Research Protocols

ISSF Purse Seine Bycatch Mitigation – WCPO Research Cruise Protocols

V2: 15 May 2012

Principal Investigators

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Port of embarkation and termination: Pago Pago, American Samoa

Cruise commencement date: 21 May 2012

Cruise duration: 40 - 45 days consisting of two equal cruise segments

Cruise Scientific staff composition:

Leg 1: David Itano (USA) Jeff Muir (USA), Melanie Hutchinson (USA), Ferral Lasi (Solomon Isalnds, Elton Clodumar (Republic of the Marshall Islands)

Leg 2: David Itano, Jeff Muir, Melanie Hutchinson, Bruno Leroy (France), Elton Clodumar

Potential areas of operation: Cook Islands, Tokelau, Kiribati (Phoenix, Gilbert Islands), Tuvalu, Solomon Islands, adjacent high seas zones

Applicable management and MCS: The vessel will operate under all the technical requirements, CMMS and applicable access arrangements as applicable of a vessel of her flag state as required by the WCPFC and carry an approved observer as for any purse seiner operating in this region.

Proposed cruise timing: 40 days

Leg 1: May 22 start

Leg 2: TBD

Potential ports for scientific crew changeout:

Funafuti, TUVALU

Pago Pago, American Samoa

Background

The International Seafood Sustainability Foundation (ISSF) is implementing a research program to develop and test technical options to reduce bycatch resulting from large-scale purse seine fishing on FADs. The core of the project is the chartering of purse seine vessels to serve as experimental platforms to conduct bycatch mitigation research in all oceans to test technical solutions under different oceanographic and fishery-specific conditions.

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 make up 70 – 85% of landings with yellowfin accounting for 15 – 25% while bigeye account for a small proportion. While bigeye landings are a relatively small component of the total catch, their landings are composed almost entirely of juvenile fish which has contributed to negative impacts on 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 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 of tuna. 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 pose 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.

Overall experimental design - justification

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. 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 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 **Fig 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

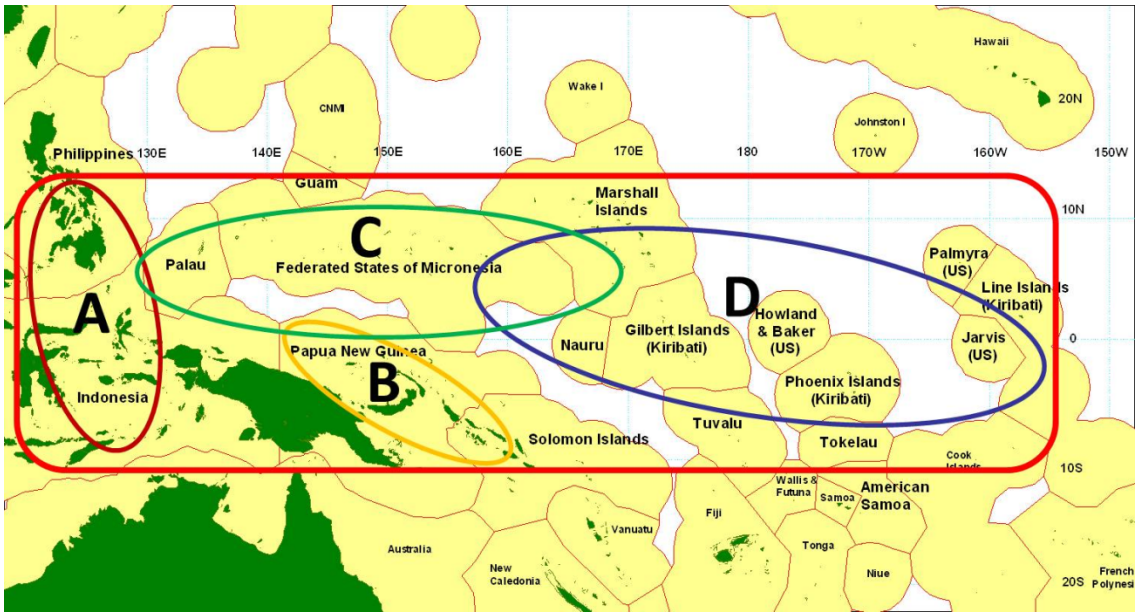

Figure 1. Purse seine activity of drifting objects in the WCPO: A - anchored FAD, B - anchored FAD, C - drifting FAD and natural objects, and D - drifting FAD

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 huge 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 charter time 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 should be duplicated between 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.

