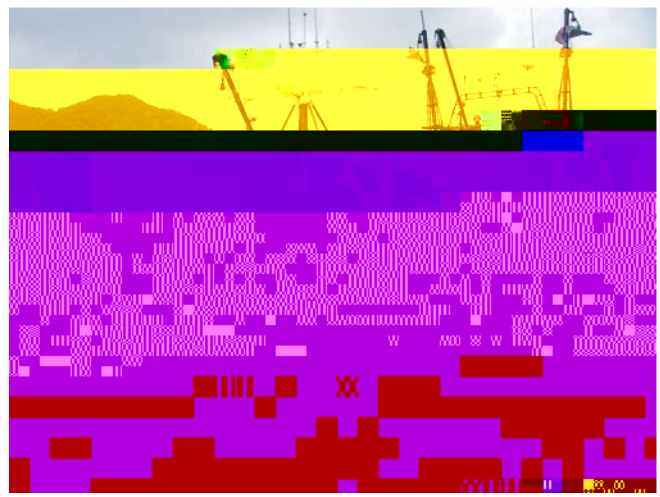

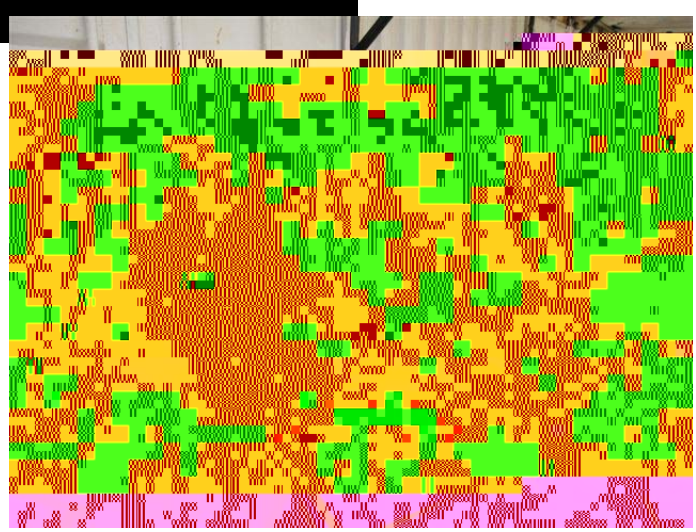

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SUMMARY

Seamounts aggregate pelagic species, including tunas, and support assemblages of pelagic species that differ from the open ocean. There is limited information on the ecological effects of pelagic fisheries on seamount ecosystems. We interviewed pelagic longline fishermen from Tonga, Fiji, Samoa, and the Cook Islands to obtain information on the frequency of fishing at seamounts, the locations and depth of seamounts regularly used for fishing grounds, factors considered when deciding whether or not to fish at seamounts, changes in methods when fishing at seamounts, distance from the seamount summit peak perceived to have an influence on pelagic fish abundance, perceived differences in catch at seamounts, and perceived differences in depredation (the removal of hooked fish and bait) by cetaceans and sharks. The 31 fishermen interviewed collectively identified close to 100 seamounts where they fish on a regular basis, with summit depths generally greater than 1000 m, and revealed that approximately 40% of their fishing effort occurs at seamounts. A third of interviewed fishermen always begin their first set of a trip at a seamount, and remain in the vicinity of the seamount if catch rates are acceptable. A third indicated that they fish at seamounts when targeting yellowfin tuna. When fishing at seamounts, some respondents indicated setting the gear along a depth contour in a horseshoe shape vs. fishing in a straight line when setting in the open ocean. When fishing at seamounts with a shallow summit, to reduce the risk of entanglement with the seabed, fishermen would reduce the number of hooks between floats, causing the gear to be deployed at a shallower depth. The fishermen estimated the range of influence of seamounts to be 20 km from the summit. Fishermen perceived the catch rates of yellowfin, skipjack, wahoo, mahi mahi and reef sharks to be higher, and albacore and blue shark catch rates to be lower at seamounts. Most fishermen perceived there to be no difference in depredation rates at seamounts relative to fishing in the open ocean. Bycatch of sensitive species (sea turtles, whales, seabirds) were perceived to be too rare an occurrence to observe a difference in interaction rates at seamounts.

