SCIENTIFIC COMMITTEE
EIGHTH REGULAR SESSION

7-15 August 2012
Busan, Republic of Korea

Overview of the ISSF Bycatch Mitigation Research Cruise in the WCPO

WCPFC-SC8-2012/EB-WP-11

David Itano[1], Jeff Muir[1], Melanie Hutchinson[2], and Bruno Leroy[3]

[1] Pelagic Fisheries Research Program, University of Hawaii
[2] Hawaii Institute of Marine Biology, University of Hawaii
[3] Oceanic Fisheries Programme, Secretariat of the Pacific Community

Overview of the ISSF Bycatch Mitigation Research Cruise in the WCPO

David Itano [1], Jeff Muir [1], Melanie Hutchinson [2], and Bruno Leroy [3]

[1] Pelagic Fisheries Research Program, University of Hawaii
[2] Hawaii Institute of Marine Biology, University of Hawaii
[3] Oceanic Fisheries Programme, Secretariat of the Pacific Community

ABSTRACT

A research cruise was conducted onboard the US flag purse seine vessel M/V Cape Finisterre from 22 May – 1 July 2012 as an integral part of the International Seafood Sustainability Foundation (ISSF) #BycatchProject which was formed to develop and test technical options to minimize non-target catch in industrial tuna fisheries. Research and fishing operations took place within the EEZs of Tuvalu, Kiribati and Tokelau where one free school and 30 drifting FAD sets were conducted. Research activities included studies on the FAD-associated ecosystem, the ability of fishermen to estimate size and species on FADs before setting, the vertical and horizontal behavior of tuna and other species surrounding floating objects, the behavior of tuna and bycatch in the net, best practices for the safe release of whale shark and manta ray from purse seine gear and a range of studies on oceanic sharks centered on their condition throughout the fishing process and post-release survival rates. Onboard protocols for estimating size frequency and species composition of the total catch, including video monitoring were also conducted for subsequent comparison analyses. The latter half of the cruise concentrated on the selective release of non-target species from the net. Preliminary data strongly suggest that ways to avoid non-target species or selectively remove them from the net should be prioritized as condition and post-release survival after brailing is very low. The use of pop-up satellite archiving tags (PSAT) to verify post release condition of various species proved to be essential to meeting the cruise objectives.

BACKGROUND

Purse seine fisheries targeting the tropical species (skipjack, yellowfin and bigeye tuna) have incorporated drifting FADs (dFADs) into their fishing strategies in all large-scale purse seine fisheries in all oceans. DFADs have achieved the desired results of increased annual yields with reduced operating costs while on the negative side contributing to increased fishing mortality on juvenile tuna and non-target species across several taxa when compared to purse seine operations on free schools. The International Seafood Sustainability Foundation (ISSF) is involved in several areas of science-based management advice related to the long-term goal of promoting the sustainable utilization of global tuna stocks while maintaining a balanced ecosystem condition, including: the elimination of IUU fishing, the control of excess fishing capacity, expansion of data support, improvements to Monitoring/Control & Surveillance, and general improvement of tuna stock condition. The sixth are of focus has been the development of a research program to develop and test technical options to reduce bycatch resulting from industrial tuna fisheries. The initial emphasis has been to address ways to reduce the incidental mortality of tuna of undesirable size, oceanic sharks and marine turtles in tropical purse seine fisheries.

ISSF's #BycatchProject (Project) began with an international gathering of fishery scientists, technologists, acousticians, vessel managers and purse seine fishermen in Sukarrieta, Spain in late 2009 (ISSF 2010). This meeting discussed a broad range of potential bycatch reduction methodologies and ideas that are well described in a document tabled at WCPFC SC6. A Bycatch Steering Committee of fishery scientists from all ocean areas whrere tuna purse seineing is conducted was formed that developed and refined the experiments to be tested in all the major PS fisheries. Progress to this end is documented in working papers to WCPFC SC6 and SC7 (Restrepo 2010; Itano and Restrepo 2011).

The Project is based on repeating similar bycatch mitigation experiments and studies in different tropical purse seine fisheries worldwide to test their efficacy under different environmental and fishery-specific conditions. The hypothesis tested is that one size does not fit all and differences in thermocline depth, water clarity, local productivity, species compositions and relative abundance of bycatch species will impact the ability to modify catch composition. The unique feature of the Project is that the research is conducted on commercial fishing vessels that normally operate within each region and specialize in the use of drifting FADs and fishing for tuna associated to floating objects in general. To date, ISSF #BycatchProject research cruises have been conducted in the Indian Ocean (2 cruises), the eastern Pacific (Schaefer and Fuller 2011) and one has been planned for the eastern Atlantic (Gulf of Guinea). This report provides a general overview of the first Project research cruise to be conducted in the WCPFC Convention Area.

WCPO #BycatchProject – CRUISE CONCEPT AND EXPERIMENTAL DESIGN

The tropical tuna fisheries of the western and central Pacific Ocean (WCPO) account for 60% of global tuna landings and 84% of Pacific landings at 2.4 million mt in 2010; the majority of which was landed by purse seine fishing on FADs. WCPO purse seine landings are dominated by skipjack which generally make up 70 – 85% of landings with yellowfin accounting for 15 – 30% while bigeye account for a small proportion (Williams and Terawasi 2011). While bigeye landings are a relatively small component of the total catch, their harvest by the fishery is composed almost entirely of juvenile fish which has contributed to negative impacts to stock condition.

Practical solutions to reduce this incidental catch of juvenile bigeye, tunas of undesirable sizes, and vulnerable species such as sharks, are urgently required. Participation in the WCPO fishery is extremely diverse, consisting of large and medium class vessels of several distant water and domestic fleets that operate on free schools and floating object associated mixed-school aggregations. In addition, and unlike other oceans, a high degree of purse seine effort on anchored FADs is a notable feature of the WCPO tuna fishery that impose their own unique issues and concerns of bycatch and small tuna landings. The large-scale use of anchored FADS to support purse seine fisheries takes place primarily in the western area of the WCPO.

The WCPO purse seine fishery for tropical tuna is roughly contained within an equatorial band from 10N – 10S, from the Philippines in the west (120W) to the Line Islands of Kiribati in the east (150W). This immense area is fished by a diverse range of vessels of many fleets that employ a wide range of equipment and technology; much of it oriented towards fishing on tuna schools found in association with floating objects (Itano 2007). Most of the FAD-based effort utilizes drifting FADs or natural floating objects (i.e. logs) in the central and eastern areas of the fishing grounds while anchored FAD use dominates the western archipelagic zones of the Philippines, Indonesia and Papua New Guinea.

Figure 1 illustrates the geographical extent of the WCPO PS fishery that stretches approximately 10,000 km east to west and normally includes the EEZs of 15 independent countries and territorial jurisdictions. Very little fishing activity takes place on the high seas.

Purse seine activity on floating objects can be roughly separated into the four regions as shown in Figure 1 and can be classified as concentrating on:

A)	Anchored FADs	Philippines and Indonesia
B)	Anchored FADs	Papua New Guinea and Solomon Islands
C)	Drifting FADs and logs	Micronesia, PNG
D)	Drifting FADs	Marshall Islands, Nauru, Kiribati

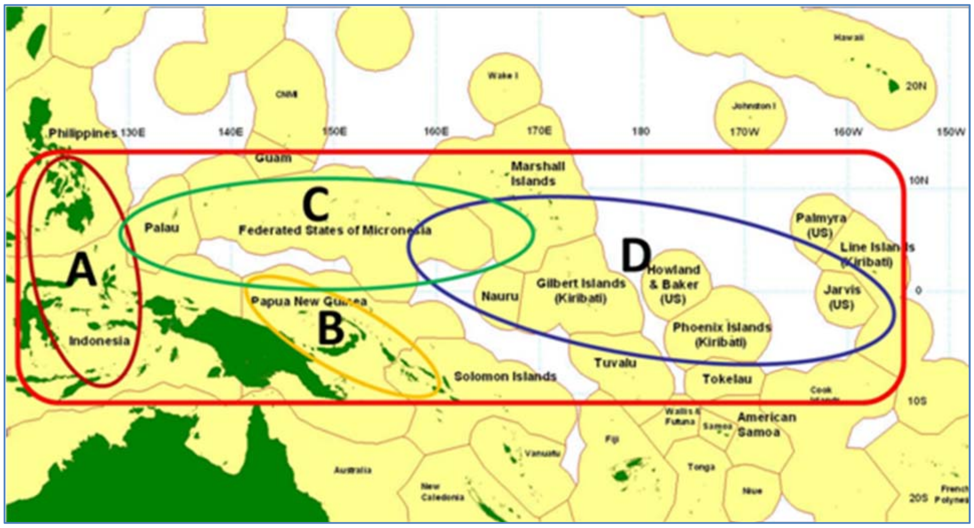

Figure 1. Generalized purse seine activity on drifting objects in the WCPO: A- Anchored FAD; B-Anchored FAD; C-Drifting FAD and Natural Objects; and D-Drifting FAD.