RESEARCH ACTIVITIES

1. UNDERWATER VISUAL CENSUS AT FADS

Objectives

To estimate the species composition and abundance of bycatch species at FADs.

Materials

- Snorkel and SCUBA dive gear
- Towboat tender
- Underwater video
- Underwater digital camera
- Sea Viewer Drop Camera with surface viewing screen

Methods

When arriving at a new FAD during daylight hours, the purse seiner will assess the biomass at the FAD using long range sonar so as to not disturb the aggregation. If a sufficient biomass is judged to be present for further investigation, the research activity will proceed. Iff local conditions allow (weather, wind, current, etc.) the tender will launch with two to three scientists and one crew member aboard and proceed to the FAD. Diving will only take place during daylight hours. After deploying the tender the PS will move off 0.5 miles from the FAD to avoid disturbing the aggregation or drawing bycatch species.
The scientists will conduct a dive lasting 10 - 30 minutes, within a maximum radius of 10 m around the FAD. The species and their abundances will be recorded. If SCUBA tanks are used, underwater visual census will be conducted using SCUBA, following the protocol described in Taquet et al. (2007). After the survey the species or species groups will be recorded with an estimate of numbers or tonnage of each at the completion of the survey onboard the PS.

In addition to providing scientific data on fish aggregations around FADs, including the biodiversity of the pelagic environment this activity will also provide the information required to decide if the FAD is abandoned or which scientific experiment will be conducted.

2. PRE-SET ESTIMATION OF CATCH AND BYCATCH

Objectives

The cruise will provide a unique opportunity to examine many issues related to catch and bycatch estimation which spans the period from before the vessel reaches the FAD to when the catch is finally unloaded in port. The project will supply GeoEye M3i echo sounder GPS buoys and computer interface to be used during the cruise. These echo sounder buoys will be compared to sounder buoys manufactured by other firms if available.

The objectives of this module are to:

1) determine the accuracy of the fishing master in determining pre-set estimates of tuna species composition, individual size, and quantities, and bycatch species quantities associated with FADs,
2) to document the methodology used and what instigated an change in estimate during the process,
3) examine whether it is possible to improve the pre-set estimation of catch and bycatch by the vessel,
4) conduct on-board sampling (for size and species composition) using both grab and spill sampling methodology to contribute to a regional study of observer sampling methodology,
5) conduct trial video monitoring of the tuna catch as it is being loaded into wells,
6) to compare final logbook estimates and estimates based on the sampling and video monitoring to weights and species composition data obtained during the unloading process, and
7) to compare the visual output of biomass size and species differentiation between different manufacturers or models of GPS echo sounder buoys if more than one type is available. Initial estimates from different makes and models of sounder buoys will be compared to subsequent estimates or catch if the FAD is eventually set.

The goal is to determine if some catch estimation skills can be documented in a form to be transferrable between vessels (development of best practices) and if particular instruments or equipment could be useful to improve pre-set estimates for potential avoidance of undesirable catch. Estimates of species composition of retained catch will also be compared to unloaded, verified landings to ascertain effectiveness in estimating retained catch.

