ISSF Meeting on mitigation of by-catches in the Tuna Purse seine Floating Object fisheries

Final Report

AZTI
Sukarrieta, Spain
24-27 November 2009

1. Introduction

A meeting focusing on potential mitigation measures related to by-catch in the purse seine fishery on Fish Aggregating Devices was convened by the International Seafood Sustainability Foundation, and held at the AZTI- Tecnalia laboratory, Sukarrieta, Bizkaia, Spain, 24-27 November 2009. The objective of the meeting was to gather experts in the fields of gear technology, acoustics, shark, and tuna behavior, fisheries, gear experts, and physiologists, to discuss with the skippers of purse seine vessels methods that could be used to mitigate the bycatches of small tunas, sharks, marine turtles and of pelagic bony fishes (mahi-mahis, wahoos, rainbow runners, etc.), in the purse-seine floating-object fisheries throughout the world. We are using as the definition of bycatch "that fraction of the capture in a set that is discarded dead; with capture being defined as all that is physically encircled and retained in the net." How to reduce the catches of bigeye tuna was also part of the discussion, even though it is not a bycatch issue. The inclusion of bigeye tuna in this group is based on the fact that although it is retained and sold, in many cases, the catches of bigeye tunas are causing negative impacts on the bigeye stock, and in the fishery for skipjack which is the main target of the FAD sets (e.g. prolonged closures). Because of this reason, it will be useful to look for ways to reduce bigeye captures under some conditions, to avoid those negative impacts.

The meeting was opened by Dr. Josu Santiago, Director of the Tuna Research Department from AZTI, who gave all a warm welcome, and by Susan Jackson, president of the International Seafood Sustainability Foundation, the organization that originated and supported the workshop. She explained the objectives and mechanisms by which ISSF wants to promote sustainability in tuna fisheries, and transmitted the apologies of Dr. James Joseph, the Scientific director of the Foundation, who could not attend for health reasons. Her statement is included as Appendix A.

Participants of the meeting did not represent countries or organizations and their opinions reflected only their personal views. This meeting did not aim to produce recommendations endorsed by meeting participants, but rather aimed at gathering a list of ideas and opinions presented and discussed by participants, which could then be considered by the ISSF for funding potential research projects, to direct harmonized data collection, and other related activities.

The list of participants is available in Appendix B, and the Agenda in Appendix C. The presentations titles and presenters are included in the Agenda. The presentations of this meeting provide more detail on the subject matter and are available at www.???.???.

The sections that follow provide a brief summary of the ideas and issues raised in presentations, and subsequent discussion in an abbreviated form.

The formal meeting was preceded by a three hour session on November 24th, where the technical aspects of purse seine fishing on FAD were presented to the audience. The purposes of this presentation were to introduce the practice to experts on other subjects (such as acoustics, or shark behavior) that were not familiar with purse seining, and to make a quick comparison among the fisheries in the different ocean areas. The emphasis was in the aspects of the fishing operations that could influence bycatches (e.g. fishing depth of the nets, duration of sets, handling of the catch, and bycatch, etc.).

The meeting started with brief reviews of the bycatch issues identified in the different oceans. Our understanding of these issues is limited in some oceans by the paucity of observer data, but there is a clear trend to increase the coverage of these programs.

Some of the issues are common to all oceans, such as the decline in some of the shark populations, which seems to be the most significant conservation concern, although for most species, the impacts from the purse seine fisheries do not appear to be of a magnitude that may be driving the declines.

Impacts on sea turtles caused by the sets are low in magnitude, and can be reduced quite simply. Impacts of entanglement in the webbing hanging under FADs are not easy to estimate, but the magnitude doesn't appear to be as high as some expected. These impacts can be mitigated by different FAD designs, or by construction with different materials.

Bycatches of a set of pelagic fish species (mahi-mahi, wahoo, rainbow runner, yellowtail, etc.) cannot be put in perspective relative to population abundances because those are not known, but most of the species involved are extremely prolific, fast growing, and with early sexual maturation. These incidental mortalities may be sustainable, however, since these species are relatively high level predators, and contribute to important artisanal and recreational fisheries, the ecosystem, and the socio-economic impacts of their removal should be considered. It would be desirable to avoid negative interactions with artisanal fisheries.

Bycatches of billfishes, where there are good estimates, were very small compared to the directed catches, or bycatches in other fisheries in the region, and they should not have a noticeable impact on the trajectories of those populations.

Discards of small tunas of all species, below marketable sizes are always undesirable for the fishermen. The catches of bigeye tuna on floating object sets has become a major management concern in the Pacific, and avenues to avoid, or exclude bigeye from purse seine sets were explored. As stated before, this is not a bycatch issue, but it was included because of its significance for the fisheries.

The summary report has been structured on the premise that there are four distinct phases in the purse-seine fishing operation where action can be taken to mitigate the catch of bigeye tuna, or the bycatch of small tunas, sharks, marine turtles, and other species:

- Avoidance : before entrapment in the net
- Release from the net
- Release from the deck
- Utilization (for some species)

2. Reducing catches of bigeye tuna, and bycatches of small tunas

Under FADs, fishers frequently encounter a mixture of tuna species and sizes. The three main species (skipjack, yellowfin, and bigeye tuna) appear in a wide range of sizes, but yellowfin and bigeye tend to be immature individuals that are well below the optimum sizes for those species. These catches, especially of bigeye, add fishing mortality to a stock that is not in a condition to sustain it. In the mixture, there may also be individuals of all of the tuna species, which are of sizes that are below what the market will accept, and therefore have to be discarded. Acoustic systems may be able to provide information on the composition of the tuna school (or schools) aggregated under the FAD, based on the fact that (a) under some conditions, some systems may show the size composition of the schools present under the FAD, and (b) that different tuna species show differences in the presence and development of the swim bladder, which plays a major role in the echo produced by the fishes, and it may facilitate the identification, and the estimation of relative abundance of the species. If the captures can't be avoided, then the next option is to release the bigeye tuna, and the non-marketable sizes of all species from the net.