Bycatch levels, bigeye composition (proportional and total) and the proportion of small tuna in total catch is claimed by industry to be different between the eastern and western regions of the fishery and between drifting and anchored FADs. For example, purse seine fleets operating on drifting FADs in Area D claim that their bigeye catches, bycatch levels of miscellaneous finfish, turtle interaction rates and proportion of small tuna are lower than for fisheries operating on anchored FADs in Areas A and B. Catch and effort data from the fishery now suggests that the central Pacific region, corresponding to the eastern portion of Area A **(Figure 1)** has a high proportion of bigeye and may be an important region for bigeye recruitment. Attempts to scientifically examine these differences have been confounded by incomplete levels of reliable and detailed observer data on bycatch. A research cruise dedicated to addressing these questions would be extremely valuable if properly staffed and executed.

The extensive area of the WCPO fishery would not be adequately represented by a single research cruise on a single vessel operating in one area of the fishery and it would be impossible for a single vessel to cover the geographic expanse of the fishery. In addition, a single vessel could not address the wide range of technology and fishing practices that exist in the region. Ideally, ISSF bycatch research in the WCPO should consider dividing effort between a vessel operating primarily on drifting FADs in the eastern region (D) and a vessel that operates almost exclusively on anchored FADs in Region A or B. Experiments would be duplicated between eastern and western regions as much as possible with an emphasis on small tuna and bycatch behavior and release, shark bycatch levels, post-release survival and catch prediction. This report documents a research cruise occurring within Region A and designated as WCPO-1.

WCPO-1: CRUISE SYNOPSIS

The research cruise began when the M/V Cape Finisterre cast off from the main container dock in Pago Pago Harbor at 1230 pm on 22 May 2012. The cruise was divided into two segments, Cruise Leg 1 (May 22 – June 13, 2012) and Cruise Leg 2 (June 14 – July 1, 2012) separated by a brief port call to change out scientific staff. Thirteen sets were made during CL-1 for an estimated 225 mt. Experiments concentrated documenting catch prediction, testing different protocols for the estimation of catch composition and length frequency, the natural behavior of tuna and other species on floating objects, shark condition and survival and and the natural behavior of tuna and other species inside the net. Eighteen sets were made during CL-2 for a total of 31 sets after which all 19 fish wells were loaded with target catch of skipjack, yellowfin and bigeye tuna from operations in the EEZs of Tuvalu, Kiribati (Phoenix Islands) and Tokelau. All but one of the 31 sets were made on drifting FADs or a floating object with one successful free school made (#8).

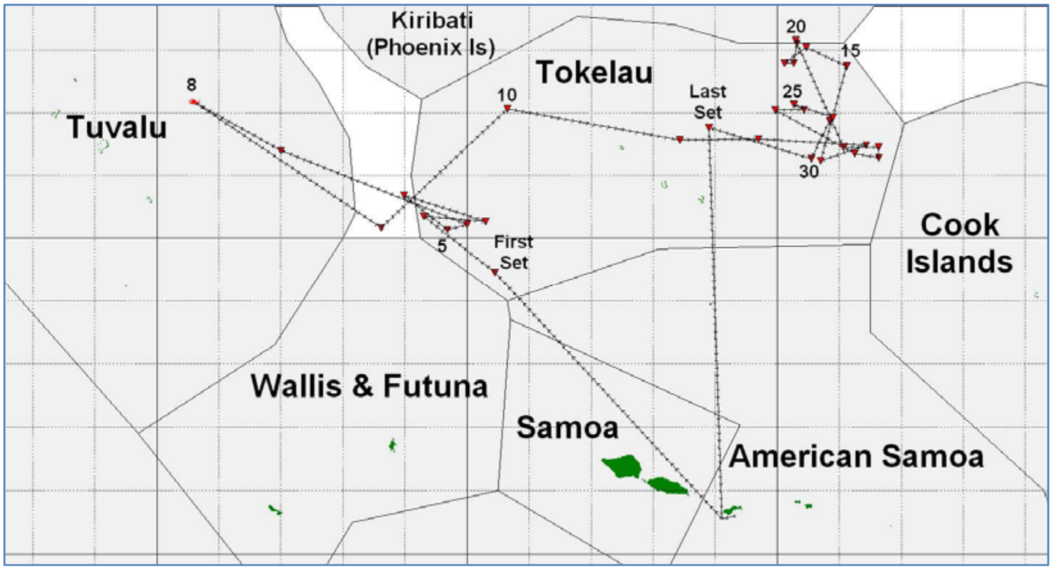

Figure 2. Linear cruise track and set locations during the ISSF #BycatchProject WCPO research cruise 22 May - 1 July 2012

The vessel returned to Pago Pago on the evening of June 10 at the end of CL-1 to exchange one scientific staff and meet with the vessel owner and other high level corporate staff to review progress and discuss options for Cruise Leg 2. A new concept “escape panel” was designed and installed in the net to test the efficacy of selective release of sharks and non-target finfish from the purse seine. The vessel sailed from Pago Pago Harbor to begin Cruise Leg 2 at 1740 on June 13, 2012. This leg of the cruise concentrated on shark and bycatch observations and trials of the release panel and recovered vertical behavior data on tuna and sharks monitored with acoustic tags. The vessel made its final set on June 30, 2012 in compliance with the beginning of the 3-month WCPFC FAD closure that began on July 1, 2012 GMT. The vessel returned to Pago Pago on the evening of July 1 to conclude the at-sea portion of the research cruise. Two scientists remained in Pago Pago to oversee the unloading process by species and size category on a per set basis. **Figure 2** shows a generalized vessel track of the cruise, originating and ending in Pago Pago Harbor, American Samoa, connecting each successive set with the majority of effort taking place in the Tokelau EEZ.

RESEARCH CRUISE VESSEL AND CREW DESCRIPTION

WCPO-1 took place aboard the US flag tuna purse seine vessel M/V Cape Finisterre, owned by Tri Marine International Ltd.; an international tuna supply company that owns and operates 17 tuna purse seine and 4 pole and line vessels in the eastern and western Pacific. The vessel was launched by J.M. Martinac Shipbuilding of Tacoma, Washingon, USA in 1979 but was in top condition having recently undergone a major refit and haul-out in New Zealand. The vessel measures 239 ft LOA (222 ft waterline) and rated at 1434 GRT with a total fish hold capacity of 1149 metric tons of tuna held in 19 brine refrigerated holds.

The strength of the project was based on conducting the research on a commercial fishing vessel that normally operates within the study area manned by a captain and crew highly experienced with tuna fishing in this area of the Pacific Ocean on dFADs (**Figure 3**). The vessel was fully equipped with a full complement of marine electronics to facilitate fishing operations including omni-directional sonar, multi-frequency echo sounders, Doppler current meter and S Band "bird" radar. Several models of GPS satellite buoys were used to re-locate drifting FADS, some of which were equipped with echo sounding features.

