Kona’s coral reefs are highly resistant to the impacts of nonpoint source pollution, and (2) that baseline habitat data do not exist yet in many places to evidence if/when Kona’s corals are impacted by land use change. Conventional wisdom has
been used locally by real estate developers, in environmental impact statements, and by others to deny potential impacts of land use change to coral reefs. While monitoring programs seldom demonstrate a conclusive impact to Hawaiian reef communities from nonpoint source impacts, most Hawaii-based scientists contest these assumptions of insusceptibility to land-based pollution (Friedlander et al. 2005; 01.07; 04.07). Kona’s ocean experts contest the assumptions of insusceptibility on several grounds. “Even the basic hydrology [in Kona’s watersheds] is not well established.” Without hydrological nor regional reef condition baseline data, scientists and resource managers are limited in their ability to detect change if it has occurred, which is extremely problematic because that data is necessary to have in the context of land use planning (06.29.06; 05.07). Because the rural Big Island is in the process of being developed, experts hope to possibly prevent experiences such as O’ahu’s.

Resource managers are scrambling to establish scientific baseline data on coral reef condition. As monitoring programs are very new (or yet to be established), the lack of historical data is a concern. As indicated by another resource manager:

The harbor expansion and the K--- development, something like a 2500 unit hotel development, 800-slip and 45-acre harbor expansion, and water theme park like Disneyland are of extreme concern. We assume that the impending development will have major effects on the coral reefs – the water cycle and its affects to the coral reefs.

More people in Kona, for tourism or living, means more people on the coral reefs. Lip service is paid to [assessing] coral reef impacts [through EISs]… But information gaps about hydrology and coral reef baselines, combined with poor land use planning are threats to these reefs. Kona’s hydrological
dynamics are relatively unknown. All fresh and brackish water sources in Kona come from submarine groundwater discharging directly to coral reefs. All of this development, particular the development right on the coastal strand, can not be great for the reefs. [044.07]

Baseline data are being collected; scientists are working to improve information exchange with those monitoring terrestrial water quality; and all of the scientists and resource managers who participated in this study reported participating as either as volunteers or professionally in land use planning activities (05.C.07). As noted wryly by a marine ecologist, “The connectivity is much more obvious to us downstream than to them [terrestrial ecologists, managers]” (06.D.07).

Finally, evidence of algal overgrowth, which is seen as an indicator of coral decline, has not been observed, but we raise the question, can low-level changes to coral be observed through passive, visual observation? We contrast the ability to detect visually low-level or slow changes in such things as the ratio of coral-cover to algae, with ocean expert’s clear and precise ability to detect dramatic change to coral (e.g., storm damage), as well as low-level change to species people extract for subsistence. While from the data herein we see no clear answer, we surmise whether some other indication of a ‘tipping point’ in coral reefs is more salient, particularly to local and indigenous people generating knowledge in, and operating within, different epistemological frameworks.
5.3.7 Hawaiian lionfish (*Dendrochirus barberi*)

5.3.7.1 Scientific description

The Hawaiian lionfish (*Dendrochirus barberi*; Steindachner 1900), or “lionfish”, is endemic to the Hawaiian archipelago. This reef-associated, non-migratory fish is found in these tropical waters from nearshore to about 50 meters (Eschmeyer and Randall 1975). Also called the Hawaiian sphex lionfish, ‘sphex’ being the Greek word for wasp “undoubtedly given to this fish because of the severity of its venomous stinging spines” (Salt Water Aquarium 2007), this striped fish exhibits long dorsal spines, and extended white spines on dorsal fins. Its coloration patterns and morphology striking, the lionfish is valued as a commercial aquarium species that brings a high price to collectors (fishbase.org). Found under ledges in turbid lagoons and clear seaward reefs (Lieske and Myers 1994), Hawaiian lionfish are collected across its depth range (Eschmeyer and Randall 1975).

The Hawaiian lionfish is considered a rare fish, as are a slough of other difficult to find or cryptic species including various scorpionfishes, and leaffish. This section focuses on lionfish as an exemplar case of the cryptic, mostly venomous ornamental rare fishes. Linked perhaps because these fishes are similar in their flashy, ornate décor, rarity, poisonous spines (most), and high value in the aquarium trade, most experts talked about several rare fishes in tandem with lionfish (lionfish being the most-oft discussed). Rare fishes of this type discussed in this study include: Decoy scorpionfish
(Iracundus signifer; Jordan and Evermann 1903); Leaffish (Taenianotus triacanthus; Lacepède 1802); Lowfin scorpionfish (Scorpaenodes parvipinnis; Garrett 1864); Jenkin’s scorpionfish (Scorpaenopsis cacopsis; Jenkins 1901).

5.3.7.2 Ocean experts who talk about Hawaiian lionfish

Both scientists and dive shop operators mentioned these fishes regularly in interviews. Not mentioned by Native Hawaiian experts, except to note how venomous they are, lionfish were neither major topics of tropical aquarium collectors or conservationists’ narratives. Perhaps because the dive industry has long been vocal about lionfish declines, tropic aquarium collectors consider the topic a politically contentious one and avoid it.

5.3.7.3 Observations and perceptions of Hawaiian lionfish

In the mid-1970s, lionfish and other rare fishes were so depleted on the Island of O‘ahu, that Waikiki Aquarium employees came to Kona to collect specimens for exhibits. One who participated repeatedly on such collecting excursions, and who now lives in Kona, recalls:

It’s weird for me [to think about my history and the changes in reefs over time] because I first dived over here in 1975, ’76, ’77 when I worked at the Waikiki Aquarium. We came here to collect species that we could no longer find on O‘ahu. I remember huge schools of yellow tang, huge schools of Achilles tang… Huge schools of many things, but those were the ones that stood out to me. I also remember reticular butterflyfish, tinker’s (Tinker’s butterflyfish), Desmoholacanthus (the bandit angelfish) - all here. Oh, I remember longnosed hawks in nice long black bushy coral trees! Many of these you couldn’t find
on O‘ahu, and today may be about to be listed as rare in Kona on the Species of Concern category that DAR and WHFC are developing.

And lionfish! You could see them anytime, anywhere you wanted to here! But that was before the collectors started here. Maybe there were one or two collectors already working these reefs, but they had small boats and didn't take as much as they did in later years. They weren't the mammoth operations like we had [in Kona] later. Not only were these species present, they inhabited shallow areas of the reefs. The *sphex* (lionfish) and longnosed hawk and *Desmoholacanthus* and *tinker* were in much shallower areas of the reefs. I mean, today, tinkers can be seen deep, at 300 feet and probably deeper than that; but in those days, we saw them regularly in 70 feet of water instead of having to go to 140 feet or more. And I haven't even seen a lionfish in 7 or 8 years. [04.14.06]

Lionfish in Kona have largely disappeared over the past 35 years. Of all ornamental fishes impacted by tropical aquarium collection, the lionfish are talked about as one of the worst-case scenarios – population depletions throughout the 1970s-1990s, some localized absences, and near failure of the population to rebound (as of 2006). Theirs is thought to be a history of the impacts of tropical aquarium fish collection on a fish whose biology or ecology prohibits easy repopulation. The following account of lionfish decline in the dive site Golden Arches is rather typical of expert's discussions of these fishes. This dive shop operator recounts observed declines, and attributes change primarily to collectors, and secondarily to predation by the invasive *roi* (peacock grouper).

