Bycatch of Olive Ridley Turtles (Lepidochelys Olivacea) in Bay of Bengal Fisheries

Abstract

The bycatch of olive ridley turtles in the Bay of Bengal has yet to be systematically quantified. The existing quantitative estimates and assessments indicate that bycatch rates are high, particularly in areas occupied by breeding aggregations associated with mass-nesting beaches in the state of Orissa, on the east coast of India. Three of the seven mass-nesting sites around the world occur in Orissa; hence these locations are critical habitat for the Bay of Bengal breeding population and the species as a whole. Bycatch in these areas tends to kill breeding adults, particularly gravid females migrating between mating aggregations and nesting beaches. Mass-nesting events, also called arribadas, involve tens- to hundreds- of thousands of nesting females. Bycatch rates over a season have been calculated to be as high as ten thousand individuals or more, a significant proportion of which have been adult females (Gopi et al, 2006). Thus, the bycatch of this population constitutes a significant threat to their numbers and genetic diversity.

Quantitative assessment of olive ridley bycatch mortality in the Bay of Bengal has thus far been limited to isolated data collection efforts and estimates. This study outlines the need for quantitative bycatch data of this breeding population over time, in terms of numbers, life stages, gender, and nesting populations. It assesses the extent to which the above information, so critical to the conservation management of this population, is simply not available. To address the lack of quantitative data, an expert opinion survey has been administered to people working either in fisheries or in olive ridley research, conservation, and management. The survey gauges knowledge and opinions of bycatch and appropriate conservation measures. Based on quantitative assessment where feasible, identification of data gaps, and qualitative information, this study makes recommendations for systematic fisheries bycatch data collection and monitoring, and suggests related conservation measures.

Background

Lepidochelys olivacea Natural History

I chose to study olive ridleys in the Bay of Bengal because of their evolutionary significance and ecological interest. The commonly accepted biogeographical history of this species holds that the original population was separated by the formation of the Isthmus of Panama, three million years ago. The population in the then newly-formed Atlantic Ocean basin evolved into a separate species,

Lepidochelys kempii (Kemp's ridley). A subset of the population in the Eastern Pacific eventually migrated into the region of the Indian Ocean today known as the Bay of Bengal. Olive ridleys elsewhere in the Indo-Pacific Ocean basin died out, leaving the Bay of Bengal population as the sole breeding population of the species. Members of this population migrated and diversified over time, forming genetically distinct populations throughout the Indo-Pacific, as well as the Atlantic via the Cape of Good Hope. The Bay of Bengal breeding population thus represents the ancestral population of extant *L. olivacea* (Avise, 2003).

Olive ridleys are ecologically diverse in their mating and nesting behavior. As with all other turtle species, olive ridleys engage in solitary nesting. Genus *Lepidochelys* (olive and Kemp's ridleys) are the only testudines to also engage in mass nesting. Mass nesting events, also known as *arribadas*, are characterized by the congregation of hundreds to hundreds-of-thousands of females at a nesting beach. Arribada nesting sites are long stretches of sandy beach that typically experience yearly shifts due to currents and tidal action. These processes clean the beach of bacterial build-up from rotting clutch sites and scattered eggs, enabling an environment conducive to the following year's nesting season. Three of the world's seven olive ridley mass nesting sites occur along the Bay of Bengal, in the state of Orissa on the east coast of India. Each of these sites occurs at or near a river mouth, suggesting the ecological functions of the associated water flow.

Mating aggregations form offshore from the arribada beaches prior to and during nesting season. This mating strategy contrasts with the solitary mating behavior typically exhibited by turtles. This alternate breeding strategy has been found to cause significant increase in the frequency and level of multiple paternity among hatchling clutches in Eastern Pacific populations (Jensen et al, 2006). Clutches with multiple paternity tend to be more genetically diverse; thus a breeding strategy conducive to multiple paternity will support a more genetically diverse population. Genetic diversity may make a population ecologically robust in terms of its ability to adapt to different environmental and ecological conditions, such as changes in nesting site or food availability. Researchers at the Indian Institute of Science and I have undertaken a study to investigate the relationship between mass nesting and multiple paternity in the Bay of Bengal breeding population.

As described above, the Bay of Bengal breeding population, and in particular the arribada nesting populations, are important to the species in terms of evolutionary significance, abundance, proportion of global mass nesting sites, and genetic diversity. The population has been historically abundant, indicating both its fitness and the conduciveness of the natural environment in which it has persisted for close to three million years. Despite the favorable natural environment and their adaptation to it, olive ridleys in the Bay of Bengal now face drastic levels of mortality from fisheries bycatch. The mass mating and nesting behavior that makes so much evolutionary sense, having the apparent function of overwhelming natural predators (Plotkin, 2004), is foiled by commercial fisheries that corral and discard them as bycatch.

Conservation and Fisheries Policy

Approximately one million people in India work in marine fishing. The total marine fishing fleet consists of 233,500 vessels, of which 47,000 are fully mechanized, 36,500 are traditional craft outfitted with outboard motors, and 150,000 are traditional non-motorized boats. The fleet has an annual expenditure of roughly 72 million fishing hours. Total spending nationally is estimated at Rs 180 billion (~$4 billion). The value of the industry is estimated to be Rs 300 billion (~$6.75 billion), of which Rs 100 billion (~$2.225 billion) is wholesale and Rs 200 billion (~$4.45 billion) is retail value (Rajagopalan et al, 2006).

The region covered in this study includes the eastern coastal states of Orissa, Andhra Pradesh, and Tamil Nadu. Reliable estimates are not available for the number of people employed in marine fishing in each of these states. In the state of Orissa there are 16.4 traditional and 4.17 mechanized craft per kilometer of coastline (Rajagopalan et al, 2006). The marine fishing fleet has a total of 14,863 vessels, consisting of 1,472 mechanized, 3,814 motorized traditional, and 9,577 traditional non-motorized boats. Fishing fleet sizes are not provided for the states of Andhra Pradesh and Tamil Nadu. Craft densities are 29.09 traditional and 2.18 mechanized per coastline kilometer in Andhra Pradesh, and 37.29 traditional and 7.37 mechanized per coastline kilometer in Tamil Nadu. The government of Orissa manages a subsidy program promoting mechanization in a drive to increase fish catches and fisher incomes (Orissa.gov.in/fisheries). It is important to note, however, that with the growth of the fishing sector, and the transition to mechanization, the average annual catch per fisher decreased by 50% in the latter half of the past century. Fishing efforts are now considerably greater than maximum sustainable yields. Overfishing threatens the viability of valued species and marine ecosystems (Rajagopalan et al, 2006).

Of the ten continental maritime states surveyed (all of coastal mainland India), seven, including the three included in this study, have significantly greater traditional than mechanized fleets. The exceptions are: West Bengal, the northernmost of the four eastern coastal states, with approximately equal numbers of traditional and mechanized craft; Maharashtra, and Gujarat, both on the western coast, with approximately twice as many mechanized as traditional craft (Rajagopalan et al, 2006). In order to understand these numbers in the context of sea turtle bycatch and conservation, it is important to keep in mind that the capacity of mechanized craft to capture both targeted and non-targeted catch is far greater than that of traditional craft. In addition, traditional craft that have been motorized have greater capacity to traverse fishing grounds and to haul catch than non-motorized boats. Although they currently constitute a minority of traditional craft, they are included in this category. Thus, when considering the impacts of mechanized fisheries on sea turtle populations, as well as on fish populations and by extension, on traditional fishing villages, we

must remember that each mechanized craft counted in a state's fleet represents a much greater volume, depending on its size, of catch and bycatch than does each corresponding traditional vessel. Likewise, each motorized traditional craft is responsible for a higher volume of catch and bycatch than a corresponding non-motorized vessel. A quantified analysis of the catch and bycatch capacities of the different size-classes of mechanized boats, of motorized traditional boats, and of non-motorized boats should be a priority in developing intelligent fisheries regulations and compliance strategies in the fleets of Indian states on the Bay of Bengal.

The problem of olive ridley bycatch in the Bay of Bengal is multi-faceted. Bycatch mortality, particularly in large numbers and frequently of gravid females, is the root matter. The problem is further defined by difficulties in compliance with and implementation of fisheries and protected species regulations. There exist several codes mandating adherence to fishing zones and seasons, the use of turtle excluder devices (TED's), and other aspects of protection for marine turtles and their habitats. Likewise, a variety of agencies hold jurisdiction and responsibility for the protection of marine turtles in Indian waters, and/or compliance with fisheries regulations. These agencies include the federal Departments of Forestry, of Wildlife Protection and of Fisheries; the Fisheries Survey of India; state Departments of Wildlife and Fisheries, and local governments.