A particular, and important issue for the case of the bigeye bycatches, is the need to have accurate figures on the bycatches. This is made difficult by the similarity of the bigeye and yellowfin tunas, especially when they are small, which may confuse observers. Several participants emphasized the need for solid port sampling schemes to validate the observations made at sea, and a short text and a presentation on the subject (that was not shown at the meeting) have been added because of this interest. See Appendix D by Miki Ogura.

2.1. Bigeye and small tuna – Avoidance

Can we avoid sets with high proportions of bigeye tuna to reduce the negative impacts on the stock ? Can we avoid sets with a large proportion of unmarketable individuals of the target species to reduce these bycatches?

To achieve these goals, having advanced information on the species and size composition expected in a set is one of the options. So the question is: Can we detect and discriminate the species and sizes of tunas aggregated under a FAD prior to setting the net? Given the time at which FAD sets happen (before sunrise), visual cues are not very reliable, so acoustics are one of the few methods available that may provide answers to the questions.

This first approach is based on the fact that if a fisher knows that a set will result in high catches of bigeye tuna, which will have negative consequences for the fishery, in spite of the economic gain, it may decide not to make that set. The same can be said if he has a large proportion of small tunas that will have to be discarded if they do not have market value. The basic questions here are: do the fishers have enough information to make those decisions? Do they know, prior to setting, what is the composition of the capture that they are going to obtain with reasonable accuracy? Conceivably, if the different species or sizes are separated (e.g. vertically) then it could be possible to restrict the capture to the desirable components. Acoustic equipment appears to be the only approach currently used for this purpose.

<u>Detection (acoustic)</u> It is necessary to determine which is the best approach to detect and discriminate. There are two basic alternatives: equipment on the seiner or on the FADs (instrumented buoys). In the seiner it is possible to install higher quality equipment, but if the vessel has sailed to the FAD before discrimination, then it will be hard to convince the fishers to pass up the set. If the instrumented buoys on the FAD send the information needed remotely, the fishermen can decide which FAD to fish before sailing and the economic cost of the decision to pass up is much lower.

Is any device capable of adequate detection and discrimination? The opinions are mixed, with some fishers maintaining that in some circumstances they can assess the presence of bigeye, but that in general the quantification is difficult. Regions with deeper thermoclines may have the species more scattered vertically, and that may make easier the identification. Fishermen noted that remote sensing of species and size with current sonar buoys is crude and unreliable but can be used as a general guide. Information from other vessels in the area is more reliable.

Do bigeye, and small tunas segregate from the other species/sizes of tunas ?
If segregation (in the wild or in the net) is not apparent then avoidance is not possible. Unfortunately, the most needed behavioral studies, those of behavior inside the net are not available.

It is necessary to define actual pursing depth of purse seine nets used by different fleets, and to evaluate the skippers ability to control depth during the operation

Interpretation of output from acoustic devices

It may be necessary to generate:

(a) a library of information collected from detection devices to establish best practices in discrimination, and then avoidance, correlating the readings with the captures.
(b) a library of behavioral patterns or measurable physical characteristics, i.e. tail beat frequency or other parameter by size and species.
(c) software to facilitate interpretation of acoustic data to aid decision making (i.e. how to better detect, and reduce subjectivity) <u>Acoustic signatures</u>

What are the relative merits of available <u>ACOUSTIC INSTRUMENTS</u> (e.g. cost versus features/capabilities)

Multiple frequencies may be needed to discriminate SPECIES (target strengths needed)
Multiple frequencies may also be needed to discriminate SIZES

Multi-beam sonar devices
Fishermen noted it is less precise in identifying species and size from return image, but more useful when viewing behavior (movement) of an active target.

Echo sounder devices
Sounder can distinguish species much easier than sonar. Fishermen and scientists noted good ability to discriminate bigeye tuna using echo sounder devices due to strong target return and depth, but pointed out that large amount of tunas, or other factors, may make the identification more difficult, and in all cases, the quantification is not solid.

Remote discrimination (e.g. GPS and detection instruments attached to drifting FADs)
Instrumented buoys could be developed with the transducer at 10m depth, instead of in the surface, to avoid shadowing from species that are occupying surface layers. Some problems could arise by entanglement with the underwater structure of FADs. Alternatively, the transducer could be lowered remotely (with a reel system) only when information is required.

Passive acoustic devices: These could constitute an interesting innovation**. B**asically hydrophones installed in the FADs that may be calibrated to identify the noises produced by different species and sizes. Studies with tuna schools in the laboratory could be helpful to develop the identification characteristics. It requires considerable research to identify/calibrate species-specific noise composition.

PROS of Remote Discrimination : It can potentially detect biomass and extent of bigeye tuna, and small tuna from a distance, and thereby save time/fuel. Vessel can select best FAD to set on without travelling to each one – gains in efficiency.

CONS of Remote Discrimination : Expensive research may be needed to make the right sensor, and fine tune it, but the sensors themselves may not be expensive to deploy on each FAD. It may need to deal with "noisy" fish on FADs.

Multi-beam Sonar
May allow to obtain a 3D picture of the school. The units are expensive

Imaging Sonar
20-130° and 120 meters. It provides a 3D acoustic image, allowing "visualization"

Underwater Cameras/Videos
Drop cameras useful for real time verification of acoustic images. However, most FAD sets happen while it is still dark. Still, video can be useful for verification of daytime images with echo sounder image as the tuna aggregation should remain relatively stable over a 12 hour time spans and training can improve acoustic discrimination during the set.

Use LYYN technology to enhance the images.