1. Introduction: Effects of Pelagic Fishing on Seamount Ecosystems, Effect of Seamounts on Pelagic Species Abundance and Diversity

Seamount ecosystems have a high degree of endemism, support diverse benthic communities of organisms including sponges, corals, and long-lived, slow-growing specialist deep-sea demersal fish species, such as orange roughy, pelagic armorhead and alfonsino, and have relatively high pelagic species richness (Allain et al., 2006; Pitcher et al., 2007; Morato et al., 2010). Seamounts are also understood to aggregate pelagic species, including tunas, support assemblages of pelagic species that differ from the open ocean, and have high pelagic species richness relative to coastal and oceanic areas (Holland et al., 1999; Allain et al., 2006; Morato et al., 2008, 2009, 2010). Seamounts that rise up to one half of the water column impact the overlying ocean's currents and possibly isotherm distribution, by disrupting water flow, creating oceanographic perturbations, such as through advection and dispersion (Young et al., 2004; Allain et al., 2006). Depending on their physical characteristics and location, seamounts are an obstacle to flow, create local currents, and can increase upwelling and cause mixing around the seamount (Lueck and Mudge, 1997; White et al., 2007).

Seamounts that reach the Deep Scattering Layer (DSL)[1], especially those where the summit reaches the euphotic zone (intermediate and shallow seamounts, per the classification scheme of Pitcher et al. [2007]) have the potential to affect the pelagic ecosystem and pelagic fisheries. Upwelling around seamounts can bring nutrients from the deeper ocean to enhance primary productivity, supporting a variety of life (Rogers, 1994). Enhanced productivity at sRogers,yTc0on: E m and Gunn, 1998; Holland et al., 1999; Itano and Holland, 2000; Sibert et al., 2000; Adam et al., 2003; Klimley et al., 2003; Campbell and Hobday, 2003). Tunas are understood to remain at an individual seamount from a few days to several months, and are not permanent residents at an individual seamount (Holland et al., 1999; Sibert et al., 2000; Adam et al., 2003). Based on a body of research at Cross Seamount, yellowfin generally do not repeat visitation to an individual seamount, while medium-sized bigeye (smaller than the spawning condition adults) generally repeat visits over a two to three-year period while they remain in the vicinity of the Hawaii archipelago (Adam et al., 2003). Adam et al. (2003) hypothesized that the larger size, spawning-aged adult bigeye tunas are not 'persistent' residents at the seamounts in the vicinity of Hawaii because the mature age classes migrate south to warmer waters where their spawning grounds are located (Nikaido et al., 1991).

In 1995, the eastern Australia longline fleet began to target swordfish along the inshore chain of Tasmantid seamounts off eastern Australia (Campbell and Hobday, 2003). Over the next six years there was a rapid and large depletion of swordfish off the central east coast of Australia (Campbell and Hobday, 2003). As effort on these seamounts and ecosystems (Morato et al., 2009). There is evidence of an increased proportion of the Pacific bigeye and albacore catch coming from seamounts in recent years (Morato et al., and marine mammals (Morato et al., 2008; Parrish, 2009). The sensitive species groups subject to bycatch are particularly vulnerable to overexploitation and slow to recover from large population declines due to their K-selected life-history strategy, characterized by long life spans, slow growth, delayed sexual maturity, low fecundity, and low natural mortality rates.

Pelagic and benthic components of seamount ecosystems may be functionally linked, such that pelagic fisheries' removal of seamount-associated pelagic species may indirectly affect seamount benthic communities. For instance, there is a trophic link between bentho-pelagic species and seamount benthos, where bentho-pelagic species, such as the alfonsino (*Beryx sp.*), have been found to feed both on pelagic and benthic prey species in New Caledonia (Lehodey, 1994; Parin et al., 1997). While the trophic link between large pelagic and the benthic component of seamounts likely exists, it is probably an indirect link, e.g., large pelagics preying on the predators of benthic prey, or preying on bentho-pelagic species (Allain, et al., 2006). Research to date has not documented pelagic species feeding directly on benthic organisms (Bulman et al., 2002; Grubbs et al., 2002). Furthermore, there is an ontogenetic link between pelagic and benthic seamount habitats: Most seamount benthic species have a pelagic stage, usually as juveniles (Allain et al., 2006). For instance, the armorhead (*Pseudopentaceros wheeleri*) demonstrates this ontogenetic link, as the armorhead is believed to have a pelagic stage from 1.5-2.5 years before recruiting to the seamount benthos (Boehlert and Sasaki, 1988). There also may be a mechanistic link between pelagic and benthic seamount habitats: a nutrient-rich benthic environment, necessary to support a diverse and productive benthic community, may likewise support a productive pelagic community, where the presence of the seamount traps food through trophic focusing (Allain et al., 2006).