While many laws exist pertaining to sea turtle conservation, beginning with the 1972 Wildlife Protection Act of India, more often than not they exist only on paper. There is often jurisdictional overlap among agencies mandated to enforce particular regulations. Multiple regulations, each corresponding to a particular agency, may target the same issue, population or geographical area. Multiple agencies may therefore argue over jurisdiction; each responsible agency may claim that enforcement belongs entirely to an agency other than their own, or they may all claim total jurisdiction. In either scenario, the result is often a complete lack of enforcement of any applicable protections.

A more basic problem of compliance is the fact that the majority of conservation regulations are underfunded mandates. Regulations cannot feasibly be enforced if patrols are inadequate or nonexistent. Lack of funding is particularly problematic in on-water enforcement of fisheries regulations. Fishing zones have been established to protect olive ridley nesting populations, prohibiting or restricting fishing activities close to shore. The mass-nesting populations in Orissa are theoretically protected by a complex of fishing zones designed to eliminate bycatch-associated fishing activities during times when olive ridleys may be present. All mechanized and commercial fishing vessels must however travel through the restricted fishing zones in order to reach their fishing grounds in deeper waters.

Since the mid-20th century, commercial operations working for the regional, national, and international seafood markets have fished in olive ridley habitat without effective oversight or restriction. Throughout this time, international agencies have promoted

fisheries mechanization and globalization. From the 1950s to the 1970s, federal and state governments promoted a legal fishery targeting sea turtles. A significant illegal trade persisted for a decade following federal protection of sea turtles. Concurrent to the decline of targeted sea turtle fishing, incidental capture of sea turtles greatly increased due to technological developments and market demand in fisheries. Between 1950 and 2000, marine fish production increased nationally from 0.54 million to 2.8 million tons, and exports increased from 19,700 to 380,000 tons (Rajagopalan et al, 2006). These numbers describe an increase of more than 400% in overall fish production, and a dramatic shift from domestic to large-scale export production. Much of this shift can be attributed to the aggressive growth of the export shrimp fishery. No other fishery in India is more lethal to olive ridley breeding populations and other marine turtles. In addition to generating high levels of bycatch mortality, this industry has been a driving force behind the mechanization of India's fisheries. Since 1980, the number of trawl nets has increased by 969%; the use of other mechanized gear, such as purse seins and drift gill nets, have increased by 411% and 610%, respectively, while the use of traditional gear has declined by smaller percentages (Rajagopalan et al, 2006). Over the past few decades, the expansion of commercial fisheries has resulted in massive mortality of olive ridleys, particularly in the vicinity of arribada breeding grounds and nesting beaches. The best estimates place mortality levels as high as 150,000 animals during the course of an abundant nesting season (Gopi et al, 2006). The most accurate recent estimate of population size was calculated for the 1998-1999 nesting season, determining that there were approximately 180,000 nesters (Shanker et al, 2004). This would indicate an adult population of approximately 360,000. It should be considered that gravid females are disproportionately targeted by fisheries bycatch near nesting sites, due to their migrations between offshore aggregations and nesting beaches.

Clearly, such levels of mortality cannot be sustained. Olive ridleys are considered to be the most abundant marine turtle species, and as such enjoy lower levels of international conservation protection. It would be a mistake not to afford them the protection they need to avoid falling into the critical conservation status that defines other marine turtle species or populations. Measures should be implemented presently to sustain a relatively healthy population of olive ridleys in the Bay of Bengal using limited financial resources.

The greatest amount of legislative protection afforded olive ridleys occurs in the state of Orissa, where all three arribada sites are located. The population densities and numbers are far higher here than elsewhere in India or the Bay of Bengal. Each of the three *arribada* nesting sites for olive ridleys has protected habitat designation. The northernmost site, Gahirmatha, was declared a marine wildlife refuge in 1997. It abuts Bhitarkanika National Park on the Orissa coast. Fishing has been restricted at Gahirmatha since 1994. Since then all fishing has been banned within five kilometers from shore; vessels with engines over ten horsepower are banned within ten kilometers. At Devi and Rushikulya, between January and May fishing boats with engines of more than ten

horsepower are banned within 20 km of shore in sensitive habitat areas, and smaller craft are banned within 5 km of shore. Vessels with engines over ten horsepower are banned within 5 km of shore year-round.

In the Bay of Bengal, large and mid-size commercial trawlers operate for the international and regional shrimp markets. Small motorized craft trawl for local markets and personal consumption. Subsistence fishers typically use non-motorized indigenous craft and kati nets. There is no bycatch associated with kati net shrimping or fishing. These craft have nevertheless been covered by the 5 km complete fishing ban at Gahirmatha. This restriction raises a safety concern for local subsistence fishers.

During mating and nesting season in particular, as well as throughout the year, olive ridleys and other species are susceptible to bycatch mortality in trawl, gillnet, seabass net, and stingray net fishing operations. Additional threats to olive ridleys at their nesting and nearshore habitat include offshore oil drilling and related onshore development, development of new ports and expansion of existing ports, in part to support commercial shrimp trawling, military operations and development, and other coastal development. These factors compound the challenges to olive ridley conservation.

Fishing operations disregard coastal and fishing regulations for a variety of reasons. State and federal entities have granted military and port operations exemptions from compliance with environmental laws, setting a poor example for all levels of the fishing industry. Enforcement of fishing regulations has been grossly inadequate. In addition, federal and international interpretation of court rulings on fishing regulations, such as in the WTO shrimp-trawling case cited below, has prevented the implementation of practical solutions that would comply with sea turtle conservation regulations and remain profitable.

Primary policy challenges consist of ensuring effective sea turtle conservation and fair implementation of conservation and fishing regulations. The Orissa Marine Fisheries Regulation Act (OMFRA) was first drafted in 1982. Since then, subsistence fishing activity has been unnecessarily impacted by regulations meant to reduce bycatch. In recent years, coalitions of conservation and local fishing interests have begun working together to address inequities in legislation and its implementation. As a result, non-motorized craft have been exempted from restriction at Devi and Rushikulya. Groups such as the Orissa Marine Resources Conservation Consortium (OMRCC) are working for the enforcement of apt regulations such as vessel size restrictions and anti-poaching laws. OMRCC also petitions the state and federal governments to either provide adequate patrolling of protected waters or eliminate ‘free passage’ zones, in which boats may travel within protected habitat as long as they do not engage in extractive activities. Protected habitat includes both nearshore areas where no fishing is allowed and areas where only small craft may legally operate. Free passage is regularly violated by fishing vessels on the way to and from the fishing zones designated for vessels of their size.

A point of contention amongst all fishers is the regular exemption of military activity and port development from environmental regulations. An area of habitat including the Wheeler Islands and surrounding waters, originally designated as part of the wildlife sanctuary at Gahirmatha, was excluded from the sanctuary to allow the Defence Research Organisation to conduct missile testing. A new port is now under construction in the excluded habitat area, only 7 km from the nesting beach at Gahirmatha. The proximity of the port to critical nesting habitat violates habitat protection laws and environmental quality. In addition to high-profile exemptions from conservation law, numerous violations of protected habitat status, such as illegal road building and shrimp farming, occur on a regular basis. These activities raze ecologically important mangrove swamps and destroy nesting habitat. They have a demoralizing effect on fishers, who are legally bound by conservation standards not adhered to by the industries with which they are in competition for resources. Increasingly, fishers find themselves at a policy disadvantage, working in a natural environment depleted by competing industries, as well as by overfishing. These impacts are felt most strongly by small-scale and subsistence fishers.

The above fishing restrictions in nearshore olive ridley habitat zones apply only to mass-nesting sites and surrounding habitat. Olive ridleys and other marine turtles enjoy little official habitat protection outside of the mass nesting sites in Orissa. On the eastern coast of India, olive ridleys nest on a solitary basis in the states of Tamil Nadu and Andhra Pradesh, as well as Orissa. Communities local to nesting beaches protect nesting sites on a volunteer basis. Several villages along the coast, including those near arribada beaches, have developed community centers and education programs out of an interest in olive ridley conservation. The protection afforded olive ridleys by community programs encompass only the nesting beaches, not the adjacent waters. In-water protection of sea turtles outside of the above-described arribada zones occurs solely on the initiative of conscientious fishers. Subsistence fishers cite the importance of checking their nets regularly, removing floating debris, and freeing turtles trapped in discarded nets as individual actions that benefit turtles in their fishing grounds. Community protection measures include monitoring the beaches during nesting season, marking nests and making turtle and nest counts, and performing nest excavations and hatchling counts upon emergence.

Protection from wild and domestic predators is a high priority at nesting sites along the length of the coast. In some communities, nests are removed to an enclosed area on the beach to protect them from human poachers and dogs. Poachers usually come from villages a few kilometers inland of the beach, rather than from the fishing villages themselves. Upon nest emergence, hatchlings are likely to be beset upon by crows, who often pursue hatchlings into the surf.

