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A progress report on the Shark Research Plan

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Abstract

This paper outlines progress against the Shark Research Plan (SRP), in particular that achieved since the last meeting of the WCPFC Scientific Committee in August 2012.

First and foremost, at WCPFC9 the Commission made four significant decisions relating to sharks and SRP:

1. It approved the extension of funding the SRP for an additional three years,
2. It designated whale shark as a key shark species;
3. It adopted a Conservation and Management Measure (CMM) for whale sharks; and
4. It approved co-financing for the GEF Areas Beyond National Jurisdiction (ABNJ) project which includes work on sharks.

Second, there have been several important areas of progress under the SRP since SC8 including:

1. A stock assessment for blue shark in the North Pacific conducted through the ISC process;
2. Development of potential catch and CPUE series for blue shark in the South Pacific – SC9 will provide guidance on the sufficiency of these data to conduct a full stock assessment for SC10;
3. Analysis of potential mitigation options for silky and oceanic whitetip sharks for WCPFC9 and SC9;
4. A revised silky shark assessment incorporating a broader range of data inputs;
5. An analysis of the spatial and temporal distribution of whale sharks in the WCPO; and
6. Distribution of 400 shark identification guides to longline vessels operating from the ports of several small island developing states.

This paper provides a summary of each of the outcomes described above and also includes: a) estimates of coverage of shark catch (both aggregate and species-specific estimates) and effort data from logsheets, observer data, and aggregate catch and effort data; b) a summary of coverage and shark condition data from SPC observer data holdings; and c) an outline of anticipated work in 2013/2014 under the shark research plan and other potential activities for the consideration of SC9.

The following recommendations are made in this paper for the consideration of SC:

A. That the stock assessment for blue shark in the south Pacific Ocean be conducted for SC10;
B. That SPC focus on the calculation of catch and CPUE series for mako shark in the South Pacific Ocean and then determine whether it progresses the assessment for SC10 based on feedback from the 2014 Pre-Assessment Workshop (PAW);
C. That SC9 consider the value of assigning SPC resources to stock assessments for shark populations in the Northern Hemisphere given the interest of the ISC. When participating in such assessments SPC does not get access to the raw data used to generate the model inputs; and SPC does not have sufficient resources to attend the multiple ISC meetings – in particular the meetings that finalize the assessments are typically in mid-late July around the SC paper submission deadline.
D. Noting (C) above, that SC9 determine the desired level of SPC involvement with other ISC members on a stock assessment for mako shark in the North Pacific Ocean. This could also

include on what form the assessment should take, e.g., integrated age structured model or production model;

E. That stock assessments for the thresher shark complex be delayed, due to the low likelihood of success and the higher priority activities that are being undertaken;
F. That WCPFC members make all available observer and research / training data that has not previously been provided to SPC or WCPFC to support the SRP assessment work and/or provide cost-effective means for collaborative research efforts; and
G. Consider the following additional pieces of work related to the objectives of the Shark Research Plan, noting that additional funding may be required in some instances:
    i. A desktop review of relevant policy and legal documents that would inform the consideration of target and limit reference points for shark species taken predominantly as bycatch;
    ii. Conducting a standardized CPUE analysis for whale sharks using observer data from the tropical purse seine fishery;
    iii. Indicator analyses for key shark species for which assessments are not undertaken;
    iv. Application of the 'key shark species' criteria to existing species on the list (for priority setting) and to other sharks and rays taken in WCPO tuna fisheries;
    v. Contributing to a stock assessment for porbeagle shark with CCSBT (if this proceeds);
    vi. Updating and enhancing the shark tagging database STAGIS;
    vii. Expanding the distribution of shark ID guides to other longline fleets;
    viii. Development of a shark ID poster that could be distributed to longline vessels as this could have greater impact than ID guides;
    ix. Development of a identification guide to allow the identification of sharks in various processed states;
    x. Biological studies to reduce uncertainty in important life history parameters of key shark species;
    xi. Electronic tagging studies to estimate post-release mortality for key shark species; and
    xii. Undertaking a review of the SRP for the development of a revised plan.

1. Introduction

In response to regional and global concerns about the status of shark populations, a Shark Research Plan (SRP) developed by the Secretariat of the Pacific Community-Oceanic Fisheries Programme (SCP-OFP) was approved by the Commission in December 2010 (WCPFC 2010). The SRP has three main inter-related components (Clarke and Harley, 2010):

- Phase 1: **assessments** to be undertaken with existing and available data;
- Phase 2: coordination of **research** efforts to supplement biological and other assessment-related information; and
- Phase 3: improvement of **data** from commercial fisheries.

This paper provides an overview of the progress made with an emphasis on the past 12 months.

2. Overall progress made through the SRP

Progress to date on the SRP has been very good and Annex 1 and 2 contain details of publications and collaborative meetings from the implementation of the SRP. In 2011 five papers were submitted to seventh regular session of the WCPFC Scientific Committee (SC), including the review of SRP progress to date (Clarke et al. 2011c) and several papers describing indicators of stock status for several key shark species (Clark et al. 2011a, 2011b). This work lead to the adoption of a Conservation and Management Measure for oceanic whitetip sharks (CMM2011-04[2]) which bans the retaining on board, transshipping, storing and landing of oceanic whitetip sharks and requires all oceanic whitetip sharks to be released in a manner that results in as little harm to the shark as possible.

For 2012, seven papers relating to the SRP were submitted to SC8, including the first stock assessments for oceanic whitetip and silky sharks. The oceanic whitetip assessment reinforced the decision to adopt the CMM while the SC requested further work before accepting the silky shark assessment for the provision management advice. In 2012 the Commission added whale shark to the list of key shark species and adopted a measure to reduce the impact of the purse seine fishery on the stock and agreed to continue funding of the SRP.

A further seven SRP-related papers have been submitted to SC9 including a revised assessment for silky sharks, a new assessment for blue shark in the North Pacific, and analysis of potential mitigation options for oceanic white tip and silky sharks taken as bycatch in longline fisheries.

3. The key shark species

The current list of the WCPFC key shark species includes 14 species (Table 1) of which eight were originally included within the proposed activities of the SRP, but for whale sharks, the 14th and most recent addition to the list, the Commission has already requested analyses to be undertaken.

[2] http://www.wcpfc.int/doc/CMM-2011-04/Conservation-and-Management-Measure-Oceanic-Whitetip-Sharks

Table 1: The fourteen key shark species of WCPFC and their status with respect to stock assessment analysis under the shark research plan.