2. Seamount Definition

For the purpose of this study, the definition of a seamount by Pitcher et al. (2007) has been used: "…any topographically distinct seafloor feature that is at > 100 m but which does not break the sea surface." This definition excludes large banks and shoals, and topographic features on continental shelves. Other literature have defined a seamount as an isolated underwater feature of limited extent across the summit, usually composed of hard substrate, and with an elevation higher than 1000 m above the seafloor (yv0.0111 Tw[(3,v used: ea unverified satellite-derived data, and thus likely contain errors. Few seamounts have undergone in situ ship and submersible-based studies to document bathymetry, geology, oceanography, and biodiversity (Allain et al., 2006). By cross checking seamount positions in the Pacific Ocean with other available datasets, Allain et al (2008) compiled a validated dataset for seamounts in the Western and Central Pacific Ocean (WCPO). Adding new records from a number of sources, their final dataset contains records for 4,021 underwater features in the WCPO. By adding additional validated data from outside this defined area, Morato et al. (2009) compiled a list of 7,021 seamounts in an area bounded by 50°N-50°S and 105°E-95°W, for their study on tuna longline fishing around West and Central Pacific seamounts.

3. Tuna Fisheries of the Western and Central Pacific Ocean

Purse seine, pelagic longline and pole-and-line fisheries are the primary commercial fishing methods for catching tunas (Majkowski, 2007). Large longline vessels in the WCPO generally catch older age classes of bigeye and yellowfin tunas for the *sashimi* market and some longline fleets target albacore for canning. Purse seine vessels catch younger age classes of target skipjack and yellowfin and incidental bigeye tunas for canning (a small volume of Atlantic, Pacific and southern bluefin tuna is currently caught for tuna ranching [GFCM, 2005]) (Majkowski, 2007). Like purse seiners, pole-and-line vessels catch fish close to the surface, catching mostly skipjack and small/juvenile yellowfin, albacore and bluefin, primarily for canning (Majkowski, 2007). Tuna products are an important food source and global commodity. They are the third most important seafood commodity traded in value terms (FAO, 2007). The export value of 2006 internationally traded tuna products was US$6.9 billion, 8% of total global fish and fishery product exports (FAO, 2009). In 2006, skipjack and yellowfin tuna comprised the third and tenth largest contribution to global reported landings from marine capture fisheries by weight, respectively (FAO, 20090d). Japan, Taiwan, Indonesia, the Philippines, and Spain accounted for half of 2004 reported global landings (Majkowski et al., 2007). Catches from the Atlantic, Indian and Pacific Oceans produce about 10, 23 and 66 percent, respectively, of the total catch of the principal market species of tunas (Bayliff et al., 2005). The WCPFC area accounts for more 50% of reported world tuna landings (FAO, 2009).

The WCPO contains the most important tuna fishing grounds in the world, contributing about 50% (2.4 million tonnes in 2007) of reported global tuna landings (Lawson, 2008). Regional management of the highly migratory species, which includes tuna, billfish, and other pelagic species, comes under the Western and Central Pacific Fisheries Commission (WCPFC), based in the Federated States of Micronesia.

There were over 5,000 pelagic longline vessels operating in the Western and Central Pacific Fisheries Convention Statistical Area in 2007 (WCPFC, 2009). They caught a total of 267,000 mt of fish, comprising 29% bigeye, 26% albacore, 24% yellowfin, and 21% other species. There were 214 purse seiners, which caught just under 1.4 million mt of tuna, consisting of 84% skipjack, 13% yellowfin, and 2% bigeye. Over the past five years, the Pacific-Islands domestic albacore fisheries have grown from taking 32% of the total South Pacific albacore longline catch in 1998 to accounting for over 53% in 2005, while foreign distant water (large freezer vessels that undertake long trips over several months and operate over large areas) and foreign offshore (smaller vessels that are domestically based out of Pacific Island ports that target bigeye and yellowfin for the fresh sashimi market and have ice or chill capacity) fleets have been reduced in size in the WCPO (Williams and Reid, 2006). Table 1 summarizes the catch by longline and

4. Methods

This study was conducted as part of the Oceanic Fisheries Management Project, funded by the Global Environment Facility, to achieve global environmental benefits through enhanced conservation and management of transboundary oceanic fishery resources in the Pacific Islands region and the protection of the biodiversity of the Western Tropical Pacific Warm Pool Large Marine Ecosystem. The project is executed by the Pacific Islands Forum Fisheries Agency in conjunction with the Secretariat of the Pacific Community and IUCN.