LYYN is an R&D company working with image enhancement for improving visibility in different industries. LYYN uses a technical platform, V.E.T., Visibility Enhancement Technology. The platform works with digital still images and video from common color cameras, in real time, but also in post processing of stored material. V.E.T. improves visibility in fog, haze, and darkness as well as in underwater applications (www.lyyn.com**)**

ROVs

ROVs with detection devices could obtain vertical and horizontal profiles. They could be equipped with acoustic, optical, and other instruments. And they could also carry Photo Measure or laser devices to determine size.

Optical instruments

Perhaps bouncing light off the targets may be used to identify species or sizes.

A combination of devices may be the best approach .

2.2 Bigeye and small tuna – Release from the net

Feasibility of controlling bigeye, and small tuna movement in the net

Find out which techniques or equipment can help control the movement of bigeye, and small tunas inside the net with the objective of releasing them from the net. The basic concept behind these ideas is the observation made by some, that tunas would not escape through the net, a grid, or other opening without some stimulus pushing it towards them (Presentations by Ogura, Oshima, experiments at Achotines (Scholey, Olson, IATTC)). So the selectivity of the net has two components: the escape opening (of whichever type and materials), and a stimulus to drive the fish towards, and through it

Some considerations

The techniques must be species-specific (i.e. segregate bigeye tuna) and size specific (segregate small tuna)

It is a requirement to avoid crowding in the net as much as possible to reduce factors that may cause mortality (e.g. reduction in oxygen in the net will affect survival)

Danger of moving fish too rapidly – gilled fish (XMAS tree)

Relative survival of tuna species in the net – do small skipjack die before small bigeye? before other non-tuna species in the net?

Moving fish too much can cause stress, lower survival

Light stimulus: experiment in Japanese seiner

Can light help move fishes inside the net?

Flashing light causes "withdrawal" of tunas from the source of light

Continuous light causes "attraction" of tunas to the light

There is some variation in the response with the moment it happens (before dawn, after, etc.). It appears to be more effective at night or before dawn.

How can light stimulus be used? (e.g. attract/move tunas towards sorting grid ?)

Is light stimulus species- and size-specific ?

Audio stimulus

Perhaps, fish can be moved by sound

Differences in hearing frequency for bigeye and yellowfin compared to skipjack (dB) shown in Ogura's experiments have potential value to separate.

ROVs can be used to observe, and move fish in the net. Whichever the stimulus, ROVs can be used to herd the fish inside the net.

ROVs can readily move throughout the enclosed net (small ROV has horizontal range 2,000 m and depth 250m)

Use in conjunction with other (light/audio stimulus) devices to move fish

It could be used to observe, or to carry some stimulus to change the selectivity of the operation ?

Minimum cost USD23,000 without on board monitor. A functional system with video camera, fiber optic tether and reel, topside controls, cases and 2 year warranty around USD37,000.

ROVS are clearly an important observational tool to assess and assist many mitigation options

[On a side conversation it was discussed the possibility of bubble curtains to move fish, as an unexplored option].

Feasibility of using Sorting Grids to facilitate the release of small tuna in the net

Evaluate the use of sorting grids to facilitate release, unharmed, from the net.

Is there segregation by size/species – can bigeye and small tuna be released without releasing target skipjack catch that are often smaller? Research by Ogura shows all species become shallow before dawn, at similar levels.

Difficult case for bigeye, but may differ between oceans with different thermocline depths, etc.. Is bigeye on the upper layer in the net as the set progresses? Is it alive? Can it survive? Different answers by skippers may reflect (alive or dead) differences in the swimming depth prior to the set. If it has shallowed rapidly from a considerable depth, it may float dead or dying. But otherwise, it may be alive, near the surface because of its larger swim bladder, when swimming slows down in a set. In this case, there is a possibility for selective release of the species.

Relative survival of tuna species in the net – do small skipjack die before small bigeye ? before all other species? Other fishermen noted a time late in net hauling process (before sacking up) when small bigeye are still in good condition relative to skipjack and could be released alive if a mechanism could be developed.

Relative survival of tuna and other species after passing the Sorting Grid

Need further studies that collect fish outside the sorting grid

Possible use of tagging methodologies to test condition

Use of underwater cameras or ROVs to assess condition

Entrapment area outside grid needs to be large to reduce stress on "released" fish

Need to assess all condition factors in relation to grid characteristics, i.e. smoothness of opening, size of opening, position in net, etc.

Behavior in the net is not understood, and skippers impressions are not all consistent. Important research gap, that perhaps could be filled using acoustics, ROVs with cameras and sensors?

Underwater Cameras could be useful (such as the Eye-Ball used by Oshima)?

Is it feasible to use a combination of light and/or audio stimuli to drive bigeye and small tunas to sorting grids, or any other escape panel, and release them?

Design of sorting grids that are transparent or present a less visible signature may be desirable to reduce avoidance by tuna

Large catches may make very difficult the moving of fish in the net, and due to time factor, have the potential for spoilage in tropical temperatures.

A concern of skippers: Is there a risk of losing too much marketable fish?

Position of sorting grid in net critical (according to some of the designers of grids, it needs to be close to the boat, and in a position where it could be "controlled" (e.g. submerged of lifted). Different designs are being tested but more testing is needed. Testing has not been structured following a scientific design, so results are not easy to interpret because of confounding factors. Fishers decide how much of the grid to submerge, and change that on a set by set basis, perhaps depending on the size of the catch.

Crowding reduces chance of survival significantly; avoiding sacking up would improve survival chances of many species.