Materials

- GeoEye echo sounder GPS buoys (supplied by project)
- Echo sounder GPS buoys (normally used on the chartered vessel)
- Echosounder on fishing vessel
- Omnidirectional sonar on fishing vessel
- Echosounder on work boat
- SEABOTIX LBV 200 mini ROV system Underwater ROV with video camera
- Sea Viewer Drop Camera with surface viewing screen
- Net depth recording gear

Methods

The fishing master will be asked to assess the fish aggregation present at a FAD at several stages leading up to and following a set. Assessments will begin prior to arriving at the FAD through visual interpretation of data output from echo sounder GPS buoy or buoys affixed to the FAD and from intelligence received from other vessels, etc. Upon arriving at the FAD, the skipper will utilize his normal

suite of assessment inputs that may include visual surface observations, acoustic surveys, line fishing or other means. If the aggregation appears promising for a set the following day, divers will conduct visual survey as outlined in **Research Activity 1** (above). In this case, the tender carrying the divers will be used to conduct echo sounder observations directly above the aggregation and the drop camera may also be utilized.

Recording of catch estimates will continue after encirclement because it is possible to release the school unharmed if found to be undesirable (due to size of fish, species mix) by releasing the rings. However, regulations on full retention need to be examined to see when this is possible during the fishing operation. The source of information input (visual, sampling, acoustics, information from other vessels, etc.) that influences an estimate and in particular, the change of an estimate will also be recorded. The parameters to estimate will include:

- Total size of tuna aggregation
- Species composition ratio of tuna aggregation (SKJ, YFT, BET)
- Size ranges of target tuna species
- Total size of bycatch aggregation
- Species composition of bycatch aggregation.

The fishing master will be asked to provide these estimates at several stages during the fishing process on a standardized form. Additional forms can be filled out at any time during the fishing process when a significant change an estimate occurs with the reason for the change also recorded. Standardized times when estimates will be recorded include:

- Before arriving at the FAD
- After initial circling and acoustic interrogation of the FAD
- Immediately before the beginning of the set
- After pursing is complete
- During net retrieval at half-net
- Beginning of sacking up procedure
- Beginning of brailing procedure
- End of brailing

Time/depth recorders will be affixed to the purse seine at the bow end, middle and stern end of the net near the chainline to record the maximum depth and pursing depth of every set. This procedure will take place during every set during the cruise to characterize the effective fishing depth of the net in relation to bycatch levels, particularly for bigeye tuna.

The ROV mounted cameras and video drop camera will be used during acoustic imaging and estimates of tuna and bycatch with echo sounder to observe and cross validate acoustic images and estimates with visual images captured by the video gear. ROV and drop cam video gear will be deployed from the main PS vessel or from an auxiliary work boat as the situation dictates.

Video observations will not be provided at the beginning of the trip to the fishing master until after the set as unbiased estimates are required to establish a baseline using traditional methods. During the second half of the trip, video images from the drop camera and ROV both before and during the set will be made available to assess the utility of this gear to improving species size and composition estimates.

Size and species composition sampling will be conducted on the tuna catch before it is loaded into the wells. Two sampling methods will be employed: 1) 'grab' sampling, whereby 5 fish are randomly selected from each brail and their size and species recorded; and 2) 'spill sampling', whereby a larger quantity of fish is spilled from selected brails (every 10^{th} brail, with the starting brail changed for each set) into a sampling bin and the lengths and species of all fish recorded. 'Grab' sampling will be conducted as part of the routine observer duties of the WCPFC Regional Observer Program observer on board the vessel. 'Spill' sampling will be conducted by the SPC technical staff.

Video monitoring of the same sets will be conducted using video cameras mounted on the well deck such that footage of tuna as they pass along the loading chute to the well can be captured. Several mounting brackets will be installed so that the camera can be shifted to the appropriate well as required. Video footage will be analysed post-cruise to evaluate the possibility of collecting species and possibly size composition data from such footage.