Figure 3. The Cape Finisterre hauling net during during Set #2 of the cruise

The most important fishing gears onboard include the net, purse winch and power block. The Cape Finisterre has a relatively new net constructed in 2010 that measures 1719 m long (corkline) and is 30 "strips" deep (approximately 330 m[4]). Vessel, electronic and fishing gear components are detailed in **Appendix I**. The complete gear complement describes a very well equipped, capable and competitive purse seine vessel currently operating in the WCPO.

Formerly the M/V Tifaimoana, the vessel normally operates with a crew of 22 that includes the Captain, Navigator, Chief Engineer, Assistant Engineer and a full time cook. Typical of regional purse seiners, the crew hailed from several countries that included the USA, Mexico, Philippines, Tuvalu, Solomon Islands, Tonga, Samoa, China and Croatia.

The crew sailed with a team of five scientists/researchers and one observer fulfilling the monitoring requirements of the WCPFC Regional Observer Program for 100% observer coverage on purse seiners operating in the WCPFC CA. The scientists came from the USA

[4] The rated maximum depth is a theoretical depth if all meshes were stretched taut vertically and is never achieved when the net is actually in use.

(Hawaii), the Marshall Islands, Solomon Islands and France while the observer came from the National Fisheries Agency, Port Moresby, PNG.

The scientific effort was directed by cruise leader David Itano from the Pelagic Fisheries Research Program, University of Hawaii assisted by Jeffrey Muir also from PFRP. Ms Melanie Hutchinson was in charge of all research pertaining to oceanic sharks including tagging, condition assessment and biological sampling. The Oceanic Fisheries Programme of SPC contributed two scientists: Ferral Lasi and Bruno Leroy who participated during the first and second cruise legs respectively. Mr Lasi was in charge of the experimental "spill" sampling for species composition and length frequency data of target catch while Mr Leroy provided expertise in tagging and support to paired sampling trials and all field operations. Space onboard for a "fifth scientist" was provided by Tri Marine and financially supported by ISSF and the WCPFC which was filled by Mr Elton Clodumar from the Marshall Islands Marine Resources Authority (MIMRA). He was put in charge of maintaining the Archipelago video monitoring system and assisting with the spill sampling but assisted with all aspects of the research conducted during the cruise.

EXPERIMENTS AND ACTIVITIES CONDUCTED DURING THE CRUISE

1. ESTIMATION OF CATCH AND BYCATCH

a) Pre-estimation of catch

Reports vary widely on the ability of individual captains to predict various parameters of a FAD aggregation prior to a set and even prior to arriving at a FAD through interpretation of data from echo sounder, or so called "sonar buoys". These buoys are not actually equipped with a sonar unit but have a simple acoustic echo sounder device that transmits images of biomass along with GPS position, water temperature, drift data and battery status to the fishing vessel via satellite link. The ability to predict the overall aggregation size, species composition (both tuna and other fish), amount of bycatch and size of available tuna is of particular interest due to the importance of pre-estimation to potential avoidance of bycatch and tuna of undesirable (too small) size.

One aspect of this sub-project pertains to the possibility that expert knowledge on pre-estimation of catch may be a transferrable skill that could improve overall selectivity of the fishery. Also, the use of specialized gear or methods may also become recommended or required gear if proven to be effective for pre-set estimates.

Other information sources that may be useful for predicting the productivity of a FAD before arriving include remote sensing data (estimates of surface chlorophyll, upwelling, wind speed/direction, maturation of productivity to baitfish), information from other fishing or scout vessels, and images transmitted by sonar buoys.

The WCPO-1 vessel received GPS positions of dFADs from satellite buoys manufactured by ZUNIBAL (Spain) and KANNAD/NAVSTAR (France) for the Neptune and Iris GPS buoys. The scientific team brought OrbImage M3i Sonar Buoys for comparison with other makes.

i) Before arriving at the FAD

Only the ZUNIBAL TUNABAL and the OrbImage M3i GPS buoys were equipped with downward directed echo sounder gear that transmitted images to the vessel. Examples of those image types are shown in Figure 3 with the ZUNIBAL display (left) and OrbImage (on right. Day and night periods are indicated with background shading with biomass intensity grading from light blue (least) to red (the most).

Figure 4. Sonar buoy displays at approximately 0430 on the same drifting FAD aggregation prior to Set # 26 with ZUNIBAL (left panel) and OrbImage (right panel)

The majority of dFAD aggregations observed with sonar buoys were equipped with ZUNIBAL gear. The consensus from the vessel officers was that the sonar buoys provided some indication of general productivity but were not yet accurate enough to be trusted for reliable estimates of tuna biomass or even "fish" biomass. There was no indication that the gear was suitable for discerning target from non-target species other than some possibility that deep marks might correspond to larger tuna. There were not enough dFAD aggregations that were monitored with both ZUNIBAL and OrbImage gear side by side to allow direct comparisons on their ability to predict species or fish size. More testing is indicated, particularly with newer model sonar buoys but at present this does not appear to be a viable means to avoid bycatch, undersize tuna or bigeye tuna in general.

ii) On arrivial at FAD (Daytime)

Before a drifting FAD was visually assessed, the search area was constantly monitored during the daytime with the S Band radar that can detect schools of birds over the horizon that often indicate surface feeding activity of tuna. On approach during the daytime, dFADs were visually assessed by the mastman located in the crows nest and two spotters forward of the bridge equipped with 25 x 150mm mounted binoculars who searched for birds or surface signs of tuna, i.e. jumpers, breezers, foamer schools, etc. Their other primary duty was to search for other drifting objects, FADs belonging to other vessels and the particular FAD that the vessel was intending to investigate.

Figure 5. Retrieving a drifting FAD after acoustic survey indicated "no fish"

The sonar was initially used to assess the associated biomass below or adjacent to the dFAD and an initial estimate given which usually amounted to "nothing worth investigating further" or the opposite. Generally, the dFAD was then approached and grappled and tied off on the bow when the depth sounders onboard the main vessel were consulted. If sufficient signs (visual or acoustic) were judged to be "good enough" for a set, the vessel would stand off at least five nautical miles or more to attempt a set the following morning. FADs judged to be unproductive or drifting in an undesirable direction/speed were retrieved for subsequent use (**Figure 5**).

iii) Pre-set estimation

A form was designed and filled out for each set to document catch prediction by size and species at four stages: 1) Before arriving; 2) Initial survey; 3) Just before set; 4) Start of brailing 5) Final estimate after fish wre loaded to the wells. The estimates were extended up to final loading to compare accuracy against onboard sampling estimates by species and with the final verified weights unloaded at the cannery.

Drifting FADs were initially investigated prior to a set around 0400 local time with sonar. If a significant sonar mark was detected the towboat was deployed. The towboat hooked up to the dFAD or floating object and began to report echo sounder readings (**Figure 6**). Landed catch was generally close to or less than the pre-set (#3) estimates based on sonar and echo sounder. The presence of bigeye and large tuna that have strong acoustic signatures on sonar or high concentrations of plankton or forage in some areas were blamed for the acoustically based over-estimates of tuna on some FAD aggregations.

These pre-set estimates will be compiled against final cannery totals when those become available.

