LONGITUDINAL ANALYSIS OF HISTORICAL SEABIRD BYCATCH DATA IN THE NORTH PACIFIC

By

Sarah Poulin

Master of Environmental Management Candidate, 2018

Dr. Pat Halpin and Dr. Daniel Dunn, Advisors

April 26, 2018

Masters Project submitted in partial fulfillment of the requirements for the Master of Environmental Management degree in the Nicholas School of the Environment of Duke University

Longitudinal analysis of historical seabird bycatch data in the North Pacific

Poulin, Sarah K.[1]

4/26/2018

1. Nicholas School of the Environment, Duke University, Beaufort, NC, 28516 USA

Abstract

Historical ecology is used by researchers to help understand how past interactions between people and their environment have shaped contemporary conditions. Though recent science has responded to the many management challenges of the ocean, the lack of analysis and limited availability of archival data hinders our ability to place current ocean impacts in the historical context of exploitation. All 22 species of albatross and several species of petrels are currently listed as Near Threatened or Threatened by the IUCN with bycatch cited as the main threat. However, there are very few publicly available datasets on the interactions between fisheries and seabirds before the 1990's. The purpose of this project was to explore and analyze historical data collections from the Smithsonian and the USGS. These overlooked records contain seabird band return cards that specify extensive information from as early as the 1940's on seabird bycatch occurrences in the North Pacific. With the inclusion of this new information, more thorough management may be implemented that accounts for the longitudinal gaps of modern day bycatch records through complementing current data sources with archival datasets.

1. Introduction

1.1 Historical Ecology

In modern ecological studies, historical ecology is used by researchers in order to help understand how past conditions and interactions between people and their environment have shaped contemporary conditions (Szabó 2015). The value of historical data in modern ecological analyses is particularly evident in the analysis of long term population trends. Long-term data series are valuable and help guard against biases of contemporary experience or short term observations only, oftentimes revealing more drastic changes than previously thought to exist (McClenachan et al. 2012). Historical data can provide context for interpretation of environmental change, such as for species that may have historically been exploited but have had recent population increases (Lotze et al. 2011). The value of archived data only grows as technologies continue to advance and new technologies and capabilities unlock even more information from the past. For example, molecular techniques can now provide insight into historic specimens and reveal physical and biological characteristics of preserved artifacts to help elucidate priorities for conservation (Barak et al. 2015).

Despite this wealth of knowledge found in historical records, oftentimes there is a general lack of investment in evaluation and analysis of these datasets. It is time and resource consuming to aggregate this data and can be tedious work. But the value that historical ecology can provide for natural resource managers today gives reason for the push to restore and document archival ecological data to continue conservation of biodiversity now and into the future (Morrison et al. 2017; Jackson et al. 2001). Ecologists assess abundance for many marine species, but due to limited use of historical data popular conceptions of species abundances have shifted over time (Pauly 1995). These shifting baselines can mask true ecological trends in species abundance over long time scales because they do not consider archival species data, and focus primarily on contemporary and short term trends in population levels (Pauly 1995). Though recent science has responded to management challenges, the lack of analysis of historical data and the limited availability of these data hinders our ability to place current ocean impacts in the historical context of exploitation (Thurstan et al. 2015). Through exploratory research into the past, we will be able to further our understanding of a changing world ahead of us more thoroughly.

1.2 Pacific Ocean Biological Survey Program (POBSP)

In 1962, the Smithsonian Institute entered into a grant agreement with the Department of Defense to initiate the Pacific Ocean Biological Survey Program (POBSP). The overarching purpose of this program was to perform biological surveys of specific areas of the Pacific Ocean to learn what plants and animals occurred on the remote islands in the region, the seasonal variations in their populations and reproductive activities, and the distribution and populations of the pelagic birds of the area. A large emphasis of the project was on the banding of birds in an effort to analyze the migration, distribution, and abundance of pelagic seabirds travelling through the region. The study area encompassed a large ranging region of the Pacific Ocean, specifically designated as spanning the equator and extending from latitudes 30 degrees north to 10 degrees south and from longitudes 148 degrees east to 180 degrees west. This area includes many clusters of islands and atolls full of vast amounts of biodiversity.

From January 1963 through June 1969, POPSP researchers performed surveys through over 120 cruises covering the remote areas of the study. During this time, both on island and at sea observation surveys were performed in this Pacific Ocean region to help understand the entire dynamic of the ecosystem and its biodiversity. At sea observations were made on research vessels to document the identity, occurrence, and abundance of seabirds along replicate tracks and transects during all months of the year on a continuous schedule from sunrise to sunset, occasionally incorporating around the clock surveys. All birds seen were recorded in a daily field log that was on every vessel, including information on: time of sighting, identification, number of birds, direction of flight, behavior, and special comments (King 1970). From these at sea observations, researchers were able to look at trends in pelagic bird movements across the different regions of the Pacific, such as coastal Oregon and Washington (Sanger 1970), the trade wind zone surrounding the Hawaiian islands (King 1970), and the Central Pacific (Ely 1971).

Along with these at sea observation surveys were on island studies of the organisms and ecosystems encountered. A central goal of the project was to identify and band new birds within the study area, and throughout the study period over 1.8 million birds of 56 different species were banded (King 1974). This large banding effort helped in further years of the project to estimate the breeding and roosting populations of the seabirds species encountered and their breeding status and trends because of the ability to go back to similar areas where they were banded and see if the same individuals were present (Johnston and McFarlane 1967; Schreiber 1970; Fleet 1972).

Throughout the 7 years of research surveys during POBSP, both new species and growth in population counts were discovered in the study area that were not previously known in the Pacific (Gould and King 1967; Clapp and Woodward 1968; Peterson et al. 1968). These studies and publications were important for development of baseline knowledge of the biodiversity of the Pacific Remote Islands and helped lay out the need for further research in the future.

1.3 Seabird Bycatch in the North Pacific

Seabirds are characterized as being late to mature and slow to reproduce in comparison with other marine and avian species. Many do not begin breeding until they are ten years old and a mating pair will generally only lay a single egg each year it is breeding. Seabirds are long-lived species though and are able to breed for many years when undisturbed, aiding in their ability to produce enough young to prosper as a species. Albatross, a group of seabirds known for their long-range movements, have been tracked across entire ocean basins (Weimerskirch et al. 2014). Three of these species, the Laysan albatross (*Phoebastria immutabilis*), black-footed albatross (*Phoebastria nigripes),* and short tailed albatross (*Phoebastria albatrus*) are found primarily in the North Pacific and therefore are of particular concern for protection by nations within national jurisdiction in these waters who have conservation obligations for these species (Birdlife International 2004). Other seabird species that use this region heavily include shearwaters, frigatebirds, and petrels, making it a highly diverse area consisting of both seabird breeding sites and migration corridors (Everett and Pitman 1993; Spear and Ainley 1999).

Fishing effort in the North Pacific is particularly high compared to other ocean basins (Kroodsma et al. 2018). Historically there have been several methods of fishing that have been utilized in this area, including long lines, purse seine, and drift nets. Commercial long-line fishing, a method that has been used world-wide since the nineteenth century, ranges from small scale artisanal fisheries to modern mechanized and industrialized fleets from distant water fishing nations (Brothers et al. 1999a). A longline consists of a main line that may extend over 100km in length with numerous baited hooks on branch lines. Although most longline gear is generally set at depths not visible to foraging seabirds, the baited hooks are often accessible when the gear is both set out and then hauled back in. Pelagic longlining, where gear is suspended from line left at the sea surface, is used to target large tunas, swordfish, billfishes and sharks around the world (FAO 1998, Brothers et al. 1999a). The primary nations utilizing high seas pelagic longline fishing include Japan, Korea and Taiwan (FAO 1998, Kroodsma et al. 2018). Demersal longline fishing, where longline gear is set at the seabed, happens largely in the

North Atlantic by Norwegian and Icelandic fleets in the northeast and Canada in the Northwest, with small scale coastal demersal longlining noted primarily by Japanese vessels in the North Pacific (Brother et al. 1998a). It is estimated that there are over 3,000 pelagic and 17,000 demersal longline vessels operating in the North Pacific today (Gilman et al. 2005). These fishing methods all pose significant threats to marine species, particularly seabirds, travelling through these areas along their migration paths.

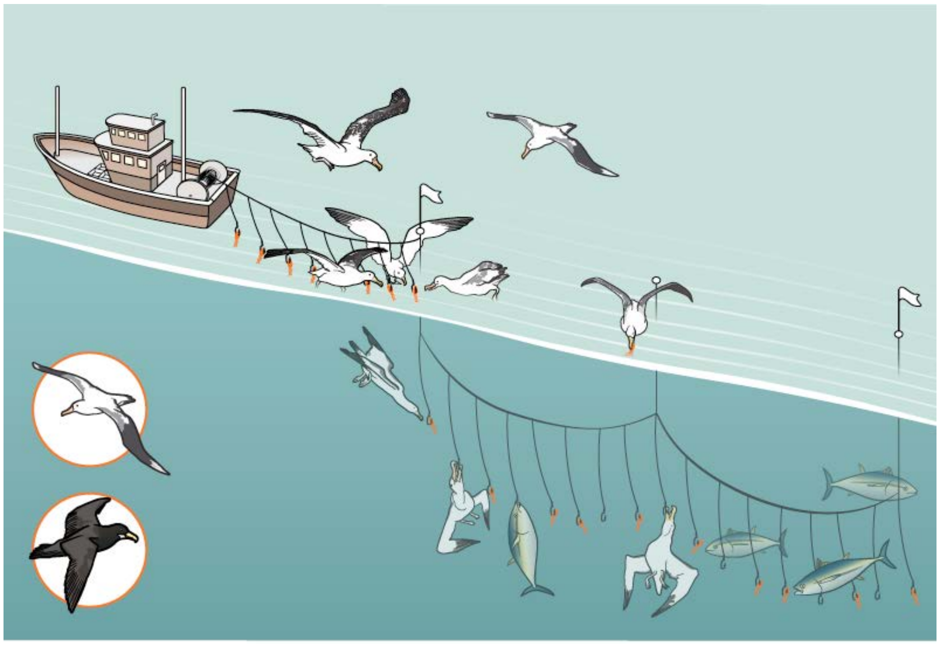


Figure 1. Seabirds take advantage of baited hooks set out by long lines, oftentimes resulting in them being caught on gear and drowning as a result (Illustration by Emily Eng).

Presently, all 22 species of albatross are listed as Near Threatened or Threatened by the IUCN, with bycatch cited as the main threat (IUCN 2017). The seven species of petrel and two species of shearwaters listed under the Agreement on the Conservation of Albatrosses and Petrels (ACAP), face similar threats. Long-liners targeting tuna and tuna-like species are found to be most concentrated in the Pacific Ocean, and often overlap high use foraging areas for seabirds such as Laysan and Black-footed albatross in these regions (Brothers et al.1999). While at sea along their migration routes many of these birds spend significant periods of time actively foraging for prey at the surface of the water column. causing them to be highly susceptible to interactions with fisheries who set baited gear in these regions. Seabirds take advantage of periods when bait is exposed to forage, but can become injured and drown if they get caught on a hook (Brothers 1991). This results in a high threat to species that use surface foraging techniques to hunt, which includes all of the North Pacific albatross and petrel species (Løkkeborg 1998; O. R. J. Anderson et al. 2011). Due to seabirds K-selected traits of late maturity and low fecundity, high adult mortality of these species can have significant negative effects on their populations (Igual et al. 2009). While there is uncertainty in interpreting exact population levels of North Pacific albatross, population and bycatch modelling experiments on known occurrences of fisheries interactions with these birds raise concern that albatross mortality in North Pacific fisheries, if not dealt with, could threaten the existence of the species (Brother et al. 1999a, Gilman et al. 2005, Tuck et al. 2001).