Community programs usually engage in both direct conservation and education, particularly for children. Conservation organizations, such as the Tree Foundation, have assisted coastal communities in integrating sea turtle conservation into their

school curriculums. As not all communities have schools, conservation programs have also served as a catalyst for establishing educational curriculum and resources. Sea-turtle related programs and activities undertaken by community organizations range from art projects to science education to festivals and parades. Such grassroots conservation efforts benefit the communities and reinforce awareness of the mutual interests of olive ridleys and coastal dwellers.

Relevant Legal Mandates and Legislative History

The legal mandates related to sea turtle conservation and fishing regulations fall into the following categories: species protection, habitat protection, fisheries management regulations, gear regulations, and regulations regarding coastal development and activities. Legislation and agreements exist at the state, national and international levels.

In 1977, sea turtles were protected under the Indian Wild Life Protection Act (WLPA) of 1972. The act grants varying degrees of protection to all recognized wildlife species, dependent upon their population status. Olive ridleys are fully protected under Schedule One of the Act as an endangered species. Although the Act prohibits activities that are considered directly harmful to sea turtles, it does not in its original form provide for habitat protection. This oversight has created a loophole through which development and oil drilling activities harmful to sea turtles have continued unregulated by WLPA. The establishment of the Gahirmatha Marine Sanctuary in 1997 under section 26(1)(b) of WLPA has provided habitat protection in territorial waters and coastal ecosystems, including nesting beaches.

Sea turtles are internationally protected under the Convention on International Trade in Endangered Species (CITES). This prevents their trade, take, or use except for permitted scientific, conservation, and rescue/rehabilitation activities. As an international agreement, CITES applies only to signatory countries, of which India is one. Olive ridleys have also been placed on the related International Union for the Conservation of Nature (IUCN) Red List of endangered species since 1990. This listing gives priority internationally to their immediate population and habitat conservation.

Prior to official establishment of the Gahirmatha Marine Sanctuary in 1997, habitat protection measures prohibiting fishing in the area were implemented under the Orissa Marine Fisheries Regulation Act (OMFRA). The OMFRA was amended in 1997 to prohibit trawl fishing at Devi and Rushikulya within 20 km of shore between January and May. In 2003, the Orissa State High Power Committee issued a recommendation to the government of Orissa to consider establishing wildlife sanctuaries at Devi and Rushikulya. Sanctuary designation would grant year-round protection to these sites. Thus far each location enjoys only seasonal protection from trawling, seasonal protection from all fishing within 5 km of shore, and seasonal protection from large fishing

vessels within 20 km of shore. The federal Environment Protection Act (EPA) was established in 1986. Under the EPA, the Ministry of Environment and Forests (MoEF) oversees zoning regulations and development proposals on public lands and in areas containing federally protected species and habitat. The MoEF reviews the Coastal Zone Regulation (abbreviated as CRZ), first established under the EPA in 1991, which oversees environmental assessments for coastal projects.

Judiciary bodies may issue new orders related to an area of legislation already on the books. The Central Empowered Committee (CEC) of the Indian Supreme Court is the federal equivalent of the State High Power Committee (HPC). In 2003, when the HPC recommended that Rushikulya and Devi be considered for wildlife sanctuaries, the CEC issued interim sea turtle conservation orders in these areas. Later that year the HPC prohibited trawling and gill-netting in the river mouths of the three *arribada* nesting sites (Dhamra River at Gahirmatha, Devi River, and Rushikulya River).

The OMFRA is the sole legislation describing fishing management regulations. OMFRA is state legislation, first instituted as an Act in 1982, with corresponding rules first issued in 1983. Although Gahirmatha is a wildlife sanctuary under the federal WLPA, fishing regulations are issued under the state OMFRA. The seasonal prohibition on trawlers is issued annually; the fishing ban at Gahirmatha is issued biennially. There are no fishing management regulations at other areas of the coast.

The OMFRA mandates fisheries management and fishing gear. A 1997 OMFRA ruling required the use of Turtle Excluder Devices (TEDs) on all shrimp trawlers in the waters off of Orissa. In 2001 the OMFRA mandated that all mechanized fishing vessels use TEDs. Depending on interpretation, 'mechanized' does not necessarily apply only to *motorized* craft. Thus, the requirement to use TED's has been extended to non-motorized small-craft fishers, including those using kati nets, to which TED's cannot be attached.

The incongruity of this requirement is made clear by observing the fishing craft, gear and methods of small-scale non-motorized fishers. The fishers keep their canoe-like vessels on the beach. These boats range in size from approximately12-30 feet, bow-to-stern. The fishers use both mono- and multi-filament nets, often storing their nets in the boats. There exists a general consensus that, although a bycatch risk, mono-filament nets are safer for turtles and require less frequent net-checks. Consequently, most fishers are transitioning their gear, replacing worn multi- with mono-filament nets. Local turtle protection and environmental education organizations promote the use of mono- over multi-filament nets. Data from other fisheries suggest that monofilament nets are safer than multifilament nets in terms of marine turtle bycatch (Wallace et al, 2009). This is one data category among many that would be highly useful in quantifying impacts to olive ridleys in this fishery.

Kati nets are used only by traditional subsistence fishers. By virtue of their design, they present no threat to sea turtles. They are made from woven cloth or plastic attached to a wooden frame, and do not become tangled. The openings in the fabric of the nets are too small to trap a turtle of any size.

The fishers remain close to shore while fishing, usually within 2-3 km from shore, and not farther than 6 km out. They report that they check their nets within 1 to 6 hours, depending on the individual, weather, and net type. They report finding turtles in their nets from time to time, in which case they simply free the turtle from the net. Occasionally they find a turtle who has died in the net. This usually occurs when the net has been set for three hours or longer without being checked, and most often when a multifilament net has been used. The fishers do not fish at the river mouth, which is where they most often observe sea turtles. The fishers explain that the turtles like to come into the river mouths to rest in the calm water. On two occasions during the same day, I observed an adult or sub-adult olive ridley swimming in an inlet at the beach, near the mouth of the Rushikulya River.

Human Ecology

The human ecology of the issues relating to sea turtle conservation in the Bay of Bengal is comparable in complexity to that of the biological ecology of marine turtles. Stakeholders hold a variety of interests. Development interests include military contractors such as Defense Research Organisation and commercial contractors such as International Private Seaports Limited (ISPL) and Dhamra Port Company Limited (DPCL). Private fisheries stakeholders include subsistence fishers and the tribes or villages that depend on them, local market commercial fishers, regional/national market commercial fishers, and Indian and foreign vessels fishing for the international seafood industry. Private stakeholders interested in sea turtle biology and conservation include academic researchers, citizen conservationists, and non-profit legal advocacy, conservation, research, community and educational organizations. Traditional subsistence fishing communities hold an interest in sea turtle and ocean conservation, and increasingly, local market communities do as well.

Subsistence and local fishing interests have formed alliances with conservationists to pursue protection of coastal lands and waters. These groups include Operation Kachhapa, Orissa Tradiitonal Fishworkers Union (OTFWU), and the Orissa Marine Resources Conservation Consortium (OMRCC). OMRCC is an umbrella group of “fishworker’s unions of Orissa, conservation organizations, development NGO’s , turtle biologists, and individuals interested in sea turtle conservation measures and/or sustainable fisheries in Orissa” (OMRCC, 2008). The member groups are as follows: The UNDP Action for Food Program; Ashoka Trust for Research in Ecology and the Environment, Bangalore (ATREE); Green Life Rural Association; Greenpeace India; Maa Ganga Devi Santhi Maitri

Yuvak Sangha; Orissa Traditional Fishworker's Union; Peera Jahania Fish Worker's Union; Project Swarajya; Rushikulya Sea Turtle Protection Committee; Sea Turtle Action Programme; United Artist's Association; World Wide Fund For Nature; Wild Orissa. The Marine Turtle Specialist Group (MTSG), based at Exeter University in the UK, is also involved in issues related to sea turtle and habitat conservation in the area (OMRCC, 2008).

Government stakeholders include the state Forest and Fisheries Departments. In addition to jurisdiction over state legislation and regulations, state governments often also implement federal regulations. The Ministry of the Environment and Forests (MoEF) and Ministry of Surface Transport (MoST) are the two federal agencies with jurisdiction over sea turtle habitat and coastal waters. In 1997 the MoEF amended the 1991 CRZ and transferred decision-making power over port projects to the MoST. This transfer of power was rescinded in 2000. The Coast Guard responds to legal and safety issues in coastal waters, including those involving turtles. The CEC of the Supreme Court rules on state and federal compliance and jurisdictional matters that are remitted to the high court. International bodies include the United Nations Development Program, the World Bank, the World Trade Organization (WTO), the IUCN, and CITES.