“Collectors are the single biggest threat to these reefs. I can tell you the decimation caused by them. In one area, Golden Arches, I once counted 36 lion fish. And that's what I could see; I'm sure there were more. Now guess how many are there?” She held her hand up and made a circle with her thumb and index finger.

“Zero,” I said.
“Zero. And that’s just one little example. I have many more. If you put all the other impacts together combined—I mean runoff, shoreline fishers, dive operations, climate—none of it combined would add up to the total impact of collectors. If I had my own way, I would line them up and shoot them all. But I don’t want to spend the rest of my life in jail, so I won’t do that.

“In another area, I watched a juvenile flame angel colony fall from 14 fish to 4. Do you think something ate all of those? Probably not. What the collectors don’t capture, the roi eat. I’ve seen roi eat juvenile lionfish. You won’t see them take the larger ones.” (05.10.06)

In other locations lionfish declined as precipitously and rapidly. Kealakekua Bay

“used to be a rich area for scorpionfish, lionfish, and leaffish. As for Lions and leafs, I hasn’t seem them in Kealakekua Bay for years. Lionfish… there were a dozen on any given dive in the 70’s” (05.22B.06). Lionfish once resided near the Fairwinds mooring buoy at the outcropping to the point and back; 2-3 fishes were near the plate corals, 2-3 near the mooring; 2-3 “beauties off the hot water cave – I wonder if the water temperature had something to do with unusually spectacular appearance”; and another 2 near the ledge. “Lionfish in Kealakekua Bay seemed to last a little bit longer than elsewhere on the coast. Lionfish disappeared in Kona, but in the early 1990s they persisted in Kealakekua Bay, perhaps because of earlier regulations on fishing in the marine life conservation district. Up through the mid-90’s, people tell me there were still a few there. Then one by one, they disappeared. Roi? I don’t think so” (05.22B.06). At other dive sites, dive shop operators report: “At Pinnacles, [since protections] the fish populations have, if anything, come back better than they were [prior to protections]. I can safely say that, but as an aside – the lions and leafs are gone” (05.17B.06).
Evidence of lionfish rebounds since the enactment of limitations on tropical aquarium fish collection seems minimal. Some speculate if failure to rebound has to do with the Hawaiian lionfish’s slow or low levels of recruitment. One scientist suggested that there does not appear to be a lionfish ‘nursery’ on or near this coast: “We get very few juveniles” (05.18B.06). A network of divers report that lionfish have recruited very sparsely around the coast in the last few years. One diver and her daughter saw “3 babies” last year [2005] in various places around the coast. Another crew found a fourth lionfish elsewhere on the coast (06.07.06). They mentioned that four sightings in one year are far less than typical historically.

5.3.7.4 Hawaiian lionfish as symbols in environmental change narratives

Hawaiian lionfish signify two main dynamics in Kona’s historical ecology. First, changes to Hawaiian lionfish populations help to explain changes in the spatial use of coral reefs. Through stories of lionfish, we can trace the abandonment and re-establishment of dive sites, and re-naming of dive sites – all of which spotlight ecological changes to coral reef communities, and the social responses resulting from them. The Lion’s Den is the most-cited example of an abandoned dive site due to aquarium fish collection. So named for the decades-long stable population of lionfish, the Lion’s Den was inhabited by 10-12 lionfish, abundant schools of yellow tang, manini, and kole, as well as a host of other characters (Tinker’s butterflyfish, dragon morays, paku‘iku‘i,
bandit angelfish, and others). One dive shop renamed the site “No Lion’s Den”, while another called it “Lead City” for the preponderance of derelict fishing gear.

In Lead City, the entire area had become so depleted, that I hated to dive there. I just hated it. The slope, the arches, was barren. Lionfish were gone. Lead City used to be called the Lions Den because the lionfish resident populations were so stable and abundant. But it just absolutely dropped, starting in 1982, 1983. By 1987 and ‘88, they were pretty much gone. On any given dive, on any given day before 1982, I would see a minimum of 4 and up to 12 lionfish under the Big Arch. Red Hill is was another favorite dive site, as isolated as you get. It, too, rapidly lost most of its fish populations in the late 80s.

Lead City has rebounded a lot! Today, compared to the 1970s, there are elements missing, like there are not schools of Achilles tang. We do have one small school of yellow tang, but it’s not the wilderness of kole, manini, yellow tangs like we used to have. Now, instead, we have schools of the white striped tangs, giant schools of them, and we never used to have those before. I’d never seen them until recently.

Still, no lions. No dragon morays. A very few flames, and teetering at that. But Lead City is rebounding in other ways. Tinkers, bandits are all coming back. The bluehead butterfly, which we used to call mud-faced because it looks like the face has been dipped and is all muddied, is a new character. In Aquarium (the northern dive spot at Pine Trees), we used to have only a reasonable population of that fish [bluehead butterfly]. But in 2003 it exploded! Babies by the 100’s! This was unusual, I’d never seen it before. They [Bluehead butterflies] spread from Aquarium all the way to Lead City and to Turtle Towers, just outside the mouth of the harbor. [05.17.06]

Several dive shop operators recounted that because of lionfish and other rare fish and invertebrate decline, they abandoned dive sites. Furthermore, one woman with multifaceted experience on the coral reefs once led dive charters near Kailua-town, and in each of four dive sites in the Kailua Bay area, there were lionfish, leaffish, dragon wrasse and other rare animals. “Little by little they disappeared [through the late 1980s-
early 1990s], so I quit diving those spots” (06.29B.06). In another example, at The Dome
dive site ocean experts recalled:

I’d like to blame the 80 or 100 year storm event, but the mid-to-end of the 80s, it really
started degrading. Into the early 90s. Some sites went under the Gentlemen’s Agreement
in 1988 [fishermen and Hawaiian people informally worked with aquarium collectors to
agree to stop collecting in several sites on the Kona Coast]. They’d taken lionfish, slipper
lobster, crabs—beautiful crabs, the blue heart crabs, disappeared. Haven’t seen one in
years! And we used to see them every dive at The Dome. Now they’re gone.

We wouldn’t go back there unless people specifically requested to go to The Dome,
because… we were embarrassed at the level of depletion at the Dome. It ceased to
function as a marketable dive site. We started going back to these sites around 2000.
Things were coming back, but still not… [she shook her head]. Lionfish – gone. [05.22.06]

Second, and related to explaining shifts in dive sites due to lionfish and other
decreases, lionfish are employed (mainly by dive shop operators, divers/conservationists,
and some resource managers) to signify the nuances of the history of ornamental species
in Kona. In general, from ~1973-2006 ornamental species followed a trend of a reverse J-
shaped curve (Chapter 4). From initially prolific populations, ornamentals experienced
gradual then rapid declines from the late 1970s-1990s due to aquarium collection,
followed by significant (but not all-encompassing) rebounds after management actions
were taken in 2000. Lionfish, not having experienced rebounds like most species,
exemplify the more negative nuances of this story, as is shown in the following passage,
the many positive examples of biological success in the coral reef community response
to management actions. This participant starts by describing that in the young days of
Kona’s dive industry, colorful and gregarious coral reef fishes were plentiful:
Rivers! Literally rivers! Hundreds of fish razing across the bottom. The primary fish was the yellow tang, with many manini and kole intermixed in the schools. A few other fish like the orange band surgeonfish would be intermixed too, but not to the degree as manini and kole. Kai‘iwi Point [near Kaloko] is the area I most readily associate with these rivers of tangs, but all the shoreline areas near Kaloko also used to dive had significant sized schools - streams rather than rivers... then it was so depleted, it was embarrassing.