Though policy has been enacted and management measures implemented within national jurisdictions to conserve these species, management of the Areas Beyond National Jurisdiction (ABNJ) is critical to migratory species survival and therefore is of utmost importance in research projects and planning initiatives for the future. The five tuna Regional Fisheries Management Organizations (RFMOs) are international governing bodies of coastal states and distant water fishing nations tasked with the role of managing fishing operations in a designated geographic area of the ocean, which includes ABNJ (Gilman 2011). Many of these RFMOs have management powers to set both fishing effort limits and gear restrictions for fleets fishing in their area. The West Central Pacific Fishing Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) are the groups that manage the waters of the North Pacific (Figure 1) and therefore oversea seabird bycatch mitigation in their regions. Each of these RFMOs manages seabird bycatch differently. In 2007 the WCPFC enacted legally binding measures on seabird mitigation, requiring that longline fishing vessels operating in areas south of 30ºS and north of 23ºN employ two seabird avoidance methods from a predetermined list (WCPFC 2007). The last tuna RFMO to legally require mitigation methods, the IATTC instituted similar requirements on seabird bycatch mitigation in 2011, requiring two mitigation methods on longline vessels limited to the same geographic areas south of 30ºS and north of 23ºN within their management boundaries (IATTC 2011). Despite the steps forward in management of seabird bycatch mitigation in the North Pacific, there is still a lack of thorough coverage in protection of these species across their entire ranges which can be addressed by looking at longitudinal accounts of these bycatch events in the area. With the inclusion of the new historical data provided by the USGS and Smithsonian and presented in this paper, more thorough management may be implemented that takes into account the longitudinal gaps of modern day bycatch records by complementing current data sources with archival datasets.

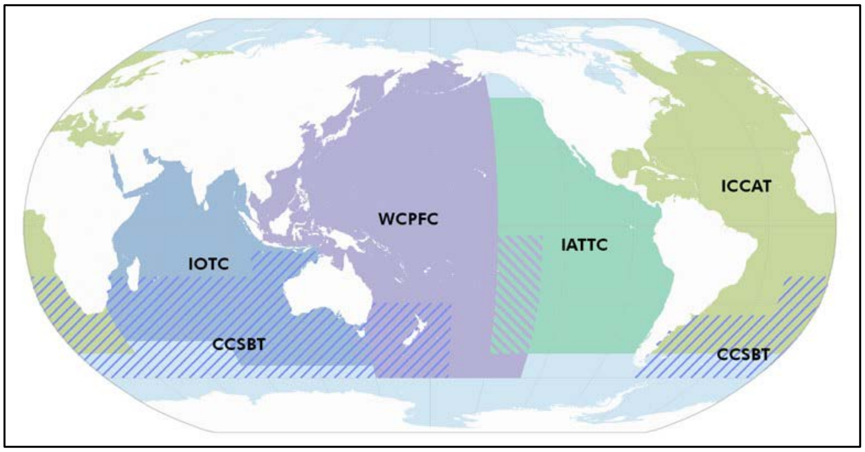


Figure 2. Regional Fishery Management Organization (RFMOs) jurisdictional boundaries
(http://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2011/07/06/recommendations-to-kobe-iii-joint-tuna-rfmo-meeting)

2. Methods

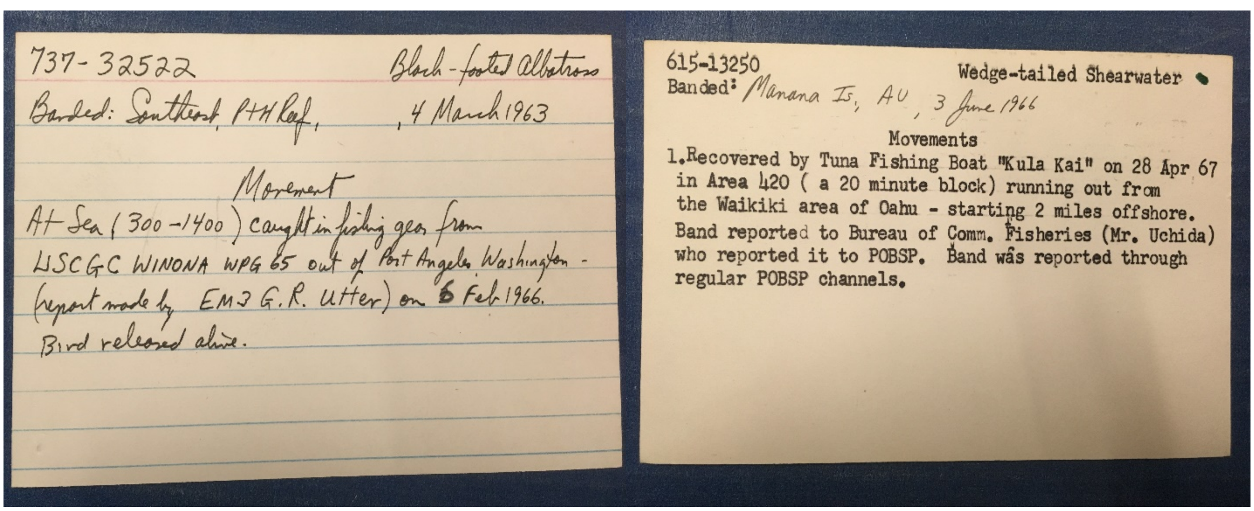
2.1 Archival Data Collections

2.1.1 POBSP Data Collections:

Currently, the data from POBSP is held in the North Attic at the Smithsonian National Museum of Natural History. Within this collection is a plethora of data, from bird banding encounter cards to hard copies of field notebooks from researchers and even a few albatross eyeball specimens. There are file cabinets full of band card return cards with valuable information about the personnel who recovered the bands as well as stacks of coded at sea observation data from the entirety of the program's length. This vast amount of data has not been transcribed or analyzed since the original study and holds incredible amounts of information about the biodiversity and ecosystems of the Pacific Remote Islands.

2.1.2 POPSP Bird Banding Return Cards

Within the data collections from POBSP are band return cards that specify at a minimum the location of the encounter with the banded bird, but occasionally provide more extensive data such as the name of the vessel that discovered the bird, the fishing method by which the bird was caught, and the status of the bird at the time of capture or sighting. Though the spatial data has been transferred over to the USGS Bird Banding lab and input into their encounter database, this additional information found on the band return cards has never been documented or analyzed. Photos of every bird band return card in the collection were taken and digitized to the computer for data collection and analysis.



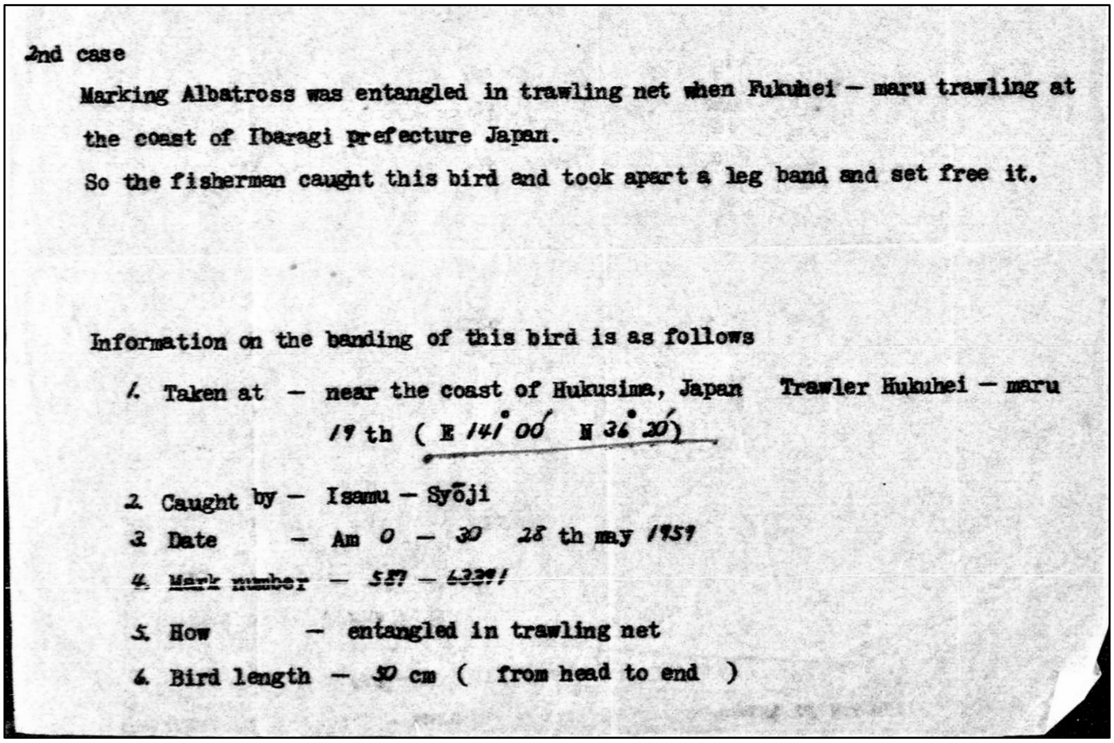
737-32522 Black-footed Albatross
Banded: Southeast, P+H Reef, 4 March 1963
Movement
At Sea (300-1400) caught in fishing gear from USCGC WINONA WPG 65 out of Port Angeles Washington - (report made by EM3 G.R. Utter) on 6 Feb 1966.
Bird released alive.

615-13250 Wedge-tailed Shearwater
Banded: Manana Is, AU, 3 June 1966
Movements
1. Recovered by Tuna Fishing Boat "Kula Kai" on 28 Apr 67 in Area 420 (a 20 minute block) running out from the Waikiki area of Oahu - starting 2 miles offshore. Band reported to Bureau of Comm. Fisheries (Mr. Uchida) who reported it to POBSP. Band was reported through regular POBSP channels.

Figure 3. Two examples of seabird band return cards from the POBSP dataset at the Smithsonian

2.1.3 USGS Bird Band Encounter Records

The United States Geological Service (USGS) Bird Banding Laboratory in Patuxent, Maryland are the overarching data holders of all return records for birds banded in North America. Recently digitized hard copies of band return letters were provided by the USGS in the form of pdfs. All return letters for Laysan albatross, Great frigatebird, black-footed albatross, and wedge-tailed shearwaters encountered in the North Pacific were used in data collection and analysis.



2nd case

Marking Albatross was entangled in trawling net when Fukuhei – maru trawling at the coast of Ibaragi prefecture Japan.

So the fisherman caught this bird and took apart a leg band and set free it.

Information on the banding of this bird is as follows

1. Taken at – near the coast of Hukusima, Japan Trawler Hukuhei – maru 19 th (E 141° 00' N 36° 20')
2. Caught by – Isamu – Syōji
3. Date – Am 0 – 30 28 th may 1959
4. Mark number – 587 – 63291
5. How – entangled in trawling net
6. Bird length – 50 cm (from head to end)

Figure 4. Example of digitized form of bird band return letter from the USGS.

2.2 Encounter Data Review and Analysis

All records of bird band returns provided by the Smithsonian and USGS were read through in search of a reference to bycatch as the cause of the encounter. If fishing was noted as the cause of capture of the bird, then the record was saved in a separate folder. Once all files were read through and all band returns where a fishery encounter was noted were pulled out of the data, the relevant documents were re-read and the following additional data was documented in a data sheet when it was given: Vessel Name, Vessel Country of Origin, Capture Method (fishing gear type), Fishery Target Species, Fishing Industry (commercial, recreational, artisanal), and additional comments. The data collected were uploaded into Microsoft Access database for data management purposes and for sharing with future collaborators.

Data were uploaded into several software formats to perform analysis and exploration into this new dataset of bycatch information. ArcMap (ESRI) was used to perform spatial and temporal analyses of the bycatch occurrence points by selecting bycatch occurrences with specific attributes. To perform a hotspot analysis of bycatch occurrence locations, a fishnet grid was produced with 5º by 5º grid squares across the North Pacific study area. Bycatch counts were totaled for each of these grids and symbology was changed to represent the relative frequency of bycatch events throughout the area. Overlap analysis with historical Japanese long line fishing effort was performed by looking at spatial overlap with catch per unit of effort (CPUE) data from Myers and Worm 2003 in the same 5º by 5º grid squares as the bycatch count data. RStudio was used to perform multi factor analysis and to look at the interactions between the multiple new data fields provided by the band return letters using ggplot2 tools.