Common name	Scientific name	Assessment	Comments
Blue shark	*Prionace glauca*	2012/2013	SPC to conduct assessment for southern hemisphere. ISC has indicated it will undertake an assessment for the North Pacific.
Longfin mako	*Isurus paucus*	2012/2013	Data deficient. To be combined with shortfin mako
Oceanic whitetip shark	*Carcharhinus longimanus*	2011/2012	SPC assessment conducted for SC8
Shortfin mako	*Isurus oxyrinchus*	2013/2014	SPC proposes to conduct assessment for mako sharks in the South Pacific. ISC undertaking an assessment for mako sharks in the North Pacific.
Silky shark	*Carcharhinus falciformis*	2011/2012 and 2012/13	SPC assessment for SC8 was not accepted so a revised assessment has been conducted for SC9
Common thresher	*Alopias vulpinus*	2013/2014	It is not clear if sufficient species specific data will be available for a full assessment
Pelagic thresher	*Alopias pelagicus*	2013/2014	It is not clear if sufficient species specific data will be available for a full assessment
Bigeye thresher	*Alopias superciliosus*	2013/2014	It is not clear if sufficient species specific data will be available for a full assessment
Porbeagle shark	*Lamna nasus*		No resources currently assigned under the SRP
Great hammerhead	*Sphyrna mokarran*		No resources currently assigned under the SRP
Smooth hammerhead	*Sphyrna zygaena*		No resources currently assigned under the SRP
Winghead shark	*Eusphyra blochii*		No resources currently assigned under the SRP
Scalloped hammerhead	*Sphyrna lewini*		No resources currently assigned under the SRP
Whale shark	*Rhincodon typus*		An analysis of the spatial and temporal distribution of whale sharks in the WCPO conducted for SC9

To assist with the further consideration of key shark species, and prioritization of activities for those species already within the list of key shark species, it is necessary to have objective criteria that can be used to assess a candidate shark species. A shared understanding of the immediate priority species can allow the allocation of currently available resources and can assist researchers in securing future funding. For these reasons the decision at WCPFC 8 to adopt the criteria for the designation of key shark species was an important step in the SRP. The proposal by Clark (2011b; 2012c) and adopted at WCPFC 8 has four[3] key criteria which are used to determine a) whether a species should become a WCPFC 'key shark species', b) whether new data collection procedures are required, and c) the priority of this species for further scientific analysis compared to other key shark species:

1. Is the species found in the WCPF Convention Area?
2. Is the species impacted by fishing?
3. Is the species of particular ecological concern?
4. Are data adequate to support detailed assessment?

This criteria was applied to whale shark (*Rhincodon typus*) by Rice and Harley (2012a) with the recommendation that whale shark be designated as a key shark species adopted by WCPFC9. There are other sharks and rays taken in WCPO tuna fisheries that could be assessed against these criteria.

[3] SC7 recommended removal of a fifth criteria from the original proposal which related to the international status of a species. Ironically this factor seems to have the greatest impact on the Commission in terms of directing the SC to undertaken work on particular shark species.

4. Phase 1: Assessments

In 2010/11 the focus of the SRP was the preliminary assessment of the fishery impacts on the key shark species based on the analysis of fisheries indicators (Clarke et al. 2011a, 2011b). In 2011/12 the focus shifted to full stock assessments and oceanic whitetip and silky sharks were the first conducted under the SRP. In 2012/13 the focus on assessments has continued, but with the addition of analysis of bycatch mitigation options (OFP 2012a; Bromhead et al. 2013).

To date, the shark stock assessments have been undertaken using the stock assessment software Stock Synthesis (as opposed to the software MULTIFAN-CL more commonly used for western and central Pacific stock assessments). This has allowed for closer collaboration with IATTC and the ISC. Further Stock Synthesis includes some 'shark-specific' developments with respect to modeling the productivity of sharks (Taylor et al. 2013).

One important matter for the Commission to address when considering the results from the shark stock assessments will be the appropriate limit and target reference points for these species. Especially given that generally the major fisheries impacts come through bycatch rather than targeted fishing. To date we have used the same MSY-based reference points and the associated criteria for overfishing and overfished. We recommend some 'desktop' examination of this issue considering the various international legal instruments (e.g. UNFSA and UNCLOS) and other relevant frameworks (e.g. CITES, IPOA-sharks, IUCN).

For oceanic whitetip sharks, the full assessment confirmed the indicator analysis conclusions that the stock was undergoing a significant decline (Rice and Harley, 2012b) and all the important data sources seemed to agree on this. The stock assessment was able to confirm that overfishing is occurring and that the stock is currently in an overfished state. We are now investigating potential mitigation measures.

For silky shark, the assessment (Rice and Harley 2012c) was not accepted by SC8 and a series of recommendations were made in relation to increasing the range of data sets included in the analysis. A preliminary update of these changes was provided to WCPFC9 (OFP 2012b) and the revised stock assessment is slightly more optimistic that the one presented to SC8, though most CPUE series lead to conclusions that the stock is subject to overfishing and more than half also suggest that it is overfished (Rice and Harley 2013b) (Figure 1 and Table 2).