In order to obtain anecdotal information from the longline fishermen actively engaged in fishing in the region, interviews were conducted with longline fishermen from four Pacific Island countries: Tonga, Fiji, Samoa, and Cook Islands. These longline fleets were selected for inclusion in the study primarily based on logistical considerations by the investigators. The principal investigator travelled to these countries and conducted interviews, with the captains when available, or otherwise with the first mate. Where possible interviews took place on board the vessels when they were in port, where the fishermen had access to their GPS plotter and charts. While it would have been useful to interview fishermen in additional countries as well, the logistics and costs involved limited the extent of the survey to these four countries.

The survey form used to structure the interviews is included as Appendix 2. Information for each fishery was collected on:

- (i) The proportion of effort on seamounts;
- (ii) Incentives for targeting and not targeting seamounts;
- (iii) Fishing gear and methods used at seamounts;
- (iv) Relative depredation levels at seamounts;
- (v) Ecosystem effects, including catch rates of target, incidental and discard species, of longline fishing at seamounts; and
- (vi) Implications for the effects of pelagic longlining on seamount ecosystems.

5. Results

A total 31 longline fishermen from four countries, including 8 from Tonga, 9 from Fiji, 8 from Samoa, and 6 from the Cook Islands, were interviewed between September 2008 and February 2009. The respondents are listed in Appendix 2. The results of the survey are summarised in the subsequent subsections.

5.1. Locations of seamounts targeted by longline fishermen

The interviewed fishermen collectively indica

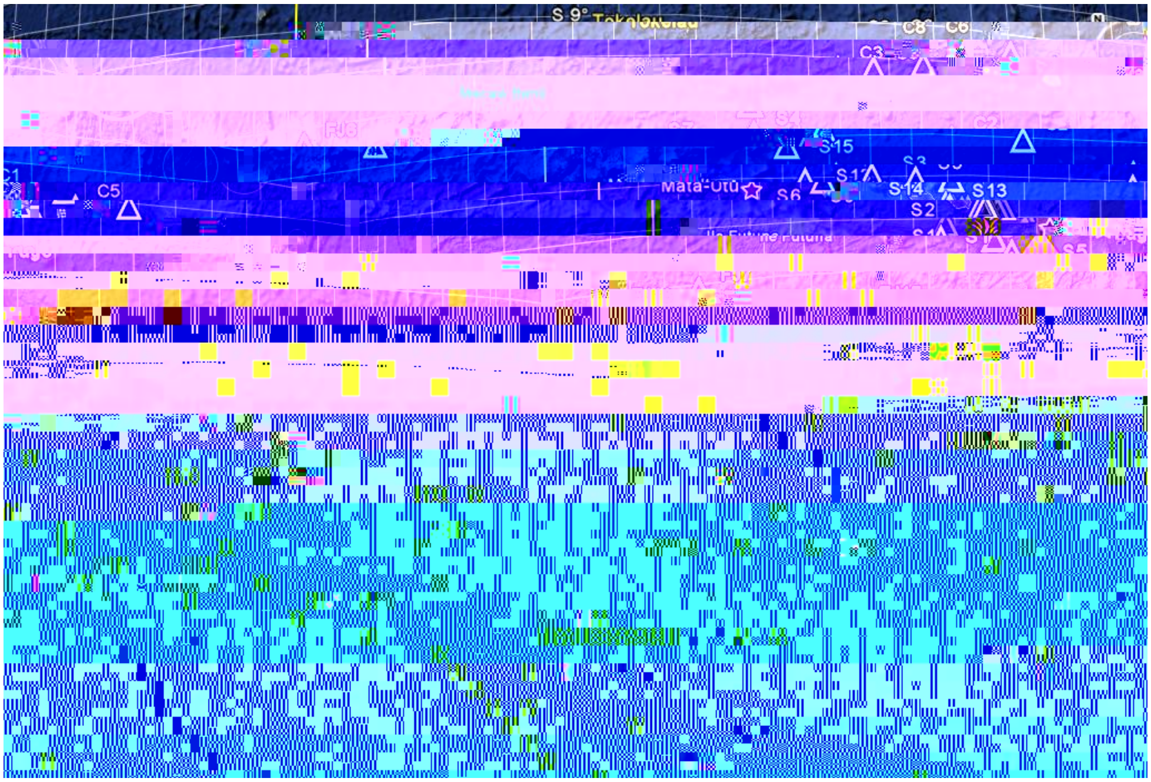


Figure 1. Approximate locations of seamounts targeted by fishermen in Cook Islands, Fiji, Samoa and Tonga.