Some opinions:

> A grid positioned between the bow ortza (bow side of sack) and the sack will not take weight or interfere with operation
>
> A grid in this position will be most effective for releasing the hardier species that survive the crowding process, i.e. rainbow runner, triggerfish, mahi-mahi.
>
> A sorting grid for tuna may have to be placed earlier in the sack or net but need to be capable of sustaining huge weights resulting from sets over 200 mt

Types and designs of sorting grid - considerations

> Need to be flexible, durable enough to pass through power block
>
> .. or must be easy to put in place and remove
>
> Must not weaken the net and capable of sustaining weight of large sets
>
> Steel – causes damage to the fish; it can't pass through power block
>
> Size and shapes of holes in grid need to be determined on a scientific basis; important for different species.
>
> Opening must be smooth, to reduce injuries to fish escaping- critical
>
> Use plastic Tubes to minimize harm to fish passing through
>
> Flexible grid designs: Arrue's, Villar's.
>
> Nylon and polyurethane cables ?
>
> Could knotless netting be used for grids?
>
> A proposed alternative, using hollow tubes filled with pressurized fluid to give rigidity to grid during set, and then release of pressure when passing through the power block was deemed too fragile and prone to breakage.
>
> There is a need to involve people that construct/build the net when designing !

Some people believe that brailing can break sorting grid if it is not robust, but there hasn't been any incident yet.

Issues of fish damage/survival with certain designs of sorting grids, make the experiments to demonstrate survival after release a critical need.

With netting of different materials and characteristics, you may create visual illusions, and reduce visual barrier (invisible and visible sections of the net or of the sorting grid) for better chance for release following experiences with trawls.

Potential use of fluorocarbon fibers and plastic flexible hosing

In general skippers expressed interest in testing the sorting grids, even after being told that initial figures for proportions of tunas released are not very high. It is clear that the grids are still evolving, and it is hard to evaluate their effectiveness after a lot of development had taken place.

Other modifications to the gear (net) to facilitate the release of small tuna

Are there modifications that can be made to the net (i.e. other than sorting grids) to facilitate to release of small tuna?

Changes in net mesh size

Japan purse seine vessel testing thin diameter twine with 300mm mesh size in large proportion of the net; large mesh size was not sufficient to increase the escapement of tunas from the net. This net sinks faster, purses faster, may show reduction in average size of fish retained

Needs further evaluation but interesting

Need to keep in contact with net manufacturers and researchers

How to evaluate success in dealing with small fish release?

Specific data collection required, including studies of size of released fish, and survival rates.

Modifications in net depth or length

From behavioral studies, it may have limited application for small bigeye reduction due to mixing, and shallowing of all species in pre-dawn period

May have application if sets are restricted to post-dawn period; but it needs testing. In any case, the proportion of sets after sunrise decreases rapidly.

May have application to avoid larger bigeye tuna; but it needs testing.

Visual illusions to facilitate release: portions of the net can be made to appear invisible to the fish similar to trawl experiments

Use of Fluorocarbon for net construction? (light monofilament)

Use of knotless netting?

Improving conditions inside the net

Aerating the water in the net, and leaving net more open when brailing – better chance for survival for many species. Relatively easy, and cheap to do, may also improve quality of fish in the catch.

Double FAD experiment

Two vertically connected FADs that could be separated prior to setting. Conceptual at this stage; consisting of surface FAD connected to subsurface FAD to aggregate bigeye

2.3 Bigeye and small tuna – Release from the deck

Dick Stephenson's Sorting hopper and wet brail system: based on using a large pump, or a "wet brailer" full of water to bring the fish live to the deck, where target catch be sent below to the wells, and bycatch and small tuna could be released unharmed to the sea. Seawater immersion would reduce the impact of sacking up and dry brailing on the tunas. Long and expensive development needed, but it could address problems of size, and species selectivity. Post-release survival studies would be required.

Otherwise, release of bigeye and small tuna from the deck was not considered feasible as they would be dead, or in such poor condition that survival is virtually impossible.

3. Reducing catches of Sharks

3.1 Sharks – Avoidance

Attraction / Deterrents (Withdrawal) devices

Use devices and strategies to either drive sharks away from, or lure them away from the area to be encircled, and thereby avoid capture (encirclement with the net).

Use Audio attractors to lead shark away from vessel prior to setting

Develop a research program to determine which are feasible.

A problem is the noisy environment near vessel that may mask some attractors.

Period for attraction needed is short, just before setting the net. Fishers may have concerns about these type of operations prior to a set due to potential disturbance of tuna aggregation.

Range of attraction by sound may not be enough to attract sharks from all area to be encircled

Other types of attractors/deterrents

Chemical attractors: are concentrations needed too high, given the volume of water?

Blood, meat, found to be not very effective, messy.

Amino acids appear to be the best attractors

Shark gonads also work (pheromones)

Consider the following

Which shark species are higher priority?

The Silky shark (C. falciformis) is the most common species of sharks in the bycatch in all oceans, followed far behind by the oceanic whitetip shark (C. longimanus), but to assess priorities would require population data that are not available. In some cases, it is clear that the impact of the bycatches in the purse seine fisheries are not high enough to drive the populations down, so other factors may be affecting them (e.g. directed fisheries, incidentals catches in other fisheries, etc.). However, the trends are down for most species in all oceans, and mitigation actions in the FAD fisheries could help slow down the declines.

Are there specific attractors for different shark species?

Do the attractors/deterrents affect the target tuna?

What are the mechanisms to use the attractor effectively (temporal sequence, platform, etc.)?

These can be used in conjunction with other techniques/strategies/devices ?

Evaluating other strategies

Double FAD experiment (see above)

3.2 Sharks – Release from the net

Feasibility of controlling shark movement in the net

Which are the conditions faced by sharks and other species in the net?

Profiles of oxygen, temperature, biomass with ROV mounted instruments surveying the net at different stages of the set may be very useful to assess the sharks' condition, together with sampling sharks (e.g. blood) at different stages of the set.

Attractors/repellent devices (audio/chemical) – see 3.1 above

Towing the FAD out of the net before the beginning of net hauling (through a gap between net and vessel during pursing)

Need to document procedure and develop best practices

Need to collect data to monitor extent of practice by fleets, and effects – observers

Need to disseminate (best practice) procedures to other skippers

Need to document what species tend to leave the net with the FAD, and to quantify.