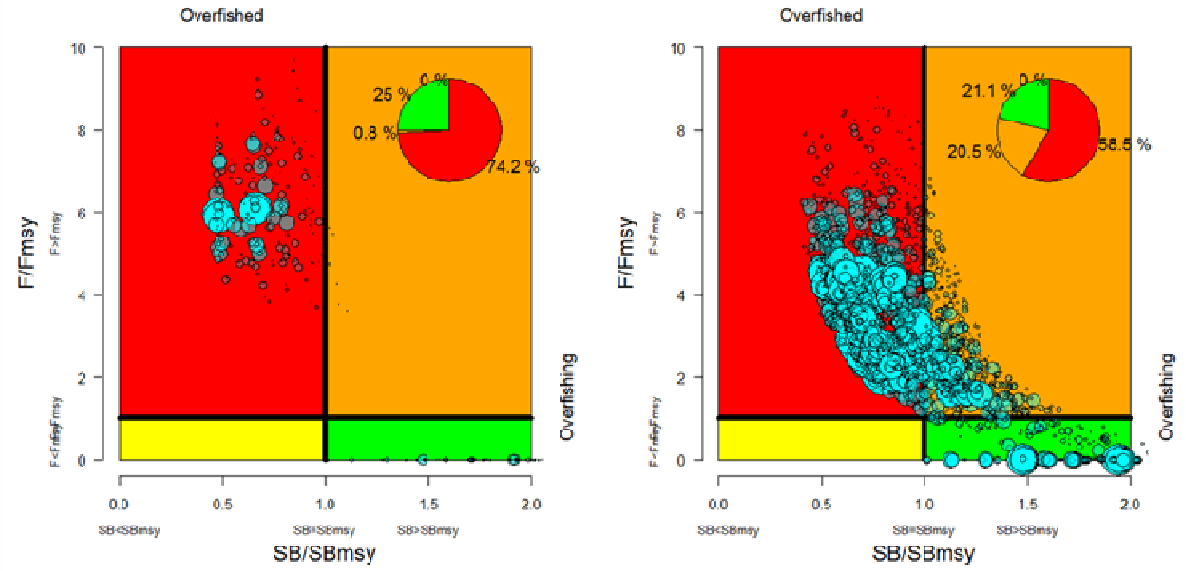

Figure 1: Comparison of the overall conclusions from the Rice and Harley (2012) (left) and Rice and Harley (2013b) (right) silky shark assessments based on the traditional Kobe plot.

Table 2: Distribution of stock status outcomes (percentage of model runs in each quadrant of the Kobe plot) for models that included different CPUE and catch time series. From the SC9 silky shark stock assessment of Rice and Harley (2013b).

	Kobe plot quadrant			
CPUE	**RED**	**ORANGE**	**GREEN**	**YELLOW**
Non-target LL (no Hawaii)	87	13	0	0
Japanese research and training vessels	52	45	3	0
Target LL	0	0	100	0
Purse seine (catch per set)	58	35	7	0
Purse seine (catch per mt of tuna)	83	17	0	0
Hawaiian LL	36	36	28	0

Catches	**RED**	**ORANGE**	**GREEN**	**YELLOW**
Lawson	57	19	24	0
Rice	58	18	24	0
Clarke (area based)	50	28	22	0
Clarke (tuna catch based)	46	33	22	0

Two assessments for blue shark were planned for 2012/13: an assessment for blue shark in the South Pacific and another for blue shark in the North Pacific. The latter assessment was undertaken through SPC's involvement through the ISC. The approach agreed by the ISC Shark working group (WG) was that a Bayesian Surplus Production model would be used as the base case for the assessment[4]. When SPC proposed to collaborate with interested parties on an age- and sex-structured catch at length model using Stock Synthesis, the WG determined that it would only be used by the WG to help confirm the results of the base case assessment. Subsequently due to the lateness of receiving data from the ISC and the difficulty of collaborating electronically with people from other time zones, we were unable to complete the assessment prior to the final WG meeting in

[4] SPC was not present at this meeting.

early July 2013 and subsequently the WG were not able to review and endorse the assessment. It requested that the assessment not be presented to SC9. The general conclusion of the stock synthesis assessment (Rice et al. 2013) was that under the WG preferred abundance indices the stock was rebuilding back towards the SBMSY level and that overfishing was no longer occurring (Figure 2). If the alternative CPUE series was used then the population was still declining and both overfished and experiencing overfishing. It is again important to note that this work has not yet been reviewed or endorsed by the WG and the WG will be presenting their own assessment to SC9.

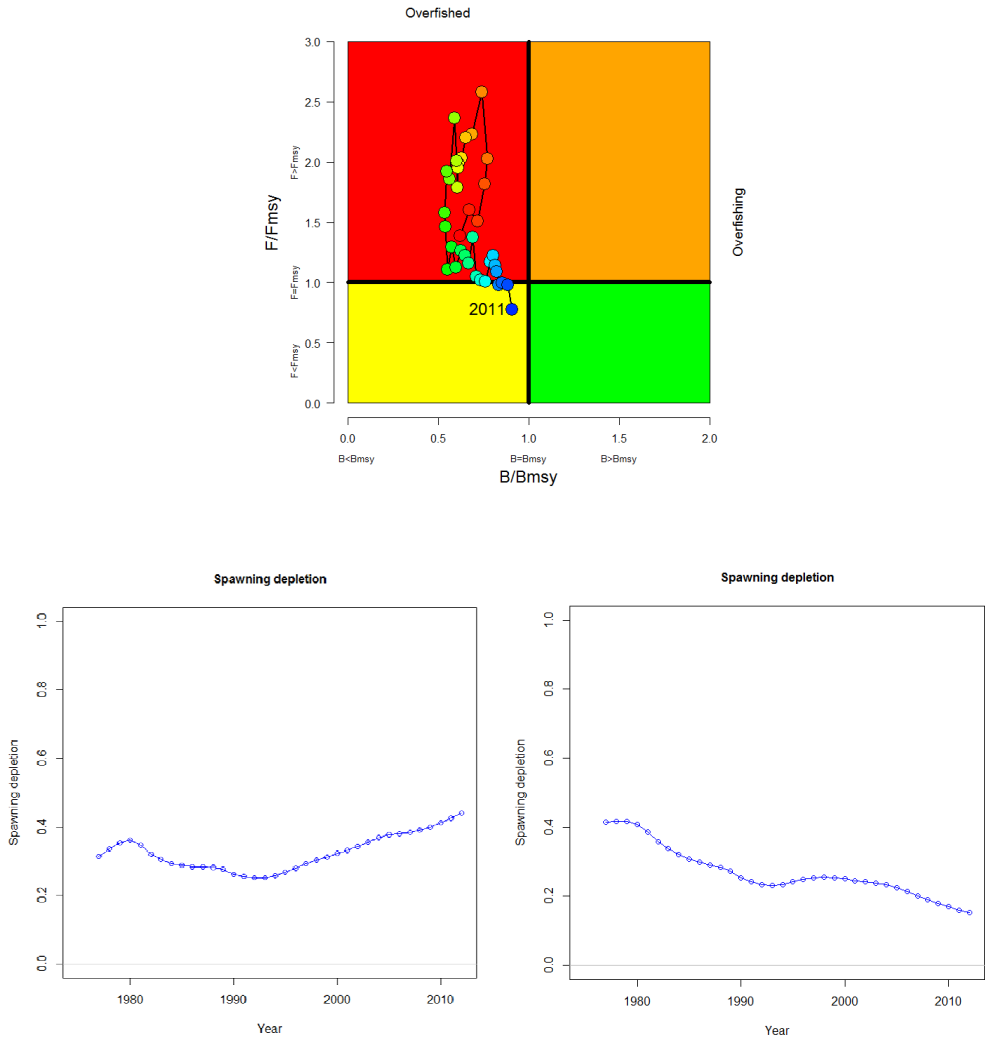

Figure 2: Summary of key results from the assessment of blue shark in the North Pacific Ocean of Rice et al. (2013); the Kobe plot from the reference case model (top), and spawning depletion trajectories for the reference case (lower left) and model run with the alternative CPUE series (lower right).