5.2. Fishing effort around seamounts

Of 30 valid responses to this question, 80% indicated that they do target seamounts some of the time. Overall effort directed at seamounts from those interviewed indicated that approximately 39% of all sets are in the vicinity of seamounts (Fig. 2). The range was from 0% for boats that never target seamounts, to 86% for 1 boat in Tonga which regularly targets seamounts.

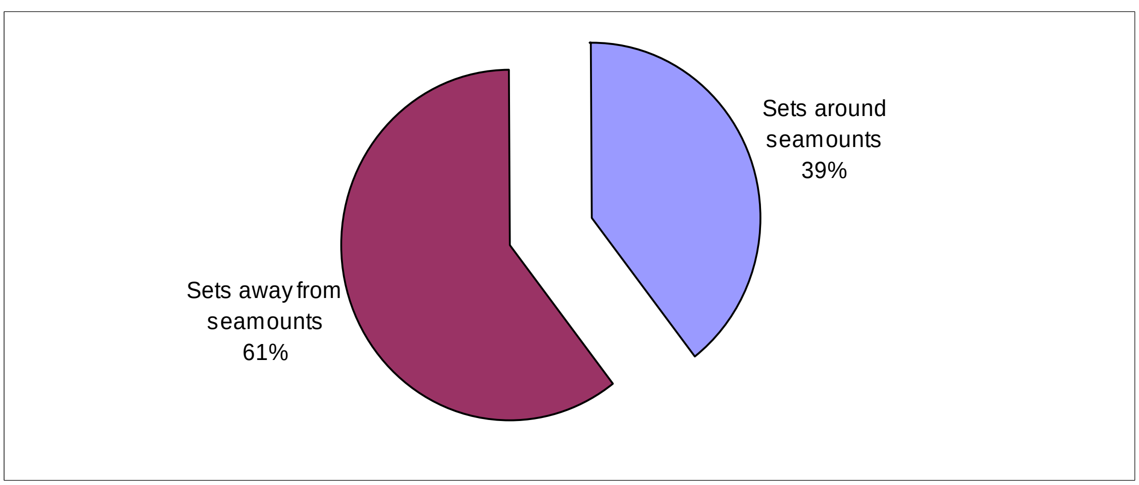
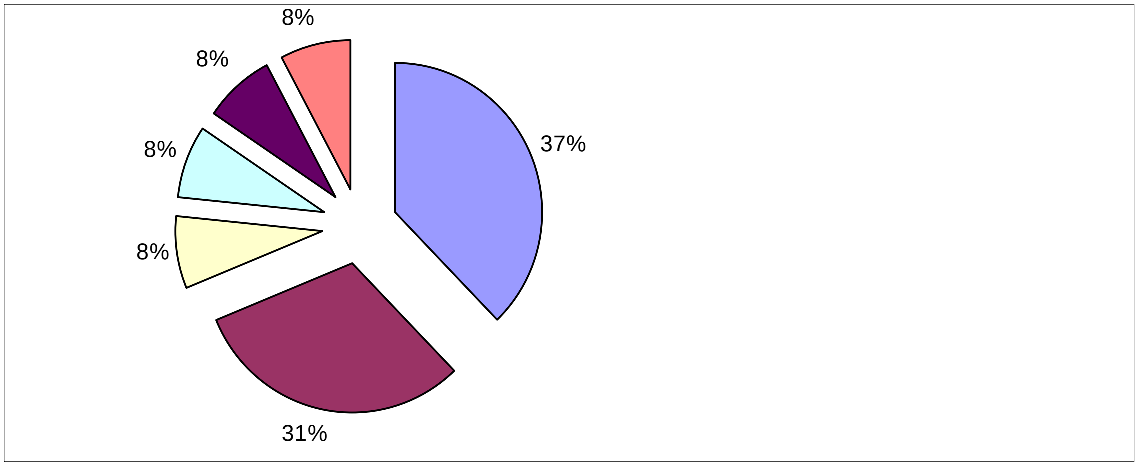


Figure 2. Percentage of effort around seamounts.