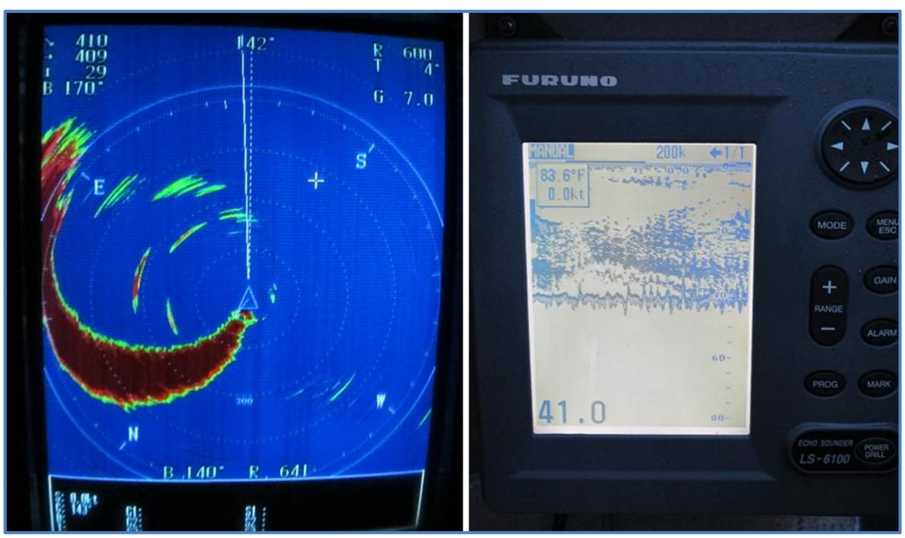

Figure 6. Attempting to get around several sonar targets during a pre dawn set (left panel) and the acoustic display from the workboat echo sounder deployed on the FAD before and during the set

b) Onboard length frequency and species composition sampling

The catch composition of each set was monitored by the WCPFC observer who recorded data on all vessel activities on the standardized SPC/FFA purse seine and vessel observer forms in accordance with the requirements of the WCPFC Regional Observer Programme. The observer conducted the standardized grab sampling where five fish from every brail is samples for species while the scientists onboard conducted paired spill sampling (see Lawson and Sharples 2011). Spill sampling requires that approximately one mt of catch is spilled from the brailer into a standardized metal bin on deck for one out of every ten brails (**Figure 7**). Every fish inside the bin is identified and measured, thus eliminating sampling bias that may occur when grabbing samples from the brailer. Unrefined statistics resulting from the paired grab and spill sampling from all sets is included here as **Table 1.**

The number of brails per set ranged from 4 – 61 that loaded an estimated (observer) 4 – 196 mt of tuna. There is no doubt that the spill sampling results in a larger sample size (15807) compared to the grab sampling conducted from the same sets (1079). However, the large sample size of the spill sample required a long time to process meaning that sampling was not spread out evenly throughout the brailing process.

No in depth analysis of the differences or similarities of results between the two protocols is provided here. Comparison of these figures with the actual unloading data will occur but these figures were not yet available at the time of the preparation of this document. This project is described in greater detail in Lawson and Lasi (2012) and it is anticipated that relationships between sampling methods, set size, set type, area, etc will emerge as more paired sampling trips have been completed.

Figure 7. Standard grab sampling (left panel) and spill sampling (right panel)

Table 1. Paired Grab and Spill sampling by set during the ISSF #BycatchProject cruise.

Set #	School Type	# of brails	Catch (mt) from observer estimates	# of samples		Average size in cm and species composition (%)					
						Spill			Grab		
				Spill	Grab	SKJ	YFT	BET	SKJ	YFT	BET
1	Fad	8	10	337	14	41 (50)	40 (36)	43 (14)	42 (66)	38 (24)	40 (10)
2	Fad	8	20	172	35	46 (72)	42 (6)	43 (22)	45 (70)	42 (16)	43 (14)
3	Fad	6	15	892	28	40 (88)	43 (12)	0	39 (86)	38 (8)	35 (6)
4	Fad	4	6	531	25	44 (87)	39 (6.5)	44 (6.5)	42 (77)	45 (13)	39 (10)
5	Fad	15	41	248	15	56 (80)	40 (11)	40 (9)	52 (69)	34 (13)	39 (18)
6	Fad	15	57	351	55	57 (98)	42 (2)	0	58 (95)	58 (3)	32 (2)
7	Fad	8	11	663	25	42 (64)	51 (28)	43 (8)	40 (84)	40 (12)	43 (4)
8	Free	9	20	118	43	63 (100)	0	0	61 (100)	0	0
9	Fad	4	8	387	18	48 (83)	40(5)	42 (12)	48 (85)	56 (15)	39 (5)
10	Fad	7	12	417	25	46 (68)	58 (20)	45 (12)	46 (69)	58 (21)	48 (10)
11	Fad	5	10	491	25	43 (85)	48 (10)	40 (5)	42 (92)	70 (6)	41 (2)
12	Fad	5	10	783	25	42 (48)	42 (44)	49 (8)	42 (82)	45 (12)	41 (4)
13	Fad	4	6	325	20	52 (60)	55 (40)	0	50 (56)	58 (38)	41 (6)
14	Fad	24	82	959	95	47 (95)	56 (3)	65 (2)	48 (78)	64 (10)	77 (12)
15	Fad	19	76	926	90	44 (98)	62 (1)	41 (1)	46 (89)	45 (9)	40 (2)
16	Fad	6	13	534	25	43 (84)	48 (10)	44 (6)	46 (92)	71 (8)	0
17	Fad	5	13	224	25	52 (54)	67 (31)	47 (15)	52 (48)	60 (40)	49 (12)
18	Fad	14	48	560	70	43 (90)	61 (7)	53 (3)	46 (89)	54 (11)	0
19	Fad	10	34	408	50	47 (76)	54 (19)	63 (5)	49 (74)	47 (20)	71 (6)
20	Fad	17	62	603	85	43 (93)	51 (5)	72 (2)	44 (87)	49 (11)	41 (2)
21	Plywood	11	22	358	40	51 (87)	64 (8)	48 (5)	52 (72)	73 (20)	42 (8)
22	Fad	61	196	665	270	45 (95)	48 (2)	53 (3)	46 (90)	58 (8)	60 (2)
23	Fad	4	5	400	15	45 (58)	51 (33)	42 (9)	46 (40)	57 (60)	0
24	Fad	8	33	693	35	43 (76)	47 (14)	41 (10)	45 (66)	59 (17)	40 (17)
25	Fad	11	33	643	55	46 (95)	44 (3)	51 (2)	44 (87)	43 (11)	48 (2)
26	Fad	10	21	545	50	47 (83)	53 (13)	42 (4)	47 (70)	53 (24)	43 (6)
27	Fad	10	19	527	50	46 (89)	53 (9)	41 (2)	47 (84)	59 (10)	41 (6)
28	Fad	14	44	432	65	47(94)	53 (3)	43 (3)	49 (81)	67 (11)	49 (8)
29	Fad	15	42	554	75	47 (87)	55 (9)	45 (4)	50 (81)	52 (16)	41(3)
30	Fad	10	29	313	45	44 (82)	62 (15)	43 (3)	45 (82)	51 (16)	46 (2)
31	Fad	24	81	808	120	47 (89)	57 (6)	49 (5)	49 (84)	51 (7)	62 (9)
Total		**371**	**1079**	**15867**	**1613**						

c) Automated video monitoring of vessel activity

In conjunction with paired Grab and Spill sampling of catch, the cruise was also monitored by an automated video observing system manufactured by Archipelago Marine Research, Ltd., Canada. The system consisted of two control boxes (on bridge and in Engine Control Room) and three sets of video cameras set up to monitor the working deck and the forward and aft portions of the well (wet) deck. The system was set up to turn on automatically when the hydraulic system was activated and also recorded activity of the purse winch activated by a drum rotation sensor and would continue recording for one hour after the hydraulics system was powered down (**Figure 8**).

Video images were captured to large capacity hard drives that contained enough volume to record the entire trip. From the integrated monitors it appeared that the working deck images could capture fishing activity very accurately as far as knowing when a set was taking place, how many brails were loaded, how long activities took, etc. The outward mounted camera could also record enough information to distinguish between a floating object set and a school set if the FAD was towed past the camera. However, the system may not be able to determine set type if the FAD is towed out of the far side of the net.

The general size of tuna deposited in the sorting hopper cold be observed easily but this would be more difficult if used on a vessel that dumped brailers directly down the loading hole in the work deck. It appeared that the resolution and magnification of the work deck images would not be adequate to differentiate juvenile bigeye from yellowfin in most cases. Bycatch identification and enumeration hould be reasonably effective.