For blue shark in the South Pacific the first problem encountered was the lack of access to South Pacific catches that were outside the convention area – this meant that the assessment had to focus on the southern part of the WCPFC convention area. Second it was found that the construction of catch series was very complex due to the mix of data sources available. To avoid the potential for SC9 to not accept the assessment based on concerns about the catch series, the 2013 Pre-Assessment Workshop recommended that the work for SC9 focus on the development of alternative catch and CPUE series for SC9's consideration rather than carrying through with the assessment (OFP, 2013). Analyses of observer, operational logsheet, and aggregate catch and effort data were undertaken to come up with potential catch time series and abundance indices (Rice and Harley 2013a) and some results from this work are provided in Figure 3.

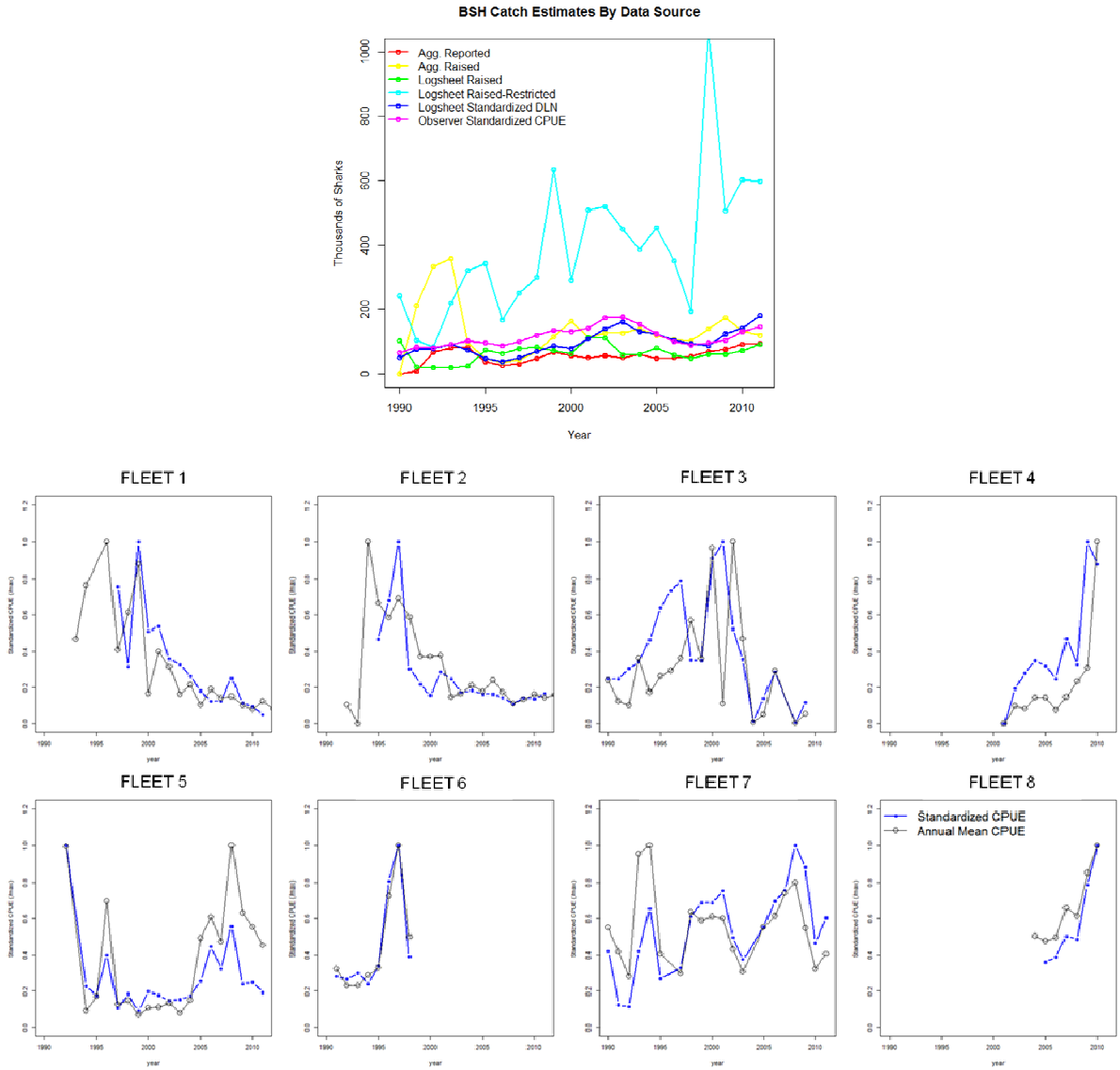

Figure 3: Comparison of potential catch estimates for blue shark in the south Pacific for difference data sources and estimation methods (top) and standardized CPUE and nominal trends based on ZINB standardization of SPC held observer data for various fleets in the south Pacific (bottom) (from Rice and Harley 2013a).

The final major piece of assessment related work was an investigation of potential measures to mitigate bycatch of silky and oceanic whitetip sharks from longline fisheries (Bromhead et al. 2013). This work was motivated by the 2012 assessments for these species that indicated that bycatch from longline fisheries was the greatest sources of fishing mortality and built on the initial investigations of wire traces by OFP (2012a). The analyses covered a wider range of potential data sets – including observer data from Hawaiian longline fisheries provided specifically to support the analyses.

Unfortunately considerable difficulty was encountered finding 'good' data sets which represented fisheries with both sufficient observer coverage and contrast in the key factors under consideration. In particular it was not possible to address the question of the interaction between leader type and hook type posed in OFP (2012a). Nevertheless the analysis was able to come to conclusions regarding the impact of 'shark lines[5] (Figure 4)' which typically result in much higher catch rates of both shark species. Wire trace analyses were less conclusive. Analysis of the species composition of

[5] These are branchlines which are attached directly to the floats of the longline and are extremely effective at catching sharks and not tuna

fish caught on shark lines (Figure 6) indicated that aside from bycatch of mahi mahi, that sharks were the major species taken with these lines.