2.3 Public Outreach and Knowledge Sharing

An ArcGIS Story Map will be created with the intent of sharing more of the story-telling aspect of the data collection with the general public. This will include any additional information found in the return records and further research performed on specific vessels or names mentioned in the documents. This Story Map will be readily available on the Smithsonian's Migratory Bird Center Website with the intended audience being members of the public with little to know knowledge of the POPSP program or seabird bycatch in the North Pacific.

3. <u>Results</u>

3.1 Exploratory Data Analysis Results

In total, 212 records of bycatch were found within the total of 10,435 total encounter records supplied by the USGS and Smithsonian. Of these records, 35 were from the POBSP collection and the remaining 187 were from the USGS return letter records. The band return year of the data ranged from 1949 to 2012 (Figure 5).

Data Holder	Number of Encounter Records Received	Number of Bycatch Records
USGS	9,697	187
Smithsonian	738	35

Table 1. Values of total encounter and bycatch records reviewed from the two data sources

In total, there were four different species determined to have been caught as bycatch: Laysan albatross (*Phoebastria immutabilis*), black-footed albatross (*Phoebastria nigripes),* wedge-tailed Shearwater (*Ardenna pacifica*), and the great frigatebird (*Fregata minor)*. Most of these bycatch occurrences were of black-footed albatross (n=150, 70.8%), followed by Laysan albatross (n= 46, 21.7%), wedge-tailed shearwater (n=14, 6.6%) and lastly great frigatebird (n=1, .5%) (Figure 6). Of these bycatch occurrences, vessels originated from 8 different countries (United States, Japan, Korea, Israel, Russia, Taiwan, China) and are spatially shown in Figure 7. The largest percentage of the bycatch occurred in interactions with Japanese vessels (n= 88, 41.5%), followed by the United States (n=29, 14%), Korea (n=20, 9.5%), Russia (n=5, 2%), Taiwan (n=2, 1%), China (n=1, .5%) and Israel (n=1, .5%) (Figure 7). There were 65 occurrences (32%) that did not specify the vessel's country of origin. 49 specific vessel names were extracted from the return records as well, primarily of Japanese tuna fishing vessels and United States government ships (Table 2). Of the 10 different gear types mentioned as the method of capture of the seabirds (dipnet, fishing gear, fishing line, fishing net, floating net, hook, hoop net, long line, trawling, trolling) the majority of the bycatch was caught through long line fishing (n=72, 34%) (Figure 8). Target species was primarily Tuna (n = 28, 52%) with others consisting of salmon, trout, billfish, shrimp, mackerel, black cod, and rockfish (Figure 9).

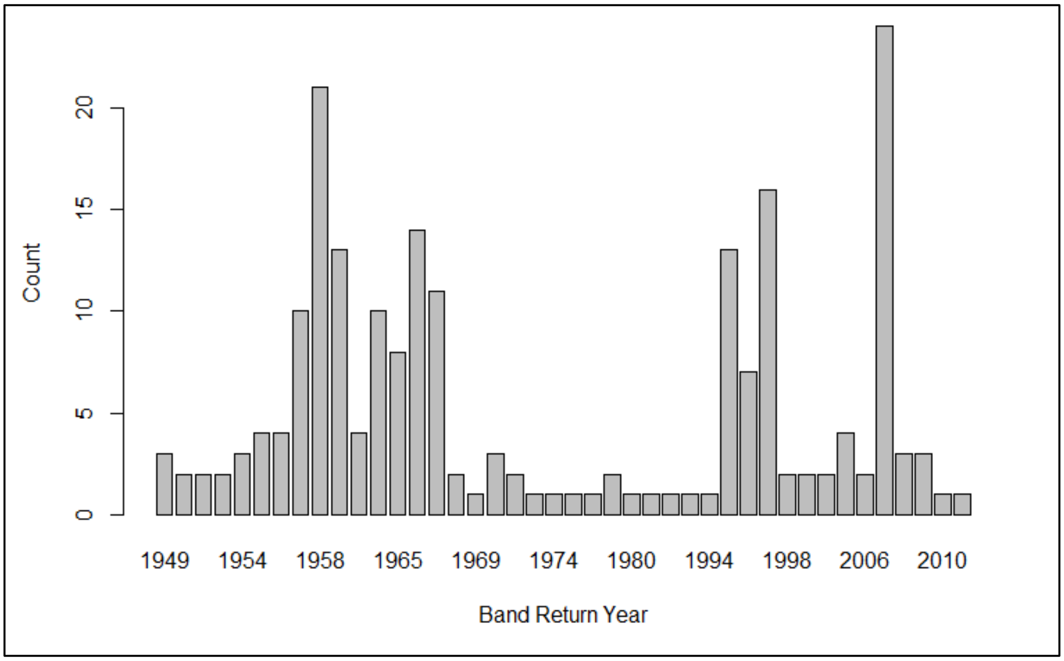


Figure 5. Distribution of bycatch records occurring per year over span of data time range (1949-2012).

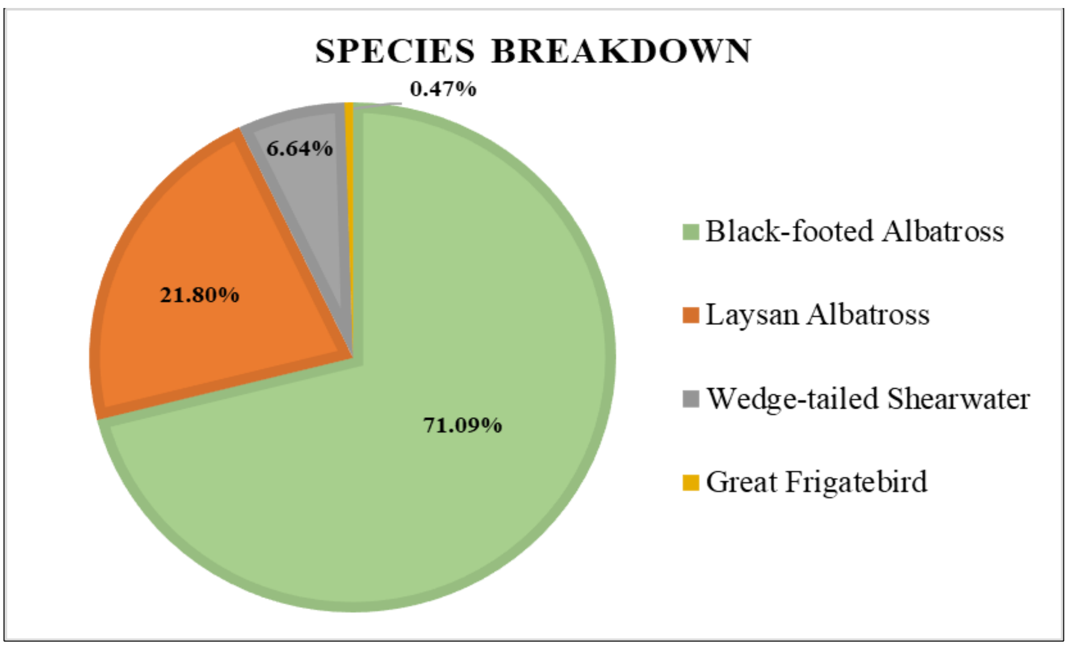


Figure 6. Count of seabird bycatch by species (n=212)

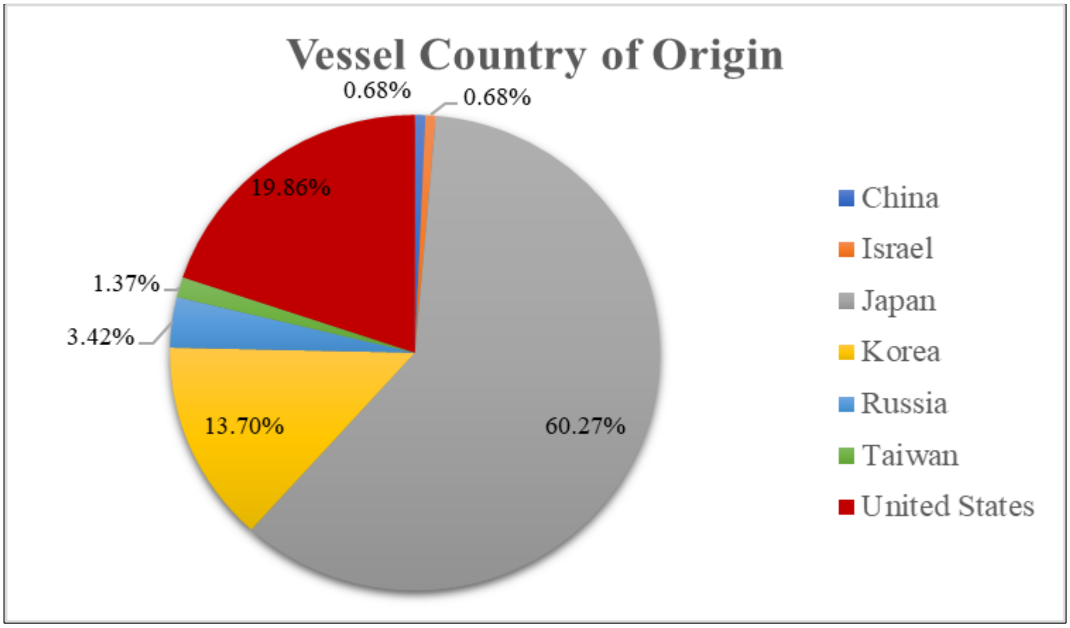


Figure 7. Count of seabird bycatch by vessel country (n= 146)

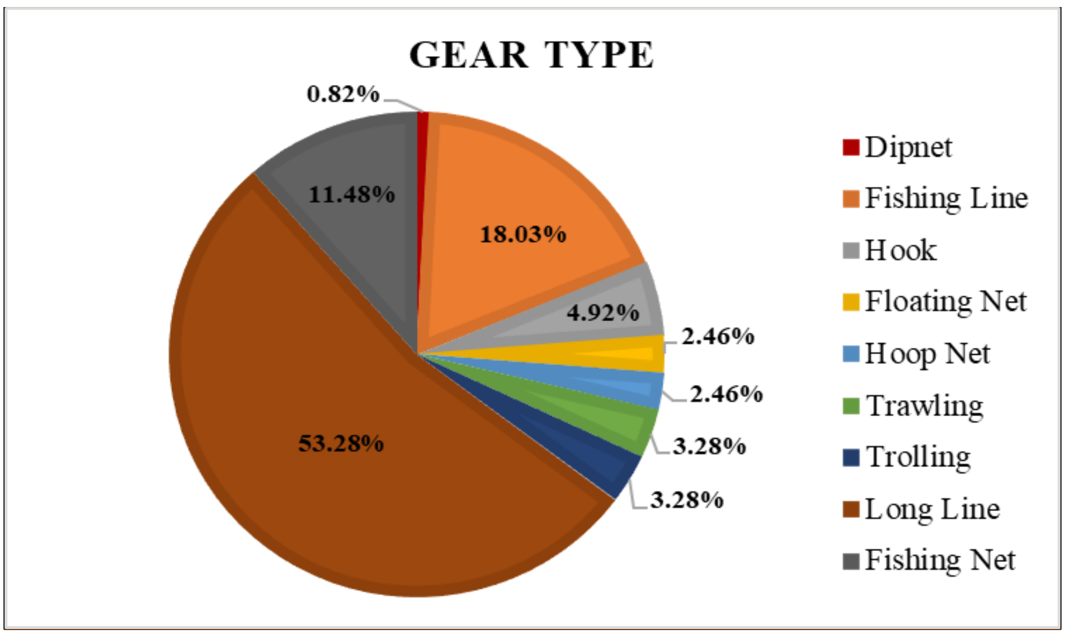


Figure 8. Breakdown of fishing gear used in capture of seabirds as bycatch as indicated in records (n=164)