[Today], it’s healthier than it was [before the areas were protected]. At Kaloko-Honokohau, the general population is way up... the population has probably doubled, if not tripled, since the closures of the FRAs. Everything has to do with the legislation. There are missing characters, but the population overall is getting pretty close... [Today] the fish are just starting to think about getting together [in schools] again. You can see them getting together in little groups, looking at each other like, ‘I think there’s something we should be doing, but we can’t quite remember.’

The general reef fish population is doing fine now, but a lot of bottom-sitting fish have disappeared. Lionfish are nonexistent. Lizard fish, leaf scorpionfish, and the decoy scorpionfish, even in protected areas these are still in decline. Lizardfish—couple dozen per dive, now only a handful... Turtle Towers [a dive site] never was heavy with lionfish, but it might have had half a dozen. Now, there are none. [05.18.06]

Furthermore, lionfish also spotlight the cascading impacts of tropical aquarium fish collection on various components of the ecosystem, as well as on the system’s human dimensions (like other uses). Lionfish, like most rare fishes, showed persistence in their localized depletions and absences. Additionally, “the disappearance of prey items caused impacts on predators. Ulua (Jacks or crevallies), it was common to see a dozen good sized ones on any given dive. By the late ‘80s, nothing. Was it a cycle? Shoreline fishermen? Or what? I think you take their food, and they go” (05.18.06).

When “protections” went into place and zoned aquarium collection, most fish populations showed strong signs of rebounds. Of the general cast of characters, lionfish
and the rare organisms have yet to show very dramatic improvements, while butterflyfish are doing really well, tangs are improving but more slowly. More recently, both dive shop operators as well as apex predators (like ulua) have subsequently returned (05.05A.06; 05.05C.06; 05.18.06; 05.22B.06).

5.3.8 Honu (Hawaiian green sea turtle, *Chelonia mydas*)

![Figure 17: Left image, Chelonia mydas, turtle pair in Honaunau (E.L. Hazen). Right image, ‘honu’ in Honokohau harbor.](image)

5.3.8.1 Scientific description

Adult Hawaiian green sea turtles (*honu*) (Figure 17) live and feed around the MHI and migrate to nesting beaches on French Frigate Shoals in the Northwestern Hawaiian Islands. Estimates of nesting females, past and present, numbered 378 in counts between 1974-1978 (Balazs 1980), and a 1991-2000 survey found 574 females (Wetherall et al. 1998; MTSG 2004). In the relatively shallow benthic feeding grounds in throughout the Hawaiian archipelago, principally herbivorous adult honu feed on
seagrass and several species of algae, though occasionally consume invertebrates (Balazs 2000). In “isolated areas” (Balazs 1980), like Kaloko-Honokohau, turtles regularly bask on beaches. Green turtles are protected by various international treaties and agreements as well as national laws. Hunting and collection in Hawaii was prohibited in 1978 when the Hawaiian population of the green sea turtle was listed as threatened under the U.S. Endangered Species Act (NOAA Fisheries OPR 2008).

### 5.3.8.2 Ocean experts who talk about honu

Honu was the single most commonly-discussed marine organism during this research, and arose in interviews of all expertise groups. In describing historic change to honu populations and behavior, respondents’ shared highly consistent observations of steady increases to honu populations and calming of their behavior around humans over the past 30 years. To various ocean experts of the Kona Coast, the green sea turtle represents a source of food and charismatic appeal. Hawaiian people long fished turtles for subsistence, used as ornaments and tools. It was exploited heavily after the arrival of Western culture, with large harvests by non-Hawaiian people throughout the nineteenth and early twentieth centuries. Older Native Hawaiian participants remember having harvested and eaten turtles some decades ago.

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9 At the time of the green sea turtle listing, populations in different regions were given different listings, depending upon their status. While Hawaiian green turtles are listed as “threatened”, others are “endangered.”
Local people and tourists alike are drawn to the honu. The Hawaiian word ‘honu’ is one tourists commonly learn (along with ‘aloha’, ‘mahalo’, ‘da kine’) during visits to the Hawaiian Islands. Dive shop operators, divers, collectors, scientists, and Hawaiian practitioners who participated in this study recognize the turtles for their aesthetic appeal – the ‘cute’ animals are charismatic inhabitants of coral reefs and nearshore areas, popular with local people and tourists alike. Yet some, like shoreline fishermen, grumble about turtles infringing on their fishing grounds by consuming limu, competing for food and displacing nearshore fishes (e.g., nenue) desirable to fishermen. A charismatic marine megafauna, representations of honu are commonly seen in bumper stickers, tattoos, petroglyphs, tourist brochures, and signs around Kailua-town.

5.3.8.3 Observations and perceptions of honu

Amongst ocean experts there is little disagreement about historical change (35 ybp-today) in Kona’s population of honu. For several decades honu have experienced steady population increases, since harvesting (typically for keepsakes, trophies as well as subsistence) was prohibited in 1978. The population has steadily risen in number across the Kona Coast (from 0-4 per site in the 1970s to 12-18 per site in the 2000’s). In turtle sightings prior to, and through early years of protections, turtles were exceptionally skittish around humans: “you would only ever see his tail” (05.05B.06). Turtles in the past, thus, may not have only been smaller in number, but harder to count.
because of avoidance behavior. Today, up to dozens are seen daily in a short dive, fishing trip, or stroll on the beach (many, e.g., 04.05.06, 06.08.06, 04.20B.06). Multiple people report regularly counting over 18 honu near the Honokohau harbor entrance, more than a dozen in Kahalu‘u, and somewhat fewer in areas like Miloli‘i where steep drops offs are closer to shore. Since being protected, turtle behavior also has become strikingly more placid, less skittish around humans. They feed on limu close to shore in high traffic areas like Kahalu‘u, and haul out on narrow beaches like those in Kaloko. During a beachside wedding in Kaloko, one participant observed 5-6 turtles haul out behind the bride and groom during the short ceremony (04.05.06).

In 2006, honu abundance near the harbor seems to have declined slightly, which some attribute to tiger shark predation, perhaps by LaVerne (the harbor’s new resident tiger shark). While diving nearby, “one of our dive instructors saw the shark swimming with a turtle in its mouth” (05.05A.06). Said another participant, a Hawaiian shoreline fisherman, “To my thinking… they saving the turtles… maybe that’s why the shark is coming in, because turtle is shark’s food, yeah? And before, the old Hawaiians they eat all the turtles. Today cannot touch nothing [cannot hunt turtles], maybe that’s why” (05.04). It is not clear if similar reductions have occurred elsewhere on the coast. Ocean experts link the large turtle aggregations, as well as nearly open ocean aquaculture, to drawing tiger sharks into nearshore waters. Evidence of fibropapilloma is nominal
according to ocean experts on the Kona Coast; several people recall a case of one ill
turtle in Kohala, North Kona coast, outside the study area (05.05C.06).