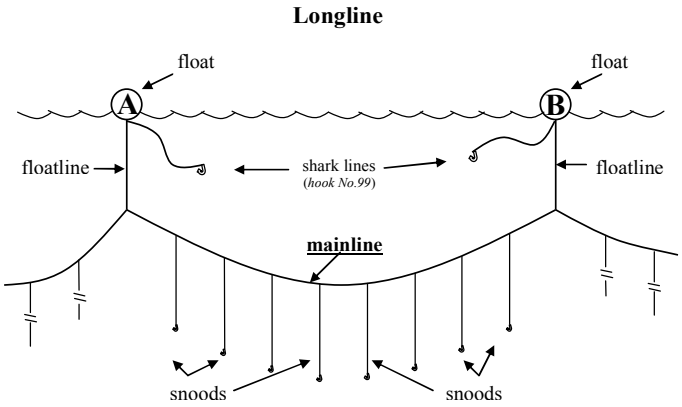

Figure 4: Schematic of part of a longline which shows the location of shark lines.

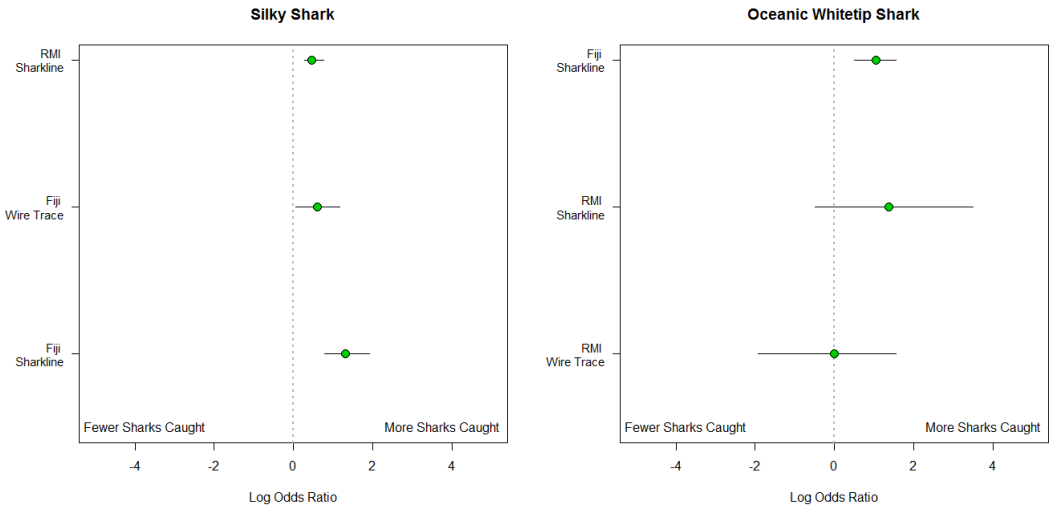

Figure 5: Estimated impacts of wire traces and shark lines on silky shark (left) and oceanic whitetip shark (right) based on data for RMI and Fiji (from Bromhead et al. 2013).

Hook type (interacting with leader type) was assessed in the Hawaii fishery but no substantial difference in effects on catch of either shark species was estimated. However model diagnostics were particularly poor for this fishery, and there is uncertainty over whether some sets in fact constituted “mixed” hook type sets and further work on the models may be required.

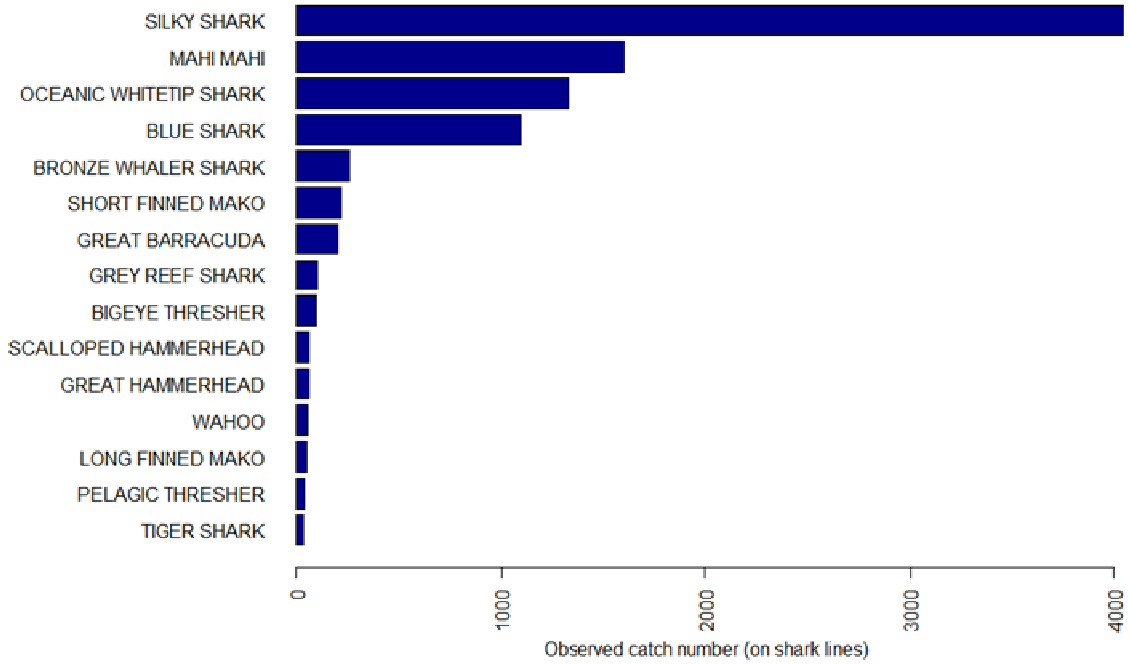

Figure 6: Species composition of observed catch on shark lines in the WCPO, for the top 15 species taken on shark lines (by catch number) (from Bromhead et al. 2013).

The focus 2013/2014 will depend on the guidance provided by SC9 and the overall level of resourcing for the SRP, but could include the completion of the assessment for blue shark in the South Pacific and development of assessments for mako shark (again likely separately for the North and South Pacific). There may additionally be work on indicators for those shark stocks not being assessed.