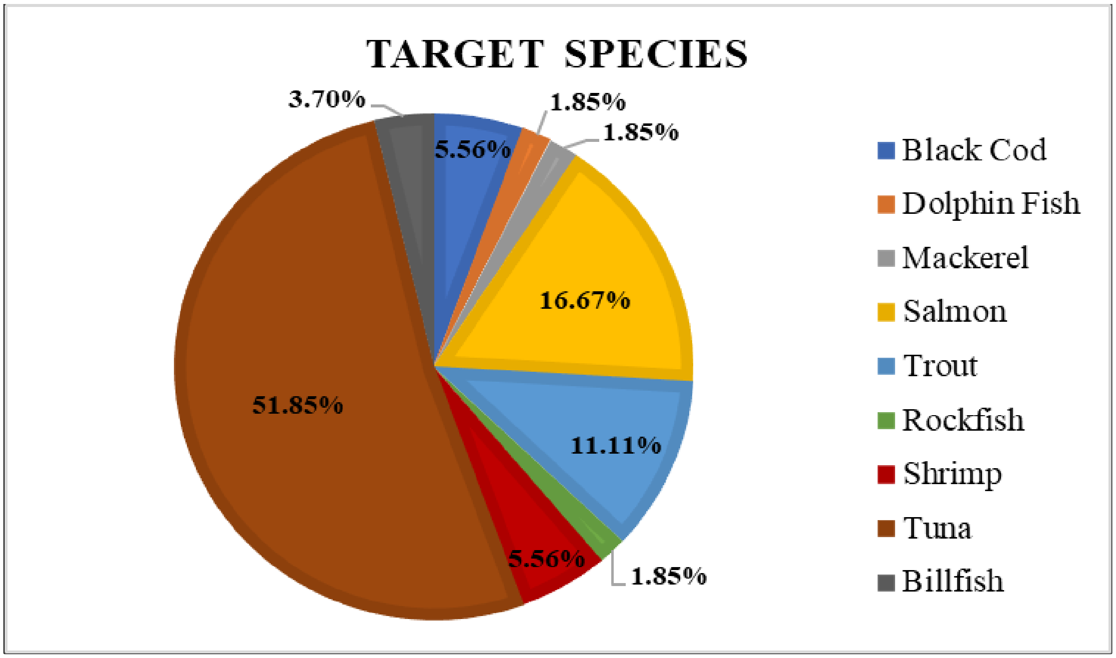


Figure 9. Breakdown of intended target species indicated in bycatch records (n=54)

Vessel Name	Country of Origin
U.S.S. Scanner (AGR-5)	United States
USNS Range Tracker	United States
23rd Kosho-Maru	Japan
Kyotokumaru	Japan
USCGC Winona	United States
Kula Kai	United States
Electa	United States
Neptune	United States
U.S.C.G.C. Minnetonka WPG 67	United States
Pushka	United States
Constitution State	United States
Ryoiti Maru No. 2	Japan
M.V. Brown Bear	United States
M.V. Nurith of Zim Israel Naval Company	Israel
Shinnan-Maru	Japan
New Mexico	United States
Ocean Papa Weather Station	United States
No. 1 Yutakamaru	Japan

No. 2 Ise Maru	Japan
R.V. Soyo Maru	Japan
Tesyo Maru No. 3	Japan
Eureka	United States
U.S.C.G.C. Gresham	United States
Tenyu Maru No. 37	Japan
Hime Maru	Japan
Sakura Maru	Japan
Chofuku-maru 13	Japan
Ryuo Maru	Japan
No. 6 Tokuju Maru	Japan
Azuma Maru No. 12	Japan
USS Durant (DER-389)	United States
No. 5 Miya Maru	Japan
No. 18 Kinsei Maru	Japan
Russian BMRT Stern trawler	Russia
No. 3 Miyasho-maru	Japan
No. 35 Kinei-maru	Japan
Nichiro Fishing Co.	Japan
Alexey Chirikov and Fedor Litke	Russian
Kosei-Maru	Japan
No. 3 Seitoku-Maru	Japan
No. 10 Yuei-Maru	Japan
No. 5 Fukusei-maru	Japan
Kyokuyo-Mary no. 7	Japan
No. 7 Fuku-maru	Japan
Kogyo Maru	Japan
Yutin Maru	Japan
No. 1 Surifumaru	Japan
Ryoiti Maru No. 2	Japan
Shunyo-Maru No. 18	Japan

Table 2. List of Vessel Names and Country of Origin

Years	Country	Gear Type	Seabird Bycatch Count
1949-1959	Japan	Net	9
		Hook	5
		Long Line	21
		Unknown	7
	USA	Net	6
		Long Line	4
	Unknown	Net	3
		Long Line	2
		Unknown	7
1960-1969	Israel	Fishing Line	1
	Japan	Net	4
		Hook	1
		Long Line	4
		Unknown	5
	Unknown	Net	1
		Hook	2
		Long Line	4
		Unknown	12
	Russia	Unknown	1
	USA	Net	1
		Fishing Line	7
		Unknown	7
1970-1979	Hong Kong	Unknown	1
	Japan	Net	1
		Long Line	3
	Unknown	Net	1
		Long Line	1
		Unknown	2
	Russia	Net	1
		Unknown	1
1980-1989	Japan	Long Line	1
	USA	Fishing Line	1
1990-1999	Japan	Long Line	14
	Unknown	Unknown	21
		Long Line	4
	USA	Long Line	2
2000-2012	Japan	Fishing Line	7
		Net	1
	Korea	Long Line	5
	Unknown	Long Line	3
		Unknown	2
	Russia	Net	1
	Taiwan	Long Line	2
	USA	Unknown	1

Table 3. Summarized data from USGS and Smithsonian historical records on bycatch within the North Pacific, separated out in ten-year intervals by country and gear type used by the vessel in capture

Year	Country	Target	Total Estimated Seabird Bycatch
1949-1959	Japan	Unknown	28
		Salmon, Trout	3
		Rockfish	1
		Tuna	10
	USA	Black Cod	1
		Dolphin Fish	1
		Unknown	6
		Shrimp	1
		Tuna	1
	Unknown	Salmon, Trout	6
		Shrimp	1
		Tuna	5
1960-1969	Israel	Unknown	1
	Japan	Unknown	11
		Tuna	3
	Unknown	Unknown	19
	Russia	Unknown	1
	USA	Unknown	13
		Shrimp	1
		Tuna	1
1970-1979	Hong Kong	Unknown	1
	Japan	Black Cod	1
		Unknown	1
		Tuna	2
	Unknown	Unknown	4
	Russia	Mackerel	1
		Unknown	1
1980-1989	Japan	Tuna	1
	USA	Black Cod	1
1990-1999	Japan	Unknown	14
	Unknown	Unknown	24
		Tuna	1
	USA	Unknown	2
2000-2012	Japan	Unknown	11
		Tuna	2
	Korea	Unknown	20
	Unknown	Unknown	5
	Russia	Unknown	1
	Taiwan	Tuna, Billfish	2
	USA	Unknown	1

Table 4. Summarized data from USGS and Smithsonian historical records on bycatch within the North Pacific, separated out in ten-year intervals by country and target fishery species

3.2 Spatial and Temporal Data Analysis Results

Spatial representations of the bycatch occurrence points are presented in Figures 10-16, symbolized based on different attributes determined from the new information in the band return cards and letters. Maps were produced showing the temporal variation between the bycatch incidences both combined into one map (Figure 13) and separated out individually by month (Figure 14) to demonstrate trends over the course of a single year as well. Descriptions of subsections of the North Pacific are as follows:

3.2.1 NORTH-EAST PACIFIC

Much of the bycatch in the Northeast Pacific was comprised of black-footed albatross, with a couple Laysan bycatch incidences in the high seas areas (Figure 10). Most of the bycatch points in this region are also closer to land within the United States EEZ. Of the known vessel country of origins in this region, most of them were from the United States with a just few Japanese vessels in the area (Figure 11). From the entire span of time that the total dataset covers, the only time-period not seen in this region was the most modern data from 2000-2012 (Figure 12). The remaining time periods were distributed in the area relatively equally. The months of the year that bycatch occurrences happened most often in this region were from May-October (Figure 13).

3.2.2 NORTH-CENTRAL PACIFIC

The only four bycatch occurrences of wedge-tailed shearwaters occurred in the waters surrounding Hawaii in this region (Figure 10). Much more of the bycatch in this region occurred in high seas to the western edge of the central part of the Pacific, mainly by Japanese and Korean fishing fleets (Figure 11). Temporally, it appears that most of the bycatch points occur in this region between December and April around the Hawaiian Islands (Figure 13).

3.2.2 NORTH-WEST PACIFIC

Most of the bycatch points happen in the Northwest Pacific region in the high seas, consisting of a split between Laysan and black-footed albatross (Figure 10). Almost every country seen in the entire dataset was seen at least once in this region (Figure 11). All of the modern data from 2000-2012 is found only in this region (Figure 12), along with almost all of the Japanese vessel bycatch occurrences (Figure 11). Throughout the course of the single year, it appears that most of the points in this region occur from May to October (Figure 13).

Through a hotspot analysis it was shown that high occurrence of bycatch over the entire timeline of the dataset occurred in the North-West Pacific, primarily in the high seas (Figure 15). Comparing this hotspot analysis of bycatch with fishing effort of Japanese long lines in that region, there is at least low effort of fishing seen over several time frames in this region as well (Figure 16). It should be noted though that this area is not the highest areas of fishing effort for this particular fishery in the entire Pacific, as it actually occurs more heavily in the Southern Pacific.

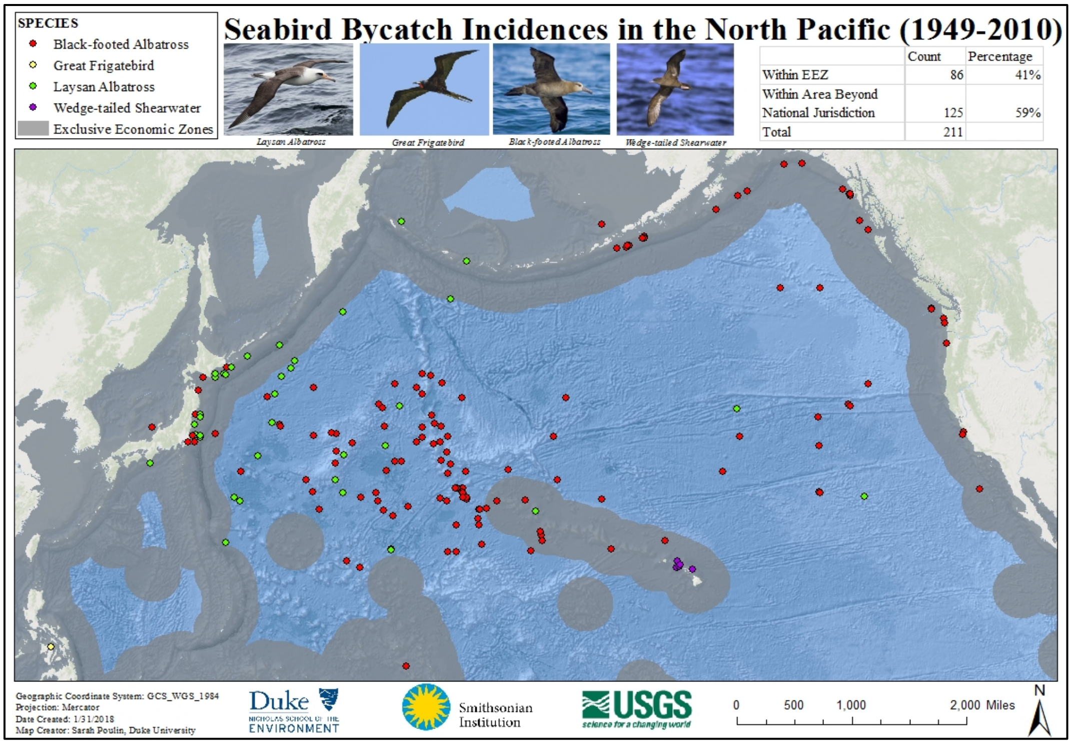


Figure 10. Spatial representation of the four species of seabirds found in the bycatch records, either in Areas Beyond National Jurisdiction (ABNJs) or within nation's Exclusive Economic Zones (EEZs).