Table 1: Marine turtle- and fisheries-related organizations operating from the community- to international scale in India.

Community/Non-Governmental Organizations	Mandates	State Ministries	Relevant Mandates	Federal Ministries	Relevant Mandates	International Organizations	Relevant Mandates
Operation Kachhapa	Conserve species and reduce mortality through habitat protection, legal action, and public support.	Tamil Nadu, Andhra Pradesh, and Orissa Forest Departments	Protect and patrol turtle habitat on- and offshore; enforce conservation regulations, e.g. no-fishing zones, collect turtle bycatch data at fish-landing	Ministry of Environment and Forests (MoEF)	Implement & enforce federal conservation and endangered species programs, laws, and regulations, e.g. fisheries bycatch-reduction requirements and no-	United Nations Development Program (UNDP)	Fund conservation research and publications; develop and fund conservation programs, e.g. regarding bycatch reduction and the use of turtle excluder devices (TEDs); compendium of marine turtle biology and conservation in

			centres; conduct marine turtle censes.		fishing zones.		India.
Orissa Traditional Fishworkers Union (OTFWU)	Support traditional fishworkers in terms of finances, cultural heritage, and unionization; promote education, health, and environmental awareness; help to author fishworker-sensitive turtle conservation.	Tamil Nadu, Andhra Pradesh and Orissa Fisheries Departments	Protect and patrol offshore turtle habitat; enforce fisheries regulations, e.g. no-fishing zones; collect fishing data at fish-landing centres.	Ministry of Surface Transport (MoST)	Author, implement and enforce shipping and sea transport regulations, including no-fishing zones, and fishing-gear transport.	International Union for the Conservation of Nature (IUCN)	Assess status of marine turtle species and populations; designate as endangered, threatened, or of special concern; publish 'red list' of most endangered species/populations; fund and conduct research and conservation programs.
Samrudam Sangha	Traditional fishworker women organized to promote the well-being of fisher women and children, and to establish turtle conservation measures sensitive to traditional fishers.			Fisheries Commission of India	Promotes commercial fisheries, advocates for the use of turtle-protective gear, obtains commercial fishing landing data.	Convention on International Trade in Endangered Species of Flora and Fauna (CITES)	International agreement under the IUCN; protects species from harm by international trade; restricts or prohibits trade in threatened and endangered species.
Orissa Marine Resources	Promotes communication and			The Coast Guard	Safety response;	World Trade Organization	Regulates international trade;

Conservation Consortium (OMRCC)	collaboration between conservationists and researchers, fishers, and state and federal agencies in the interests of turtle conservation and fishing communities.				legal enforcement of turtle protection.	(WTO)	seeks to reduce or remove restrictions to trade. In 1996 required the US to remove its ban on shrimp imports from non-TED-using countries (e.g. India).
						World Bank	Promote international trade and investment, through loans to low-income countries, for capital development programs. Heavily promoted the development of a commercial fishing industry in India from the 1950s.

Fisheries policy challenges

There are multiple challenges to protecting sea turtles, sustainable fisheries and coastal habitat. Among the barriers to effective policy implementation is overlap in jurisdiction between agencies and levels of government within India, as illustrated in Table 1, above. For example, the Orissa Department of Forestry, the Coast Guard, and the MoEF share jurisdiction over fishing regulations in Orissa's coastal waters. Responsibilities include ensuring that boats are in compliance with no-fishing and size-restricted zones. If the government entities were well-funded and amenable to cooperation, multiple-agency jurisdiction would be to the benefit of environmental protection. As it is, lack of funding and resultant corruption and lack of enforcement lead to poor data collection, record-keeping and information-sharing. This makes it more difficult to determine levels of bycatch, poaching, and fisheries zone

violations, and to ensure environmental compliance, than if only one agency regulated related activities in an area (Upadhyay & Upadhyay, 2006, Rajagopalan et al, 2006, Pandav et al, 2006, Kartik Shanker, *Personal Commentary*.

In addition to complex jurisdiction within India, international rulings have further complicated the sea turtle/fisheries/development debate. This can be illustrated by the lawsuit brought before the WTO court by India, along with Pakistan, Malaysia, and Thailand, against the US. In 1989 the US made Turtle Excluder Devices (TED's) mandatory equipment in the US shrimping industry. In 1996 the US began banning imports of shrimp from countries where sea turtles are found that did not use TED's. The ban arose from the 1989 legislation, which required negotiations with other countries to either implement turtle-safe shrimping practices or forego imports. The US implemented the ban under directive by the US Court of International Trade in 1995. India, Malaysia, Pakistan and Thailand subsequently sued the US in the WTO court. The scientific panel convened by the WTO found that turtle-safe shrimping methods, such as TEDs, should be applied globally. Nevertheless, the WTO ruled against the US ban on the basis that it impeded global trade. The US appealed the ruling, but offered to provide generous compliance timelines to shrimp-exporting countries to adopt the use of turtle-safe shrimping methods. The appeal held, but has been rendered ineffective (Crouse, 1999).

Although the appeal ruling did not specify the type of turtle-safe shrimping gear required, it has been interpreted by the governments of both the US and India to mandate TEDs. Unfortunately, federal and international bodies have mandated TED's without considering the cultural, economic, and practical factors that determine whether fishers will employ turtle-safe fishing methods. TEDs are distributed to Indian fishing boats free of charge, without proper fitting of TEDs to trawls and without education about their use. Consequently the fishers have no personal investment in their use. The TEDs imported for distribution fit poorly and reduce the shrimp catch to impractical levels. Currently, not a single trawler in the waters off India is known to use their TED. There is in fact significant pressure amongst trawlers and gillneters not to use their TEDs. Although TED use is mandated, it is not enforced. As a result, turtle bycatch rates in the Indian shrimp industry remain some of the highest in the world. The US nevertheless continues to import this shrimp. In the above case, it is clear that international agreements have been imperfectly applied, to the detriment of the species they were designed to protect (Sridhar et al, 2000; Pandav, B and BC Choudhury, 1999; Crouse, 1999).

In contrast, the Orissa fishing zone regulations, while in need of improved enforcement, are a positive regulatory model that ought to be replicated along the coast. At Gahirmatha Sanctuary, all fishing is banned in the core area within five kilometers of shore. Only non-motorized craft are allowed in the 10-to 5 km buffer zone. Small motorized craft (<10hp) are subject to the same zone restrictions (outwards of 10 km) as larger vessels. At Devi and Rushikulya, small craft are banned within five km of shore from January to May. Mid-to-large vessels are banned within 5 km year-round and within 20 km January-May. Only non-motorized craft

are allowed inshore of five km year-round. These regulations could be further improved upon by engagement with fishworkers. As mentioned previously, there are four basic classes of fishing boats operating in the waters off the eastern coast of India: non-motorized craft, small motorized craft of less than ten horsepower, mid-size vessels supplying state and regional markets, and large national and international industrial ships. The fisheries regulations that differentiate among these size-classes are a step towards equitable distribution of resources and protection of critical nearshore sea turtle habitat. They are nevertheless a point of contention amongst traditional fishworkers using non-motorized craft. Many of these fishers do not agree with their exclusion from traditional fishing grounds at Gahirmatha Sanctuary in the name of sea turtle conservation. They point out that they use Kati nets, not trawlers, gill nets, or other gear with associated turtle bycatch (although it should be noted that they may use monofilament nets, which do carry an associated bycatch risk). Because they do not use motors, their boats do not pose a lethal hazard for sea turtles. Small motorized-craft fishers take exception to the TED mandate. The (unenforced) ruling requiring TED's on all fishing craft is inapplicable to those small motorized craft that do not use trawls or gillnets. In the opinion of the fishworker's unions, both the ban on traditional craft in the sanctuary and the TED requirement are blanket regulations, made without proper consultation of small fishing interests, and lacking in effectiveness and applicability. Both the unions and some sea turtle conservation biologists see the restrictions on small craft as political maneuvers not justifiable in light of the extensive concessions made to port development and military interests.

Methods

The existing data on olive ridley bycatch and mortality in the Bay of Bengal are sparse. While it is commonly accepted that the occurrence of bycatch in this region is a severe problem, quantitative assessments are limited to snapshots of brief periods of time, ranging from a single nesting season to a few years. Population and bycatch mortality data at mass nesting beaches must often of necessity be based on estimates. The population density of arribada nesting populations and corresponding mortalities are too great to enable direct counts. Estimates at these beaches are largely derived from extrapolations based on sample counts.

This study uses a combination of quantitative and qualitative information to assess regional bycatch and mortality, and to determine data needs and conservation strategies. I began by researching sources of quantitative data from published documents, studies available on the internet, and unpublished studies available only in print. The latter category includes monitoring projects conducted by community organizations and villages as well as by government agencies, and studies authored by individuals who gathered information from these groups.