The individual catch per set will be isolated within the brine storage wells using sections of heavy net placed in the wells to separate each set following the successful protocols utilized in the ISSF Bycatch cruise in the Eastern Pacific Ocean (Schaefer and Fuller 2011). Basically, the set is brailed aboard, allowed to freeze solid and the well is then pumped dry. Crewmen attach a separating panel of heavy net by tying the edge of the net to the tails of large tuna frozen in place. The well is kept dry frozen until just before the next set when it is re-flooded with circulating brine when the next set is loaded on top. This procedure continues for every set that does not completely fill a well. At the conclusion of the cruise, the tuna and bycatch species composition, quantities, and sizes from each set will be determined based on the sorting done by the cannery following unloading, and additional sampling by the research staff assisted by port sampling staff if agreeable arrangements can be made. These results should provide very accurate estimates of size and species composition of the sets in question, and can be used to ground truth the estimates of total catch and species composition by the skipper, as well as the estimates based on the two on-board sampling methods and video monitoring.

3. NATURAL BEHAVIOR OF TUNA AND BYCATCH IN THE NET

Objective

To observe the behavior of tuna and bycatch species in the purse seine net to explore possibility of isolating and releasing in good condition bigeye tuna, sharks and other bycatch species. The development of release techniques during daytime would be of interest requiring daytime visual observations.

Materials

- Echo sounder on fishing vessel
- Omnidirectional sonar on fishing vessel
- SEABOTIX LBV 200 mini ROV system Underwater ROV with video camera
- Sea Viewer Drop Camera
- Workboat operating Simrad ES 70 and ROV video gear and drop camera
- Scuba equipped divers with still camera and video gear

Methods

A pre-dawn set would be made on a FAD having a mixed species aggregation of tuna and bycatch species as per normal operating procedures in the WCPO.

When pursing is complete the net will be retrieved until one third to one half of the net is aboard depending on the size of the aggregation and the prevailing environmental conditions. If the quantity of fish is judged to be appropriate to continue the experiment and weather, current and local conditions are favorable as judged in consultation between the Captain and Chief Scientist, then:

The net will be held open using the net skiff, bow thruster, towboat(s) and speedboats for a period of up to six hours.

The aggregation would be observed using ROV video, drop camera video and video equipped scuba divers to observe tuna species, different size tuna and bycatch as they move around the net. Observations of bycatch and tuna behavior in relation to the FAD will also be noted.

The workboat would remain inside the net, recording simultaneous images on the SIMRAD ES60 echo sounder and drop camera or SEABOTIX ROV mounted cameras. The workboat would also serve as a safety base of operations for camera and video equipped scuba divers.

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

Objectives

To obtain fine scale spatial and temporal information on the natural behavior of tuna and other species of fish (bycatch) in mixed-species aggregations that may be useful for avoidance of bigeye tuna and bycatch. These opportunities may result from vertical separation when in aggregation with the FAD (day or night) or horizontal separation of species at certain times of the day or night. The overall objective of this experiment is to see if economically viable landings of skipjack and yellowfin tuna can be maintained while avoiding bigeye, small tuna and miscellaneous bycatch species.

Acoustic tagging of common bycatch species that have a significant influence on echo sounder and sonar returns will also be conducted. This is important as species such as rainbow runner (*Elegatis bipinnulata*) and oceanic triggerfish (*Canthidermis maculata*) have a large swim bladder and can form dense aggregations under a drifting FAD that can negatively impact acoustic signals transmitted by sonar buoys or images observed from the onboard omnidirectional sonar. These signals can obscure or distort the interpretation of acoustic data from tuna that are found below the FAD bycatch community. It is important to understand the diurnal and spatio-temporal pattern of their movements when interpreting acoustic data

Materials

This experiment is focused around acoustic equipment, acoustic transmitter tags, acoustic receivers and tracking equipment with visual verification and recording with underwater video and still camera gear. Camera gear will be operated via drop cameras, ROV mounted video and scuba divers. Basic equipment required for the experiment will include but is not limited to:

- Echosounder on fishing vessel
- Echosounder on work boat
- Omnidirectional sonar on fishing vessel
- Workboat fitted with VEMCO VR28 acoustic tracking system
- VEMCO VR2W acoustic receivers
- VEMCO acoustic transmitter tags
  - V13Pcoded transmitter tags for skipjack, yellowfin and bigeye tuna
  - V9P coded transmitter tags for smaller bycatch species.

