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Bycatch of Taiwanese Tuna Longline Fisheries in the Pacific Ocean

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Abstract

Forty-three trips of observed data on Taiwanese large scale tuna longline fishing vessels in the Pacific Ocean from 2004 to 2007 were used to analyze the scale of bycatch. Albacore, bigeye, and yellowfin tuna were the most commonly caught species, and the composition were varied by fleets. The bigeye accounted for over 44% of the catches by the tropical bigeye fleets, while the albacore accounted for over 85% and 72% of the catches by the northern and southern albacore fleets respectively. The major bycatch were swordfish, blue marlins, blue sharks, and silky sharks. As for the discards, 2.59-3.1 % albacore, 1.6-4.8% of bigeye tuna, 0.5-3.9 % of yellowfin tuna were discarded because of their smaller sizes or depredation by sharks or dolphins. The depredation percentage of tuna was around 0.3% - 0.7 % by cetaceans, and 0.5%- 0.6% by sharks. Regarding to other ecological related species, 31 species of seabirds, four species of sea turtles, and five species of cetaceans were sighted during these observations. Three hundred and sixty one seabirds and seventy six sea turtles were bycatch, which the major species were black-footed albatross and Laysan albatross in North Pacific Ocean and Olive Ridley turtles in tropical areas. No cetaceans were bycatch in these trips.

Keywords: bycatch, cetacean, depredation, discard, observer, Pacific Ocean, sea birds, sea turtles, tuna longline fisheries

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1. Introduction

The increasing demand for fisheries resources has substantially increased the pressure to explore the resources. Currently, 80% of global fisheries stocks were either fully overexploited, depleted, or recovering from depletion(Pulvenis 2009). Bycatch, the combination of discarded catch plus incidental catch, have drawn a lot of attentions in recent years, as it is considered an important element in fishery management. Discarded catch, defined as the portion catch of the total animal (either dead, or alive) in the catch, which is thrown away, or dumped at sea for whatever reason, especially represents a significant proportion of global marine catches, and is generally considered as wastes, or suboptimal use of fishery resources (Kelleher 2005). The reasons for discards or live release may be the size is small with low value, depredation by sharks or cetaceans, quota limitation or other management measures. Studies showed the discarded rate for longline fisheries were around 0-40%, and the average discard rate of tuna longline fisheries were 22%(Kelleher 2005).

Meanwhile, there has been increasing global awareness for the protection of incidental catch species, included the marine mammals, sea birds, sea turtles and sharks (Hall et al. 2000; Lewison et al. 2004; Moore et al. 2009). Longline fishing has been indicated as one of the major threatens against those species. In the Pacific Ocean, The use of longline fishing technique have resulted in the decline in sustainability of some populations of albatrosses, and petrels in the North, and South Pacific(Baker and Wise 2005; Tuck et al. 2001). In tropical areas, fisheries bycatch has been implicated in population declines of several species of sea turtles worldwide (Lewison et al. 2004). In order to conserve these ecosystem related species and to reduce the impact of longline fisheries, the Food and Agriculture Organization(FAO) adopted an International Plan of Action for reducing incidental catch of seabirds in longline fisheries(FAO 1999) and guidelines for conservation sea turtles(FAO 2005).

Pacific Ocean is the world's largest tuna fishing ground (Majkowski 2007). The initial development of the tuna longline fishing occurred following World War II, as the Japanese fleet expanded its operation throughout the Pacific. The longline fisheries are catching yellowfin tuna (*Thunnus albacares*) and bigeye tuna in equatorial waters, and albacore at higher latitudes. The fleets are comprised of large distant water freezer vessels(Japanese, Taiwanese, and Korean) and smaller longline vessels (Langley et al. 2008). There were around 6,400 longline vessels operating by 34 countries in 2007 (IATTC 2009; Lawson 2009), and most of them were small scale vessels. Japanese and Taiwanese fleets are currently the largest distant water longline fleets fishing in the Pacific Ocean.