5.3. Why do fishermen choose to target seamounts?

Of 29 valid answers to this question, 10 fishermen responded that they always start at a seamount, and if fishing is not good there, they will then move away. The other major reason for fishing around a seamount was if the vessel was targeting yellowfin tuna, with 8 fishermen giving this reason. Other less common reasons given; were: moon phase (new moon to full moon); information from other boats that fishing was good around a particular seamount; the time of year; and if they were having no luck in the open ocean. One respondent indicated that they fished at seamounts because of the upwelling, and another for research purposes (Fig. 3).



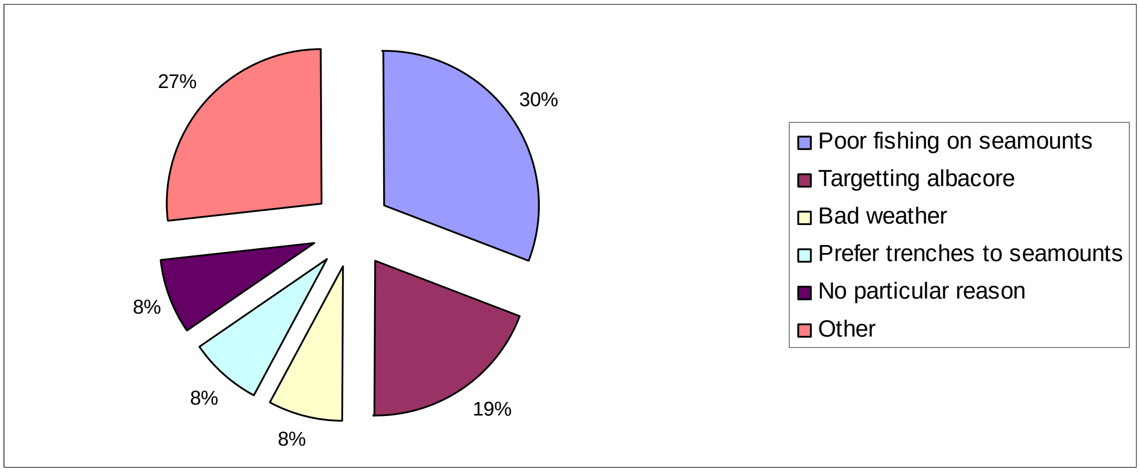


Figure 4. Why fishermen decide not to fish at seamounts.

5.5. Fishing methods at seamounts

The most common method for pelagic longlining in the Pacific Islands utilises monofilament line stored on a large hydraulically powered reel (drum). The survey showed that tuna longliners generally set between 1500 and 3000 hooks attached to 25 to 40 nautical miles (nm)[2] of line, on a daily basis. However, the smaller alia boats in the Samoan fleet utilise hand cranked longline reels setting around 5 nm of line and 300 hooks. Boats targeting swordfish generally set less hooks, ranging from 800 to 1300 over a similar distance. Branch lines are baited with small whole fish, such as sauri, though swordfish fishermen prefer to use squid.

For fishing around seamounts, approximately 50% of fishermen reported that they reduce the number of hooks they set between floats, which sets the line shallower, and reduces the risk of hook ups on shallower seamounts. Several fishermen also indicated that rather than set in a straight line, they would follow the contour, and set around the seamount, in a horseshoe formation. Others reported no change in the method used compared to the open ocean. Obviously the depth of the seamount would be a factor, with very deep seamounts providing no risk of hook ups, and therefore no need to reduce depth of set.

5.6. The range of seamount influence

The nature of the longline fishery made this a difficult question to answer for most fishermen. The average distance covered by the longlines was nearly 28 nm (52 km), so while one end of the line may have been dropped very close to a seamount, the other end could have been up to 40 nm away on the longer fishing lines. The distance that the line would drift between setting and hauling is also a complicating factor, making it difficult for fishermen to say with any degree of accuracy how far the influence of the seamount extended. Despite this, most fishermen still made an educated guess, resulting in an estimate for the average distance for seamount influence from the summit of 10.7 nm (20km), with a range from a high of 30nm (56km) to a low of 3nm (5.5 km). This is consistent with the results of an SPC analysis of longline observer data from the region, which found the influence of seamounts on pelagic species diversity (more species caught) to extend to 30-40 km from seamount summits (Morato et al, 2009).