Quantitative data on regional olive ridley bycatch and mortality is limited to either reliable information as to the numbers of adults/subadults captured and/or killed at individual nesting beaches over a period of a few years, or of estimates, with a wide margin of error, of the numbers of adults/subadults captured and/or killed statewide over periods of time up to two decades (Gopi et al, 2006; Rajagopalan et al, 2006; Shanker et al, 2006). Limited information is available as to the quantities of various gear types present in the fisheries, and the percentages of capture and mortalities that can be attributed to each. To address the gaps in available data, I developed a survey (See Appendix 1). The survey is directed at people from a variety of fields related to sea turtle conservation in the Bay of Bengal and along the eastern coast of India. It consists of 24 questions designed to gather information and opinions on olive ridley population and bycatch mortality trends, fisheries threats, and regional conservation and monitoring efforts. The survey has been approved for human subjects research.

I have combined the information provided by quantitative data and surveys to best illustrate the nature and scope of olive ridley bycatch mortality in Indian fisheries in the Bay of Bengal. I have used this information, along with articles and essays that discuss the societal, environmental, and political contexts of regional marine turtle conservation and fisheries, in order to develop proposed conservation strategies.

Results

Data on olive ridley bycatch in the study region is commonly separated into data from solitary versus arribada nesting populations. This distinction enables the presentation of bycatch numbers in the context of the size of the nesting population of origin. Solitary nesting populations consist of tens to hundreds of adults, while arribada populations can number from hundreds to hundreds-of-thousands of adults. The size of a nesting population in a given year and over time is influenced by anthropogenic mortality levels, food availability at foraging grounds, and climate and weather events affecting nesting habitat. Data from available studies have been used to develop estimates of bycatch in the region of concern of this study. These data are presented below.

A study conducted in the coastal states of India over the years 1997-1999 developed statewide estimates of yearly bycatch and mortality based on activity at fish-landing centers (Rajagopalan et al, 2002; Rajagopalan et al, 2006). During observation periods, numbers were recorded of live-trapped and dead turtles at randomly-selected landing centers in each mainland maritime state. Fishers were interviewed as to trap and mortality levels for the time between observations. Yearly estimates were based on sample data and interviews. The arribada beach on the protected Gahirmatha Coast was excluded; during this period of time, all recorded mass-nesting activity occurred at Gahirmatha. Since then, it has shifted south to Rushikulya (K Shanker, *personal commentary*).

Bycaught turtles recorded at fish-landing centers were not identified by species; the authors of the study assume that most would be olive ridleys because of their nesting range throughout the coast of India. The majority of turtles were captured in the winter and spring, during the olive ridley nesting season. Bycatch data from West Bengal, Orissa, Andhra Pradesh, and Tamil Nadu are presented in Table 2, below. Numbers reflect both turtles killed in fishing gear and those alive when released.

Table 2: Marine turtle bycatch recorded on the east coast of India, 1997-1998. Data source: Rajagopalan et al, 2002.

State	1997	1998
West Bengal	96	125
Orissa	328	506
Andhra Pradesh	384	435
Tamil Nadu	2056	1357
Total	3190	2605

The same study calculated the percentages of bycatch caused by various gear types (Rajagopalan et al, 2002). Bycatch data by gear type is presented for West Bengal, Orissa, Andhra Pradesh, and Tamil Nadu in Table 3, below. Trawl and gillnet data for the three latter states, where olive ridley nesting occurs, are consistent with the qualitative data provided by survey respondents (see Survey Results, below).

Table 3: Percentage of bycatch caused by gear type on the east coast of India, 1997-1998. Data Source: Rajagopalan et al, 2002.

State	Trawl	Gillnet	Seine	Other
West Bengal	0.0	0.0	0.0	100.0
Orissa	13.9	64.7	0.0	0.0
Andhra Pradesh	27.5	34.7	32.1	21.4
Tamil Nadu	2.8	72.5	1.7	5.5

Persistent solitary nesting populations of olive ridleys are found in Bangladesh and Sri Lanka. In Bangladesh, they are known to nest along the Teknaf Peninsula in the region of Cox's Bazaar, and on the nearby islands of Sonadia and St. Martin, in the southeast of the country. Nesting populations in these areas have been monitored consistently since 1996 (MZ Islam, *personal commentary*). A census of the nesting population on St Martin's Island was recorded from 1996-2001, during a field study of this population.

Between 83 and 137 individuals were recorded per year (MZ Islam, 2002). A study conducted at Sonadia Island over the past five years recorded somewhat higher nesting population numbers (MZ Islam et al, *In Review*). Population counts are not available for the Teknaf Peninula. It can be assumed, however, that many of the same individuals nest in all three locations, as olive ridleys do not exhibit fidelity to a particular nesting beach. Mortality counts were recorded at Sonadia and St. Martin Islands and along the Teknaf Peninsula from 2004-2010 (MZ Islam et al, *In Review*). The counts included only turtles washed ashore, and were significantly higher than the nesting populations recorded at either St. Martin's or Sonadia, indicating that a fair percentage came from nesting populations elsewhere in the Bay of Bengal.

Records of Sri Lankan nesting populations are not available; however bycatch data was collected at several locations near nesting populations during the 1999-2000 nesting season. Data was collected through interviews with local fishers. Species were identified anecdotally by interviewees. This data is presented in Table 4, below. Data in the column labeled 'Lo' contains olive ridley bycatch data. Counts of turtles captured and released and those who died in the fishing gear were included together (H Purnima, *Data provided by survey*).

Table 4: Marine turtle bycatch by species in Sri Lanka, November 1999-November 2000. Data Source: H Purnima, 2010.

Site	Number of Interviews	Cm	Cc	Lo	Dc	Ei	Uk	Turtle by catch
Kandakkuliya	608	0	0	107	0	0	0	107
Chilaw	591	1	25	0	1	2	0	29
Negombo	1429	43	115	483	1	4	8	654
Colombo	881	43	25	29	9	29	7	142
Panadura	350	5	4	1	14	3	0	27
Wadduwa	229	2	2	4	1	7	0	16
Beruwala	699	13	28	36	36	7	0	120
Moragalla	885	1	0	6	0	2	0	9
Galle	1421	473	678	597	40	263	4	2055
Weligama	1008	104	61	50	44	184	45	488
Mirissa	922	75	146	55	106	51	68	501
Dondra	481	4	8	9	6	24	0	51
Kottegoda	1176	15	51	2	115	23	7	213
Tangalle	1030	10	6	11	24	137	4	192
Hambantota	1395	2	1	0	2	0	3	8
Kirinda	655	117	160	236	32	82	2	629
Total:	13760	908	1310	1626	431	818	148	5241

Reliable population estimates of the Bay of Bengal breeding population are available for only a few years of the past several decades. It is likely, although not yet known, that they belong to a single breeding population (K. Shanker, *pers. comm.*). The timing of consecutive arribadas at different locations on the Orissa coast suggests that they consist of the same individuals nesting

throughout a season. Individuals from this arribada population also engage in solitary nesting at the same beaches, and at solitary nesting beaches down the coast (Shanker et al, 2006). Arribada population estimates, therefore, provide a fair estimate of the adult females in the breeding population. Despite this, it is difficult to accurately estimate the size of the population. Most of the arribada population estimates are questionable, deriving from the same source, yet providing inconsistent numbers (Shanker et al, 2006). In addition, the methods by which the original data were obtained are uncertain. The original data was gathered by the Orissa Forest Department, probably using a transect method wherein all turtles at regular demarcated intervals along the beach transect were counted, and then marked to prevent re-counting. All individuals encountered at transect intervals were counted, whether ovipositing or not (Shanker et al, 2006). This method would have provided information as to the overall breeding population for that year, but would not have provided information as to the effective arribada nesting population size, a more accurate indicator of the population's reproductive success.

Arribada population estimates of adult females range from 100,000-800,000 individuals. The population is currently estimated at between 150,000-200,000 adult females. Arribadas of over 100,000 nesters occurred almost yearly at Gahirmatha between 1974-2001, and smaller arribadas occurred during some of these years as well (Shanker et al, 2006). There has been no mass nesting at Gahirmatha since 2001. Since then, arribadas have occurred only at Rushikulya, and these events have been smaller (K Shanker, *pers. comm.*). Since arribada nesting was first documented at Rushikulya in 1994, the estimated nesting population declined from perhaps 200,000 nesters in 1994, to 20,000-50,000 nesters each year from 1995-98, to upwards of 10,000 nesters in 2001, to, depending on information source, an arribada of fewer than 10,000 nesters, or no arribada, in 2002 (Shanker et al, 2006).