Considering the wide distribution of marine megafauna and fisheries, it is important to evaluate the impact of fisheries across large ocean regions (Lewison 2005). However, because of the difficulties to arrange observers onboard (Moore et al. 2009), especially for those distant water fishing longlines countries (Black 2008; Lewison and Crowder 2003), there was limited information relating to the scope of bycatch of tuna longline fisheries in high sea. To correctly assess the scale of bycatch, and to identify potential conservation points, primary observation data, collected during Taiwanese tuna fishing trips were used in this study.

2. Methods

2.1 Fishing Gear and Efforts data

Taiwanese tuna longline fishery started to operate in the Pacific since the 1950s. There are two major fleets: the albacore, and the bigeye fleet. The albacore vessels deployed 3,000 to 4,000 hooks per set, with secondary lines of about 26-30 m length, and use squid, saury, and sardines as baits. These vessels targeted on albacore for supplying to canneries in Pago Pago. The vessels generally operate seasonally from September to March in the North Pacific, and shift to the south from April to August.

In recent years, more vessels target on tropical species, including bigeye tuna and yellowfin tuna for Japanese frozen sashimi market. The bigeye vessels, which deployed 2,000 to 3,000 hooks per set, with secondary lines of about 40-50 m length, use squid, mackerel, milkfish as baits. The fleet conducts a year round operation, transships catches at sea to carriers, and receives fuel and supplies during transshipment.

2.2 Observer Program

Catch and bycatch data were collected from the observers since September 2002. In line with the government's policy and availability of budgets, the number of observers increased from 1 in 2002 to twenty in 2007. Three weeks training course are designed for scientific purposes. While onboard, observers shall record basic information of the vessels, daily fishing activities (which included fishing position (latitude and longitude), number of hooks, time of set and hauling, wind speed weather condition, using bird-scaring equipment or not, bait types, etc), catch information(number and weight of catches), bycatch information(the species and numbers of sighted during fishing operation, incidental catch number, species and status (live/dead)) and biological samples for specific species (Huang et al. 2008). For improving the ability to identify bycatch species, identification cards and training programs were developed. In addition, observers will take photos for species identification if necessary. The data we used were from 2004 to 2007.

2.3 Estimating the discard percentage and weight

For each set, observers recorded the number of retained, discard, live release, and depredation by sharks, depredation by cetaceans and unknown depredation. Because of time limitation, and some fishes were discard or released without onboard, only those retained will record the weight. The discard composition was estimated by calculating the percentage of each species to the total catch by number. For example,

Discard %=No. of discard/(No. of retained+ No. of discard +No. of live release + No. of depredation by cetaceans + No. of depredation by sharks + No. of unknown depredation).

3. Results

3.1 Fishing Efforts and distribution

The fishing grounds of Taiwanese longline fishing fleets were located in the whole Pacific region (Figure 1).The number of Taiwanese large scale tuna longline fishing vessels was 137 in 2004. Owing to the bigeye quota restriction by WCPFC, perceiving of the overcapacity of the fleet, the Government decided to carry out fleet reduction program to reduce the fishing vessels, offering to buyback a large number of LTLL (Huang and Chuang, 2009). The number of LTLL decreased to 97 in 2007, with 40% decreasing. The total catch in western and central Pacific Ocean was decreased from 42 thousand ton in 2004 to 19 thousand tons in 2007 (Lawson 2009).

A total of 43 observers trips were deployed in the Pacific Ocean from 2004 to 2007, 26 for bigeye tuna fleet, 10 for north albacore fleet and 7 for south albacore fleet. The observation days were 2,463. The overall coverage rate was 8.8 % by trip. Observations were distributed as Figure 2.