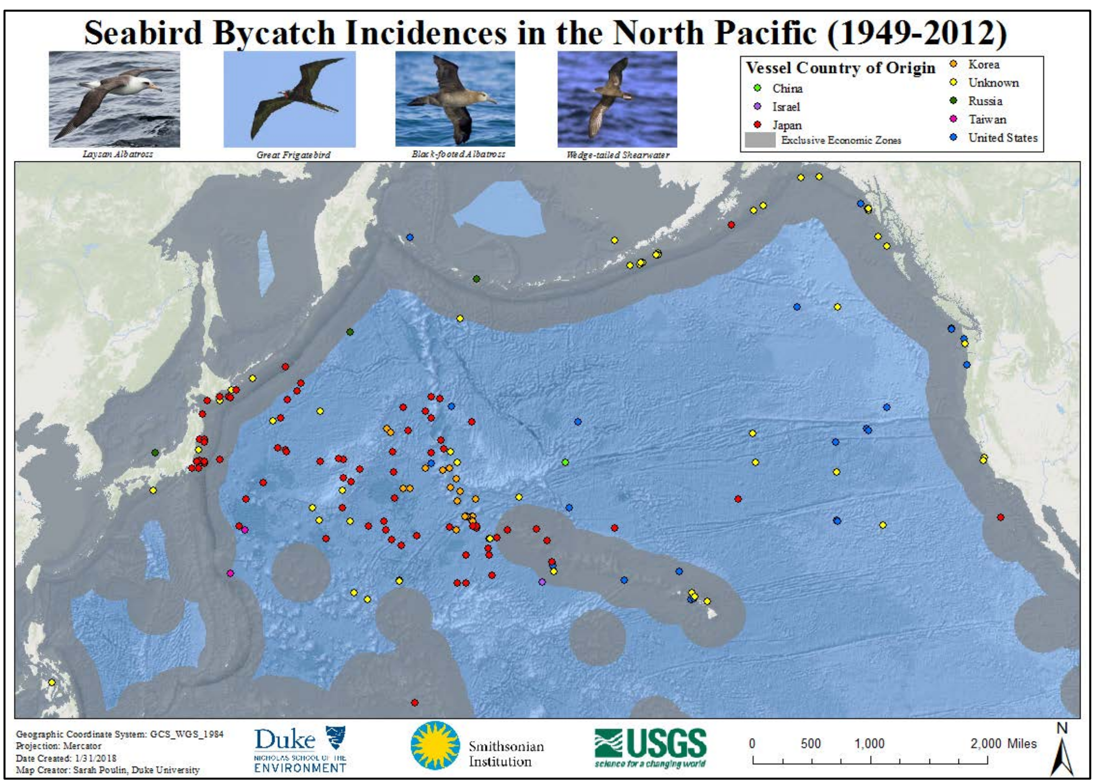


Figure 11. Spatial representation of the bycatch points labelled by the vessel country of origin which captured the seabird.

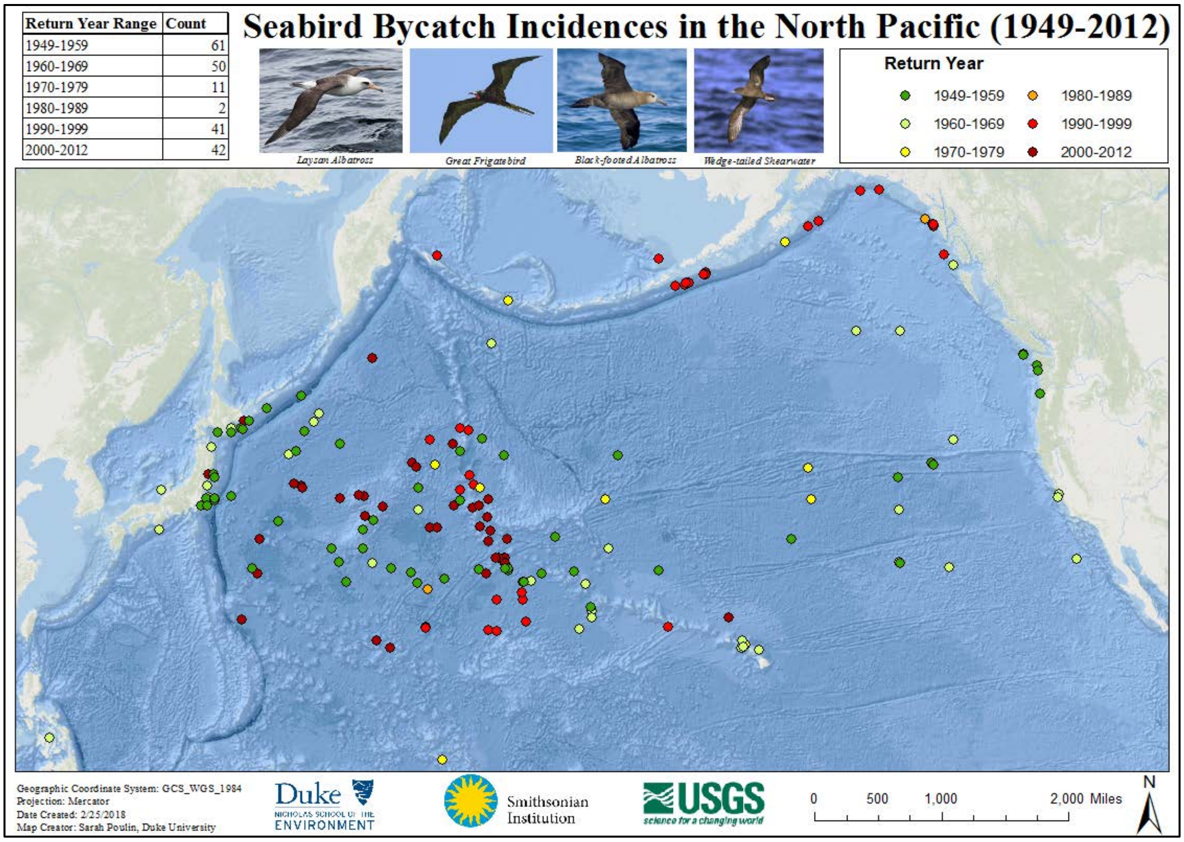


Figure 12. Bycatch occurrences spatially shown categorized by year ranges, spanning from 1949 to 2012

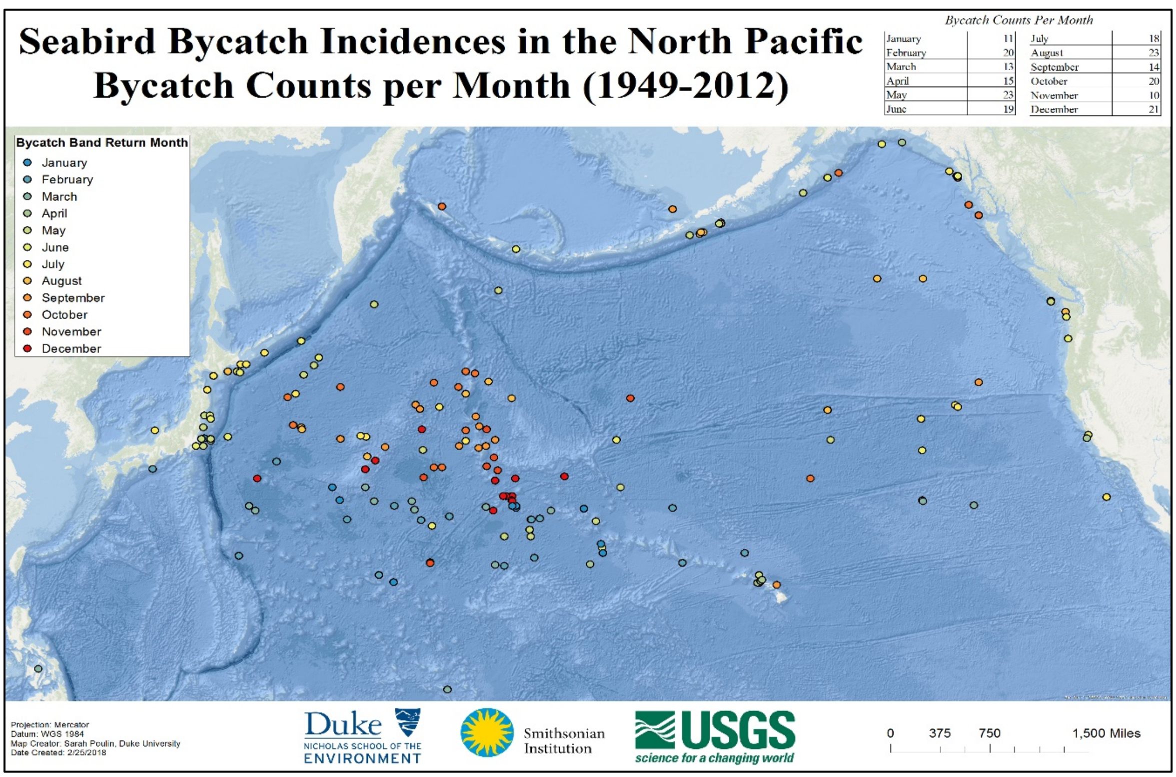


Figure 13. Spatial representation of bycatch occurrence totals in every month throughout the year.

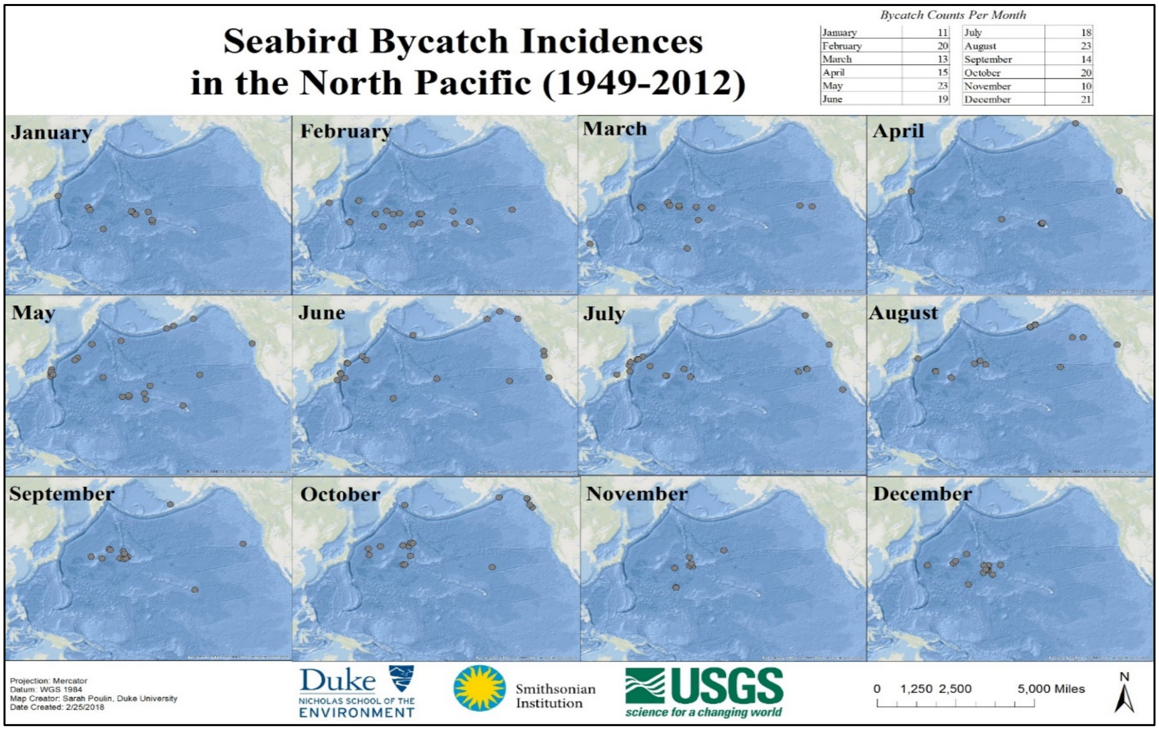


Figure 14. Total bycatch occurrences separated by month, representing spatial change over the course of a year