The first year for which data are available during which each arribada site was devoid of biologically significant mass nesting events was 2002. Since then, arribadas have occurred at only one site, rather than consecutively at different sites, as had been previously observed. Shanker et al (2006) developed consensus estimates of population for the nesting years 1975-76 to 2001-02 (for the purposes of this paper, a single year indicates the spring end of a nesting season, i.e. '1974' indicates the 1973-74 nesting/hatching season, which occurs between October and May), and developed a population trend analysis based on these estimates. Population trends during this time reflect changes in fishing activity. The most reliable estimates indicate that the nesting female population increased from ~150,000 to ~280,000 between the middle of the 1970s and the mid-1980s, after which it declined to ~180,000 in the late 1990s. Estimates for the years 1975-76, 1984-85, and 1998-99 are considered to be the most reliable figures, and indicate overall changes in nesting population size from 158,000, to 280,000, to 180,000, respectively. The 1998-1999 estimate was derived by K Shanker in March 1999 via transect census. This is the only yearly estimate obtained using standardized methodology (Shanker et al, 2006).

Marine turtles became protected by the WLPA in 1974, at which time the legal marine turtle fishery ceased. The olive ridley population is estimated to have almost doubled during the following ten years. Since the mid-1980s, incidental catch has increased as mechanized fisheries have expanded. The impact of fisheries bycatch mortality on the olive ridley population seems to be reflected by its subsequent decline. Shanker et al (2004) statistically analyzed the above population trends. Linear regression shows a marked decline from the mid- to the late 1990s; however the data is inconclusive due to a lack of population estimates during this time. The only data point between 1995-96 and 1999-2000, the endpoint of the statistical analysis, is the estimate derived from the transect survey by K Shanker for the 1998-99 nesting season. There were no arribas at Gahirmatha in 1996-97 and 1997-98, and arribada sizes at Devi and Rushikulya were not estimated. Arribada sizes at Gahirmatha in 1999-200 (and in the subsequent year) are unknown (Shanker et al, 2006).

The mortality of 90,000 marine turtles, mostly olive ridleys, was recorded on the shores of Orissa in a span of eight years. Shore-based mortality estimates usually capture 7-14% of all mortality at sea (Shanker et al, 2006). Thus the total mortality during the same time period would be estimated to be between just over 642, 857 and 1,285,714, and 80,357 to 160,714 per year. Using the 1998-99 transect population estimate of 180,000 females (approximately 360,000 breeding adults), these mortality estimates indicate a critical threat to the continued viability of this population.

Commonly-used gear includes gill nets, trawl nets, seine nets, bag nets, stake nets, and hook-and-line (Sridhar and Shanker, 2007, Rajagopalan et al, 2006). Based on available data of live entrapments caused by gear type, gill nets account for the majority of gear used and the majority - 60-75% - of all bycatch in Indian fisheries, followed by trawl nets, which account for approximately 13-18%. The remaining gear types make up less than a quarter of bycatch totals. Data on gear types responsible for mortalities, as opposed to live landings, is not systematically collected. Mortality estimates conducted at arribada beaches suggest that trawl nets are disproportionately responsible for mortalities, as they may capture turtles at rest, and are infrequently checked (Shanker et al, 2006b).

Survey Results

The survey was intended for people whose livelihoods relate to marine turtle conservation and/or fisheries in the western Bay of Bengal. Participants were primarily in India, as well as in Sri Lanka and Bangladesh. Respondents were asked to identify the nature

of their work from a variety of categories, and were free to list multiple categories (see Appendix 2). The survey asked for observations regarding olive ridley population trends, fishing methods and gear, data collection efforts, threats to olive ridleys, and conservation obstacles and needs. Survey response has been low; thus far ten surveys have been returned. Survey results from selected questions are presented graphically in Appendix 1; the full survey is summarized in Appendix 2.

The recipient pool was limited by the geographic scope of the survey and by the ability to contact potential participants. I was fortunate to contact field assistants and fishers at the Rushikulya mass-nesting site and nearby locations. This opportunity was nevertheless limited by language. It was only possible to conduct a survey either with an individual who spoke English, one who spoke Hindi in the presence of a third party who spoke Hindi and English, or one who spoke a local language in the presence of a third party who spoke both that language and English. The researchers at the field site are fluent in Hindi and English, but do not speak Odissi, the regional language of Orissa, nor any of the local dialects. Most of the local fishers and field assistants speak only their local language. Although I was shown a variety of fishing gear and methods, olive ridley nests and adult 'resting habitat', surveys were simply not feasible with most of the local people whom I encountered. Apart from the southern coast of Orissa, it was not possible to administer the survey to coastal villagers. The only method of contact would be travel to each location, an undertaking beyond the scope of this project.

The other groups primarily targeted by the survey were government officials, marine turtle researchers and conservationists. These groups were contacted primarily via email. No surveys were returned from government officials. This zero response rate can be attributed to two factors, the first being the difficulty of obtaining accurate contact information. While most government offices and officials now have email addresses, they are frequently listed incorrectly and inconsistently, or are unused. The second factor to which I attribute the lack of government response is a tendency for agencies mandated with sea turtle protection and fisheries enforcement not to communicate and share information outside of their own agencies. Survey responses from researchers and conservationists were limited to personal acquaintances.

Discussion

Conservation Options

Alternatives are possible in the arenas of fishing regulations and the proposed port development. Actions taken in each of these areas will continue to significantly influence the environmental quality of coastal areas, specifically in terms of sea turtle conservation, fish populations, and quality of life for coastal communities. I evaluate the options on the following criteria: 1. Conservation of sea turtle populations, consisting of reduction/elimination of anthropogenic mortality, preservation of habitat, avoidance of behavioral disturbances. 2. Ecological integrity, including: water quality, fish populations, ecosystem/habitat conservation (coastal lands, river mouths, inshore and open-water ecosystems). 3. Human safety. 4. Cultural and community integrity, including ability to sustain subsistence economies. 5. Prosperity, sustainability, and independence of local and state/regional economies. 6. Financial feasibility of implementation. Each option is scored 1 (detriment), 2 (marginal effect), 3 (benefit), or unknown (?) according to each criteria. Options scored '?' are tentatively assigned a value of 2.

Table 5: Turtle bycatch-reduction gear policy options

Criteria (see text)	1	2	3	4	5	6	Score
Maintain current TED requirement for all mechanized vessels with current level of enforcement	1	2	(2)	1	1	2	9
Maintain current TED requirement with effective level of enforcement and education	3	2	2	2	2	1	12
Implement regulations specific to vessel and fishing gear type	3	3	3	3	3	2	17

Table 6: Fishing zone regulations options

Criteria (see text)	1	2	3	4	5	6	Score
Maintain current fishing zone regulations	1	1	2	2	2	2	11

With current enforcement levels							
Maintain current regulations with effective enforcement	3	3	2	3	2	1	14
Allow traditional non-mechanized boats using kati nets in G. sanctuary	?	3	3	3	2	? (2)	13
G. sanctuary: Restrict mid-large vessels to 15 km fr yr-round. D&R: restrict mid-lg to 10km yr – round (maintain 20 km in-season); small motorboats to 5km yr-round	3	3	? (2)	3	2	? (2)	15

Policy Recommendations

I have chosen the best alternative for each policy area based on the above evaluations. I would strongly recommend developing bycatch-reduction gear regulations based on the type of fishing gear and vessel being used. The cooperation of fishworkers is crucial to the success of gear regulations. Bycatch-reduction gear that is too unwieldy for a small boat, that reduces target catch below economic feasibility, or that does not fit properly (or at all) into fishing gear will not be used and will therefore not help sea turtles. Cooperative development of bycatch-reduction gear will promote sea turtle conservation and will reduce the likelihood that fishers will go to restricted zones due to low catch. When people are willing to use required gear it will reduce safety hazards posed both by risky behavior to increase catch and/or avoid enforcement and by frequent enforcement activities. Cultural integrity is enhanced when traditional communities are authorities in designing appropriate and effective gear modifications. Certainly, boats using no-bycatch gear should not be saddled with inapplicable regulations. Gear that enables an acceptable profit level and protects sea turtles and other non-target species will benefit small economies and thus the economic stability of the state. This option would entail a potentially significant initial cost to develop and implement gear and regulations.

In analyzing available policy options for fishing gear regulations, I conclude that it would significantly benefit sea turtles, environmental quality, and small/subsistence communities to further restrict larger vessels from sea turtles aggregating and nesting habitats at Gahirmatha, Devi, and Rushikulya. Small boat operations would likely benefit more, in terms of profit and safety, from decreased competition from larger boats than they would lose in profit from new year-round five km restrictions at the two southern sites. This option would however require a study of whether there are potential safety hazards from a five km restriction during monsoon season. Likewise, a consideration of whether to allow traditional boats in Gahirmatha Sanctuary outside of nesting season would require an analysis of whether this would pose a disturbance to sea turtles. The financial feasibility of implementation and enforcement would have to be considered in light of the potential for use during prohibited months and/or by motorized boats.