The wet deck images did not appear to be useful for precise identification or enumeration of catch by species due to the high speed at which the fish came down the chutes and the opaque nature of the brine combined with stacking of fish in some areas of the chute system (see **Figure 9**). This type of monitoring would be far more effective on vessels that utilize conveyor belts to move fish to storage wells. High definition Go Pro video cameras were also tested to see if their HD images could allow differentiation of small bigeye from yellowfin.

Figure 8. Archipelago system camera (bottom left) and control box/monitor onboard the Cape Finisterre.

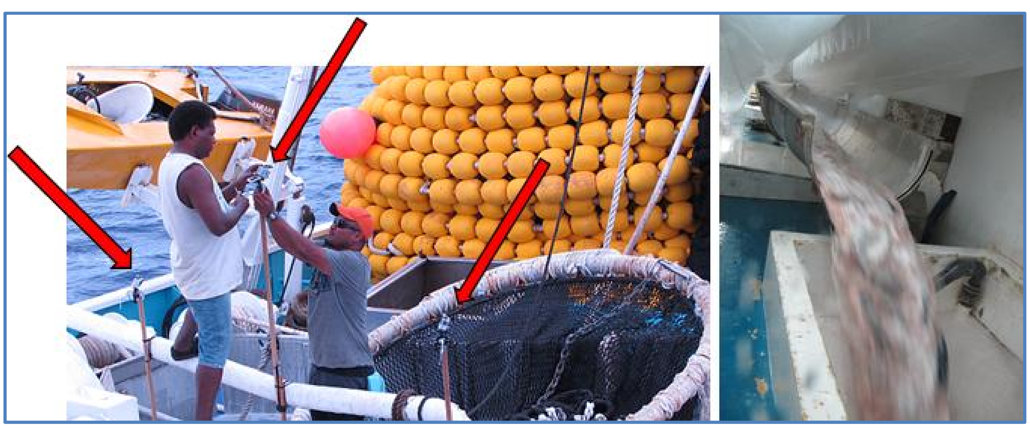

Figure 9. Go Pro high definition video cameras set up to monitor species-specific identification of catch (left) and a mixed catch being brailed into the Starboard 2 well.

2. UNDERWATER VISUAL CENSUS AT FADS

Drifting FADs were investigated acoustically as described in section 1.a.iii above. If local conditions allowed (weather, wind, current, etc.) the scientific team deployed in the workboat to investigate the FAD and to conduct tagging operations. After the workboat was deployed the main vessel would move away at least one mile to avoid disturbing the aggregation or drawing fish away from the FAD.

Seven formal underwater census dives were conducted following the protocols established by Taquet et al. (2007) when diving on drifting FADs during the European Union funded project FADIO in the Indian Ocean. In addition to providing scientific data on fish aggregations around FADs, including the biodiversity of this area of the WCPO, census dives were designed to provide information to decide which scientific experiment would be during the set (**Figure 10**).

Figure 10. Netting suspended below a drifting FAD to a depth of 40 m (left) and ISSF scientist conducting UW visual census.

Silky sharks, mahi mahi, wahoo, pelagic triggerfish, rainbow runner, bigeye jack, round scad (Decapterus macarellus), amberjack, rudderfish, filefish (Aluteres monoceros, A. scriptus), driftfish (Psenes cyanophrys) and juvenile yellowfin tuna were observed on the census dives. Informal surveys were also conducted by free diving during tuna tagging trips to FADs but no additional species were noted.

Visibility was highly variable throughout the cruise and in some cases greatly limited the divers ability to conduct an effective survey of the associated species. Local productivity and high density of plankton and larval fish appeared to be the primary reason for limited visibility in some areas. In general the numbers and diversity of non-target fish species in the study area were very low. Due to restricted visibility and the wide ranging habits of many of the aggregated species, it became apparent that these surveys were not very useful for planning experiments.

Observations of the actual hanging depth of the net aggregators below the FADs were one of the more useful outcomes of these dives. Most FADs had a net appendage that was suspended to a depth of 35 – 40 m. Observations were also made of silky sharks entangled in the webbing which were only observed when large mesh (>8 inch) was used. These FADs were not constructed by the Cape Finisterre but were "found" FADs.

3. INITIAL RELEASE OF FISH FROM THE NET BY TOWING THE FAD

After the net has been fully pursed the drifting FAD or natural floating object must be removed from the net. The FAD can be towed out over the corks at any location in the net or it can be towed out between the port stern of the purse seiner and the beginning (stern end) of the net. This gap is created by moving the main boom to port and slacking the heavy line attached to the stern oertza (end of the net), creating a gap between the oertza and the first chain bridle (**Figure 11**).

Fishermen attending ISSF workshops have claimed that a significant amount of bycatch will follow the FAD or log out of the net at this time allowing non-target fish a way to escape. Indeed many fishermen feel that it is in their best interest to release as much of this non-tuna community as possible as they believe its presence helps to aggregate tuna (for some unknown reason).

Figure 11. Workboat towing a drifting FAD (left) and exiting the net after pursing is complete (right).

This may be true to some extent for logs or natural drift objects that are slowly towed out of the net. However, after observing all drifting FAD sets during the cruise, we do not believe this is an effective method to release significant amounts of non-target species. The FADs used during this cruise had very long sections of nylon net hanging beneath the FAD and a certain amount of speed is needed to bring the netting to the surface so that it can clear the chainline when exiting the net. No non-target species were observed to remain with the raft or appendage or follow the FAD out of the net. During set #29, scientists were in the towboat during the pre-dawn setting process. Three silky sharks, one oceanic white tip shark, rainbow runner and mackerel scad were observed from the surface around the towboat at the beginning of the set when drifting with the FAD. However, these species were quickly left behind and not observed once the raft was towed any distance.

Another option explored was the use of a long handled dipnet to scoop bycatch or undersize tuna out of the top of the net during the sacking up and brailing process. This did not appear to be an effective or viable solution.

4. VERTICAL AND HORIZONTAL BEHAVIOR OF TUNA AND BYCATCH SPECIES ON FAD AGGREGATIONS

Acoustic tags[5] equipped with pressure sensors were implanted into the peritoneal cavity of skipjack, yellowfin tuna, bigeye tuna and silky shark and released on three separate drifting FADs during the cruise. These tags record tag specific (fish specific) presence/absence and fine scale depth data ultrasonically to automated acoustic receivers mounted on the same dFADs (**Figure 12**).

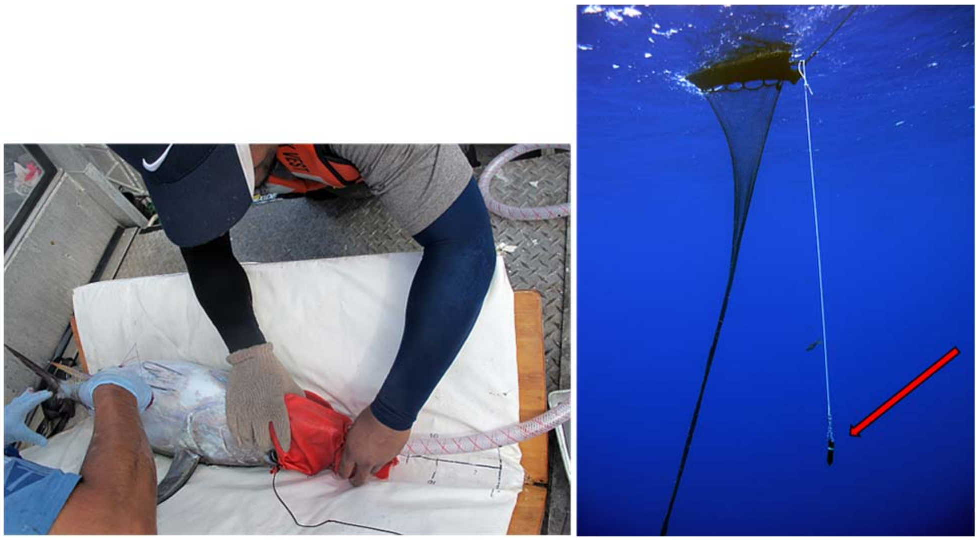

Figure 12. Implanting a depth reporting acoustic tag into a bigeye tuna (left) and acoustic receiver mounted beneath dFAD

Details of this research module of the ISSF cruise are reported in detail in WCPFC-SC8-EB-WP-13.