3.2 Catch composition

More than 28 species were recorded, including 11 tuna and tuna-like species, 10 shark species, and 7 species of other fishes. Catch composition were summarized by fleet in Table 1. Among them, three target tuna species, including bigeye, albacore, yellowfin, covered more than 76.39 % of the total catch which are varied by fleet. Skipjack, blue shark, and swordfish were the major bycatch. Billfishes were composed of 0.82%- 5.85% by fleets, sharks were composed of 1.89%-6.59% by fleets, as for other fishes, were around 6.38 - 11.17%.

In north albacore fleet, over 90% were three major target tunas, which 85.8 % were albacore, 3.37% bigeye, followed by 0.35 % yellowfin tunas. Blue shark was 1.56% which were the third. In tropical area, 44.3 % were bigeye, 14.75 % yellowfin, 13.66 % albacore and 3.68% were skipjack. The diversity of billfishes and shark species are were higher than albacore fleets. At least six billfishes and nine species of sharks were identified, which swordfish were 3.01% and blue shark was 2.68%. Other fishes, included 0.55% dolphin-fish, 0.14% spotted opah, 0.55% pomfret, 0.03% oilfish, 1.04% escolar and 0.71% Pacific king-fish were caught in this area, were composed of around 11.17 %. As for south albacore fleet, albacore accounted for 72.33 %, 3.83% bigeye, 5.14 % yellowfin and 2.08% skipjack. Other fishes, included dolphin-fish, spotted opah, pomfret, oilfish, escolar and Pacific king-fish were caught in this area, were composed of around 10.74 %.

3.3 Discard and Depredation

The discard percentages by number of Taiwanese tuna longline fleets were showed in Table 2 to Table 4. In north albacore fleet, among those tuna, more than 96% were retained; only 3.1% albacore were discarded, included 1.6% discard, 0.5% live release, 0.3% depredation by cetaceans and 0.6% depredation by sharks. Billfishes and most sharks retained rate were high, only other sharks discarded rate was high. In the contrary, the other fishes has higher discarded rate, such as the 25% of Pacific king-fish were discarded. The total discard percentage was 4.2%.

For bigeye tuna fleet has higher discarded rate was around 11.3%, 95.2% pomfret, 76.9% Ocean sunfish, 92.4% other sharks were discarded. The depredation percentage by cetaceans and sharks were 1.1%, and 0.3% for bigeye. The depredation rate was high for billfishes, which were ranged from 0.7% to 1.9%.

As for south albacore fleet, the composition was similar to north albacore. They kept most of the catch, including billfishes and sharks. Only 2.3 % were discarded, which most of them were other sharks, oilfish, ocean sunsifh and unknown fishes. The percentages of cetaceans and sharks depredation were 1.4% and 0.9% for bigeye, which were high than other fleets.

3.4 Ecological related species

The distribution of ecological species sighted were showed in Figure 3 and listed in Table 5, the detail information and bycatch status are as follows,

3.4.1 Seabirds

Thirty-one species of seabirds are sighted, including albatross, petrel, gull, shearwater, tropical birds in north Pacific, booby, frigate birds, tern, noddy in tropical areas, and albatross, giant petrel in south Pacific. 361 seabirds, including black-footed albatross, Laysan albatross, great frigate bird, yellow-nosed albatross and giant petrel, were incidentally caught. The seabird was bycatch more often in north of 30N north, 165E to 155W were shown in Figure 4. The major species and seasons were black-footed albatross and Laysan albatross in North Pacific from October to February.

3.4.2 Sea turtles

Four species of sea turtles are sighted, 76 sea turtles were incidentally caught. The distribution showed the sea turtles were bycatch in tropical area, especially in 0-10N, 135-145W (Figure 4). Of the sea turtles caught, 66 were Olive Ridley turtle, 4 were loggerhead turtles, 4 were leatherback turtles, 1 was Kemp's Ridley turtle and 1 unknown. Turtles ranged in size from 48 to 113 cm. More females were caught than males.

3.4.3 Cetaceans

During these trips, 5 species of cetaceans were sighted (Figure 3). None were incidentally caught during these observations.