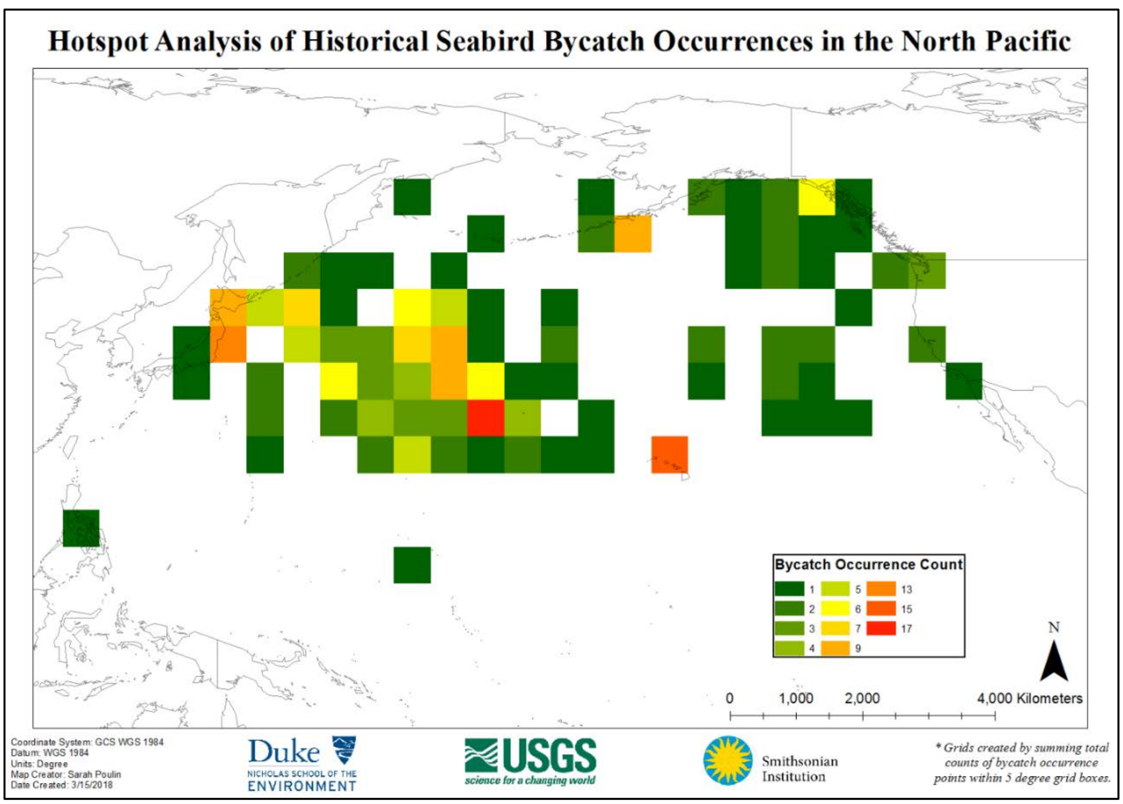


Figure 15. Bycatch hotspot areas within the North Pacific divided by 5^{o} x 5^{o} grids

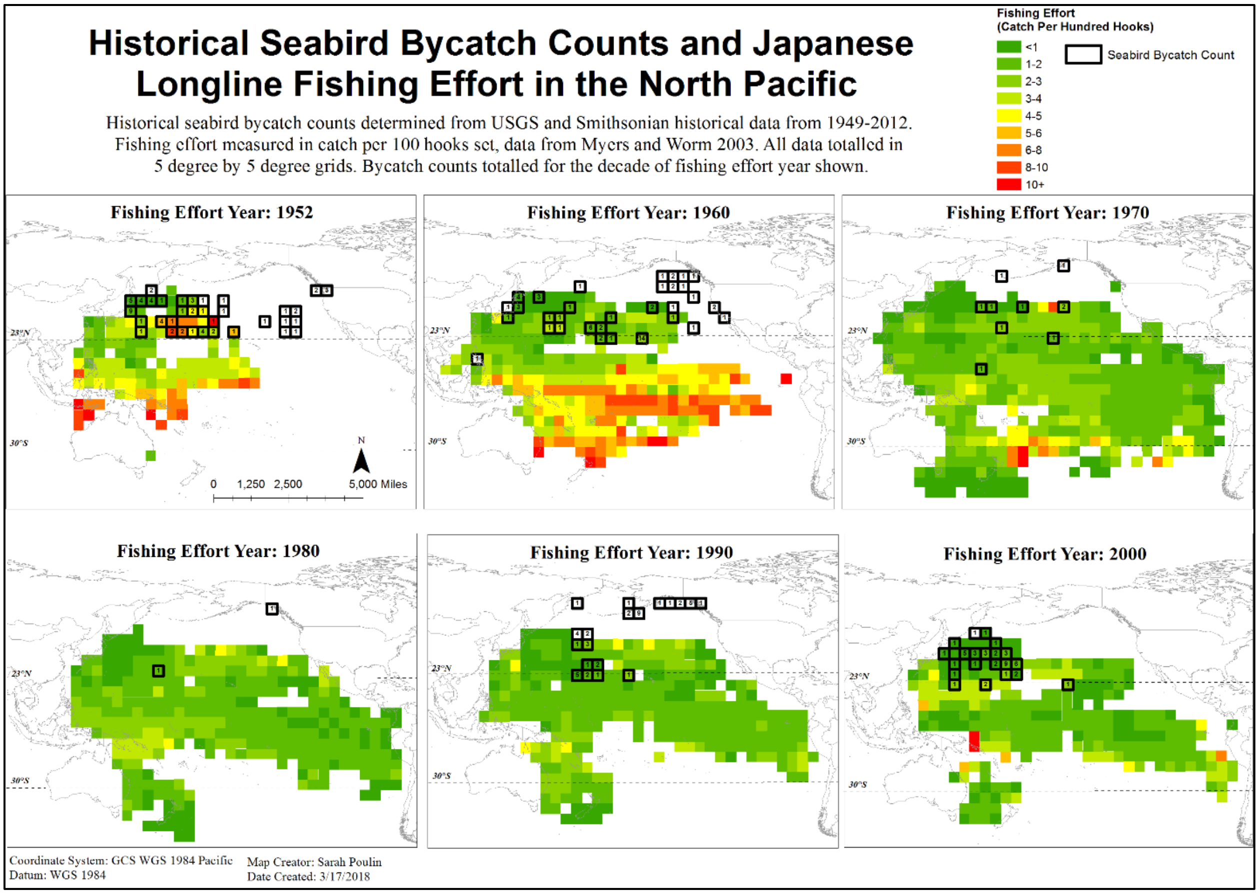


Figure 16. Spatial overlap of historical Japanese long line fishing effort (catch per hundred hooks) with the occurrence of seabird bycatch in the Pacific

4. Discussion

4.1 Data Exploration findings

The results of this data exploration showed that there is a wide range of new information about historic records that can be obtained by transcribing and analyzing these datasets. The documentation of the 212 bycatch records found in the USGS and Smithsonian band return documents provided a vast amount of new knowledge on historical seabird bycatch in the North Pacific. Of the four species encountered in the band return cards as bycatch, the highest was of black-footed albatross by a large margin (Figure 10). It is not surprising that albatross in general were seen in high numbers as bycatch in this region, as these species are often cited as following fishing vessels in the Pacific. Historically, notes on at-sea seabird observations in the North Pacific have shown the same higher frequencies of black-footed albatross being recorded compared to Laysan albatross (Thompson 1951). Interestingly though, more recent observations and population status reports of albatross in the North Pacific indicate significantly higher breeding pair counts of Laysan albatross compared to black-footed albatross (Arata, Sievert, and Naughton 2009). Delving deeper into the spatial localities of the bycatch occurrences for each of these two species of albatross, there is a clear trend in Laysan falling victim to fishing gear interactions in the Western Pacific while black-footed albatross are caught in more widespread patterns throughout the entirety of the study region (Figure 9). Modern tracking data has shown trends in Laysan albatross utilizing Western Pacific waters more often throughout migration and foraging ranges during their breeding season, supporting the patterns seen in this dataset of higher bycatch occurring there for these species as well (Conners et al. 2015).

Looking at the general trends of the locations of all the bycatch occurrences, more incidences happened in the high seas, or Areas Beyond National Jurisdiction (ABNJ), than in country's Exclusive Economic Zones (EEZs) (Figure 10). Though there are specific regulations for fishing and bycatch mitigation methods for both national and international waters, monitoring and management of the ABNJ tends to be more difficult due to the large spatial extent of these waters and the need for international cooperation to set regulations. Upon closer examinations of what regions of the North Pacific specific countries are interacting with seabirds most, it is demonstrated that almost all of the Japanese and Korean bycatch occurrences, two nations that constituted extremely high proportions of all the incidences, are in Western Pacific closer to their home ports but also expanding out to the ABNJ (Figure 11). As another large contributor to the bycatch occurrences, the United States tended to catch birds within their own national waters surrounding the Hawaiian Islands in the Central Pacific and coastal California and Aleutian Islands areas.

There were 9 different target species, what the fishers noted as their intended catch, in the bycatch records. Although this attribute was the least cited in the records, we can still see that most commonly fishing for tuna resulted in the occurrence of seabird bycatch occurrences within these records by a large margin. This is not surprising, as both historically and currently high rates of tuna fishing are noted particularly for the Pacific Ocean compared to other areas of the world (Miyake, Miyabe, and Nakano 2004)

There were several temporal trends in the dataset worth noting, particularly in regard to the life history traits of the seabirds commonly noted as bycatch. Though the breakdown of bycatch counts happening in each month were not significantly different over the course of the year, when the points were broken down spatially by the month there were more interesting patterns seen (Figure 14). Trends noted here are discussed only in regard to North Pacific albatross breeding cycles, as almost all of the bycatch points represented these species.

November begins the breeding season for albatross in the North pacific, happening almost exclusively on the Hawaiian Islands. Once the eggs are laid in mid-November the parents will take turns sitting at the nest during incubation period while the other leaves the breeding site, alternating short term foraging trips for a period of about two months (Kappes et al. 2010). From November to January, it is evident in the spatial localities of the bycatch points that many of the interactions occurred within a foraging range distance from the Hawaiian islands (Figure 14). From mid-January to mid-February the eggs begin to hatch, and the adults enter what's called the chick-rearing period, when parents continue to take turns guarding the chick at the nest while the other forages. In early chick-rearing the parents tend to forage closer to the nest location, but as the chick grows they are known to expand further and further out during their foraging trips to more productive waters (Young et al. 2009). This trend is very much visible within the bycatch data, as the points range farther from Hawaii in the later months of May and

June (Figure 14). By July chicks have fully fledged and left the nest, and adults begin their non-breeding migration routes farther out to Western Pacific and Alaskan waters (Suryan and Fischer 2010). This again is visible in where the bycatch is happening during these months, an interesting supplement to tracking data today that demonstrates similar trends between where the albatross are expected to be found according to their life history trait at that time and where higher rates of bycatch are occurring.