Can be done by careful enumeration of bycatch during brailing (being done in MADE project)

Can be assisted by underwater camera mounted on ROV

Using Attractors (e.g. chumming when towing outside ? (Attractor – audio and chemical)

Used in conjunction with other attraction/withdrawal devices ? Fishermen from some fleets noted this has been common practice since the beginning of the fishery

Other fishermen stated that sometimes the FAD is towed out to save bycatch but sometimes it is towed out over the corkline. The concern is losing part of the catch if the tunas follow the FAD.

Not feasible to attempt to catch and release individual shark from net, although it may be possible to calm a big shark with certain devices (e.g. taser, but only in the air) then release

Whale Sharks: very rare in most fisheries – need to develop and distribute best practices for non-lethal release from net and sack

3.3 Sharks – Release from the deck

Need to determine the following

Structure of vessels and bycatch handling practices: which is the proportion of vessels with sorting hoppers on the deck? How and when are these hoppers used? Which are the prevalent brailer capacities?

Do they have a mechanism (e.g. moving belt) to return the sharks to the water fast? See for instance the special belt for releasing bycatch onboard some French purse seiners

Is this done by hand at the end of the set (long exposure)?

Survey of vessels to determine release system and techniques in use.

Observer collection of data on release method.

Likelihood of Survival

On deck and below deck

Ensure techniques (best practice) handling (need to produce a guide, well illustrated on best practice handling). How to lift a shark, how to handle, how to release, etc.

Survival versus tonnage in set, size and style of brailer

Survival versus vertical position in the brail

Survival versus time out of water

Species-specific survival

Evaluation of likelihood of survival

Monitoring Ph / Lactate

Monitoring indicator HSP70 heat shock proteins

Tagging (PSAT and other types?) Release tagged sharks from vessels operating with different release systems, and evaluate survival. Modern tags differenciate tag shedding from mortality.

Keep blood tissue samples by dissection for Histology/necropsy analyses (on-board?)

Monitoring shark handling and release practices to determine likelihood of survival and estimates of mortality

Observer data collection (may need two observers: one on the upper deck, one on the lower deck).

Can observers be trained to make a better assessment of shark condition?

Sequence of research:

Is there a significant survival in present release conditions? (In vessels with different release processes). Tagging studies using PSAT tags appear most promising. If it is too low, concentrate efforts and funding on attraction research. If not, improve conditions of the shark release process to increase survival.

Sample sharks in different stages of process (e.g. in net before sack up, after brailing from wet deck, etc) to assess condition. Autopsies? Can observers be trained to improve assessment of condition?

Compare survival rates with and without use of specific bycatch conveyor belts, wet deck release hatches, etc. If there are significant differences, then recommend gear and procedural changes.

4 Reducing interactions of Marine Turtles with the gear

4.1 Marine Turtles – Avoidance

Spatial techniques are useful, especially in the vicinity of nesting beaches, but are outside the scope of this workshop

4.2 Marine Turtles – Release from the net

Motivation for release: survival of turtle, potential gear damage. If turtle lifted with net towards power block, danger to turtle and to crew. Negative image.

Established practice in the eastern Pacific, suggested by skippers,- use of speedboat to monitor turtle entanglement, then retrieve at waterline, and release unharmed. Very effective, cheap, simple, with minimal disturbance to fishing operations, and no harm to turtles. Adopted by the fleet, then added to required procedures.

Need to have documented best practice for release – development of approved release technique guide, including how to handle turtles (e.g. don't lift by the flippers)

Need to monitor fleet practices with regard to releases from the net

Adopt similar practice in other oceans

Marine Turtles – Passive capture – FADs

Use of webbing under the FADs causes turtle entanglements. Sharks and other finfish can also be entangled

More of a problem than capture in the purse-seine net, but observed entanglement rates in the eastern Pacific around 1% of sets (IATTC only), and many of those entanglements can be released alive, so magnitude of potential mortality is not high.

Turtles affected tend to be the most abundant (leatherbacks, loggerheads, or hawksbills rarely associated with FADs), although data for some regions is needed.

To reduce entanglements:

Change design of FAD, so that entanglement is not possible or much less likely;

Structures of ropes hanging under FADs.

Solid materials (e.g. cloth, weaved fibers, etc.)

An additional issue: FADs could be lost, and drift towards beaches, etc. Materials that are biodegradable, non polluting, and not leading to ghost fishing by lost FADs are desirable. "Ecological" FADs developed by the MADE program use better materials and do not entangle turtles

Ropes of natural fibers (e.g. sisal)

Bamboo

Biodegradable products

Reduce surface area of FAD to keep turtles from climbing on top and getting tangled.

It is necessary to show the fishers that "new FADs" attract tunas at a similar rate than previous ones, to gain acceptance.

Quantify the turtle encounter rate – tradeoff (if it is good for turtles but bad for fishing, it won't be adopted)

Need to monitor fleet practices with regard to releases from the net

4.3 Marine Turtles – Release from the deck

Unlikely to happen if turtle released beforehand

It is necessary to release turtle before lifting the net with the turtle entangled. Usually avoid to prevent turtle going through power block and causing damage.

Reducing catches of other bycatch species (mahi-mahi, wahoos, rainbow runners, etc.)

5.1 Other bycatch – Avoidance

Many of the issues discussed for small tunas also apply here

5.2 Other bycatch –Release from the net

Feasibility of controlling other bycatch species movement in the net

(see Sections 2 and 3 above)

Towing the FAD out of the net through a gap between seine and vessel during the pursing operation

Some skippers do so routinely, others never. We need to compare bycatches in skippers with different behaviors (amounts, and species composition, since it may be useful only for some species).

Need to assess influence of FAD design and other factors, i.e. use of chum, lights etc.

Use of Sorting Grids may be promising in some situations.

Need to assess post release condition in relation to Sorting Grid characteristics and position in net.