[2] One nautical mile is equivalent to 1852 metres.

5.7. Catch rates near seamounts

Initially it was thought that it would be possible to get specific catch rates from the fishermen, in number of fish or kg. per 100 hooks. However, this proved a little ambitious, with fishermen reluctant to spend the time to analyse their historical catch records and relate these to specific geographical locations. Thus it was only possible to get a general indication of whether fishermen perceived that their catch rates were higher or lower for specific species near seamounts. Not all respondents had an answer for all species. Results from those fishermen that responded indicated that yellowfin, wahoo, mahi mahi, reef associated sharks, skipjack, bigeye, and swordfish were perceived as having higher catch rates around seamount. Table 2 summarizes the responses in regard to the more common species caught at seamounts.

Table 2. Relative catch of pelagic species around seamounts

	Relative catch rate around seamounts		
Species	**Higher**	**Lower**	**Same**
Yellowfin	14	1	0
Wahoo	13	2	0
Mahi mahi	13	0	0
Grey, brown, reef sharks	11	0	0
Skipjack	10	0	1
Bigeye			

Results for other species were even less conclusive, with only 2 respondents reporting smaller skipjack near seamounts, and 2 others saying swordfish were smaller. Another said marlin and mai mai were larger, and another said wahoo were also larger. Of the other respondents, 3 said in general fish were larger around seamounts, 3 said they were the same size as elsewhere, and the rest had no opinion.

5.9. Depredation

In relation to the question on depredation, there were 21 valid responses (Fig. 5). Of these, 14, or 67% indicated there was no difference between seamounts and open ocean, 5 respondents (24%) indicated it was worse near seamounts, and 2 (10%)

is because, for each PIFC, existing legislation provides a basis to make regulations and/or make fishing the subject of a license from which conditions may be attached that could prohibit fishing from a specified area.

Whether the existing legislation is actually used to protect seamounts is not a legal question, rather it is a question of policy for each PIFC. Only one example was found during this study of an FFA Member Country with a measure in place that restricts pelagic longline fishing at or near underwater features, the definition of which would include seamounts. This was for the Federated States of Micronesia (FSM)[3].

A basis for the introduction of stand alone legislation (such as a *Seamount Fishing Prohibition Zone Act*) prohibiting fishing around seamounts may arise where the regulation and/or license making powers of the existing fisheries legislation is identified as being insufficient to manage compensation and/or political issues. However, care should be taken in drawing the conclusion that stand alone legislation (or even regulations) is needed to protect seamounts within an EEZ. Stand alone legislation (or regulations) will certainly lift the regulatory profile of the issue. However, appropriately
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Appendix 1

List of Fishermen Participating in Interviews

Country	Fishing Vessel	Interviewee
Samoa	Coureur	Viliamu Chu Shing
Samoa	Yellowfin	Russell Finnety
Samoa	Lady Thailand	Samoa Tuifalefa
Samoa	Jay kay	Shay Nicholas
Samoa	Taumaia	Mr Manan Makalaw and Mr Sooty
Samoa	Tifa Aimoana	Tevita Hala
Samoa	Violamanu	Bob Bedford
Samoa	Kingfisher	Alfred Schwalger
Cook Islands	Island of Pukapuka	Kalo Uhrle
Cook Islands	Te Ravakai	Rodney Sparks
Cook Islands	Lady Mary	Tevita Vakasavi
Cook Islands	Ana	Panipasa Gede
Cook Islands	Gold Country	Bill Williams
Cook Islands	Viking Spir78o 7vTwc8Pave Pooleety	

Appendix 2

Survey Form
Pelagic Longline Fishing on Seamounts
Gear, Methods, Effort and Ecosystem Effects

INTRODUCTION

Study Purposes: We aim to determine (i) the proportion of pelagic longline effort targeting seamounts; (ii) incentives for targeting/not targeting seamounts; (iii) gear and methods used to fish at seamounts; (iv) amount of depredation that occurs at seamounts; (v) catch rates of target, incidental and discard species when at seamounts; and (vi) implications related to the effects of pelagic longlining on seamount functioning.