Conclusion

Legislative reform is needed for organized and effective environmental protection. Fishing regulations in wildlife sanctuaries and endangered species habitat should be standardized and administered by federal wildlife protection agencies under the jurisdiction of the WLPA. Policy improvements will be ineffective, however, unless existing well-planned policies are funded and implemented and thereby set a standard of effectiveness for future legislation.

Currently, quantitative data on the impacts of fisheries bycatch to the study population are limited to estimates, and geographically- and temporally isolated counts. This paper addresses the need for comprehensive data collection and conservation measures to address the bycatch mortality problem outlined above.

In order to significantly reduce and eventually eliminate bycatch and bycatch mortality in the study population, it will be necessary to collect data that identify the number of turtles caught and killed yearly. This data must be delineated by the location, life-stage and, when possible, gender of bycaught individuals, as well as by the type of fishing gear and vessel by which they were caught. This information will enable us to quantify the impact of the various fishing operations and gear on different nesting populations, lifestages, and habitats, and to identify those of special concern. In addition, it would be useful to conduct assessments of the relative and compounded impacts to this population of the various threats they face from different kinds of fisheries, port development, military operations and development, coastal development, and related pollution.

With the benefit of the above information, it will be possible to draft appropriate and effective conservation measures. All bycatch data should be kept in a shared, comprehensive database to enable data contribution and comparison across demography and gear. This will provide a clear delineation of bycatch mortality in this population for the purposes of management and policy decisions.

The above measures are ecologically and economically necessary. Delay could witness a population crash, necessitating critical interventions to sustain an ecologically fragile, genetically-depleted population. We have a responsibility to protect species and their populations from anthropogenic harm at our earliest opportunity. A timely and informed course of action is the most ecologically sound for conservation of the species, and one that recognizes the impossibility of conserving every impacted species should we allow them to all become critically endangered.

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Appendix 1: Selected demographics and observed trends from survey

Figure 1. Livelihood of survey respondents

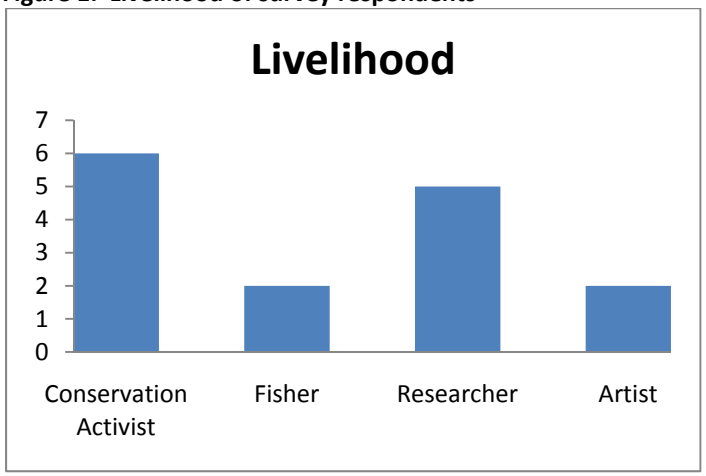


Figure 2. Years since began livelihood

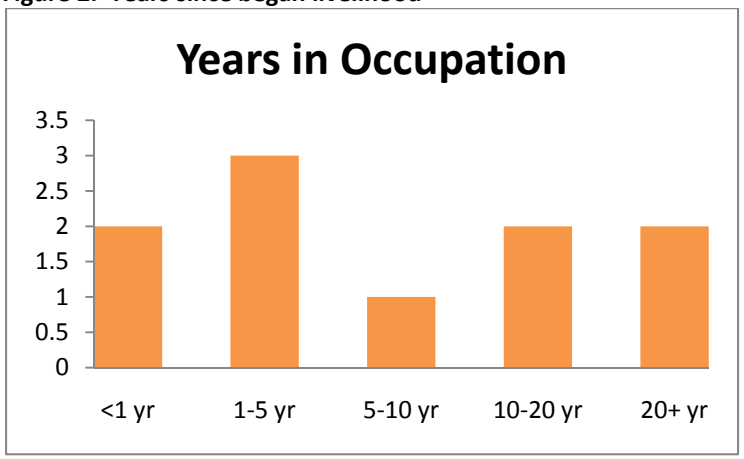
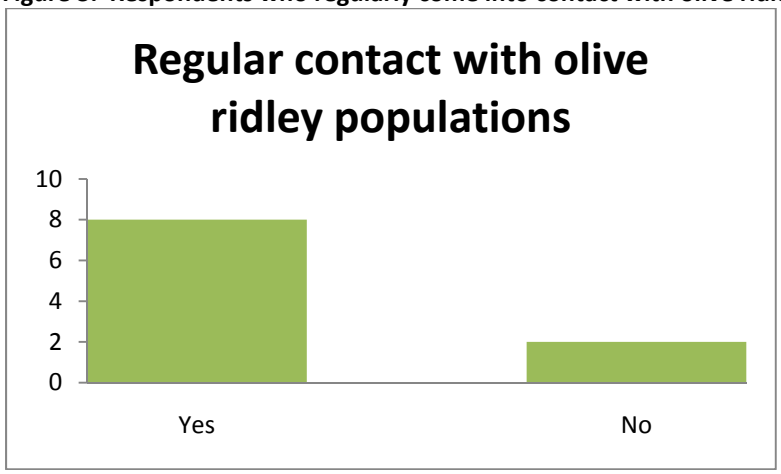


Figure 3. Respondents who regularly come into contact with olive ridleys in the course of their work.



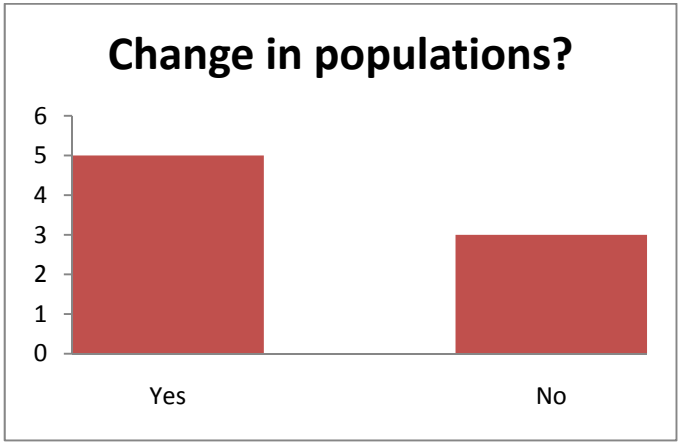


Figure 4. Observation of change in populations.

Figure 5. Observation of decrease by life stage.

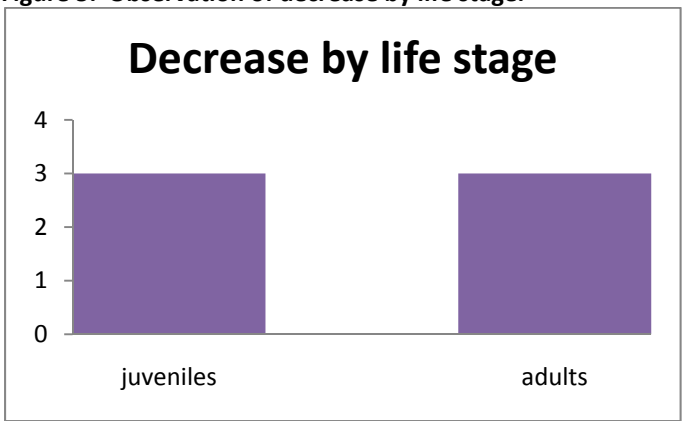


Figure 6. Observation of increase by life stage

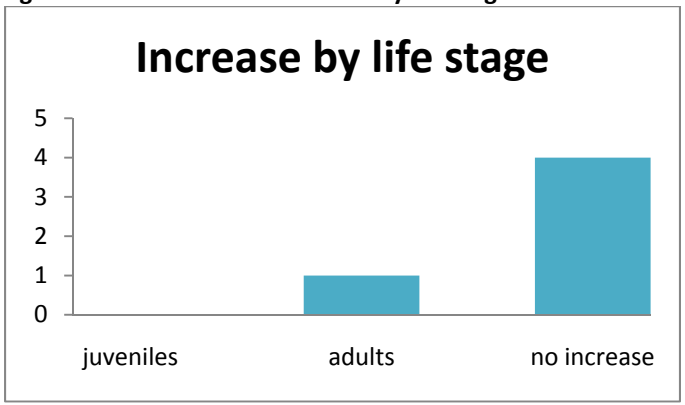


Figure 7. Evaluation of threat to olive ridleys in Bay of Bengal from fisheries bycatch.