5. TARGETING SKIPJACK AFTER DAWN – WHILE AVOIDING BIGEYE AND BYCATCH

This experiment is based on tagging tuna with continuous transmitting acoustic tags to allow active tracking of tuna if they leave the FAD. The workboat was successfully modified in Pago Pago to mount the VEMCO VH165 directional tracking transducer and the VR28 multi-frequency tracking transducer necessary for this phase of the project. The gear was deployed and tested satisfactorily in Pago Pago Harbor prior to the commencement of the cruise. Unfortunately the nature of the aggregations encountered during the cruise and the facilities onboard the workboat were not conducive to completing this experiment. It is hoped that this gear can be deployed in future ISSF supported research cruises.

[5] VEMCO Division, AMIRIX Systems Inc., Halifax, Nova Scotia, Canada

6. NATURAL BEHAVIOR OF TUNA AND BYCATCH IN THE NET

A total of fifteen scuba surveys were conducted in the purse seine net during fishing operations: 7 during Cruise Leg-1 and 8 during CL-2. On most of these occasions, surface observations were also carried out with snorkel gear or by additional skin divers. Four additional sets were observed only by skin divers.

These dive surveys and observations by pelagic fishery scientists experienced with the blue-water diving environment appear to be new and unique to science. The images captured with high definition video and digital still cameras reveal behaviors that have to now only been a matter of speculation (**Figure 13**). In particular, the repeated observation of clear separation by size and species for tuna and non-target species suggests that selective release of unwanted species may be possible.

Details of the behaviors observed are documented in Working Paper SC8-EB-WP-13 to this meeting.

Figure 13. Photo and digital documentation of tuna behavior in the net

7. NET MODIFICATIONS – ESCAPE PANEL OPERATION AND MODIFICATIONS

The WCPO-1 cruise was evenly divided into two cruise legs by the need to return to Pago Pago on June 10 for a scheduled port call to exchange scientists from SPC. Repeated observations of tuna and other species (particularly silky sharks) indicated a clear and dramatic separation of species in the net as described in SC8-EB-WP-13. The separation of silky sharks into the shallow, distal bend of the net was so pronounced that an agreement was made to design, install and test a new concept “escape panel” during Cruise Leg-2 (**Figure 14**).

Details of the placement, design, testing and observations are provided in SC8-EB-WP-14.

Figure 14. Experimental "release panel" installed and tested during the research cruise

8. CONDITION AND POST-RELEASE SURVIVAL OF SHARKS

The primary objective of this portion of the research plan was to determine if specific release procedures could be developed to reduce mortality rates of various shark species encountered by the fishery. The primary species of concern is the silky shark (Carcharhinus falciformis) as it is by far the most commonly encountered species. The pelagic white tip (C. longimanus) is taken in much smaller numbers but both species have been flagged as key species of concern in relation to stock condition and abundance trends (Clarke 2011).

Silky sharks comprised a significant component of the non-target catch during the research cruise. A combination of pop-off satellite archival tags, acoustic and conventional tags were deployed with blood sampling carried out to define the point in the fishing operation when sharks sustain injuries that result in mortality (**Figure 15**).

Details of the methodology and results of shark related research conducted on the cruise are provided in SC9-EB-WP-12.

Figure 15. Melanie Hutchinson performing a blood draw on a silky shark prior to tagging and release

9. BEST PRACTICES FOR THE HANDLING AND LIVE RELEASE OF WHALE SHARKS AND MANTA RAYS

A whale shark (estimated 5m) was spotted by the mast man on the first set but was not captured. Two 2m tagging poles were fitted with a Microwave Telemetry PAT tag and a Wildlife Computers survivorshipl PAT in case a whale shark was encountered in the net. A 1.5” diameter Sampson line sling was made to test a specific release procedure that has been suggested by industry and fitted with a cork to facilitate practice and recovery. One whale shark (approx. 3.5m TL) was observed near the drifting vessel on June 8, 2012 (**Figure 16**). Large acoustic signatures of presumed baitfish or plankton were noted on June 7 and 8 on the sonar and bridge echo sounders which may have attracted the whale shark to the area. No whale sharks were encountered during the remainder of the cruise. However, one objective of this cruse was to document the experience and ideas of fishermen on what they believe to be the best, safest and most efficient way to remove whale sharks and rays from the net. It is clear that an increased dialogue with industry is needed and more work along these lines is essential to addressing these issues but scientific verification of post-release condition is also needed.

During the latter part of Cruise Leg 2 it was decided to utilize the MT PAT tags for other shark species if they were large enough to carry the MT PAT tag. The tag leaders on two MT PAT tags were shortened to a suitable length for carcharhinid sharks typically found in the fishery. The tags were deployed on one pelagic white tip and one silky shark as described in Section 7 above.

Figure 16. The deck boss describing a way they have developed to safely remove whale sharks from the sack (left panel) and the juvenile whale shark seen during the cruise (right panel)

10. COLLABORATIVE RESEARCH AND ANCILLARY PROJECTS

Net depth measurements

Three Time/Depth recorders were affixed to the net at the location where the chainline selvedge is laced to the first (deepest) net strip at evenly spaced intervals adjacent to purse rings #31, 62 and 93. Sensors were downloaded after sets and the information relayed to the Captain who was keenly interested in the performance of the net under pursing speeds and current conditions. This information will be incorporated into the analyses of various research modules of the cruise, such as the vertical behaviour of tuna and sharks and issues related to the avoidance of bigeye tuna. **Figure 17** is an example of the vertical temperature and depth profile obtained during set # 10.

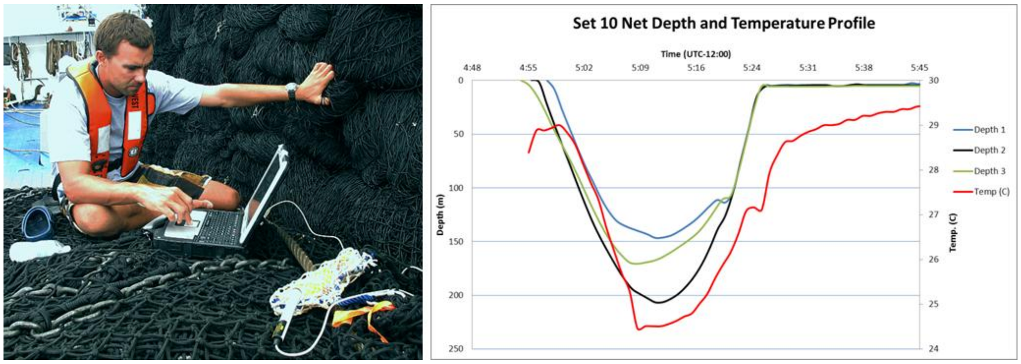

Figure 17. Downloading TDRs (left panel) and vertical temperature and depth profile of the bottom of the purse seine during Set # 10

Bigeye and Yellolwfin tuna biological sampling

Muscle tissue and otolith sampling of bigeye and yellowfin tuna for stock structure analyses continued during the report period. Sampling of both species was completed during Cruise Leg 2 (115 samples each) of muscle and otolith pairs stored in individual vials for later analyses. The tissue samples will be analyzed at the CSIRO laboratories in Hobart, Australia as part of a large-scale investigation on the stock structure of WCPO tunas. Otolith samples will contribute to ongoing studies based from the University of Hawaii and Texas A & M using otoliths as chemical repositories that can elucidate nursery area and scales of mobility of tuna species (Wells et al. in press).