Despite the high counts of bycatch found in this dataset, there was an obvious gap even within this historical data between the late 1960s and the early 1990s (Figure 3). Though it is difficult to give concrete reasons as to why this might have occurred, as this report represents only two datasets of information over the scale of many years of potential interactions, there are several potential ideas as to the causality of this data gap. Reporting of bycatch within US national waters did not become mandatory until the early 1990s, when the NOAA National Marine Fisheries Service began their National Observer Programs in different regions of the countries waters. Until this time, there was little formal establishment of methods for reporting bycatch on the water, and therefore little information could be collected by fishermen who may have still been having seabirds caught in their gear. Similarly, the two Pacific RFMOs did not begin requiring observers on vessels in their waters until much later, in 2007 for the WCPFC and 2008 for the IATTC ("Observer Programmes of RFMOs" 2016). Due to the high rate of incidental mortality to marine species, including seabirds, a global moratorium on pelagic driftnet fishing in the high seas was implemented in December 1991 by the United Nations General Assembly Resolution 46-215. In 1992 the UN also banned the use of drift nets of a certain length, a strong push to limit these negative interactions. The data gap could therefore be a result of better reporting outside of these lacking year ranges, or potentially a true lowering of bycatch rates when certain gear types began to be removed from the waters.

4.2 Comparisons with current bycatch counts

It was not until 1990 that the North Pacific Observer Program began in the United States, where NOAA took the lead on requiring fishery vessels with frequent marine mammal interactions to carry observers for 20-30% of their fishing days. These observer programs provide much of the data that we have on all bycatch in national waters today, specifically with recent address to the issue of seabird bycatch. Though they provide much helpful information now, prior to their use there was little organized methodologies set up for tracking bycatch occurrences on vessels, and therefore this data has not been used as frequently in management and population count measures. Looking through RFMO seabird bycatch documents and management plans, the most updated bycatch estimates show only rates of bycatch in the past 30 years with some values even being extrapolated from smaller accounts in particular regions (Table 5). Current management surrounding seabird bycatch mitigation for the two RFMOs in the Pacific only are in effect for regions north of 23ºN within their management boundaries, yet evidence in both the historical data in this paper and in the other accounts in the RFMO documents show bycatch occurring beyond these boundaries.

RFMO	Region	Country	Target	Year	Total Estimated Seabird Bycatch	Sources
IATTC	15-40ºS, 75-120ºW	Spain	Swordfish	1998-2005	[260]	Moreno et al. 2007, ATF Report
IATTC	USA West Coast	USA	Tuna, Swordfish	2001-2004		Dai et al. 2006, IATTC 2007
IATTC	3-17ºS, 96-146ºW	China	Bigeye Tuna	2003	[866]	IATTC 2007
IATTC	5º42'-11º23'S, 123º39'-146º43W	Korea	Tuna	2004-2005	[727]	Moon et al. 2005
IATTC	IATTC Area	Japan	Tuna, Swordfish	2005	[1434]*	Ayala et al. 2008
IATTC	IATTC Area	Taiwan	Tuna	2005	[614]	Mejuto et al. 2007, Mejuto and Garcia-Cortes 2005
IATTC	Hawaii	USA	Tuna	2005	125	Chang et al. 2007, Huang et al. 2008
IATTC	Hawaii	USA	Swordfish	2005	69	Rivera 2006, IATTC 2007
IATTC	3-10ºS, 80-86ºW	Peru	Dolphinfish	2006-2008	0	Rivera 2008, IATTC 2007
IATTC	FAO Area 87	Chile	Swordfish	2007	517-923	Rivera 2008, IATTC 2007
WCPFC	Australian EEZ	Japan	Tuna	1988	33	Brothers 1991
WCPFC	New Zealand EEZ	Japan	Tuna	1988-1990	263	Murray et al. 1993
WCPFC	Australian EEZ	Japan	Tuna	1988	12	NMFS Southwest Fisheries Science Center, Cousins et al. 2000
WCPFC	Australian EEZ	Japan	Tuna	1988-1995	NA	Baker & Wise 2005
WCPFC	New Zealand EEZ	Japan	Tuna	1991-1992	59	NMFS Southwest Fisheries Science Center, Cousins, et al. 2000
WCPFC	New Zealand EEZ	Japan	Tuna	1991-1996	116-1359	E. Gilman 2004
WCPFC	Australian EEZ	Japan	Tuna	1992-1995	1076	E. Gilman 2004
WCPFC	USA	USA	Swordfish	1994-2002	106	E. Gilman 2004
WCPFC	Australian EEZ	Japan	Tuna	1997	36	Murray et al. 1993
WCPFC	Australian EEZ	Australia	Tuna & billfish	2001-2003	87	Manly et al. 2002
WCPFC	USA	USA	Swordfish	2001-2003	61	Brothers 1991
WCPFC	Australian EEZ	Australia	Tuna & billfish	2001-2003	84	Klaer and Polacheck 1997
WCPFC	Tasmania	Japan	Tuna	2001-2002	5	Gales et al. 1998
WCPFC	USA, mostly south of 23ºN		Tuna	2002-2003	0	Brothers et al. 1997
WCPFC	USA, all north of 23º		Tuna	2002-2003	1	Baker and Wise 2005
WCPFC	USA, mostly south of 23ºN		Tuna	2002-2003	5	Kiyota and Takeuchi 2004

Table 5. Records of seabird bycatch in the Pacific from IATTC (O. Anderson 2009) and WCPFC (Birdlife International 2006) records (* indicates bycatch rate taken from similar fisheries in IATTC (Korea and China) to allow estimation of total bycatch).

4.2 Use of Historical Data in Management

This new data from the Smithsonian and USGS truly complement the current datasets that these organizations hold and could be of high benefit to more accurate estimations of seabird bycatch on longer time scales. Several studies have estimated historical bycatch incidences of both Laysan and black-footed albatross using modern data and retro-modelling, but very little raw data has been documented or analyzed from before the 1970s despite bycatch still being an issue during this time (Arata, Sievert, and Naughton 2009). This issue stems from the fact that only a few cases of this historical bycatch data have been formally written up in reports, and most do not reach back farther then the late 1970s (DeGrange and Day 1991; Ogi et al. 1991; Yatsu et al. 1993). This report has begun to address the overlap of archived seabird bycatch data with historical fishing effort data (Figure 16), but further analysis of this relationship with more thorough fishing data will aid in the furtherance of longitudinal analyses on the interactions between fishing and seabirds throughout the 20th century.

There is an obvious lack of historical data on seabird bycatch in the North Pacific used in management today. This can lead to issues pertaining to the shifting baseline syndrome, skewing our perspectives on the state of the ocean and future management to only consider the present circumstances we find ourselves in. One unquestionable beneficiary of an initiative for documentation of historical datasets would be conservation. Even in the face of increasing ecological and global change, information about past conditions will remain an important input when setting priorities for marine conservation and management. But, for this to be effective we need to be deliberate about documenting this change, before the opportunities to do so are lost. More recognition of historical datasets will add to the value of this information so that they can be treated on an equal level to the large amounts of data we are collecting today. Small projects, such as this one, are a start to help push the proof in the worth of historical data now and for the future of ocean management.

<u>References</u>:

Anderson, Orea. 2009. "Estimating Seabird Bycatch Rates in IATTC Industrial Longline Fisheries." *Birdlife International* Seabird Technical Meeting of the IATTC Stock Assessment Working Groun (Del Mar, California, USA).

Anderson, Orea R. J., Cleo J. Small, John P. Croxall, Euan K. Dunn, Benedict J. Sullivan, Oliver Yates, and Andrew Black. 2011. "Global Seabird Bycatch in Longline Fisheries." *Endangered Species Research* 14 (2): 91–106. https://doi.org/10.3354/esr00347.

Arata, JA, Paul R. Sievert, and MB Naughton. 2009. "Status Assessment of Laysan and Black-Footed Albatrosses." *U.S. Geological Survey Scientific Investigations Report 2009* North Pacific Ocean.

Ayala, L., S. Amoros, and C. Cespedes. 2008. "Catch and Bycatch of Albatross and Petrel in Longline and Gillnet Fisheries in Northern Peru." *Final Report to Rufford SmallGrants Foundation*.

Barak, Rebecca S., Andrew L. Hipp, Jeannine Cavender-Bares, William D. Pearse, Sara C. Hotchkiss, Elizabeth A. Lynch, John C. Callaway, Randy Calcote, and Daniel J. Larkin. 2015. "Taking the Long View: Integrating Recorded, Archeological, Paleoecological, and Evolutionary Data into Ecological Restoration." *International Journal of Plant Sciences* 177 (1): 90–102. https://doi.org/10.1086/683394.

Barry Baker, G., and Brent S. Wise. 2005. "The Impact of Pelagic Longline Fishing on the Flesh-Footed Shearwater Puffinus Carneipes in Eastern Australia." *Biological Conservation* 126 (3): 306–16. https://doi.org/10.1016/j.biocon.2005.06.001.

Birdlife International. 2006. "Summary of Seabird Bycatch Rates Recorded in the Western and Central Pacific." *Second Session of Teh WCPFC Ecosystem and Bycatch SWG* Manila (August).

Brothers, N. 1991. "Albatross Mortality and Associated Bait Loss in the Japanese Longline Fishery in the Southern Ocean." *Biological Conservation* 55: 255–68.

Brothers, N, R Gales, and T Reid. 1999. "The Influence of Environmental Variables and Mitigation Measures on Seabird Catch Rates in the Japanese Tuna Longline Fishery within the Australian Fishing Zone, 1991–1995." *Biological Conservation* 88 (1): 85–101. https://doi.org/10.1016/S0006-3207(98)00085-8.

Chang, S-K, J-P Tai, and C-H Shiao. 2007. "Seabirds Incidental Catches and Shark Bycatches in the Pacific Ocean from Taiwanese Observer Data of 2002-2005." *SAR-8-12e* 8th Meeting of the Stock Assessment Working Group of IATTC (La Jolla, California).

Clapp, Roger B., and Paul Woodward. 1968. "New Records of Birds from the Hawaiian Leeward Islands." *Proceedings of the United States National Museum* 124 (3640): 1–39.

Conners, Melinda G., Elliott L. Hazen, Daniel P. Costa, and Scott A. Shaffer. 2015. "Shadowed by Scale: Subtle Behavioral Niche Partitioning in Two Sympatric, Tropical Breeding Albatross Species." *Movement Ecology* 3 (September): 28. https://doi.org/10.1186/s40462-015-0060-7.

Cousins, K.L., P. Dalzell, and E. Gilman. 2000. "International Efforts to Manage Pelagic Longline Albatross Interactions in the North and Central Pacific Ocean." *Marine Ornithology* 28: 9–17.

Dai, X., L. Xu, and L. Song. 2006. "Observation of Seabird Bycatch in the Chinese Longline Fishery in the IATTC Waters." *SAR-7-05e* 7th Meeting of the Stock Assessment Working Group of IATTC.

DeGrange, A.R., and R.H. Day. 1991. "Mortality of Seabirds in the Japanese Land-Based Gillnet Fishery for Salmon." *Condor* 93: 251–58.

Ely, Charles A. 1971. “Pelagic Observations of the Japanese White-Eye in the Central Pacific.” *The Condor* 73 (1): 122–23. https://doi.org/10.2307/1366140.

Everett, William, and Robert Pitman. 1993. “Status and Conservation of Shearwaters of the North Pacific.” *Canadian Wildlife Service Special Publications, Ottawa, Canada* The Status, Ecology, and Conservation of Marine Birds of the North Pacific: 93–101.

Fleet, Robert R. 1972. “Nesting Success of the Red-Tailed Tropicbird on Kure Atoll.” *The Auk* 89 (3): 651–59.

Gales, R., N. Brothers, and T. Reid. 1998. “Seabird Mortality in the Japanese Tuna Longline Fishery around Australia, 1988–1995.” *Biological Conservation* 86 (1): 37–56. https://doi.org/10.1016/S0006-3207(98)00011-1.

Gilman, E. 2004. “Assessment of Strategies to Reduce Seabird Bycatch. Employed by Hawaii Pelagic Longline Tuna Vessels and of Observer Program Data Collection Protocols.” *Prepared for the Western Pacific. Regional Fishery Management Council* Blue Ocean Institute.

Gilman, Eric, Nigel Brothers, and Donald R. Kobayashi. 2005. “Principles and Approaches to Abate Seabird By-Catch in Longline Fisheries.” *Fish and Fisheries* 6 (1): 35–49. https://doi.org/10.1111/j.1467-2679.2005.00175.x.