Need to collect standardized data to evaluate quantity and monitor affect – observers

It will be very useful to produce an educational video showing the recommended practices as identified by the best skippers, to disseminate procedures to other skippers

Some bycatch species have "close" association with floating object, so this strategy works well. Fishermen noted more effective for triggerfish, rainbow runner but less effective for sharks

Potential problems: is there a risk of losing a large part of the catch?

Feasibility of using **<u>Sorting Grids</u>** to facilitate the release of bycatch

(see Section 2 above)

Excellent results with Arrue's grid (e.g. releases of 50% of mahi-mahi, 75% triggerfishes, etc.), and the grid is still in evolution.

Whale Shark and Manta Ray

Both species are quite rare in the FAD fishery, and it appears that manta rays do not associate with floating objects. However, both manta rays and whale sharks can become FADs themselves, aggregate tuna and become an incidental capture in the process of purse seining. They are more frequently recorded as being taken in sets on unassociated tuna schools.

Need to examine observer program records and consult industry for best practices for release

Fishermen noted many years of operation without harming whale shark, standard release techniques already in place

Need to document these practices by fleet and develop guidelines

5.3 Other bycatch – Release from the deck

Less of an issue because it involves lower priority species, and survival expectations are not high? Perhaps feasible for some species.

Likelihood of Survival

Develop guidelines for techniques in best practice handling

Ensure techniques (best practice) for good handling are disseminated

Species-specific survival (some species will not survive)

Evaluation of survival/damage

Tagging ??

Floating collection: net pen to hold released bycatch to assess condition

Brief summary of discussions with Spanish purse-seine skippers, and others.

1. Acoustic discrimination of bigeye tuna and other non marketable species.

- Bigeye tuna stays deeper at FADs compared to Skipjack and other species. Other species (mahi-mahi, elagatis, triggerfish…) are usually at the surface.
- When bigeye tuna is small, it is difficult to discriminate from skipjack because the two species are mixed at the same depth.
- Small YFT and BET are also mixed at the same depth so that discrimination is difficult between the two species. When BET grows, they occupy deeper layers resulting in a better discrimination.
- Fishers explain that with the sounder onboard they are able to discriminate individuals from shoals.
- When the biomass of small tuna at FAD is around 70% then fishers can predict the presence of small tuna with the sonar, due to its behaviour, shoal speed and depth. However, when the quantity of small and big tuna is 50% is difficult to discriminate one from the other.

Instrumented buoys:

- The strategy on the use of sounder buoys is: deploying 2 to 3 instrumented buoys with sounder, every 10 FADs with simple buoys attached.
- From these instrumented buoys fishers get an estimate of the biomass and the depth of the biomass. It is not possible to discriminate between species. When the buoy sends a big biomass in surface, they consider it as the submerged part of the FAD (net).
- Fishers believe Satlink buoy provides better estimates of biomass compared to Zunibal buoy.
- Fishers think that a deeper transducer of the sounder buoy (to better access tuna shoals) will cause entanglement with the submerged structure of the FAD.

2. Sorting grids

Fish behavior in the net:

- Fishers explain how fish behaviour in the net is different for each set. There is no vertical stratification. For fishers, two sets in the same area, or around the same FAD results in different behaviour of fish in the net.
- Skipjack, when alive in the net, is usually in surface compared to the distribution of other species.
- Fish swim fast in the net. BET if alive within the net, can not be found in surface but mixed with other species and moving FAST. Fishers see difficult to separate them from other species.

Sorting grid models:

- Fishers using Arrue´s grids state that most of the problems are due to oxidation and the fact that target species also escape.
- Arrue states that there are no breaks in the purse seiner net but in the grid. They have replaced metal components with polyethylene to avoid oxidation.
- One of the fishers said grids are working properly as a lot of by catch is escaping, although quite a lot of tuna too.
- Another fisher said that 90% of fish is suffocated when the grid starts working. Changing grid position could help to change this fact.
- One of the problems testing the effectiveness of grids is the percentage of submerged part of the grid, which can be modified by skippers in each set.
- Most of fishers working in Indian and Atlantic Oceans know nothing about sorting grids.

3. Sharks

- Most of fishers agreed that the best would be to remove sharks from the net after the setting, instead of doing it when arriving at the FAD.
- Fishers believe that other bycatch species would follow the shark when attracting sharks out of the net.
- Fishers state that a protocol to remove sharks from the deck without damaging them would be helpful to have. They have no information on how to manipulate sharks.
- Some fishers said that removing sharks from the net is avoiding problems on the deck.

4. Turtle entanglement

- Fishers state that turtle bycatch is low.
- In Atlantic Ocean submerged structures of FADs have 100 m depth. Fishers said they aggregate more and better quality of tuna. They do not know if it's due to the attraction of the net or due to the drift of such a structure.
- Fishers asked if it's worth changing FAD structure having such a low turtle bycatch. Ecological FAD models should be tested to see if the are productive for fishing and to see if they do not entangle turtles. Fishers also comment that we should consider the cost of the proposed new ecological FADs, since traditional FADs are almost free since they are recycled from purse seiner material (net, floats..).

The meeting was closed by Dr Josu Santiago from AZTI

The organizers thanked the students from AZTI that had supported all the work, and very especially Gala Moreno for her hard work that resulted in a very well-organized event, and Josu Santiago and AZTI for the hospitality.

And a special thanks to Peter Williams, SPC for an excellent and rapidly produced report.