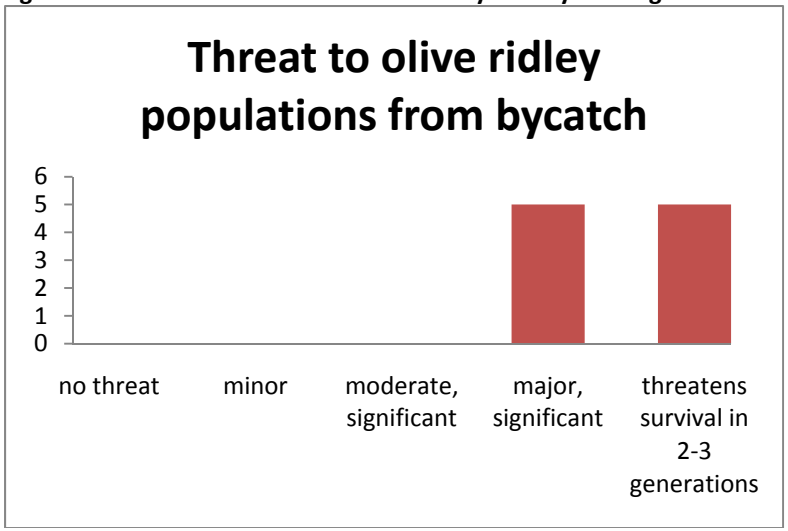
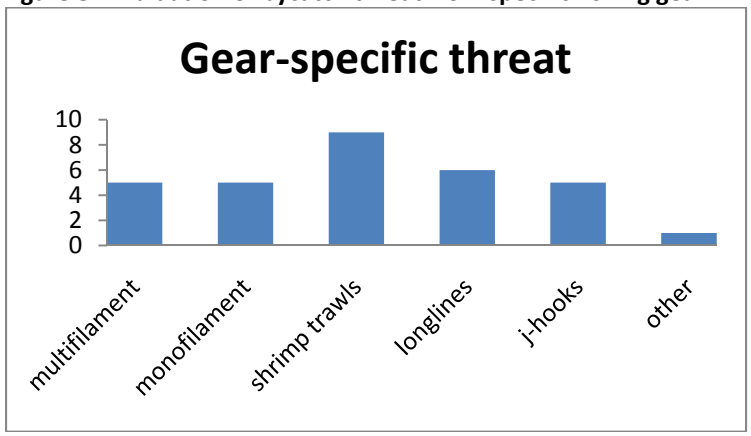


Figure 8. Evaluation of bycatch threat from specific fishing gear.



Appendix 2: Survey of Olive Ridley Fisheries Bycatch in the Bay of Bengal; Summary of Results

1. Please indicate the term(s) that describe(s) your primary relationship to olive ridley turtles in the Bay of Bengal:

A. Scientist/researcher B. Conservation activist C. Subsistence fisher – nonmotorized D. Subsistence fisher – motorized. E. Commercial fisher F. Student G. Teacher H. Artist I. Social Scientist/policy worker J. Government official
A.- 5; B - 6; D.- 2; H.- 2.

2. Do you live year-round on/near the Bay of Bengal? Yes/No
Yes- 5; No- 5.

3. If no, how many months of the year do you spend there?: A. More than 6 months B. More than 3 months up to 6 months C. More than 1 month up to 3 months D. One month or less.
A.- 2; C.- 1; D-1.

4. For how long have you worked in a subject area related to olive ridley populations in the Bay of Bengal?

<1yr: 2; 1-5yrs: 3; 5-10yrs: 1; 10-20yrs: 2; 20+yrs: 2.

5. Does your work bring you into direct contact with sea turtle populations?
   Yes- 8; No- 2.

6. Do you work with fishers or other populations who interact with sea turtles?
   Yes- 6; No- 4.

If your work brings you into direct contact with olive ridley populations and/or data, please answer questions 7 – 13:

7. Have you noticed a change in olive ridley populations over time? Y/N
   Yes- 5; No- 2; too soon to tell - 1.

8. If yes, have you noticed a decreasing trend among some or all life stages? Y/N
   Yes-5; No- 0. Decrease in juveniles : 3; decrease in adults: 3.

9. Have you noticed an increasing trend among some or all life stages? Y/N
   Yes- 1 (adults); No- 4.

10. Are the changes you notice dependent on location, or are they similar across locations with which you are familiar? Please explain.

    Location-dependent: 1; similar: 2 (no additional responses).

11. Are the changes you notice similar across life stages, or do you see different trends among different size/age classes? Please explain.
Similar: 1 (decline). Variable: 2. Primarily record adult data only: 2.

12. Do you observe highly variable trends depending on size/age class and location? Please explain.
No (similar trends)-1. Yes-1. No additional responses.

13. Do you notice similar or different trends in mass-nesting versus solitary nesting populations? If different, please elaborate.

Similar- 2. 'Both exhibit highly variable trends, with possible decline.' Different – 1 (mass nesting greater decline). Work away from mass-nesting areas- 2.

14. Does mortality from fisheries bycatch threaten the well-being of olive ridley populations? Please choose the description that best suits your opinion: 1. No threat at all 2. Minor threat 3. Moderate, significant threat 4. Major, significant threat 5. Very great - threatens their survival within the next 2-3 generations.
Major, significant threat: 5; Very great – extinction threatened within 2-3 generations: 5.

15. Which types of fishing/fishing gear are harmful to sea turtles? Please check all that apply:
A. Multi-filament nets B. Monofilament nets C. Trawls (shrimp trawls) D. Longlines E. J-hooks F. Other. Additional comments: **Other harmful gear types: marine set bag; bottom set gill net; drifting gill net; shark gill net (large mesh size); some hand-held gear.**
A.- 5; B.- 5; C.- 9; D.- 6; E.- 5; F.- 1.

16. Are you aware of data collection efforts to quantify olive ridley fisheries bycatch and mortality? Please list any such efforts of which you are aware.
Yes- 7: respondent efforts; Wildlife Institute of India (WII); Operation Kacchapa; Orissa Forest Department; NGOs.

17. Are you aware of when efforts to quantify bycatch of these populations began (year)?
From 15 years prior to single- and first-year data efforts.

18. Please rate your opinion of bycatch data collection of olive ridleys in the Bay of Bengal/east coast of India: 5 – thorough and extensive; 4 – adequate; 3 – somewhat lacking; 2 – very inadequate; 1 – non-existent.
Adequate (4)- 1; somewhat lacking(3)- 4; very inadequate (2)-2 (no additional responses).

19. Is the collection of quantitative bycatch data for these populations necessary for assessment of the status of these populations?: 5 – critically necessary 4 – necessary 3 – somewhat necessary 2 – marginally indicated 1 – not at all needed.
Critically necessary- 7; necessary- 2; somewhat necessary- 1.

20. Is the collection of quantitative bycatch data for these populations necessary for their conservation?: 5 – critically necessary 4 – necessary 3 – somewhat necessary 2 – marginally indicated 1 – not at all needed.
Critically necessary- 3; necessary- 4; somewhat necessary- 3.

21. In your opinion, what are the greatest fisheries-related threats to sea turtle/olive ridley populations in the Bay of Bengal?
Un-regulated fishing during breeding season
Lack of TED use; use of incompatible gear
Repeal of US ban on non-TED shrimp
Ghost fishing
Problematic gear, especially trawlers, floating and bottom-set gill nets, and longlines with J-hooks.
Un-regulated fishing during breeding season. Construction of harbors. Pollution. Ghost fishing.
Large operations (trawls, set bags) owned by unconcerned elites

22. What are the greatest obstacles to effective conservation of these sea turtle populations?
Construction of harbors Pollution Lack of political will/lack of enforcement
Poverty
Lack of interagency coordination
Lack of communication and cooperation between agencies, communities and conservation NGOs
Coastal development activities, and policies promoting construction and expansion and offshore oil exploration
Habitat destruction
Fishing pressure

23. What strategies might make conservation in this area more effective?
Development and promotion of fisheries-appropriate turtle-excluding gear
Enforcement of legal protections
Monitoring of fishing activities
Bringing local communities into conservation and management
Improving communication between stakeholders
Increased nesting beach monitoring and conservation
Making sea turtle conservation a national priority
Strict fishing regulation during breeding season near the breeding areas, and proper monitoring and enforcement.
Compulsory usage of BRD's
Raising of compensatory corpus funds for the fisher folks during catch loss during breeding season

24. Please add any additional comments you'd like to make on the subjects of fisheries bycatch and sea turtle conservation on the east coast of India/ Bay of Bengal. Thank you; your time and interest are greatly appreciated.

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