Gilman, Eric L. 2011. “Bycatch Governance and Best Practice Mitigation Technology in Global Tuna Fisheries.” *Marine Policy* 35 (5): 590–609. https://doi.org/10.1016/j.marpol.2011.01.021.

Gould, Patrick J., and Warren B. King. 1967. “Records of Four Species of Pterodroma from the Central Pacific Ocean.” *The Auk* 84 (4): 591–94. https://doi.org/10.2307/4083340.

Huang, H-W, S-K Chang, and J-P Tai. 2008. “Preliminary Estimation of Seabird Bycatch of Taiwanese Longline Fisheries in the Pacific Ocean.” *SAR-9-11c* 9th Meeting of the Stock Assessment Working Group of IATTC (La Jolla, California).

IATTC. 2007. “The Fishery for Tuna and Billfishes in the Eastern Pacific Ocean in 2006.” *IATTC-75- 06* 75th Meeting (Cancun, Mexico).

———. 2011. “Resolution to Mitigate the Impact on Seabirds of Fishing for Species Covered by the IATTC.” *IATTC Resolution C-11- 02* La Jolla, CA, USA: Inter-American Tropical Tuna Commission.

Igual, José Manuel, Giacomo Tavecchia, Stephanie Jenouvrier, Manuela G. Forero, and Daniel Oro. 2009. “Buying Years to Extinction: Is Compensatory Mitigation for Marine Bycatch a Sufficient Conservation Measure for Long-Lived Seabirds?” *PLoS ONE* 4 (3). https://doi.org/10.1371/journal.pone.0004826.

Jackson, Jeremy B. C., Michael X. Kirby, Wolfgang H. Berger, Karen A. Bjorndal, Louis W. Botsford, Bruce J. Bourque, Roger H. Bradbury, et al. 2001. “Historical Overfishing and the Recent Collapse of Coastal Ecosystems.” *Science* 293 (5530): 629–37. https://doi.org/10.1126/science.1059199.

Johnston, David, and Robert W. McFarlane. 1967. “Migration and Bioenergetics of Flight in the Pacific Golden Plover.” *The Condor* 69 (2).

Kappes, Michelle A., Scott A. Shaffer, Yann Tremblay, David G. Foley, Daniel M. Palacios, Patrick W. Robinson, Steven J. Bograd, and Daniel P. Costa. 2010. “Hawaiian Albatrosses Track Interannual Variability of Marine Habitats in the North Pacific.” *Progress in Oceanography*, CLimate Impacts on Oceanic TOp Predators (CLIOTOP)CLIOTOPCLIOTOP International Symposium, 86 (1–2): 246–60. https://doi.org/10.1016/j.pocean.2010.04.012.

King, Warren B. 1970. “The Trade Wind Zone Oceanography Pilot Study, Part VII: Observations of Sea Birds, March 1964 to June 1965.” *U S Fish and Wildlife Service Special Scientific Report-Fisheries*, no. 586.

———. 1974. “Pelagic Studies of Seabirds in the Central and Eastern Pacific Ocean.” http://repository.si.edu//handle/10088/5305.

Kiyota, M, and Y. Takeuchi. 2004. “Estimation of Incidental Take of Seabirds in the Japanese Southern Bluefin Tuna Longline Fishery in 2001-2002.” *Paper Submitted to CCSBT’s Ecologically Related Species Working Group, CCSBT*.

Klaer, Neil, and Tom Polacheck. 1997. “By-Catch of Albatrosses and Other Seabirds by Japanese Longline Fishing Vessels in the Australian Fishing Zone from April 1992 to March 1995.” *Emu - Austral Ornithology* 97 (2): 150–67. https://doi.org/10.1071/MU97019.

Kroodsma, David A., Juan Mayorga, Timothy Hochberg, Nathan A. Miller, Boerder Kristina, Francesco Ferretti, Alex Wilson, et al. 2018. “Tracking the Global Footprint of Fisheries.” *Science; Washington* 359 (6378): 904–8. http://dx.doi.org.proxy.lib.duke.edu/10.1126/science.aao5646.

Løkkeborg, Svein. 1998. “Seabird By-Catch and Bait Loss in Long-Lining Using Different Setting Methods.” *ICES Journal of Marine Science: Journal Du Conseil* 55 (1): 145–49. https://doi.org/10.1006/jmsc.1997.9997.

Lotze, Heike K., Marta Coll, Anna M. Magera, Christine Ward-Paige, and Laura Airoldi. 2011. “Recovery of Marine Animal Populations and Ecosystems.” *Trends in Ecology & Evolution* 26 (11): 595–605. https://doi.org/10.1016/j.tree.2011.07.008.

Manly, Bryan F. J., Claire Cameron, and David J. Fletcher. n.d. *Doc Science Internal Series 43*.

McClenachan, Loren, Francesco Ferretti, and Julia K. Baum. 2012. “From Archives to Conservation: Why Historical Data Are Needed to Set Baselines for Marine Animals and Ecosystems.” *Conservation Letters* 5 (5): 349–59. https://doi.org/10.1111/j.1755-263X.2012.00253.x.

Mejuto, J., and B. Garcia-Cortes. 2005. “Documentacion Sobre El Preparacion de Datos Cientificos de La Pesqueria Espanola de Pez Espada (Xiphias Gladius) En Las Regiones Del Pacifico, Con Especial Referencia a Los Anos Mas Recientes 2002 y 2003.” *DC-1-02d* Data and Standards Review Meeting of IATTC (La Jolla, California).

Mejuto, J., B. Garcia-Cortes, A. Ramos-Cartelle, and J. Ariz. 2007. “Preliminary Overall Estimations of Bycatch Landed by the Spanish Surface Longline Fleet Targeting Swordfish (Xiphias Gladius) in the Pacific Ocean and Interaction with Marine Turtles and Seabirds: Years 1990-2005.” *BYC-6-INF A* 6th Meeting of the Bycatch Working Group of IATTC (La Jolla, California).

Miyake, MP, N Miyabe, and Hideki Nakano. 2004. “Historical Trends of Tuna Catches in the World.” *FAO Fisheries Technical Paper* No. 467: 1–74.

Moon, D-Y, S-S Kim, and J-K Koh. 2005. “A Summary of the Korean Tuna Fishery Observer Program for the Pacific Ocean (2004-2005).” *WCPFC-SC1 ST IP-3* WCPFC Scientific Committee Meeting (Noumea, New Caledonia).

Moreno, C.A., R. Vega, H. Ruiz, and H. Flores. 2007. “Albatross Task Force, Chile, Activity Report.”

Morrison, Scott A., T. Scott Sillett, W. Chris Funk, Cameron K. Ghalambor, and Torben C. Rick. 2017. “Equipping the 22nd-Century Historical Ecologist.” *Trends in Ecology & Evolution* 32 (8): 578–88. https://doi.org/10.1016/j.tree.2017.05.006.

Murray, T. E., J. A. Bartle, S. R. Kalish, and P. R. Taylor. 1993. “Incidental Capture of Seabirds by Japanese Southern Bluefin Tuna Longline Vessels in New Zealand Waters, 1988-1992.” *Bird Conservation International* 3 (3): 181–210. https://doi.org/10.1017/S0959270900000897.

Myers, Ransom A., and Boris Worm. 2003. “Rapid Worldwide Depletion of Predatory Fish Communities.” *Nature* 423 (6937): 280–83. https://doi.org/10.1038/nature01610.

“Observer Programmes of RFMOs.” 2016. *4th Meeting of the Commission* COMM-04-INF-04.

Ogi, Haruo, Akihiko Yatsu, Hiroshi Hatanaka, Akira Nitta, Japan, and Suisanchō. 1991. *The Mortality of Seabirds by Driftnet Fisheries in the North Pacific*. Japan: Fisheries Agency of Japan.

Pauly, Daniel. 1995. “Anecdotes and the Shifting Baseline Syndrome of Fisheries.” *Trends in Ecology & Evolution* 10 (10): 430. https://doi.org/10.1016/S0169-5347(00)89171-5.

Peterson, Richard S., Carl L. Hubbs, Roger L. Gentry, and Robert L. DeLong. 1968. “The Guadalupe Fur Seal: Habitat, Behavior, Population Size, and Field Identification.” *Journal of Mammalogy* 49 (4): 665–75. https://doi.org/10.2307/1378727.

Rivera, K.S. 2006. “Seabirds and Fisheries in the IATTC Area.” *IATTC-SAR-7-05c* 7th Meeting of the Working Group on Stock Assessment of IATTC (La Jolla, California).

———. 2008. “Seabirds and Fisheries in the IATTC Area: An Update.” *IATTC SARM-9-11a* 9th Meeting of the Working Group on Stock Assessment of IATTC (La Jolla, California).

Sanger, Gerald A. 1970. “The Seasonal Distribution of Some Seabirds off Washington and Oregon, with Notes on Their Ecology and Behavior.” *The Condor* 72 (3): 339–57. https://doi.org/10.2307/1366013.

Schreiber, Ralph W. 1970. “Breeding Biology of Western Gulls (Larus Occidentalis) on San Nicolas Island, California, 1968.” *The Condor* 72 (2): 133–40. https://doi.org/10.2307/1366622.

Spear, Larry B., and David G. Ainley. 1999. “Migration Routes of Sooty Shearwaters in the Pacific Ocean.” *The Condor* 101 (2): 205–18. https://doi.org/10.2307/1369984.

Suryan, Robert M., and Karen N. Fischer. 2010. “Stable Isotope Analysis and Satellite Tracking Reveal Interspecific Resource Partitioning of Nonbreeding Albatrosses off Alaska.” *Canadian Journal of Zoology* 88 (3): 299–305. https://doi.org/10.1139/Z10-002.

Szabó, Péter. 2015. “Historical Ecology: Past, Present and Future.” *Biological Reviews* 90 (4): 997–1014. https://doi.org/10.1111/brv.12141.

Thompson, Daniel Q. 1951. “Notes on Distribution of North Pacific Albatrosses.” *The Auk* 68 (2): 227–35. https://doi.org/10.2307/4081189.

Thurstan, R. H., L. McClenachan, L. B. Crowder, J. A. Drew, J. N. Kittinger, P. S. Levin, C. M. Roberts, and J. M. Pandolfi. 2015. “Filling Historical Data Gaps to Foster Solutions in Marine Conservation.” *Ocean & Coastal Management*, Making Marine Science Matter: Issues and Solutions from the 3rd International Marine Conservation Congress, 115 (October): 31–40. https://doi.org/10.1016/j.ocecoaman.2015.04.019.

Tuck, Geoffrey N., Tom Polacheck, John P. Croxall, and Henri Weimerskirch. 2001. “Modelling the Impact of Fishery By-Catches on Albatross Populations.” *Journal of Applied Ecology* 38 (6): 1182–96.

WCPFC. 2007. “Conservation and Management Measure to Mitigate the Impact of Fishing for Highly Migratory Fish Stocks on Seabirds.” *CMM 2007-04* Palikir, Federated States of Micronesia: Western and Central Pacific Fisheries Commission.

Weimerskirch, Henri, Yves Cherel, Karine Delord, Audrey Jaeger, Samantha C. Patrick, and Louise Riotte-Lambert. 2014. “Lifetime Foraging Patterns of the Wandering Albatross: Life on the Move!” *ResearchGate* 450 (January): 68–78. https://doi.org/10.1016/j.jembe.2013.10.021.

Yatsu, Akihiko, K Hiramatsu, and K Hayase. 1993. "Outline of the Japanese Squid Driftnet Fishery with Notes on the By-Catch." *International North Pacific Fisheries Commission Bulletin* 53: 5–24.

Young, Lindsay C., Cynthia Vanderlip, David C. Duffy, Vsevolod Afanasyev, and Scott A. Shaffer. 2009. "Bringing Home the Trash: Do Colony-Based Differences in Foraging Distribution Lead to Increased Plastic Ingestion in Laysan Albatrosses?" *PLOS ONE* 4 (10): e7623. https://doi.org/10.1371/journal.pone.0007623.