- SEABOTIX LBV 200 mini ROV with video camera
- Sea Viewer Drop Camera
- Scuba equipped divers with still camera and video gear

Methods

This experiment will require several medium sized mixed-species aggregations of skipjack, yellowfin and bigeye tuna with a diverse bycatch population of the common species of sharks and miscellaneous finfish that associate with FADs in the WCPO. The tuna aggregation should ideally be >20 but < 60 mt with a bycatch population of at least 3 mt. However, larger or smaller aggregations will be examined as necessary depending on current conditions.

FADs selected for the study will have echo sounder GPS buoys attached to the FAD of different makes and models for comparison. A VEMCO VR2W receiver will be attatched to the FAD to hand 8 m below the FAD. Receivers will be deployed on surface accessible chains to allow retrieval and data acquisition without entering the water (see Figure 2). The VR2W will be replaced and downloaded at variable time

intervals of one day or more depending on several factors, i.e. the number of tagged individuals present, environmental conditions, vessel operations, etc.

Tuna and bycatch species as outlined below will be tagged and released with a combination of depth recording and standard acoustic tags. Experiments will target three tags each for skipjack, yellowfin and bigeye tuna for three different FAD aggregations. Fish will be captured using a variety of trolling, jigging and baiting techniques from the workboat using pole and line gear. Tags will be surgically implanted into the peritoneal cavity of the fish as per procedures utilized by the chief scientist and other pelagic scientists for marking tuna with acoustic and archival tags. All capture and tagging will take place from the workboat. All acoustically tagged fish will also be individually marked with a standard SPC plastic dart tag (PDT) below the second dorsal fin as per protocols long adopted by the SPC and IATTC.

The following species will be marked with acoustic coded, depth sensing tags to examine natural behavior of FAD aggregations: Skipjack tuna, yellowfin tuna, bigeye tuna, Rainbow runner, and oceanic triggerfish. The VR2W receiver on the FAD will record presence/absence and vertical behavior of tagged individuals that remain associated with the FAD. The workboat will deploy on the FAD at night monitoring the aggregation with echo sounder while continuing to tag additional specimens if necessary.

Figure 2. VR2W acoustic receive rigged for deployment and a VR2W deployed on an anchored FAD

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

Objective

To determine if bigeye, yellowfin and skipjack tuna separate horizontally after dawn allowing the targeting of pure skipjack or skipjack and yellowfin mixed schools both AT the FAD and AWAY from the FAD that they were associated with during the previous evening.

Materials

The materials are essentially the same as for **Experiment 4** above but with acoustic tagging of tuna species with V13P continuous tags that will allow active tracking of tuna if they leave the FAD using the VEMCO VR28 and VH110 Hydrophone tracking gear on the workboat and long range sonar utilized by the purse seine vessel.

Methods

Set Type 1: Delayed setting time of FAD.

The aggregation will be monitored using the sonar and echo sounder of the purse seiner and the echo sounder onboard the workboat (positioned near the FAD) before dawn as for a normal set.

- Tagged tuna and bycatch species would simultaneously be transmitting presence/absence and depth data to the FAD mounted VR2W receiver. This information would later be used in relation to catch composition of the set by time of day.
- The time of the beginning of set would be delayed to various times noted in relation to the time of local sunrise, i.e. Sunrise (S-0), 15 minutes before sunrise (S-15), 30 minutes past sunrise (S+30) etc. for different sets that occur during the cruise.
- Due to variations in setting and pursing times for every set, the exact time when rings surface (end of pursing) will also be recorded.
- Catch resulting from these sets would be identified and enumerated in detail with particular attention on levels of bigeye catch
- Special attention would be given to identifying tagged fish during the brailing process

Set Type 2: Active tracking of tuna

- If skipjack are observed to leave the FAD after dawn, either through visual means, via sonar or by active tracking of tuna marked with continuous acoustic tags, the school will be followed using sonar, acoustic tracking or visually.
- The purse seine vessel will attempt to capture the free school if it remains visible or otherwise vulnerable to purse seine gear and moves a distance of one nm or more from the FAD[1]
- Catch resulting from these sets would be identified and enumerated in detail with particular attention on levels of bigeye catch
- Special attention would be given to identifying tagged fish during the brailing process
- Results will later be compared to tagged tuna data received on the VR2W mounted on the FAD.