Figure 18. Otolith sampling (background) and Bioelectric Impedance Analysis (forground)

BIA sampling

Bioelectrical Impedance Analysis was conducted on skipjack, yellowfin and bigeye tuna during the cruise. The sampling utilizes a Quantum II Bioelectrical Body Composition Analyzer from RJL Systems. Pairs of electrodes are inserted into the dorsal musculature of the fish and a high frequency, low amplitude current is passed through the tissue that measures resistance and reactance between two electrodes (**Figure 18**). These numbers provide an estimate of body composition and metabolic condition by measuring the electrical impedance of the musculature. Studies have previously been conducted on Bluefin tuna to test the reliability of this method and on skipjack tuna to test the FAD 'ecological trap hypothesis'. BIA analysis was conducted on tuna caught in association with FADs and tuna caught in free schools, although only one "free school" set was made.

Photo documentation

Digital photographs and high definition video recording continued during report period. Digital photos and video were transferred to computer, edited and backed up daily.

11. CAPACITY BUILDING AND TECHNOLOGY TRANSFER

The ISSF and the WCPFC (via contributions from PNG National Fisheries Authority for purse seine bycatch reduction) funded Mr Elton Clodamur (MIMRA, RMI) to participate as a fifth member of the scientific team during the entire ISSF research cruise. This effort was supported to promote capacity building and dissemination of information to the region.

Mr Clodumar has extensive experience as a purse seine observer and as an observer trainer for the FFA and WCPFC ROP and was designated as the point person to liaise with Archipelago Marine Research to monitor the performance and maintenance (if necessary) of the video monitoring equipment. He proved to be a valuable and dedicated member of the scientific team, participating in all aspects of the work and assisting the crew whenever possible. Ferral Lasi (SPC Spill Sampling Coordinator) trained Mr Clodumar to conduct and document Spill samplinig during Leg 2 of the cruise after his departure from the boat on June 10. **Table 2** lists activities Mr Clodumar has engaged in during this time period.

Table 2. Training and support during ISSF #BycatchProject research cruise

Archipelago Marine Research LTD Adam Batty and Paul Wesley	**Scientific Staff (Hawaii) David Itano, Jeff Muir and Melanie Hutchinson**	**Scientific staff (SPC) Ferral Lasi Bruno Leroy**
1 Ran systems cables from top deck to the control centre at the bridge, and systems cables from wet deck to the control computer at the engine control room.	1 Assisted David and Jeff with equipment preparations and testing in port	1 Assisted Ferral to conduct 'Spill sampling" during all sets
2 Installed cameras, 4 on the top deck and 6 on the wet deck	2 Assisted crewmen Celso to make modifications to vessel's lightboat to accommodate scientific equipment to be used on the trip	2 Learn and familiarize myself with spill sampling equipment and protocol before sampling began
3 Installed hydraulic pressure gauge sensor and laser sensor	3 Assisted scientific team on their and diving surveys, on rafts and within the net	3 Assist with installation of the 'GoPro' HD cameras in strategic locations around the vessel to monitor catch as they are loaded into the chute and wells.
4 Received basic instructions on the overall operations of the system	4 Assisted scientific team on their fishing surveys on rafts, deployments of acoustic tags on BET and satellite tags on sharks	4 Downloading and storing of video footage taken from wet and work deck using GOPRO cameras. Images to be analyzed later at SPC HQ.
5 Installed and tested computer systems, 1 on the bridge and 1 in the main engine control room	5 Helped Melanie with her shark sampling protocol during hauling and brailing	5 Transcribe voice data from spill sampling to relevant data forms. Fill PS-4 forms relating to spill sampling.
6 Active monitoring and checking video footage from each set on the system	6 Instructed on scuba tank refill by Jeff and carried out this task along with crewmen Lord, keeping a record of any refills done, compressor hours and maintenance	6 Transcribe voice data from spill sampling to relevant data forms. Filled PS-4 forms relating to spill sampling.
7 Slight adjustments were made on cameras 1 and 2 on the upper deck to capture better footage of each activity	7 Assisted with the 'shark panel' operation with opening and closing of the door	
8 Replaced hard drive at end of CL-1, replaced with blank.	8 Assisted scientific team on diving surveys on FADs and within the net. Served as safety and communication link between workboat and divers	
9 Assisted in changeout of primary CPU on wetdeck monitoring station		

	9 Assisted scientific team on their fishing and tagging activities on FADs, constraining sharks to draw blood samples then tag and release 10 Retrieved sharks gilled in the net for Melanie to sample, during hauling 11 Trained in the use and maintenance of dive compressor. Refilled scuba tanks after use	7 Assisted with calculating the average lengths of tuna sampled from the 'Spill Samples' 8 Downloaded and stored video footage taken from wet and work deck using GOPRO cameras. Images to be analyzed later at SPC HQ

In relation to capacity building and personal enrichment, Mr Clodumar listed the following specific items (**Table 3**) below:

Table 3. Training, capacity building and technology transfer

Scientist	Skill and lessons learned
Ferral Lasi	Spill Sampling Use of the voice recorder Operation of the GoPro cameras
Bruno Leroy	Microsoft Office (calculations) GoPro camera features and use
David Itano	Basic Knots and Splicing Communication and signals for diving Gear and equipment organization/preparation Basic fishing and chumming Basic safety issues and awareness Importance of team work
Jeff Muir	Scuba Tank refill and gear maintenance Basic fishing and diving Understanding of tuna behavior through tagging data (recovered and download acoustic receivers)
Melanie Hutchinson	Basic use of Microsoft Office Safe handling of sharks landed onboard Better understanding of shark survival rates after release through satellite tag data Equipment preparation and storage (syringes and blood samples)

12. OUTREACH AND DISSEMINATION OF INFORMATION

The vessel returned to Pago Pago on June 10 for several reasons; one of which was to meet with and provide a progress report on cruise objectives to high level Tri Marine staff, including the owner or Tri Marine International, Mr Renato Curto. A detailed presentation was provided to Mr Curto, Thierry Le Guennec, Joe Hamby, Mike Wisneske and the captains of all Tri Marine purse seiners in port (Danny Mendeses/Cape May; Frank Sanfilippo/Cape Horn; Ralph Silva/Cape San Lucas; Rolland Verissimo/Captain Vincent Gann. The chief scientist provided a Powerpoint overview of the cruise to date while Melanie Hutchinson showed and narrated a video she had put together that described all cruise objectives and activities.

The presentations clearly showed the separation of tuna species in the net and between tuna and bycatch species. The potential for separation and release of sharks was thoroughly discussed. These discussions concentrated on the potential for putting an "escape panel" in the net at the "pocket" to release sharks and non-tuna species. The presentations were very well received by Mr Renato, Tri Marine staff and the other Captains in attendance who represented the toughest and most knowledgeable critics of putting any sort of "hole" in their net.

The Chief Scientist provided a radio interview to a local Pago Pago radio station on the cruise and a written article to Samoa News.

The research objectives and outcomes of the cruise will be presented to this meeting, the ***Eight Meeting of the Scientific Committee of the WCPFC*** (Busan, Korea, 7 – 15 August 2012). The work will be described in working papers to be presented in the Ecosystems and Bycatch Theme of the meeting. These results will also be presented at a scientific symposium in Montpellier, France (15 – 18 October 2012): ***Mitigating impacts of fishing on pelagic ecosystems: towards ecosystem based management of tuna fisheries.*** Reports of this cruise will be distributed directly to the countries that provided Research Permits to allow the cruise to take place. The data and information gathered during the cruise will be used to develop scientific papers to be submitted to peer reviewed journals for publication.

ACKNOWLEDGEMENTS

The scientific staff and the ISSF would like to thank the WCPFC, FFA, SPC and the specific countries that provided research permits for this work to take place (Cook Islands, Kiribati, Tuvalu, Tokelau, New Zealand, Solomon Islands). We would also like to express our gratitude to Renato Curto, Thierry Le Guennec and Tri Marine International for providing such an excellent fishing/research platform and for the full cooperation of the Tri Marine staff of American Samoa and their net expert Mr Valerio Revalinera. Thanks also to Mr Brett Butler and his staff at Starkist Samoa and Mr Gordon Yamasaki for their cooperation in the verification of catch data at the time of unloading. Finally we wish to express our sincere gratitude to Captain John Crisci, navigator Michael Tallerida and the crew of the M/V Cape Finisterre for their full cooperation, patience and assistance in every aspect of the research cruise.