4. Summary

This study helps us to identify hot spots for ecological related species conservation. Due to budget and personal might be limited for observer deployment,

it’s important to set priority for observation hot areas. In addition, outreach and conservation measures are required. In Taiwan, posters, sheets and booklets for guidance of mitigation measures and species identification for seabirds and sea turtles were disseminated to the fishermen would helps fishermen and industries to take appropriate measures in accordance with the NPOA. Through observers, captains and crews could get better information. More international cooperation on research would be helpful for sustainable of marine ecosystem and fisheries.

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Table1 Percentage of retained species by numbers by fleet from 2004 to 2007

Species\fleet	North Albacore	Bigeye tuna	South Albacore
TUNA	***90.90%***	***76.39%***	***83.38%***
Albacore	85.82%	13.66%	72.33%
Bigeye	3.37%	44.30%	3.83%
Yellowfin	0.35%	14.75%	5.14%
Skipjack	1.36%	3.68%	2.08%
Other tunas		0.00%	
TUNA-LIKE	***0.82%***	***5.85%***	***3.53%***
Swordfish	0.42%	3.01%	0.42%
Striped marlins	0.34%	0.53%	0.29%
Blue marlins	0.01%	1.63%	0.78%
Black marlins	0.01%	0.02%	0.03%
Sailfish		0.05%	0.09%
Shortbill spearfish	0.04%	0.52%	0.59%
Longbill spearfish		0.00%	0.00%
Other billfishes	0.01%	0.08%	1.32%
SHARKS	***1.89%***	***6.59%***	***2.35%***
Blue shark	1.56%	2.68%	1.45%
Silky shark	0.00%	1.76%	0.52%
Shortfin mako	0.27%	0.19%	0.33%
Scalloped hammerhead		0.03%	
Smooth hammerhead		0.02%	
Oceanic whitetip shark		0.19%	0.02%
Sandbar shark		0.00%	
Thresher shark	0.00%	0.08%	0.00%
Bigeye thresher		0.27%	0.02%
Great white shark	0.05%	0.02%	0.00%
Other sharks	0.01%	1.34%	0.01%
OTHER	***6.38%***	***11.17%***	***10.74%***
Common dolphifish	0.65%	0.55%	0.13%
Spotted Opah	0.53%	0.14%	0.65%
Pomfret	0.00%	0.55%	0.35%
Oilfish	0.03%	0.03%	0.15%
Escolar	0.12%	1.04%	1.76%
Pacific king-fish	0.01%	0.71%	4.78%
Ocean sunfish		0.02%	0.00%
Other fishes	5.04%	8.13%	2.92%

Table 2 Retained and discarded percentages of the total number of fish caught by north albacore fleet from 2004 to 2007

	Landing	Discard					
		Total	Discard	Live Release	Depredation by cetaceans	Depredation by sharks	Unidentified depredation
TUNA							
Albacore	96.9%	3.1%	1.6%	0.5%	0.3%	0.6%	0.0%
Bigeye	98.4%	1.6%	0.3%	0.9%			
Yellowfin	99.5%	0.5%		0.5%			
Bluefin tuna	100.0%						
Skipjack	97.5%	2.5%	1.2%	1.2%			
BILLFISHES							
Swordfish	94.6%	5.4%	1.3%	2.7%	0.4%	0.4%	0.4%
Striped marlins	100.0%						
Blue marlins	100.0%						
Black marlins	100.0%						
Shortbill spearfish	95.2%	4.8%	4.8%				
Other billfishs	100.0%						
SHARKS							
Blue shark	97.5%	2.5%	0.5%	2.0%			
Silky shark	100.0%						
Shortfin mako	100.0%						
Thresher shark	100.0%						
Great white shark	100.0%						
Other sharks	66.7%	33.3%	33.3%				
OTHER FISHES							
Common dolphifish	86.0%	14.0%	6.0%	2.0%	2.0%	2.0%	2.0%
Spotted Opah	96.5%	3.5%	0.3%	3.1%			
Oilfish	100.0%						
Escolar	100.0%						
Pacific king-fish	75.0%	25.0%	25.0%				
Unknown	74.3%	25.7%	17.2%	8.4%		0.0%	
Sum	95.8%	4.2%	2.3%	1.0%	0.3%	0.5%	0.1%