5. Phase 2: Coordination of research

5.1 Shark TAGging Information System (STAGIS)

One important development for the coordination of research was the Shark TAGging Information System (STAGIS) launched on the SPC web site[6] on 5 July 2011 (Clark et al. 2012c). The primary focus of the STAGIS is to house meta-data on shark tagging studies (i.e. data about data). The database was designed and populated in order to be hosted on the SPC-OFP website for free public access. In addition to supporting stock assessments of the key shark species, STAGIS can assist in highlighting issues for further research, facilitating research collaboration, and identifying critical habitats.

It is recommended that specific funding be allocated to continue work on STAGIS. Subject to available funding support, STAGIS content will be updated or enhanced (see Clarke et al. (2011c) for details of potential enhancements). Any researchers who have published any shark tagging work during 2011-2013 are encouraged to provide these details to the Joel Rice (joelr@spc.int).

5.2 ISSF bycatch work

The ISSF has an active area of research focusing on purse seine bycatch and a research cruise has recently been completed in the WCPO. This work has involved some tagging and biological studies of

[6] It can be accessed at: http://www.spc.int/ofp/shark/index.php.

sharks taken as bycatch and ISSF representatives provided an update of this work to SC8 and further updates will be provided to SC9. SPC has been involved in some of these activities, but our primary focus has been on sampling protocols rather than specific work on sharks.

5.3 Collaboration with other agencies

An important part of the SRP is collaboration with other agencies to maximize the efficiency of the resources available for shark science and stock assessment. Three main collaborations have occurred during 2011-13 with the ISC, the IATTC, CSIRO in Australia, and NMFS in the United States.

As a member of the ISC, SPC tries to attend the meetings of their Shark Working Group when funds and resources allow. Importantly we were not able to attend all meetings of the Shark WG and for that reason the group rejected the inclusion of some data series that had previously been reviewed by the SC. The meeting that finalized the blue shark assessment was held during mid-July 2013 – a time at which it is simply not possible for us to attend given the other commitments for the WCPFC SC. Further SPC has been subject to strong and completely unfair criticism by the ISC for conducting stock assessments that the ISC is also doing. This is an issue that the SC should consider, in particular those countries which are members of both.

The shark CMM (CMM2010-07) mentions specifically the need to collaborate with the IATTC and we continue to communicate with them on a range of shark-related matters. To date we have had one visit to the IATTC lab in La Jolla each year and this has supported the work on assessments for both silky shark and blue shark in the North Pacific.

Australia and New Zealand both have research programs directed at the temperate water shark species such as mako and blue sharks. In February 2012 we met with researchers from Australasia at a workshop hosted by CSIRO to discuss data availability and the potential for a stock assessment for mako shark in the southern hemisphere. We will continue this dialogue to ensure that all available biological and fishery data, as well as expertise is utilized in the conducting of the 2013/14 mako shark assessment if it goes ahead.

In December 2012 the United States offered the observer data from the Hawaiian longline fleet to support the examination of mitigation methods for silky and oceanic whitetip sharks.

We encourage those agencies that would like to work on shark science and stock assessment in the WCPO to contact us[7] to discuss the scope for collaborative work. Details of collaborative visits to date under the SRP are provided in Annex 2.

6. Phase 3: Improvement of data

6.1 Provision and access of shark data

Clarke et al. (2011c) provided a comprehensive summary of shark data holdings by SPC and WCPFC and data submissions to WCPFC with respect to the new requirements to submit shark catches and updated information is now available annually through the online accessible WCPFC Data Catalogue (http://www.wcpfc.int/wcpfc-data-catalogue). Therefore in this section we will simply highlight a few relevant statistics.

[7] Joel Rice (joelr@spc.int) and Shelton Harley (sheltonh@spc.int)

The provision of annual catch estimates is now a requirement and submissions are summarized in Table 3. In Figure 7 we examine the coverage of shark catch data across the raised aggregate longline data set that includes actual and estimated effort for all fleets operating in the convention area.

Prior to 1990 there is very little information on shark catches and what is available is not species-specific – it is just generic shark. Since then there has been an increase in the reporting of sharks, both generic and species-specific, but when longline effort over the past ten years is considered, less than a third of it is associated with species-specific estimates of catch – and for these it is not clear whether discards are included or not. This indicates the level of challenge in assessing sharks and generating plausible catch and CPUE time series.

Table 3: Provision of annual catch estimates of sharks

Entity	Years
Australia	1991-2012
Belize	2011-2012
China	2010-2012
Spain (EC)	2006-2012
Fiji	2011-2012
Japan	2006-2012
Korea	2011-2012
New Caledonia	2001-2012
New Zealand	2000-2012
French Polynesia	2009-2012
Portugal (EC)	2011-2012
Chinese Taipei	2009-2012
United States	2005-2012

Observer data will be particularly important to the successful assessment of shark populations and Table 4 provides a summary of observer coverage (observed total tuna catch as a proportion of the annual catch estimate for the EEZ) for two broad latitude bands. The observer coverage on the high seas was even lower.

Table 4: A summary of recent levels of observer coverage (observed total tuna catch as a proportion of the annual catch estimate for the EEZ) in Pacific Island EEZs.

Year	LONGLINE OBSERVER COVERAGE in combined PIC EEZs BY Latitude bands	
	10°S-15°N	10°S-25°S
2005	1.1%	2.2%
2006	1.5%	2.4%
2007	1.2%	1.5%
2008	1.3%	2.4%
2009	0.4%	2.0%
2010	0.1%	2.1%
2011	0.2%	1.2%
2012	0.0%	0.3%
TROP EEZs = Palau, FSM, PNG, RMI, Kiribati, Solomon Islands		
SUBTROP EEZs = Vanuatu, New Cal., Fiji, Samoa, Cook Islands, French Polynesia, Tonga		

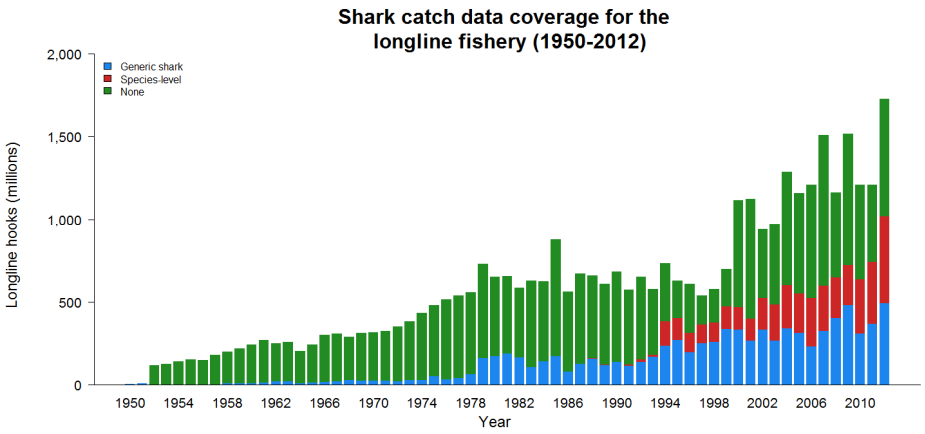

Figure 7: Coverage of shark catches (aggregate and species-specific) for the aggregate longline catch and effort data

The requirement to increase longline observer coverage to 5% by 1 June 2012 throughout most of the WCPF Convention area is now in effect and the improved data on sharks and other bycatch that come from these programs will be extremely valuable for future analyses.