REFERENCES

AZTI. 2010. Purse seine by-catch mitigation techniques. WCPFC Scientific Committee Sixth Regular Session. 10-19 August 2010. WCPFC-SC6/FT-IP-03.

Clarke, S. 2001. A Status Snapshot of Key Shark Species in the Western and Central Pacific and Potential Management Options. WCPFC-SC7-2011/EB-WP-04.

ISSF. 2010. ISSF meeting on mitigation of by-catches in the tuna purse seine floating object fisheries: Sukarrieta, Spain 24-27 November 2009. WCPFC Scientific Committee Sixth Regular Session. 10-19 August 2010. WCPFC-SC6/FT-IP-02.

Itano, D. G. 2007. A SUMMARY OF OPERATIONAL, TECHNICAL AND FISHERY INFORMATION ON WCPO PURSE SEINE FISHERIES ON FLOATING OBJECTS. WCPFC Scientific Committee Third Regular Session. 13-24 August 2007. WCPFC-SC3/FT-IP-4.

Itano, D. and V. Restrepo. 2011. Status of the Purse Seine Bycatch Mitigation Project and research cruises funded by the International Seafood Sustainability Foundation with notes on the development of best practices for the live release of encircled animals. WCPFC Scientific Committee Seventh Regular Session. 9-17 August 2011. WCPFC-SC7/EB-WP-11.

Lawson, T. and P. Sharples. 2011. Report on Project 60: Collection and Evaluation of Purse-Seine Species Composition Data. WCPFC Scientific Committee Seventh Regular Session. 9-17 August 2011. WCPFC-SC7/ST-WP-03.

Lawson, T. and F. Lasi. 2011. Report on Project 60: Collection and Evaluation of Purse-Seine Species Composition Data. WCPFC Scientific Committee Eighth Regular Session. 7-15 August 2012. WCPFC-SC8/ST-WP-02.

Restrepo, V. 2010. International seafood sustainability foundation initiatives to develop and test bycatch mitigation options for tropical purse seine fisheries. WCPFC Scientific Committee Sixth Regular Session. 10-19 August 2010. WCPFC-SC6/FT-WP-04.

Schaefer, K. M. and D. W. Fuller. An Overview of The 2011 ISSF/IATTC Research Cruise for Investigating Potential Solutions for Reducing Fishing Mortality on Undesirable Sizes of Bigeye And Yellowfin Tunas, and Sharks, in Purse-Seine Sets on Drifting FADs. WCPFC Scientific Committee Seventh Regular Session. 9-17 August 2011. WCPFC-SC7/EB-WP-13.

Marc Taquet, Gorka Sancho, Laurent Dagorn, Jean-Claude Gaertner, David Itano, Riaz Aumeeruddy, Bertrand Wendling and Christophe Peignon. 2007. Characterizing fish communities associated with drifting fish aggregating devices (FADs) in the Western Indian Ocean using underwater visual surveys. Aquat. Living Resour. 20, 331-341 (2007).

Wells, D. R. J., J. R. Rooker and D. G. Itano. In press. Nursery origin of yellowfin tuna in the Hawaiian Islands. M.E.P.S. doi: 10.3354/meps09833.

Williams, P. and P. Terawasi. 2011. Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions – 2010. WCPFC Scientific Committee Seventh Regular Session. 9-17 August 2011. WCPFC-SC7/GN-WP-1.

Appendix I. Vessel and gear detail – MV Cape Finisterre

VESSEL CHARACTERISTICS		
Designer/Builder	Martinac Shipbuilding corp.	
Year built	1979	
GRT	1434	
LOA	239’	
Length Waterline	222’	
Breadth	44’	
Draft	19’	
Displacement	3040 tons	
Cruising range	7100 km (permanent fuel)	
Crew Compliment	22	
Fuel Capacity	99,000 gal permanent	
	145,000 gal total	
Fresh Water hold capacity	54,000 gal	
Fish Well Capacity	1242 metric tons	19 wells, brine
		Ammonia refrigerant
Fish Loading system		
	Brine chute, port and starboard	
	Aluminum sorting hopper	
	Brailing boom	
	Brailer (Spanish style)	6 mt capacity
Main Propulsion		
	Electro-Marine Diesel 4,200HP	20 cyl. 900RPM max
Drive train	12” drive shaft	
	15’ 4 blade propellor	
Generators-Auxillary Power (4)		
	3412 Caterpillar	831HP @ 1800 RPM
	D-353 Caterpillar (2)	435HP @1200RPM
	3406 Caterpillar	305HP @ 1800RPM
Hydraulic Auxiliary Power		
	3412 Caterpillar (2)	831HP @ 1800 RPM
Refrigeration		
	Vilter 12 cyl. 200HP	Ammonia refrigerant
	Vilter 6 cyl. 75HP	
	Vilter	Screw compressor
Primary Net Skiff		
Main Propulsion	3412 Caterpillar	671HP @ 1800RPM

Work Boat		
Main Propulsion	671 Detroit diesel	
Speedboat (2)	Single 115HP Yamaha gas outboard	
Deck Machinery		
Power block	Marco (Spain)	Model B9978E (78” diameter)
Purse Winch	Westec TW 8063 (modified)	
Net Characteristics		
	Manufactuer	CHING FA (Taiwan) (supervised by V. Revalinera)
	Date of primary construction	August 2010
	Corkline length	940 fathoms (1719 m)
	Length stretched	1258 fathoms (2300 m)
	Corkline hanging ratio	27% avg
	Depth	30 strips (approx. 330 m stretched)
	Rings	123 pcs, roller type
	Webbing type	Nylon, knotted
Marine Electronics		
Bridge		
	Sperry Gyrocompass and helm control	
	Navitron Auto Pilot	NT 888G
Radios		
	ICOM IC - M126 DSC	VHF
	ICOM IC – M422	VHF
	Furuno FS – 1503	SSB
	ICOM IC – 2100	2 meter
	ADI AR – 247	1.25 meter
	Standard Horizon Quest-X GX 1500S	VHF
	ICOM IC – M700 PRO	SSB (x2)
Navigation		
	MaxSea GPS satellite data	
	Furuno GPS Navigator GP - 500	
	Furuno GPS/WAAS Navigator GP – 32	
	Garmin GPS Map 526	
	Furuno Universal AIS FA150	

Radar		
	Furuno 21" High Res Color FDP 124	X Band navigation radar
	Furuno 21" High Res Color FR 2125	S Band Bird radar
	Furuno RCU – 014 Bird radar	S Band Bird radar
	Furuno NavNet 3D radar	Backup 24 v
Sonar		
	Furno Color Sonar CSH 53	usual range setting: 300 – 600 m
	Furuno Color sonar Z CSH5	usual range setting: 400 m
Depth recorders – Cape Finisterre		
	Furuno	50
	Furuno FCV 1150	84 kHz
Depth recorder – Workboat/Lightboat		
	Furuno LS 6100	
Current Indicator		
	Furuno Current Indicator	set to 40, 80, 98 m
	JRC Doppler Current Meter JLN - 627	set to 20, 50, 80 fathoms
GPS and Radio buoy systems		
	Taiyo Calling Signal Generator	Radio direction finder
	Furuno Scanning DF FD - 160	
	Zunibal Controller & Tracking receiver	Net-Sonar 0341 (x2)
	ZUNIBAL GPS	Zuni-7
	ZUNIBAL sonar buoy	TUNABAL
	Neptune	GPS buoy
	IRIS	GPS buoy
	GeoEye MSR Receiver	
	GeoEye sonar buoy	M3i
Net depth TDRs		
Time/Depth recorders		
	NKE Instrumentation	SP2T 600 m