5.3.8.4 Honu as symbols in environmental change narratives

While commonly mentioned by all groups of people in this study, honu rarely
play a prominent role in respondent’s narratives of change. In this way, they differ from
the 7 other ‘spotlight’ features in this paper. Instead, in a typical interview, respondents
mention honu in passing, as if to say, ‘everyone knows the turtles are doing much better
than 30 years ago’, then they move on to, presumably, more interesting (indicative,
telling) examples and stories of change. Given that turtle populations have steadily risen
for the past three decades, they also remain one of a few exceptions in that their
populations have consistently been improving since the 1970s.

Occasionally, honu symbolize broader ecological or socio-political issues. While
not a prominent discussion topic, a few kupuna voiced nostalgia about the taste of turtle,
onece not an uncommon component of the local diet (02.04; 01.04.06; 08.31.06).
Reinstating a subsistence harvest was not an opinion vocalized by this group of people;
rather, it came up once in conversation, but only to tease a strongly conservation-
oriented Hawaiian friend being interviewed with him (06.04). To a few shoreline
fishermen, honu are one of several factors that relate to the impinging and unintended
effects of marine regulations on shoreline fishing. See, for example, the section on nenue.
But while increases in honu are not currently a much-used symbol of change, there seems to be potential for them to become one in the future. I point to recent literature describing the successful rebound throughout the Pacific, including Hawaii, of the “once severely exploited” green sea turtle (Chaloupka et al. 2008). These findings raise interesting considerations for the honu to become a symbol in people’s environmental change narratives, as questions may start to arise about lifting certain protections such as re-introducing a subsistence harvest. We thus suggest honu exemplifies the potential for such ‘spotlight species’ to be dynamic, change over time be claimed and abandoned as symbols.

5.3 Discussion

5.3.1 Exploring ‘change’ through a multiplicity of perspectives

In a given seascape, ‘change’ is multifaceted, pervasive, complex, and ongoing. Experts describe the ocean and its components as dynamic across space (from a few meters of reef, to bays, a coastal region, and the archipelago) and time (across a day, tidal cycle, seasons, years, and decades). To the six expertise groups in Kona today, ‘ecological change’ spans watersheds to pelagic fisheries, population to ecosystem level, some 271 species, over a dozen biophysical processes, and 80 years. Furthermore, when exploring change through the observations, perceptions, and experiences of ocean experts, we tap into the ocean’s human dimensions. Given each individual’s
positionality (people are all situated in political, social, economic, historical context, per Haraway (1988)), we cannot uncouple ecological change from social context. Moreover, in the choices people make in what they develop intimate ecological knowledge about, and what topics they employ to describe change, they reveal some of their values, attitudes, and beliefs about the oceans. In these ways, we get to the nature of the dynamics of a marine social-ecological system, because, as seen through a multiplicity of perspectives, ‘ecological change’ inextricably involves the relations within and among humans, ecosystems, and institutions.

Even though most any topic can exemplify marine ecological change, it seems that a few species and biophysical processes allow us to more deeply penetrate the nature of change. Not only do they spotlight broader trends across the system, but they also seem indicate key human/environmental interactions. That is, they are keystone because they help represent the diverse and multi-layered values, attitudes and behaviors within the coastal community, as well as how these influence how people interpret, respond to, and thereby influence (affect, affected by) oceans. I chose 8 features in this paper because they each seem to spotlight key interactions within and among people, ecosystems, and marine management. Furthermore, these 8, as opposed to a few others that I might have chosen, represent the array of perspectives on this coast and carry some deeper significance to the groups of peoples’ overall stories and
experiences of change. By looking at these 8 biophysical features, I trace some of the major themes of change, and explore what accounts for change.

5.3.2 Keystone features unravel dynamics of the social-ecological system of Kona’s coral reefs

Drawing upon diverse local, traditional, and scientific narratives of ecological change reveals not only that ecological knowledge is expansive and complex, but that certain species and processes are central to the historical ecology of Kona Coast coral reefs. These biophysical features are integral to peoples’ and groups of peoples’ observations, perceptions, and explanations of ecological change – and ultimately to spotlighting the broader story of social-ecological dynamics. Though the fields of meaning surrounding each feature are quite complex, a number of themes emerged:

1. Certain features are more widely known and valued than others.

Of the several hundred ecological topics raised (271 marine species, in addition to various life stages, processes, and terrestrial species), a few features of the seascape – species and processes alike – carry symbolic roles in narratives of change. In discussing ecological change, certain topics came up again and again for specific reasons, others more rarely. Still, other features in the seascape were not discussed at all. What people know and describe in ecological change interviews indicates what they value, believe, and from what positionality they come. It also helps point to the key nodes in human/environmental relationships, or how people and oceans affect and are affected by one another. The eight features discussed herein represent many but not all of the
more important ecological topics, and roles they play in Kona’s social-ecological history – socially, ecologically, and with respect to marine management. Some of the roles they play are discussed in points 2-7 below.

(2) Not all features discussed spotlight broader trends in the SES, even those widely discussed.

Over time some features are employed as being more representative of SES change than other features, but these are also employed, transformed, and abandoned dynamically.

While widely discussed, honu are not used as an explanatory tool, and thus not particularly representative of people’s narratives of ecological change or experiences therein. Each of the other features described herein envelop the experiences of multiple people, if not groups. Honu and yellow tang exemplify how spotlight features are not static, rather people employ, transform, and abandoned spotlight features as the system itself changes and transforms. The meanings attached to yellow tang over the past 35 years have transformed from exemplifying a past user-conflict, to exemplifying more cooperative social relations today. With honu, in considering new scientific findings which may change the international, national, and local field of management of the green sea turtle, honu stands the possibility of becoming a symbol in people’s environmental change narratives.

(3) Certain features help to explain changes observed across the ecological realm.

Hawaiian lionfish represent declines across multiple rare fishes with muted to negligible improvements; yellow tang signifies similar declines but substantive
rebounds across ornamental organisms; and paku‘iku‘i and nenue exemplify widespread, persistent declines in subsistence organisms. Corals serve as a symbol of the status of both the nearshore marine environment, and as a proxy of the state of development in coastal watersheds. Through corals, and their disturbance by storm events, ocean experts trace natural variability, its cascading biological and social impacts, and how that relates to the expert knowledge of locally-living people.

(4) Certain features help to explain biophysical, anthropogenic, and synergistic disturbance (i.e., threats) to coral reefs.