[1] The definition of a "FAD set" according to the WCPFC FAD regulations is if any portion of the vessel or net is within one nautical mile of a FAD

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

Objectives

Some PS captains routinely tow drifting FADs or logs out of the net after pursing is complete but before the net retrieval begins. They feel that this process allows bycatch species to follow the FAD out of the net which they favor for a variety of reasons. Many skippers feel that the bycatch aggregation somehow enhances the tuna aggregation somehow and avoiding bycatch simply means less sorting and more room in the storage wells for tuna. However, it is not known how effective this process is and how much of the bycatch can be saved using this technique.

The objective of this exercise will be to record the amount and species of tuna and bycatch that will follow the FAD when it is towed out of the net prior to net retrieval. These observations will be compared to the quantity of FAD associated bycatch that is observed to be released, discarded or unloaded at the completion of the trip.

Materials

- SEABOTIX LBV 200 mini ROV system Underwater ROV with video camera
- Sea Viewer Drop Camera with surface viewing screen
- SCUBA equipped divers
- Underwater video

Methods

If a drifting FAD or natural floating object is set there are a number of possible scenarios that may take place following the pursing procedure. In some cases, the natural behavior of the aggregation may be observed inside the net. For this experiment, the workboat will already be in the net tied up to the drifting FAD inside the net enclosure. One scientist will be onboard to operate the ROV and Drop Camera with one or two crew to operate the vessel and assist with the video equipment. The ROV and Drop Camera will be used to record video of the bycatch aggregated around the FAD when it is in the middle of the net. If fish are seen to actively avoid the ROV then only the Drop Camera will be used.

When there is sufficient light to dive safely and after pursing is complete, the FAD will be slowly towed towards the stern of the PS vessel. SCUBA equipped divers on a speedboat will enter the net area near the stern end of the net to observe the FAD being towed out of the net. This was a direct recommendation from the EPO cruise that observed that tuna actively avoided the ROV apparently due to the noise created by the thrusters.

An opening in the net between the port stern of the PS and the stern oertza (end of the net) will be formed by shifting the boom to port and slacking the line attached to the oertza ring. SCUBA divers will video the operation as the FAD is slowly towed out of the net with whatever bycatch species may follow. This video will be compared to the Drop Camera video of the bycatch underneath the same FAD when it was in the center of the net.

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

Objectives

Whale sharks ((*Rhincodon typus*), manta rays (*Manta birostris*) and mobula rays (*Mobula spp*.) can be inadvertently encircled during purse seine operations and are difficult to release due to their large size. Interactions occur in tropical purse seine fisheries as tropical tuna can form associations with large, slow moving animals such as whale sharks and rays (Bailey et al. 1996). Releasing these large animals can be hazardous to fishing crews and injurious to the animals and a number of mortalities of whale sharks interacting with purse seine gear have been documented by observer programs (SPC-OFP 2011). The development of release techniques for these large animals is a high priority by all tuna RFMOs and techniques that provide for the safety of the crew and release of the animal in good condition must be developed, as discussed in Itano and Restrepo (2011). Experience in dealing with whale shark and large ray release resides with the industry and needs to be tested in the field using scientific verification and reporting. The objective of this experiment is to develop and test specialized gear and techniques to handle and release whale sharks and large rays and ascertain post-release survival through the deployment of Survivorship PAT tags deployed on released animals.