APPENDIX A – Message from Susan Jackson, President of ISSF

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APPENDIX B – List of participants

Name	Organisation	Email
Susan Jackson	ISSF	
Robin Davies	WWF	
Konstantinos Kalamantis	ISSF	
Javier Ariz	Steering Group – Instituto Español de Oceanografia	
Laurent Dagorn	Steering Group – Institut de Recherche pour le Development	
Martin Hall	Chair, Steering Group – Inter-American Tropical Tuna Commission	
David Itano	Steering Group - Univ. Hawaii, Pelagic Fisheries Research Program	
Gala Moreno	Steering Group – AZTI	
Thierry LeGuennec	skipper, Tri-Marine fleet manager	
Patrick Helies	Skipper IO - AT – Pac	
Taro Kawamoto	Purse seine fishing WP Kyokuyo Suisan Co.	
John Cabral	Skipper, EPO, WP	
Frank Reier Knudsen	SIMRAD biologist, head fisheries research	
Takashi Shimizu	FURUNO acoustic instruments	
Magdalena Iglesias	IEO Mallorca acoustics expert	
Francois Gerlotto	IRD acoustics	
Jacques Sacchi	IRD Sete, purse seine expert	
Aurelio Arrue	net person, fleet manager	
Ole Misund	IMR Norway Acoustics and gear expert	
Chris Glass	Univ. New Hampshire fish behavior, gear expert	
Eliseo Villar	net expert, UGAVI	
Tatsuki Oshima	Researcher tuna behavior in net JAMARC	
Yoshinori Nomura	net expert NITTO SEIMO Co	
Sean Newsome	ROV expert Sea Robotix	
Peter Klimley	Shark behavior, telemetry expert UC Davis	
Rich Brill	Shark survival, behavior Virginia Inst. Marine Sci. NOAA	
Diego Bernal	Shark survival Univ. Massachussets	
Jimmy Martinez	SRP Ecuador shark biologist	
Bernard Seret	IRD Shark expert Paris	
Kurt Schaefer	Tuna behavior IATTC	
Miki Ogura	Tuna behavior NRIFSF, Japan	
Alicia Delgado	Purse seine fishing, IEO	
Peter Williams	Bycatch data SPC	

APPENDIX C – Agenda - List of presentations and presenters at the meeting

November 24

Agenda Item	Presenter	Presentation title
Introduction to FAD fishing	David Itano	Introduction to FAD fishing Powerpoint A
Studies in Fishing depth (Ariz et al.)		Included in Powerpoint A

November 25

Agenda Item	Presenter	Presentation title
Welcome	Josu Santiago	
Introduction	Susan Jackson	Objectives of workshop in ISSF program Text available
Introduction	Martin Hall	Scope of WORKSHOP Powerpoint 1
Review of regions		
Eastern Pacific	Martin Hall	Powerpoint 2
Western and Central Pacific	David Itano	Powerpoint 3
Atlantic Ocean	Javier Ariz	Powerpoint 4
Indian Ocean	Laurent Dagorn	Powerpoint 5
Small tunas/bigeye		
Acoustics	Gala Moreno	Powerpoint 6
FURUNO	Shimizu	Powerpoint 7
SIMRAD	Frank Knudsen	Powerpoint 8
Acoustic selectivity	Magdalena Iglesias	Powerpoint 9
Net modifications		
Sorting grid	Martin Hall	Video 1 and Powerpoint 10 (Aurelio Arrue)
Mesh sizes	Miki Ogura	Powerpoint 11
Attraction fish	Tatsuki Oshima	Video 2 and Powerpoint 12
Mesh Size	Taro Kawamoto	Powerpoint 13
Instruments	Sean Newsome	Powerpoint 14

November 26

Sharks		
Introduction Sharks	Laurent Dagorn	Powerpoint 15
Attraction	Peter Klimley	Powerpoint 16
Survival in net	Diego Bernal/ Rich Brill	Powerpoint 17
Sea Turtles		
Alternative models for FADs	Alicia Delgado	Powerpoint 18

Turtles Ecological FADs	Gala Moreno Javier Ariz	Powerpoint 19
Sheet FAD	Tatsuki Oshima	Powerpoint 20
Underwater video	David Itano	Powerpoint 21
Pelagic species	Martin Hall	Powerpoint 22

November 27

Agenda		
Welcome	Josu Santiago	
Introduction	Susan Jackson	Objectives of workshop in ISSF program Text available
Introduction	Martin Hall	Scope of WORKSHOP Powerpoint 1
Review of regions	Javier Ariz	
Acoustics	Gala Moreno	Powerpoint 6
Sorting grid for tunas and other species	Martin Hall	Video 1 and Powerpoint 9 (Aurelio Arrue)
Sharks	Gala Moreno	Powerpoint 14
Turtles Ecological FADs	Javier Ariz	Powerpoint 17
Sheet FAD & Attraction	Tatsuki Oshima	Powerpoint 18
Attraction	Peter Klimley	Powerpoint 15
Discussion		
Closing address ISSF	James Joseph	Text available
Closing Address AZTI	Josu Santiago	

APPENDIX D Document provided by Miki Ogura (an accompanying presentation will be included with other presentations)

A proposal: Port Monitoring for evaluating the efficiency of a mitigation technique

Miki Ogura (National Research Institute of Far Seas Fisheries)

During the Sukarrieta workshop, we were talking many possible mitigation techniques. To evaluate the effectiveness of a mitigation technique for small bigeye tuna catch in the P.S. FADs operation, accurate estimate of species (and size) catch are needed, especially on the experiment at sea implemented with a commercial fishery operation. As mentioned in the Dr. Jim Joseph's statement, in the next step will conduct such verification tests at sea for a particular mitigation technique with many cooperation of the ISSF and RFMO programs and national programs. For this verification test, It is important that the accurate estimation of actual bycatch information which will be suitable for statistical analysis. To do so, the port monitoring scheme which Japan is conducting would be one of the best way.

Port monitoring is composed with the species and size composition information by the port sampling and the landing data by market categories

1. Landing data are compiled by species and market category at all landing site.

2. Landing data are corrected by using the coefficient of species composition in the market category derived from the port sampling program which have been conducted periodically. (Fish are sampled from each of the pre-sorted market category by species. Species and size of the sampled fish are precisely examined.)