Profound but ‘natural’ biophysical disturbance and processes are represented by corals and recruitment. Coral also exemplifies the potential for synergistic impacts of land use change, storms, and fishing out herbivores. Paku‘iku‘i signifies a resource subject to multiple anthropogenic stressors, as it appears to be impacted at two life stages. But this fish and nenue also illustrate how demise in cultural practices and Westernization indirectly threaten both communities (villages) and marine species which are seen as co-evolved. As explored above, the interplay of people’s perceptions surrounding yellow tang, lionfish, paku‘iku‘i, and recruitment signify synergies among all aspects of natural and anthropogenic disturbance, ecological and social change, management interventions, and the dynamics therein.

(5) Certain features help to explain social change.
Limu, for instance, signifies to ocean experts a generational decline in the cultural affinity for Hawaiian foods, and more broadly a decline in attention to, and transmission of, the Hawaiian culture in general. Enveloped in the story of nenue and limu (in addition to several other organisms like opelu (mackerel scad), akule (bigeye scad), and manō (sharks) not discussed in this paper) is a broader story of the Hawaiian people, and their now well-established inequitable experiences with economic development, post-colonial experience of cultural subversion, displacement from native lands, Westernization and globalization of cultures and economies. Yellow tang has been a dynamic spotlight feature, first as user conflicts and more recently in improved social relations between user groups, and between some groups and management.

(6) Certain features help to explain the pathways and impact of management strategies on ecological resources.

Honu evidences the success of the population “since hunting” or “subsistence fishing” was banned. Social, cultural, and institutional practices regulating use, or otherwise tempering human impacts to oceans, historically have been important elements in the people-ocean relationship, as illustrated by yellow tang, nenue, and paku‘iku‘i. Kapu and its remnant cultural practices of respecting village- and family-based rights to and responsibility over resources helped to limit collection in space and time (nenue, paku‘iku‘i). The 1980s Gentleman’s Agreement attempted to informally (through social rather than institutional means) zone uses of the coral reefs (yellow
tang). As described through pakuʻikuʻi, the presence of longtime local or Hawaiian fishing families along the coastline limits take in the immediate proximity. But the coast’s social transitions (rise in population and diversity) seem to have undermined these informal enforcement mechanisms’ efficacy. The rapid population rise, construction boom, land use change, and persistent influx of new user groups means there are more people on the coral reefs, and altogether fewer who know local rules of the sea. Centralization – away from decentralized village- or ahupuaʻa-based oversight of resources and uses – also has led to fewer otherwise knowledgeable people abiding by cultural or social mechanisms of use. Currently, the FRAs seem to be biologically effective for many (but not all) ornamental organisms (pakuʻikuʻi, Hawaiian lionfish); however, there are several important biological and social issues which may need to be addressed in the future, including the varying social impacts (pakuʻikuʻi), and the FRA’s resiliency in the face of continued land use change (corals).

(7) Certain features help to explain the impact of management on various people in local community.

Yellow tang as a symbol transforms over time to explain neighboring islander’s (those from islands other than O‘ahu, where the state capital and many state/federal agencies are located) feelings of the lack of representation; and specifically it, along with rare fishes and butterflyfishes, signifies how the perceived lack of on-island science and management impacted the diving community and industry. Later, yellow tang came to
represent, along with recruitment, the impact of management interventions (MPAs) on collectors, and this group’s conflicting feelings of moving from being the scapegoat, to an industry fighting and succeeding to survive with limitations on use, then to cooperative but still tenuous partners. Furthermore, to resource scientists and others, yellow tang now also embodies the recent coral reef research focus. Today scientists “hang their hat” on the MPA issue. Though their data on reef fishes is immense, they have been forced to focus first on yellow tang because of strong political, public and local interest.

Additional spotlights include the pakuʻikuʻi, which is often used to invoke the inequitable impact of recent management on Hawaiian practitioners and local fishermen; that is, few subsistence fishes not have improved as a result of MPAs. In addition, pakuʻikuʻi helps to explain why the community-based management efforts (WHFC) may be less satisfying to Hawaiian practitioners than the village-based movements gaining in momentum today (see also Chapters 3 & 4). In turn, many resource scientists also talk about pakuʻikuʻi, worrying about how they do not yet know the full extent of the problem with pakuʻikuʻi, how to address it, or have enough enforcement officers to ensure compliance. Additionally, although data is increasingly more plentiful on pakuʻikuʻi, and scientists earnestly express concern for these fish and subsistence resources, their few personnel thus far have been forced to respond to mandates and political pressure (ie, analyze data on political issues like yellow tang).
Certain features are widely known (or valued, experienced, perceived, utilized) across groups, while other features are known (etc.) by one or two groups.

Yellow tang exemplify a species widely known across all expertise groups, and representing substantive components of the narratives by experts in the science, resource management, conservation, and dive community. Collectors speak extensively about the processes, i.e., recruitment, surrounding yellow tang. Alternatively, limu is almost exclusively a topic of Hawaiian participants in this study, similar to nenue which is primarily discussed by Hawaiian fishers and a few divers.

Related to point 8, certain features are central to groups of peoples’ narratives of ecological change – symbols of the ‘big picture story’, rather than elements therein (i.e., points 1-8).

Expertise groups’ unique narratives can be traced through a few features: (a) tropical aquarium collectors: recruitment; (b) dive shop operators: yellow tang, Hawaiian lionfish, and coral; (c) conservation/recreational divers: yellow tang; (d) Hawaiian people paku‘iku‘i, nenue, limu; (e) fishermen: paku‘iku‘i, nenue; and (f) scientists: coral, recruitment, yellow tang. Even though most individual participant’s narratives are quite complex, the gist of each expertise groups’ story seems to invoke a few key symbols. While this is not an exhaustive list of the themes in each group’s narratives, it is meant to exemplify how different groups value and make meaningful different parts of the SES. Where group narratives do and do not overlap might seem to be revealing to the nature of their interactions.
5.3 Conclusions

The results of this paper indicate meanings and values of great complexity surround features of the seascape. In diverse ways, ocean experts come to know and make meaningful the marine environment. People harness the biophysical as intricate and unique symbols of change, and of their experiences with change. These meanings and values are dynamic historically, as they transform with the changing of social and ecological dimensions of the SES. At times peoples’ meanings are synchronous, at other times, conflicting. Across individuals and groups there may be very similar or very different meanings drawn for a particular fish or process (e.g., yellow tang is a very different symbol to the dive shop operators, scientists, and tropical aquarium fish collectors). Thus within the community, there may be many layers of complex, cooperative and/or competing ideas surrounding the SES.

Where people’s narratives converge or overlap, and where they do not, seems to be important not simply in spotlighting broader trends within and among the components of the social-ecological system. But in addition, the fields of meanings seem to indicate key nodes in human/marine environmental relationships, which is why I have called these keystone features of the SES. By identifying keystone features we can begin to articulate all the different values, attitudes, and beliefs, which are important to understanding why people behave the way they do. In sum, tracing convergence and divergence of meanings surrounding keystone features addresses many questions about
the nature of SESs. First, it appears to portray the dynamics of the social-ecological system (SES), or how people affect and are affected by the marine environment. Dynamics of change are evident in all ecological topics discussed in peopled historical ecology interviews; however, the co-evolution of the SES is far more explicit in certain biophysical features, such as the 8 explored in this paper. Second, tracing the convergence and divergence enables us to see how some people identify with the history of some features, how people’s experiences are more pronounced with certain features, and ultimately, how certain features are symbolic of people’s experience in the social-ecological system. Third, where people’s knowledge, values, and experiences converge and diverge on biophysical features appears to be a good indication of the potential for cooperation and conflict among people, and marine management. It also serves to show what is, and what is not, on the radar of marine management.