Table 3 Retained and discarded percentages of the total number of fish caught by bigeye tuna fleet

		Discard					
	Landing	Total	Discard	Live Release	Depredation by cetaceans	Depredation by sharks	Unidentified depredation
TUNA							
Albacore	97.0%	3.0%	1.3%	0.1%	0.5%	1.0%	0.1%
Bigeye	96.7%	3.3%	1.2%	0.2%	1.1%	0.3%	0.4%
Yellowfin	98.1%	1.9%	0.6%	0.1%	0.4%	0.7%	0.1%
Skipjack	47.7%	52.3%	51.8%	0.1%	0.1%	0.3%	
Other tunas	100.0%						
Billfishes							
Swordfish	88.0%	12.0%	9.8%	1.2%	0.7%	0.2%	0.1%
Striped marlins	97.7%	2.3%	0.6%		1.5%	0.3%	
Blue marlins	97.1%	2.9%	0.3%	0.5%	1.0%	1.0%	0.2%
Black marlins	100.0%						
Sailfish	100.0%						
Shortbill spearfish	97.6%	2.4%	1.2%	0.0%	0.9%	0.3%	
Longbill spearfish	100.0%						
Other billfishs	94.2%	5.8%	1.9%	0.0%	1.9%	1.9%	
SHARKS							
Blue shark	77.4%	22.6%	20.7%	1.9%	0.1%		
Silky shark	94.5%	5.5%	5.2%	0.3%			
Shortfin mako	96.8%	3.2%	3.2%				
Scalloped hammerhead	95.2%	4.8%	0.0%	4.8%			
Smooth hammerhead	81.3%	18.8%	18.8%				
Oceanic whitetip shark	89.6%	10.4%	8.8%	1.6%			
Sandbar shark	0.0%	100.0%	100.0%				
Thresher shark	50.0%	50.0%	50.0%				
Bigeye thresher	55.0%	45.0%	44.4%	0.6%			
Great white shark	90.0%	10.0%		10.0%			
Other sharks	7.6%	92.4%	92.0%	0.3%			
OTHER FISHES							
Common dolphifish	94.1%	5.9%	4.5%			1.4%	
Spotted Opah	77.5%	22.5%	22.5%				
Pomfret	4.8%	95.2%	94.1%		0.6%	0.6%	
Oilfish	100.0%	0.0%	0.0%			0.0%	
Escolar	87.3%	12.7%	11.2%	1.3%		0.1%	
Pacific king-fish	98.5%	1.5%	0.7%	0.7%		0.2%	
Pacific king-fish	54.5%	45.5%	36.4%			9.1%	
Ocean sunfish	23.1%	76.9%	23.1%	53.8%			
Unknown	51.7%	48.3%	44.6%	3.6%	0.1%	0.1%	
Sum	88.7%	11.3%	9.4%	0.6%	0.7%	0.5%	0.2%

Table 4 Retained and discarded percentages of the total number of fish caught by south albacore fleet