Nevertheless the available observer data does have some potential to address the questions of ways to reduce non-target shark catches (Bromhead et al. 2013) and also information on the condition of sharks when they are at the side of the boat. This fate and condition data was considered by Clarke (2011) and a summary of the current holdings of these data for several key shark species is provided in Figure 8.

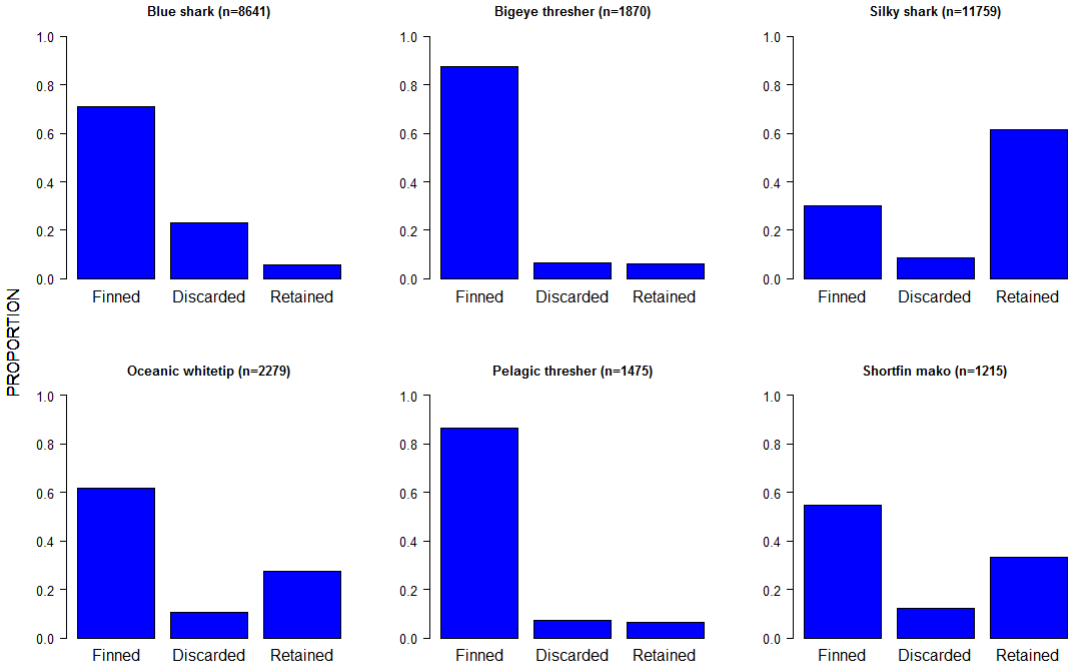

Figure 8: Fate from observer data across both sub-regions identified in Table 4.

Observer reports from purse seine vessel were used by Harley and Williams (2013) to examine the spatial temporal patterns in whale shark records. They all observed purse seine sets as the sampling effort to detect whale sharks and a positive record was any instance where either the school association was recorded as whale shark, whale shark was listed on the catch records, or a whale shark interaction was recorded.

We found that the occurrence of whale sharks in free schools sets has dropped by about half over the past ten years (Figure 10). While this could be a result of improved detection of whale sharks prior to setting, or other factors that would be included in a formal standardization, the possibility that this reflects a trend in abundance warrants closer examination.

Spatial analysis of observed fishing sets and whale shark records indicated that whale sharks were generally encountered anywhere where significant amounts of fishing were observed(Figure 11). While there were some isolated areas where the rate of records per observed set were high, these were generally areas with low observed whale shark records, but even [relatively] lower observed effort. Further statistical modeling is necessary to determine the extent to which whale sharks are informally distributed across the region versus overlapping with the main purse seine fishing grounds.

There remains some important observer data which has not been submitted to SPC or WCPFC since the establishment of the WCPFC and there are also some extremely valuable research and training vessel data sets which would provide useful information. WCPFC members are encouraged to make these data sets available to SPC or WCPFC – if necessary, specific arrangements could be accommodated, but the costs of these will need careful consideration.

6.2 Shark identification guides

In 2012 this paper noted the request from Small Island Developing States (SIDS) for shark identification guides to assist them in implementing the CMM for oceanic whitetip sharks. In early 2013 SPC used its own resources to distribute almost 400 identification guides to eight SIDS.

The guides were taken from SPC stocks used for observer training and therefore it is likely that we may need to replace these in the future as further training is undertaken for observers to work longline vessels.

There are three other areas where further work to enhance the identification of sharks and therefore improvement in shark data could be undertaken:

- Expanding the distribution of shark ID guides to other longline fleets;
- Development of a shark ID poster that could be distributed to longline vessels as this could have greater impact than ID guide; and
- Development of a identification guide to allow the identification of sharks in various processed states (see Figure 12);

The SC, members, and NGOs are all encouraged to consider how they might be able to contribute to these.

6.3 Expanded longline logsheets

In conjunction with the Data Collection Committee Report (a joint SPC/FFA initiative) various data collection forms have been developed and are used throughout the regions fisheries. These forms are developed to be consistent with the WCPFC guidelines for the provision of data. One important form recently developed is the expanded logsheet form which allows the collection of data for all key shark species (note that the hammerheads and thresher sharks are included but not separated to species). These forms are being increasingly used by coastal states in the region and have been translated into English, Japanese, Korean, Spanish, and Mandarin. These are freely available through the SPC website[8]. Please contact us if versions in other languages are required.

The SC and WCPFC should strongly encourage CCMs to use data collection forms consistent with the data provision rules, and note that an expanded logsheet currently exists to assist with shark catch reporting.