In any seascape, we suggest, certain features of the seascape – species and processes alike – are central to understanding diversity and complexity in people’s understandings, perceptions, values, of the ecosystem and ecological change. Moreover, around these features and the meanings people attach to them, the diverse people in the local community reveal how they affect and are affected by one another, the ecosystem, and marine management. In this manner, these biophysical features can be seen as keys to revealing dynamics of the SES, or what we call social-ecological keystone features. By gaining insight into keystone social-ecological features, we also gain insight into coupled
SES dynamics, and ultimately, begin to incorporate these understandings into how marine management is enacted.
Chapter 6. Conclusions
6.1 Ecological vs. social-ecological history: Insights gained from the case of Kona Coast coral reefs

In a given seascape, ‘change’ is multifaceted, pervasive, complex, and ongoing. Experts describe the ocean and its components as dynamic across space (from a few meters of reef, to bays, a coastal region, and the archipelago) and time (across a day, tidal cycle, seasons, years, and decades). To the six ocean expertise groups in Kona today, ‘ecological change’ spans watersheds to pelagic fisheries, population to ecosystem level, some 271 species, over a dozen biophysical processes, and 80 years. Furthermore, when exploring change through the observations, perceptions, and experiences of ocean experts, we see that while observations of change are surprisingly consistent across expertise groups, perceptions of change are not. This finding not insignificant scientifically, nor in its implications for managing coastal ecosystems, which confront complex ecological issues and social ones. In doing so, we tap into the ocean’s human dimensions.

Given each individual’s positionality (situated in political, social, economic, historical context, per Haraway (1988), Berkes et al. (2003), and others), we cannot uncouple ecological change from social context. Moreover, in the choices people make in what they develop ecological knowledge about, and what topics they employ to describe change, they reveal some of their values, attitudes, and beliefs about the oceans. In these ways, we get to the nature of the dynamics of a marine social-ecological system, because,
as seen through a multiplicity of perspectives, ‘ecological change’ inextricably involves the relations within and among humans, ecosystems, and institutions. To push the envelope of ‘change’ as portrayed in the marine conservation literature, and rather explore a culturally-inclusive, coupled social-ecological history, is an underlying objective of this paper.

Specifically, this dissertation contemplates the prevailing thinking in marine conservation, and considers how well-suited it is to a peopled science and management of SESs. In the historical ecology of Kona Coast coral reefs, elements of the current thinking in the coral reef and coastal conservation literature are evident – both the synergistic disturbances of overharvesting, land use change and polluted runoff, and ‘natural’ disturbance events, as well as the complex challenges that marine (conservation) management face in rapid global change. Over-fishing and over-collecting are responsible, in part, for the rather pervasive declines in coral reef organisms, as evidenced by yellow tang, lionfish, paku‘iku‘i, and possibly the nenue. Through ocean experts’ talk about corals, ocean experts reveal their concerns about the impacts of nonpoint source pollution, land use change, and synergistic disturbances. While these issues were actualized on O‘ahu reefs, in Kona their precursors seem increasingly apparent and are a source of pervasive concern across a multiplicity of perspectives. Management interventions to protect resources evidently have had biological successes, such as the honu and ornamental fishes (yellow tang), but
biological conservation challenges still remain as evidenced variously by paku‘iku‘i, lionfish, and nenue. In the backdrop to anthropogenic disturbances are ‘natural’ variabilities, such as annual recruitment intensity of recruitment and storm-induced disturbance to corals.

But the ‘current thinking’ only partially accounts for change in Kona’s reef systems. Considering humans primarily as threats to ‘pristine’ ocean condition, and sources of anthropogenic impacts, represents but one part of a more complex story, relating to the interactions of people and ecosystems. The peopled perspective adds several other dimensions to the story of change on Kona’s coral reefs, as evidenced by the diverse perceptions of and experiences with change in a single reef region, and by the various meanings attached biophysical features by some people, but not always others. The convergence and divergence in different people’s knowledge, perceptions, and meanings attached to the ecosystem seems to be fundamental to the interactions between and among people and the marine ecosystem.

Kona’s coral reefs on the local to regional scale appear to be influenced historically by the interplay between biophysical variability, anthropogenic impacts, and tenure/management practices; by changing cultural practices; by a transitional landscape towards globalization and urbanization; and by the convergence and divergence of the diverse interests of highly cross-cultural peoples interacting coral reef ecosystem
components. Here, I explore the prevailing influences on Kona’s reef SES by referencing the social-ecological keystone species.

From the ‘peopled’ perspective, biophysical variability (storms, recruitment, corals), profound disturbances (corals), and a long history or perhaps a co-evolution with humans (limu, nenue) form the ‘backdrop’ to Kona’s coral reefs’ historical ecology. That is, these three themes are accepted by Kona’s ocean experts as part of the ‘natural baseline,’ so to speak. Some of the oldest stories in this historical ecology are of social, political, and economic change as the Hawaiian Islands experienced the post-colonial process of Westernization (limu, nenue), processes which are somewhat more delayed in Kona’s rural pockets of cultural continuity, as opposed to elsewhere in the MHI. The traditional Native Hawaiian and kama’aina setting, over time has given way to a highly cross-cultural island setting, due to a transition to a globalized, urban landscape (limu, nenue, coral). Diversification of human uses and user-groups on the coral reefs ensued (yellow tang), and ecological change elsewhere in the archipelago (corals, lionfish) further catalyzed the process as ocean enthusiasts and industries came to Kona’s more ‘pristine’ reefs. Throughout Kona’s social-ecological history, formal (yellow tang, lionfish) and informal (paku’iku’i) management practices have been enacted to temper human uses of marine species and communities.

While a demise in some marine populations seems to have occurred in earlier decades (paku’iku’i), it accelerated in the 1970s (yellow tang, paku’iku’i, nenue, lionfish).
Overharvesting by tropical aquarium fish collectors (yellow tang, paku‘iku‘i, lionfish) affected suites of species, and impacts were more severe in species biologically or ecologically less resilient (lionfish). This and other forms of over-harvesting were felt more acutely in species facing a multiplicity of impacts (paku‘iku‘i, nenue). Resource conflict – and cooperation – can occur, when a single coastal system is faced with a multi-layered competing and cooperating uses of marine species and communities (e.g., the aesthetic bent of the dive community, the collection for the aquarium trade, and cultural and subsistence use by Hawaiian practitioners (yellow tang, lionfish, paku‘iku‘i)). In addition, resource declines, when compounded with natural variability (recruitment), seem to have further ignited enough local opposition to collection to pass legislation limiting it (yellow tang). Marine protected areas limiting collection, apparently coinciding with natural high point in the intensity of recruitment, appears to have bolstered many ornamental organisms (yellow tang) but not subsistence (paku‘iku‘i), or particularly rare species (lionfish).