Japan has implemented the port monitoring for purse seine unloading to keep the Japanese P.S. catch limitation for the WCPFC resolution. Preliminary result of this program is available in the delegation paper of the 5^{th} WCPFC TCC meeting, WCPFC-TCC5-2009/DP-06. During this year monitoring, we found that there is a huge gap between the reported volume from the logsheet and actual one monitored at the port. This gap happens even when an observer was onboard. Therefore the port monitoring at the unloading site are necessary.

APPENDIX E– Closing address by Dr Jim Joseph

Please accept my apologies for not being able to join in this important workshop.

Thanks to Gala and her AZTI team, Martin and the steering committee, and to all of you who are making presentations and joining in the discussions.

The issue of bycatch is becoming increasingly important for tunas. There is a great deal of attention being directed to the bycatch issue, particularly as a result of fishing on FADs. There are efforts to prohibit the use of FADs by attempting to restrict market access for fish taken in association with FADs, and to replace purse-seine fishing with pole-and-line. Obviously, to replace the catch of purse-seine vessels with catch taken by a pole-and-line fleet is impossible. A pole-and-line vessel is about a tenth as efficient as a purse-seine vessel. Even if this were possible the carbon footprint for a pole-and-line fleet would be enormous relative to a purse-seine fleet. Supplies of natural bait would not be sufficient to support such a fleet. In addition, any major harvests of bait would impact the ecology of the delicate ecosystems where baitfish are usually found, particularly in tropical waters, and could have adverse impacts on small coastal fishing communities.

For most bycatch species, with the exception of such endangered animals as marine turtles, sea birds, and sharks which are of low fecundity and slow growing, we do not understand the impact of removals on the stock from which they are harvested, nor how their role in the ecosystem might be altered as a result of removals. On the one hand, it has been argued that selectively harvesting one or two species from an ecosystem might alter the dynamics of that system, so therefore the fishery should be removing other associated species, while on the other hand, not knowing these impacts, caution would dictate reducing the removal of all non target species. However, we do understand that if the bycatch of very small tunas can be averted, productivity of the stock would increase in terms of increased biomass and potential catch.

Notwithstanding this gap in our knowledge, governments and the tuna industry has taken the decision to reduce the bycatch of unwanted non-target species and under-sized tunas to as low levels as possible, and the objective of this meeting is to examine various research options that can facilitate accomplishing this objective. What has resulted from this meeting is 1) a review of the research that is currently underway in various parts of the world directed to identifying and developing gear and fishing strategies that might lead to reduced bycatch, 2) identification of which areas of research might hold the greatest promise of success in terms of mitigating bycatch, and 3) setting priorities on that research. The next step we must consider is how to facilitate the carrying out of that research, which will obviously entail taking it to sea. A number of promising research projects already have been carried out at sea aboard operating purse-seine vessels by scientists from nations working in cooperation with their governments and industry. This research has however been hindered by the fact that it is so difficult to have ship time available.

There is an urgent need to expand this research and this will require the availability of a dedicated at-sea-platform. ISSF is prepared to address this problem of at-sea research and to initiate efforts to facilitate the availability of such a research platform and in that respect will strive to acquire a purse-seine vessel or vessels that will be devoted to this work for a period of two years. This dedicated vessel will be made available to scientists who are working on bycatch mitigation research. ISSF will contribute to, and lead fund raising efforts for the acquisition of the dedicated vessel and will work to make available funding for specialized gear aboard the vessel and support of the sea-going scientists. Funding for the individual research projects that will be carried out aboard the vessel will be expected to derive mostly from the scientists proposing the research. A steering committee of experts will be established to provide guidance and advice with respect to how the vessel will be utilized, which research projects will be selected, and in which ocean or oceans it will operate. Decisions will have to be made as to whether it should be the same vessel moving from ocean to ocean, or a different vessel for different oceans. Not all fishing captains have the same success fishing in different oceans; some are more expert in one ocean than in another. The steering committee will need to seek the advice of fishing captains when making decisions on, the size and specifications of a vessel, its acquisition and deployment, and how this project should move forward.

Once the program is underway, and promising mitigation techniques or gear types are identified, the next step will be to encourage the captains of a number of purse-seiners to test the techniques and gear. To do this properly and test the efficacy and practicality of the methods will require a proper experimental design that will involve a specific number of vessel fishing in selected strata throughout the various tuna fisheries. The steering committee in conjunction with national scientists and RFMOs will be responsible for initiating these studies and designing such experiments, and will call on the advice, help, and cooperation of WPTO and other national fleets.

We have already initiated efforts to obtain funding for a vessel for a two year period. There is no guarantee that we will be successful. If we are successful, which I think we will be, it will be a least a year before a vessel would be available. In the intervening period, the steering committee will continue to work on formulating how this project can move forward. It will likely be necessary to hold additional small workshops to key on specific issues. Likewise, it will be necessary to have the full cooperation of the scientific community involved in bycatch research, and particularly fishing captains. Scientists are able to do many things, but are at sea for short periods of time, so the chance of observing situations that might lead to solutions to bycatch mitigation are limited. Fishing captains are the best observers of fish behavior and gear performance. They are at sea everyday, observing and experimenting. We need their experience, expertise and ideas if we are to be successful. In this context, ISSF is considering holding a series of small workshops/interviews with fishing captains to discuss "best practices" regarding bycatch mitigation. It is envisioned that a small team of experts, say a scientist and a fishing captain, will meet with small groups of fishing captains in various key ports around the world to discuss these issues and to iterate towards a series of "best practices." In fact, one such small meeting was held recently in San Diego, California at the offices of the American Tuna Boat Association. Dr. Martin Hall and Dr. Peter Williams met with several skippers to discuss "best practices" and general ideas for developing "best practices." The meeting was quite encouraging.

This meeting in Sukarrieta is the first step in a concerted international effort to address the issue of bycatch mitigation, and its conclusions allow us to formulate a plan for moving forward. Hopefully, we'll be successful in having a research platform to support this plan and that within a year the current at sea research can be expanded.

Thanks to you all for your efforts to make this workshop successful and we look forward to the future.