Materials

- Wildlife Computers survival tags (sPAT)
- Cargo type lift nets
- Workboat tagging platform
- Other gear as developed

Methods

Various options for the release of large animals from the net sack will be explored with the fishing captain and experienced crewmen onboard the vessel, fabricated and tested during the cruise. If no such animals are encountered, tests will be made in an effort to develop release gear and techniques to *be tested in the future.*

If a whale shark or large ray is encircled in the net and is not detected or able to be release immediately, it will be confined to the sack during the fishing process. At that time, a survival PAT tag (WC sPAT) with long tether and dart will be deployed posterior to the dorsal fin or in the back of rays using a long handled applicator pole. A standard inter-muscular metal headed dart tag will also be applied to all released animals. The time of confinement of the animal in the sack will be recorded up to the point of release.

The animal will be released by the captain and crew, allowing them to use whatever methods they employ under “normal” fishing conditions. Through discussion with the captain and crew, scientists will attempt to develop new methods and purpose built gear or modifications to the net and corkline that will make the release of large animals easier and safe for the crew.

Several release methods have been suggested by fishermen but none have been independently tested and the condition of the released animals remains unknown. There is some consensus that allowing the animal to swim out head first either by depressing the corkline or cutting net lacings is a good option. Ways to depress the corkline or "quick release" snaps between the corkline and netting in the sack will be explored. Purpose built, heavy duty cargo nets attached to the bow side of the sack corkline could assist in rolling a large animal out of the sack but these are theoretical and untested. Working onboard a commercial purse seiner will allow a much better development of various ideas with experienced fishermen on hand to troubleshoot and advise. The goal is to develop a series of "best practices" for further discussion by the WCPFC Scientific Committee.

8. CONDITION AND POST-RELEASE SURVIVAL OF SHARKS

Objective

The overarching objective is to determine if specific release procedures can be developed to reduce mortality rates of various shark species encountered in purse seine sets. Oceanic sharks are taken as bycatch in tuna purse seine fisheries and often discarded dead or in poor condition. The primary species that interacts with purse seine gear in the WCPO fishery is the silky shark (*Carcharhinus falciformis*) with smaller numbers of the pelagic whitetip encountered (*C. longimanus*), both of which have been flagged as key species of concern in relation to stock condition and abundance trends. In particular, datasets for the pelagic whitetip shark show clear, steep and declining trends in abundance in the WCPO (Clarke 2011; Walsh and Clarke 2011). While oceanic sharks are regularly discarded at sea during the brailing process, the fate of those discarded animals is unknown. Further, it is not known whether the survival of sharks has been compromised even before the brailing operation begins.

The primary objective of this experiment will be to determine post-release survival of oceanic sharks that are released immediately prior to commencement of brailing – that is, while they are still swimming in the constricted net. The intent of this experiment is to determine more precisely when sharks incur the injuries that result in mortality. Because oceanic sharks require forward motion to maintain water flow over the gills we hypothesize that mortalities occur at the very last stages of the seining procedure and during brailing. That is, simply being encircled in the net does not cause fatal trauma to the sharks. To test this, we need to tag and release sharks that are still swimming in the very last stages of the seining process – just before they would normally be brailed and brought aboard.

Depending on the survivorship, it is possible that technical recommendations can be developed to reduce shark mortalities in the purse seine fishery. A secondary specific objective will be to assess the post-release survival of sharks that arrive on deck after brailing at timed/recorded periods of confinement in the sack.. However, *only sharks determined to be in good condition* will be tagged and released. The rationale for this approach is to provide estimates of 'best case' survival of sharks that have been exposed to the brailing process. Preliminary results from previous experiments indicate that sharks in poor condition that were released after the brailing process exhibited very high post-release

mortality. In both experiments, it will be essential to collect data on the timing of various phases of the set and the time of release and condition factors of released animals.