Through these organisms, we see that not all species, nor groups of people were equally affected by management actions. In recent decades the narratives have focused on ornamental species (yellow tang, lionfish), rather than others like subsistence (limu, nenue). Recent activism and resulting management narratives have implicated aquarium fish collection (yellow tang, lionfish), but perhaps does not articulate the natural/anthropogenic synergies in ecological change, an oversimplification at the
expense of a user-group (recruitment). When ornamental organisms have multiple uses other than aquarium fish collection (paku‘iku‘i), management interventions have not succeeded. To local fishermen and Native Hawaiian practitioners especially, this has led to feeling marginalized by management, and that other people’s interests are prioritized over their own. With other species (nenue), we explore a more complex story of decline – where fishing, overuse of immediate nearshore reefs, potential freshwater intrusion from upstream development, and cascading impacts from sea turtle protections may have influenced behavior and aggregations in space and time. On a more metaphysical note, there is an element of self-blame, relating to slow loss of cultural practices meant to nurture the relationship between fish and fishermen, and the balance of the universe (nenue). Other topics (limu, nenue, paku‘iku‘i) shed light on the importance of traditional foods to Native Hawaiian people and culture, the depth of relationship between Hawaiian culture and the oceans, and that for various economic and cultural reasons, many traditional foods and practices are not being transmitted to younger generations.

Finally, the importance of the place-based knowledge of locally living people, whether indigenous, local, or scientific, is seen throughout Kona’s history (yellow tang, corals, nenue). Ocean experts are central characters in the SES, not only in observing knowledge and practices surrounding the seascape, but also in shaping the course of ecological, social, and institutional history. Because science and management were long
absent, and because locally-living people first observed and brought attention to pervasive coral reef fish declines, the authority of local people has been solidified in management (yellow tang). Elements of this assertion continues today in discussing current land use change, the lack of baseline scientific data on reef and watershed condition, and development’s potential impacts to the marine environment (corals).

6.2 Next steps: The marine social-ecological history of Kona Coast coral reefs

In this dissertation I have taken a ‘peopled’ approach to marine historical ecology and explored the social-ecological history of Kona Coast coral reefs. Empirically, I traced (1) the human seascape through knowledge and power relations of ocean experts, (2) the biophysical seascape through trends in abundance and distribution of eight social-ecological guilds, and (3) the coupled social-ecological seascape through the values and meanings attached to eight keystone social-ecological features. Each of these three topics is integral to, but does not fully encompass, the broader story of Kona’s social-ecological history.

The next steps in this research will be to address a few additional topics, and finally to weave these together. Next steps include exploring: (1) The history of management and enforcement, including traditional, informal, and formal regimes, past and present. (2) ‘Natural’ disturbance and biophysical processes, including tsunami, storms, disease, and recruitment. (3) Heterogeneity within the region, based on the six
study sites. (4) Expert’s overall narratives of ecological change, particularly focusing on differences within expertise groups. (5) Kama‘aina fishermen, as well as other possible ‘hidden’ expertise groups. (6) Testing the principles of SES dynamics.

6.3 Towards interdisciplinary approaches in marine science and management

These findings have several implications for the fields of marine ecosystem-based management, marine historical ecology, and resilience thinking. It concurs with the thinking that suggests coastal communities, and perspectives therein, are quite complex, including the kinds of ocean ecological knowledge that exist. In working with ocean experts, it is apparent that these may be natural stakeholders to include in historical ecology research and in the management processes. From a multiplicity of perspectives, the story of change is broader and richer in detail than from any one alone. ‘Ecological change’ is described across suites of organisms, which I have called social-ecological guilds, and also includes insights into how the ecosystem, social relations, and management institutions affect, and are affected by, one another. Through social-ecological keystone features these processes are especially evident.

Additionally, from findings herein, it appears that whether or not, and why, ocean expertise groups participate in management may be important information regarding power dynamics within the community and with management. Different levels of stakeholder participation may indicate ecological change that may be otherwise
unknown; as well as cultural and other reasons why some participatory strategies work for various people and not others. Findings herein, regarding the various biological and social responses to MPAs and CBM strategies, show that ecological and social successes of management might be evident, but given the complexity of ocean and coastal issues, MPAs and CBM may not be the only tools necessary to manage a coastal SES. Thus, based on findings on human, biophysical, and coupled social-ecological dimensions of the seascape, and historical social-ecological change, this dissertation evidences the importance of ‘peopled’ approaches to understanding and managing ‘sea change’.
Appendix 1

Catalogue of examples of organisms in each social-ecological guild. Organisms are alphabetized by the name most commonly used (Hawaiian, common, or scientific). If the Hawaiian name was not used, it is not included in this list.

<table>
<thead>
<tr>
<th>Hawaiian name</th>
<th>Common name</th>
<th>Scientific name</th>
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<tbody>
<tr>
<td><strong>SUBSISTENCE ORGANISMS</strong></td>
<td></td>
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</tr>
<tr>
<td>A`ama</td>
<td>Rock crab</td>
<td><em>Grapsus tenuicrustatus</em></td>
</tr>
<tr>
<td>Ahi</td>
<td>Yellowfin tuna</td>
<td><em>Thunnus albacares</em></td>
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<tr>
<td>Aku</td>
<td>Bluefin tuna</td>
<td><em>Thunnus thynnus</em></td>
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<tr>
<td>Akule</td>
<td>Bigeye scad</td>
<td><em>Sedar crumenophthalmus</em></td>
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<tr>
<td>Kala</td>
<td>Hawaiian dascyllus</td>
<td><em>Dascyllus albisella</em></td>
</tr>
<tr>
<td>Maiko</td>
<td>Lobster – spiny lobster!</td>
<td><em>Scyllarides squamosus, e.g.</em></td>
</tr>
<tr>
<td>Manini</td>
<td>Blueline surgeonfish</td>
<td><em>Acanthurus nigricans</em></td>
</tr>
<tr>
<td>Ohua</td>
<td>Convict tang (adult)</td>
<td><em>Acanthurus triostegus</em></td>
</tr>
<tr>
<td>Ophihi</td>
<td>Convict tang (recruit)</td>
<td><em>Acanthurus triostegus</em></td>
</tr>
<tr>
<td>Paku’i’i</td>
<td>Achilles tang</td>
<td><em>Acanthurus Achilus</em></td>
</tr>
<tr>
<td>Paku’i’i</td>
<td>Octopus</td>
<td><em>Octopus sp.</em></td>
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<tr>
<td>Umaumalei</td>
<td>Parrotfish</td>
<td><em>Serrus sp.</em></td>
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<thead>
<tr>
<th>Hawaiian name</th>
<th>Common name</th>
<th>Scientific name</th>
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</thead>
<tbody>
<tr>
<td><strong>ORNAMENTAL ORGANISMS</strong></td>
<td></td>
<td></td>
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<tr>
<td>Ornamental organisms (general)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bandit angelfish</td>
<td><em>Desmoholacanthus arcanatus</em></td>
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<tr>
<td>Chevron tang</td>
<td><em>Cheilodactylus hawaiensis</em></td>
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<tr>
<td>Flame angelfish</td>
<td><em>Centropyge loricaus</em></td>
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<tr>
<td>Lau'ipala</td>
<td>Yellow tang</td>
<td><em>Zebrasoma flaresens</em></td>
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<tr>
<td>Kole</td>
<td>Goldring surgeonfish</td>
<td><em>Cheilodactylus strigosus</em></td>
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<tr>
<td>Orangespot surgeonfish</td>
<td><em>Acanthurus olivaceus</em></td>
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<tr>
<td>Pearl wrasse</td>
<td><em>Acanthoceras ceuen</em></td>
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<tr>
<td>Ringtail surgeonfish</td>
<td><em>Acanthurus blochii</em></td>
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<tr>
<td>Psychadellic wrasse</td>
<td><em>Acanthoceras chrysocephalus</em></td>
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<tr>
<td>Razor wrasse</td>
<td><em>Xyrichtys pavo</em></td>
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<tr>
<td>Redstripe/Baldwin’s pipefish</td>
<td><em>Dunckerocampus baldwinii</em></td>
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<tr>
<td>Yellowtail coris</td>
<td><em>Coris gaimard</em></td>
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</table>