	Landing	Discard					
		Total	Discard	Live Release	Depredation by cetaceans	Depredation by sharks	Unidentified depredation
TUNA							
Albacore	98.5%	1.5%	0.1%	0.3%	0.4%	0.6%	0.1%
Bigeye	95.2%	4.8%	0.8%	1.7%	1.4%	0.9%	
Yellowfin	96.1%	3.9%	0.3%	0.3%	0.6%	1.7%	1.1%
Skipjack	99.3%	0.7%	0.0%	0.1%		0.6%	
Billfishes							
Swordfish	97.9%	2.1%	0.7%	0.7%	0.7%		
Striped marlins	99.0%	1.0%			1.0%		
Blue marlins	97.0%	3.0%	0.0%	0.4%	0.4%	1.5%	0.7%
Black marlins	100.0%	0.0%					
Other billfishs	88.0%	12.0%	10.9%	0.2%	0.2%	0.4%	0.2%
SHARKS							
Sailfish	96.8%	3.2%		3.2%			
Shortbill spearfish	99.5%	0.5%				0.5%	
Blue shark	92.7%	7.3%	3.7%	3.7%			
Silky shark	97.2%	2.8%		2.8%			
Shortfin mako	97.3%	2.7%		2.7%			
Oceanic whitetip shark	100.0%						
Thresher shark	100.0%						
Bigeye thresher	100.0%						
Great white shark	100.0%						
Other sharks	33.3%	66.7%	66.7%				
OTHER FISHES							
Common dolphifish	95.6%	4.4%	2.2%	2.2%			
Spotted Opah	99.5%	0.5%	0.5%				
Pomfret	95.0%	5.0%	4.2%	0.8%			
Oilfish	68.0%	32.0%	14.0%	18.0%			
Escolar	95.3%	4.7%	2.5%	2.2%			
Pacific king-fish	99.1%	0.9%		0.1%	0.3%	0.4%	
Ocean sunfish	0.0%	100.0%		100.0%			
Unknown	91.3%	8.7%	7.8%	0.1%	0.8%		
Sum	**97.7%**	**2.3%**	**0.6%**	**0.5%**	**0.4%**	**0.6%**	**0.1%**

Table 5 Ecological related species sighted by areas

Area	Seabirds	Sea turtles	Cetaceans
Northern Pacific	Black-footed albatross Laysan albatross Short-tailed albatross Mottled petrel Kermadec petrel Leach's storm petrel Flesh-footed shearwater Short-tailed shearwater Northern fulmar Brown booby red-tailed tropical bird Slaty-backed Gull Glaucous gull Red phalarope **Kittiwake** **Storm petrel**		Blackfish (*Superfamily Delphinidae*) unidentified whale
Tropical	Leach's storm petrel red-footed booby masked booby brown booby brown noddy Ascension frigatebird Great frigate bird Lesser Frigatebird redtail tropical bird Buller's albatross Southern Giant Petrel Cape petrel **Tern** **shearwater** **Storm petrel**	Leatherback turtle Olive Ridley turtle	False killer whale spinner dolphins bottlenose dolphin Blackfish, unidentified whale
Southern Pacific	Black-browed albatross Yellow-nosed albatross Wandering albatross Westland Petrel Southern Giant Petrel Northern Giant Petrel	Loggerhead turtle Green turtle Leatherback sea turtle	Blackfish