Who is Doing the Study: Eric Gilman and Kelvin Passfield are the principal researchers and work for the International Union for the Conservation of Nature (IUCN) (eric.gilman@iucn.org, kelvin.passfield@iucn.org). IUCN is an international membership organization with offices around the world, including the Regional Office for Oceania located in Fiji (http://www.iucn.org/oceania), and an office in Hawaii. The headquarters is in Switzerland. Members include 83 States, 110 government agencies, and about 800 non-governmental organizations. Website: http://www.iucn.org.

This study is part of the Oceanic Fisheries Management Project, funded by the Global Environment Facility. The Project aims to achieve global environmental benefits by enhanced conservation and management of transboundary oceanic fishery resources in the Pacific Islands region and the protection of the biodiversity of the Western Tropical Pacific Warm Pool Large Marine Ecosystem. It is executed by the Pacific Islands Forum Fisheries Agency in con-junction with the Secretariat of the Pacific Community and IUCN. Website: http://www.ffa.int/gef/

DATE:
NAME OF FISHERMAN:
NATIONALITY:
F/V:
VESSEL FLAG STATE:
SEAPORT:
TARGET SPECIES:
POSITION ON VESSEL:
NUMBER OF YEARS LONGLINE FISHING:
YEARS LONGLINING FROM THIS SEAPORT:
FISHING GROUNDS:
NO, OF HOOKS SET PER TRIP (AVERAGE)
TOTAL DISTANCE COVERED BY LONGLINE

What do we mean by "seamount": We use the term loosely in this survey, to refer to any underwater feature, including a drowned reef, drowned atoll, bank or mountain, where the summit can be very deep or just below the surface.

1. What is the maximum distance that you normally travel from port to go fishing?

2. Do you ever fish at seamounts?

If NO, why not? (e.g., none at fishing grounds, too far from port, relatively low target species CPUE). End of survey.

If yes, how many trips do you make per year?
On average, how many days does each trip take (from port to port)?
How many sets do you make on an average trip
How many of these sets would be around seamounts?

3. Do other vessels fish at these seamounts.
If yes, how many other vessels do you think use these seamounts regularly
If no, why not (are they not known by other fishermen, are they too far from port, etc)?

4. For seamounts that you fish at that are not known by other fishermen, how did you learn about the seamount's location?

5. How many seamounts do you think are within the EEZ.

6. How many seamounts do you think are within fishing distance of the port?

7. How many seamounts do you fish on regularly?

8. Could you provide the following details of the seamounts on which you fish?

Name of Seamount.	Lat	Long	Shallowest depth	substrate if known (rocky, sand, muddy etc (how do you know?)

9. When do you choose to fish at seamounts? For instance, do you only fish at seamounts seasonally, or when particular oceanographic/atmospheric conditions exist (currents, wind direction or strength, SST)?

10. Why do you decide not to fish at seamounts (e.g., distance, wrong season, wrong oceanographic or weather conditions, too crowded with other vessels, gear conflicts, government restrictions, catch of non-target species is too high, not practical for some reason)?

11. Do you change your fishing method or gear in any way when fishing at a seamount? Please be as specific as possible – draw an illustration if helpful. E.g., do you change the length of your float lines or branchlines, or the depth at which you fish? Do you change the distance between hooks? Do you change the type of bait? Do you set gear upcurrent from the seamount and let it drift over the seamount? Do you change the timing of setting, soak or hauling?

12. Do you use satellite maps (SST, currents, etc.) or other tools differently when at seamounts versus at other grounds?

13. How far away from the seamount can you fish and still see a noticeable effect of the seamount on your catch?

14. Is depredation (removal of your hooked fish and bait) higher, lower, or the same at seamounts vs. at other fishing grounds? Please complete the following table for depredation (% of total bait or fish removed per set.

Depredation by	Near seamount		Greater than 10 NM from seamount	
	Bait taken	Fish taken	Bait taken	Fish taken
Sharks				
Whales				
Dolphins				
Others (specify)				

If depredation is higher at seamounts, do you do anything to try to avoid/reduce depredation?

15. For which fish species, if any (e.g., sharks, marlins, wahoo, tunas), is the catch rate or size of individuals different at seamounts from when not fishing at seamounts? Please complete the following table, in catch per set.

Species caught	**Near seamount**		**Greater than 10 NM from seamount**	
	No/set	**Av wt. Kg. per fish**	**No/set**	**Av wt kg per fish**
Albacore				
Big Eye				
Yellowfin				
Skipjack				
Wahoo				
Dolphin fish				
Marlin				
Swordfish				
Other billfish				
Sharks				
Others (specify)				