Ornamentals (Rare species) | | |
<p>| Decoy scorpionfish | <em>Scorpaenidae sp.</em> |
| Dragon moray eel | <em>Etmelophare pardalis</em> |
| Hawaiian lionfish | <em>Dendrochirus barberi</em> |
| Leafish | <em>Taenianotus tricanthus</em> |
| Potter’s Angelfish | <em>Centropyge potteri</em> |
| Reticulated cowrie | <em>Cypraea maculifera</em> |
| Tiger cowrie | <em>Cypraea tigris</em> |</p>
<table>
<thead>
<tr>
<th>Ornamentals (Butterflyfishes)</th>
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<tbody>
<tr>
<td>Tinker’s butterflyfish</td>
<td>Chaetodon tinkeri</td>
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<tr>
<td>Bluestripe butterflyfish</td>
<td>Chaetodon fremblii</td>
</tr>
<tr>
<td>Blacklip butterflyfish</td>
<td>Chaetodon kleinii</td>
</tr>
<tr>
<td>Fourspot butterflyfish</td>
<td>Chaetodon quadrimaculatus</td>
</tr>
<tr>
<td>Lined butterflyfish</td>
<td>Chaetodon lineolatus</td>
</tr>
<tr>
<td>Longnose butterflyfish</td>
<td>Forcipiger longirostris</td>
</tr>
<tr>
<td>Milletseed butterflyfish</td>
<td>Chaetodon militaris</td>
</tr>
<tr>
<td>Ornate butterflyfish</td>
<td>Chaetodon ornatissimus</td>
</tr>
<tr>
<td>Oval butterflyfish</td>
<td>Chaetodon lunulatus</td>
</tr>
<tr>
<td>Pyramid butterflyfish</td>
<td>Hemitarichthys polypsis</td>
</tr>
<tr>
<td>Raccoon butterfly</td>
<td>Chaetodon lunula</td>
</tr>
<tr>
<td>Reticulated butterflyfish</td>
<td>Chaetodon reticulatus</td>
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<tr>
<td>Saddleback butterflyfish</td>
<td>Chaetodon ephippium</td>
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<tr>
<td>Teardrop butterflyfish</td>
<td>Chaetodon unimaculatus</td>
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<tr>
<td>Threadfin butterflyfish</td>
<td>Chaetodon auriga</td>
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**PREDATORS**

<table>
<thead>
<tr>
<th>Predators (Invasives)</th>
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<tbody>
<tr>
<td>Roi</td>
<td>Peacock grouper</td>
</tr>
<tr>
<td>Ta’ape</td>
<td>Bluestripe snapper</td>
</tr>
</tbody>
</table>

**Predators (Shark)**

| Mano                                          | Tiger shark                   |

**Predators (Eel/Reefsharks)**

| Mano                                          | White tipped reef shark       |
| Puhi                                          | Yellow margin moray           |
| Puhi                                          | White mouth moray             |
| Weke                                          | Yellowfin goatfish            |
| Weke                                          | Yellowstripe goatfish         |

**Predators (Ulua & native piscivores)**

| Kahala                                        | Amberjack                     |
| Moano                                         | Multibar goatfish             |
| ‘Omilu                                        | Bluelfin trevally              |
| Ulua                                          | Jack                          |

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References


Christie, P. 2004. MPAs as biological successes and social failures in Southeast Asia. 155-164 in J. B. Shipley, editor. Aquatic protected areas as fisheries management tools: design, use, and evaluation of these fully protected areas. American Fisheries Society, Bethesda, Maryland.


DAR (Division of Aquatic Resources, Hawaii Department of Land and Natural Resources). 2004. A report on the findings and recommendations of effectiveness of the West Hawaii Regional Fishery Management Area. *Report to the twenty-third legislature regular session of 2005, in response to Hawaii revised statues (188F-5).*


Krupnik, I., and D. Jolly. 2002. The Earth is faster now: indigenous observation on Arctic environmental change. Arcus, Fairbanks, Alaska, USA.


Williams, I. D., W. J. Walsh, A. Miyasaka, & A. M. Friedlander. 2006. Effects of rotational closure on coral reef fishes in Waikiki-Diamond Head Fishery Management Area, Oahu, Hawaii. Marine Ecology Progress Series 310: 139-149.


Biography, Janna M. Shackeroff

Education

PhD Candidate, Marine Sciences and Conservation (2003-April 2008, expected)
Duke University Marine Laboratory, Nicholas School of the Environment & Earth Sciences, Beaufort, NC. Advisors: Larry B. Crowder & Lisa M. Campbell
Thesis: Historical ecology and human dimensions of Hawaiian coral reef ecosystems: Towards ‘peopled’ approaches to marine science and ecosystem-based management

BA, Earth & Environmental Sciences, Phi Beta Kappa (2001)
Wesleyan University, Middletown, Connecticut
Highest academic achievement in graduating class in Natural Sciences & Mathematics
School for International Training, Natural/Cultural Ecology, Queensland, Australia (1999)

Professional Experience (Abbreviated)

Fisheries and Coastal Anthropologist and Geographer
Impact Assessment, Inc., Honolulu and Hilo, Hawaii (2004-present)

Coastal Programs Analyst

Honors, Awards, & Grants (Abbreviated)

• National Science Foundation Scientists in Schools, K-12 Teaching Fellow (2004-2005)
• Marine Conservation Biology Institute, Mia Tegner Memorial Research Grant in Historical Ecology (2004)
• Oak Foundation Graduate Student Research Fellowship (2004)
• California Assn. of Community Colleges, Statewide 1st Place News Article (2002)
• Wesleyan University Mary & John Sease Fund, awarded to the graduate with the highest academic achievement in graduating class in the Natural Sciences & Mathematics (2001)
• Wesleyan University Pearce Prize for highest academic achievement in graduating class in the Earth & Environmental Sciences (2001)
• Phi Beta Kappa, awarded ‘Junior PBK’ as one of top 10 scholars in Class of 2001 (2000)
• Collegiate Water Polo Association, Academic All-American (2000, 2001)

Publications (Abbreviated)