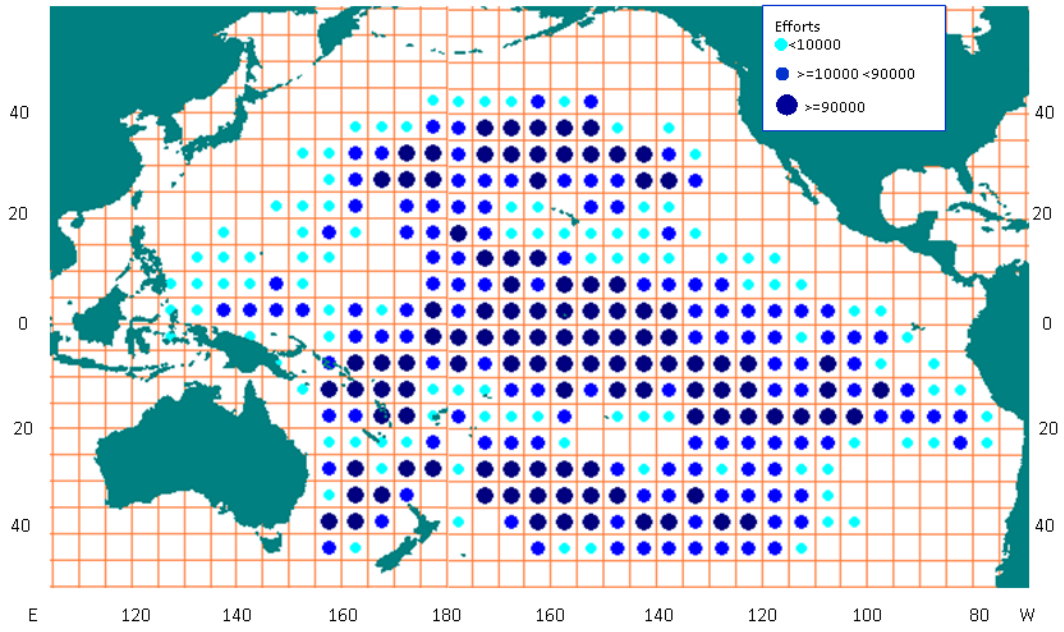

Figure 1 Distribution of Taiwanese tuna longline efforts (hooks), 2004-2007.

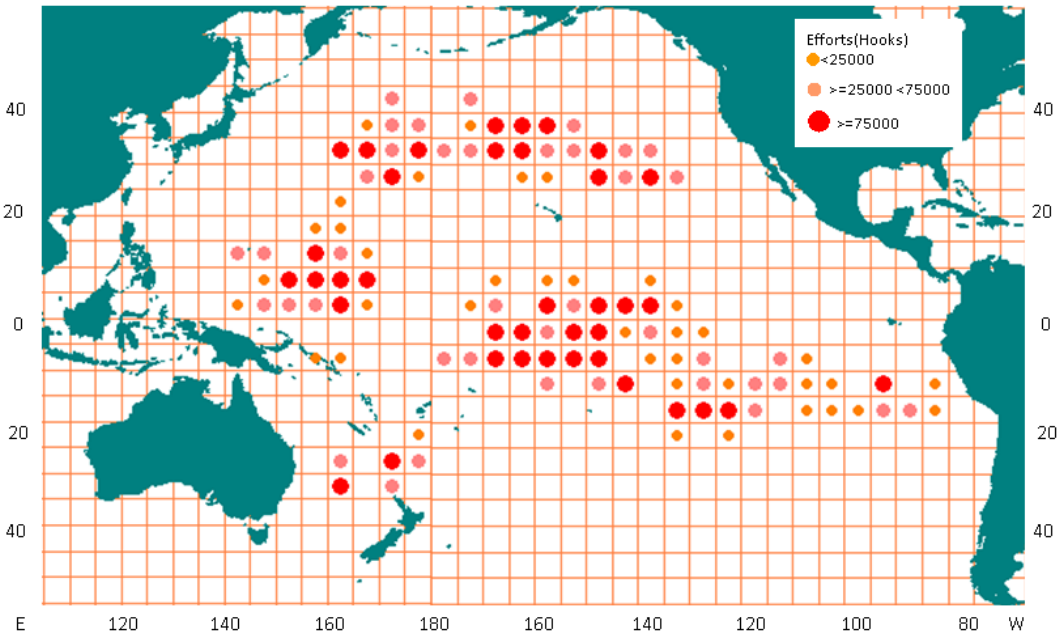

Figure 2 Distribution of observed fishing efforts (hooks), 2004-2007.