Technical procedures

Recently developed "survival" pop-up tags (sPAT) will be used to assess survivorship. Survival tags monitor key aspects of shark behavior and then detach from the shark if mortality occurs or at a pre-set time after deployment if the shark survives to that date (e.g., 30 days) and uplink a summary of the animal's status via the ARGOS satellite array for data transfer to the researcher. sPAT tags are darted into the back of a shark and eventually detatch, float to the surface and report. A premature release will occur if the tag passes below 1700 meters depth indicating that the animal is a "sinker" and has died. Premature releases will also occur if the animal is floating or sitting (e.g. no change in depth over a period of two days). On board processing by the tag can determine whether or not the tag was ingested by a predator by transmitting the number of days with no recording of light levels. Survival algorithms will also use temperature and depth ranges over 24 hour periods to decide whether or not the tag and animal have washed up onshore. Survival tags are less expensive than standard pop-up tags because they are designed for shorter deployments and they provide a summary of the animal's status rather than a complete time series of the animal's behavior. Also, ARGOS satellite charges are included (pre-paid) in the cost of each sPAT.

Several studies on the stress physiology of sharks have shown that certain blood metabolites correlate with post-release mortality (eg. Hematocrit, lactate, pH, pCO_2, plasma Mg^{2+}, K^+ and Ca^{2+}) in other shark species (e.g. Moyes et al., 2006; Hight et al., 2007; Skomal, 2007; Brill et al., 2008; Mandelman and Skomal, 2009; Heberer et al. 2010). In this study we will quantify the blood concentrations of these key physiological indicators of post release condition of sharks caught and released at different points in fishing operations. These data will increase our effective sample size and enhance the statistical power derived from the tagging data.

Materials

- Wildlife Computers survivorship tags (sPAT)
- Lift net, large dip nets
- Skiff (workboat) tagging platform
- Blood extraction equipment
- Automated blood chemistry analyzer (i-STAT and CHEM 8 analyzer)
- Blood storage cartridges

Methods

1) The work boat (skiff) will be maneuvered alongside the cork line on the forward (bow) side of the net and beginning of the sack (e.g. forward of the brailing bunch). Using this platform, free swimming sharks will be removed from the net using a purpose built dip net or small curtain net deployed inside the cork line immediately across from where the skiff is secured. Captured sharks will be brought aboard the skiff, tagged with a pop-up sPAT tag and released (see detail of blood sampling below). Only sharks of manageable size will be tagged. This procedure will require the captain to pause in the seining procedure before commencing brailing long enough for the scientific crew to establish if any suitable sharks are present and to then attempt to capture and tag them. If multiple sharks are present, more time may be required.

2) If capture of free swimming sharks is not feasible, tags will be applied to sharks coming on board at the beginning of the brailing process – provided that they appear to be in good condition. A shallow "skimming" brail system may be adopted that would scoop off free swimming sharks if present just before the sack is fully dried up for brailing. Similarly, if sufficient numbers (e.g., ten) of free swimming sharks are successfully tagged and released, attention will be turned to tagging sharks that come aboard on the first "regular" brail. Sharks will be removed from the brail or hopper and placed on a padded tarpaulin where they will be immobilized and tagged with pop-up tags. Following tagging, sharks will be released over the starboard (non-fishing) side of the vessel.

3) Blood Sampling. If sufficient free swimming sharks are tagged with pop-up tags, similar capture procedures will be used to acquire sharks for blood sampling. As in the tagging procedures, blood sampling will occur on the skiff at the cork line and potentially on deck immediately after brailing. Again, this will require the captain to pause briefly during the brailing process. Sharks will be released after blood samples have been acquired. As with the tagging experiment, blood samples will also be taken from sharks on deck after removal from the brail. The use of a brailing hopper would be necessary to allow sorting of sharks and bycatch while accommodating loading of the catch as quickly as possible.

4) In all cases, tagging and taking of blood will require precise documentation of the time in the seining operation at which these activities occur (e.g. timed to start of sacking up, end of sacking up, start of brailing, brail number etc.)

5) For each set, we will also be observe and record the total number of sharks that are in the set, and their condition (e.g. alive, moribund, dead) that are detected on the upper work deck or later detected on the lower deck prior to flowing into a fish well

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