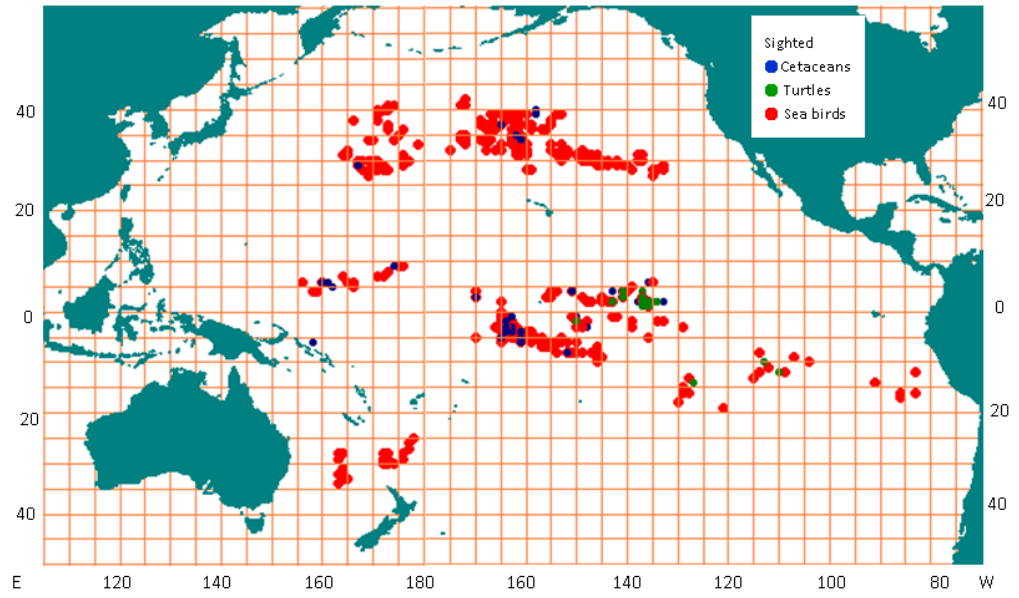

Figure 3 Distribution of Ecological related species sighted, 2004-2007

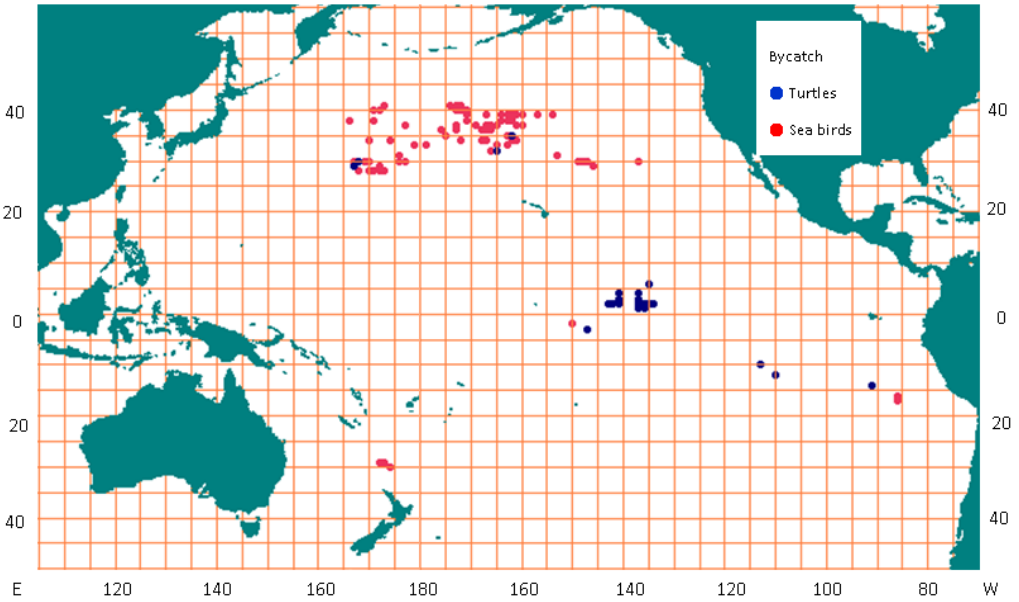

Figure 4 Distribution of seabirds and sea turtles bycatch, 2004-2007