[8] http://www.spc.int/oceanfish/en/data-collection/241-data-collection-forms

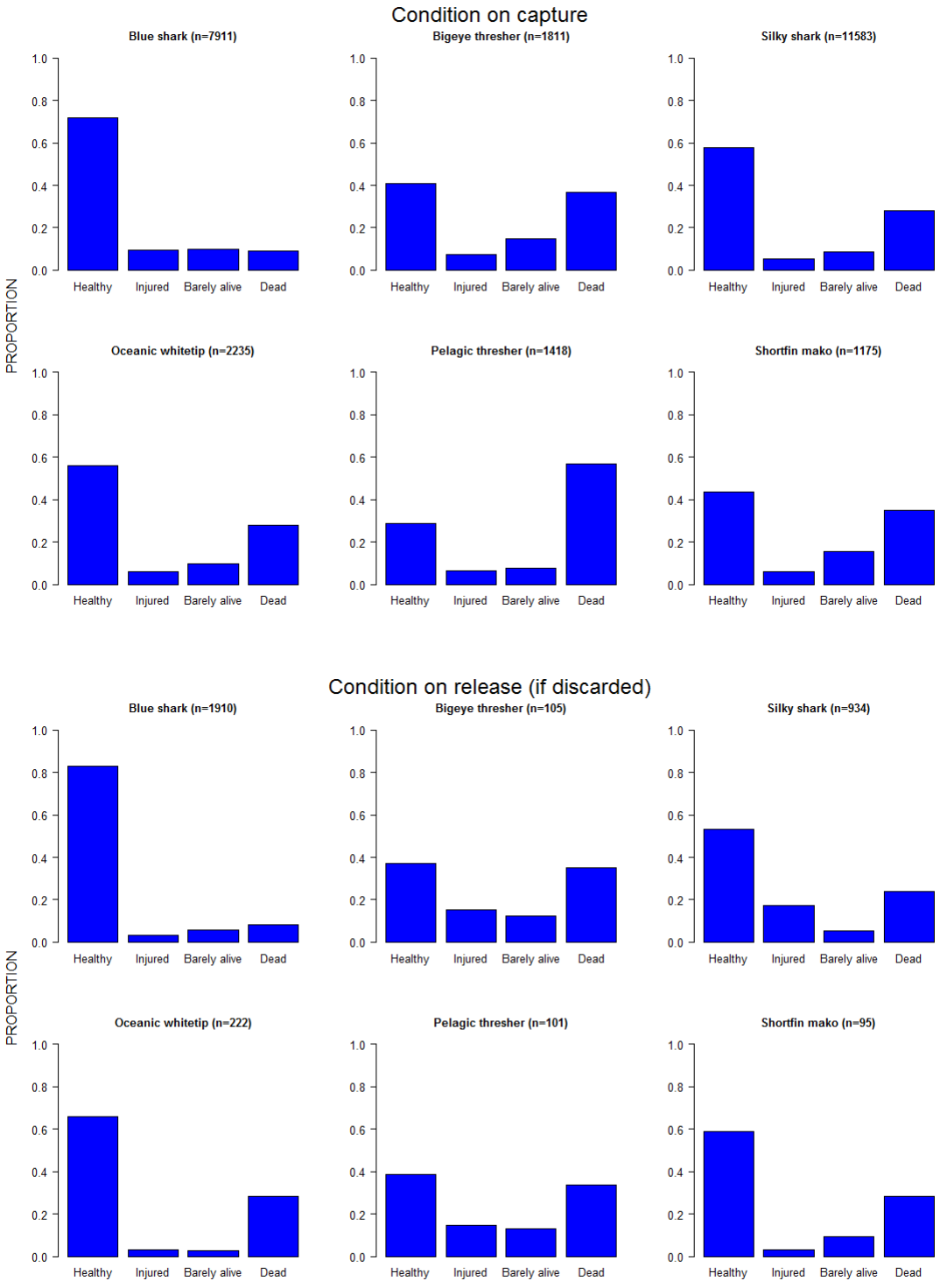

Figure 9: Condition at capture (top) and release if discard (bottom) from observer data across both sub-regions identified in Table 4.

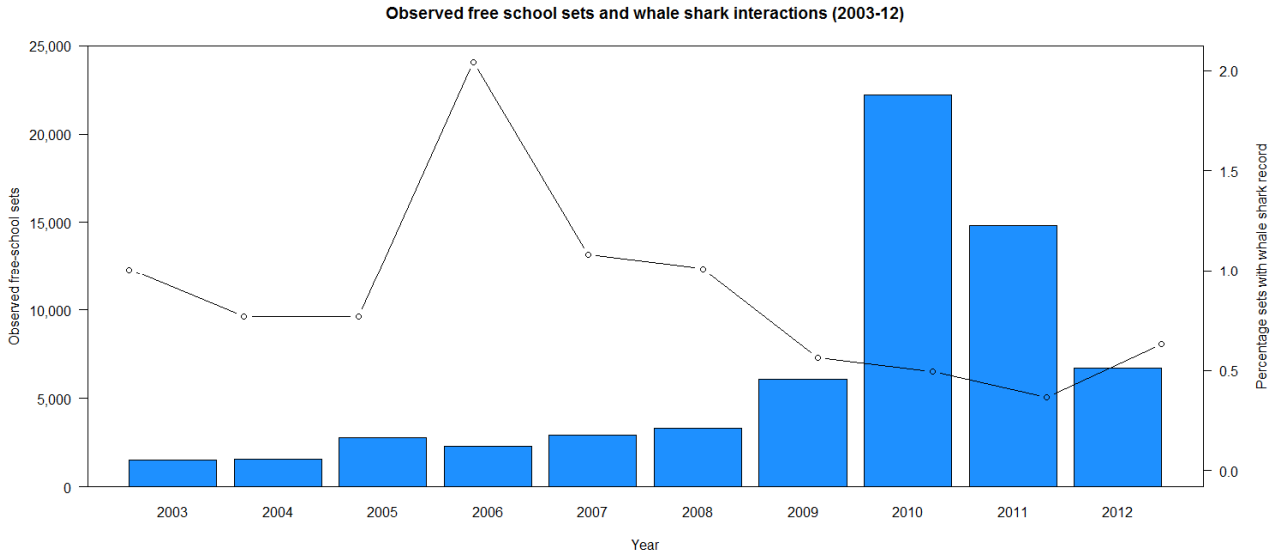

Figure 10: Annual number of observed free school sets (bars) and proportion of sets with some form of whale shark interaction (from Harley and Williams (2013)).

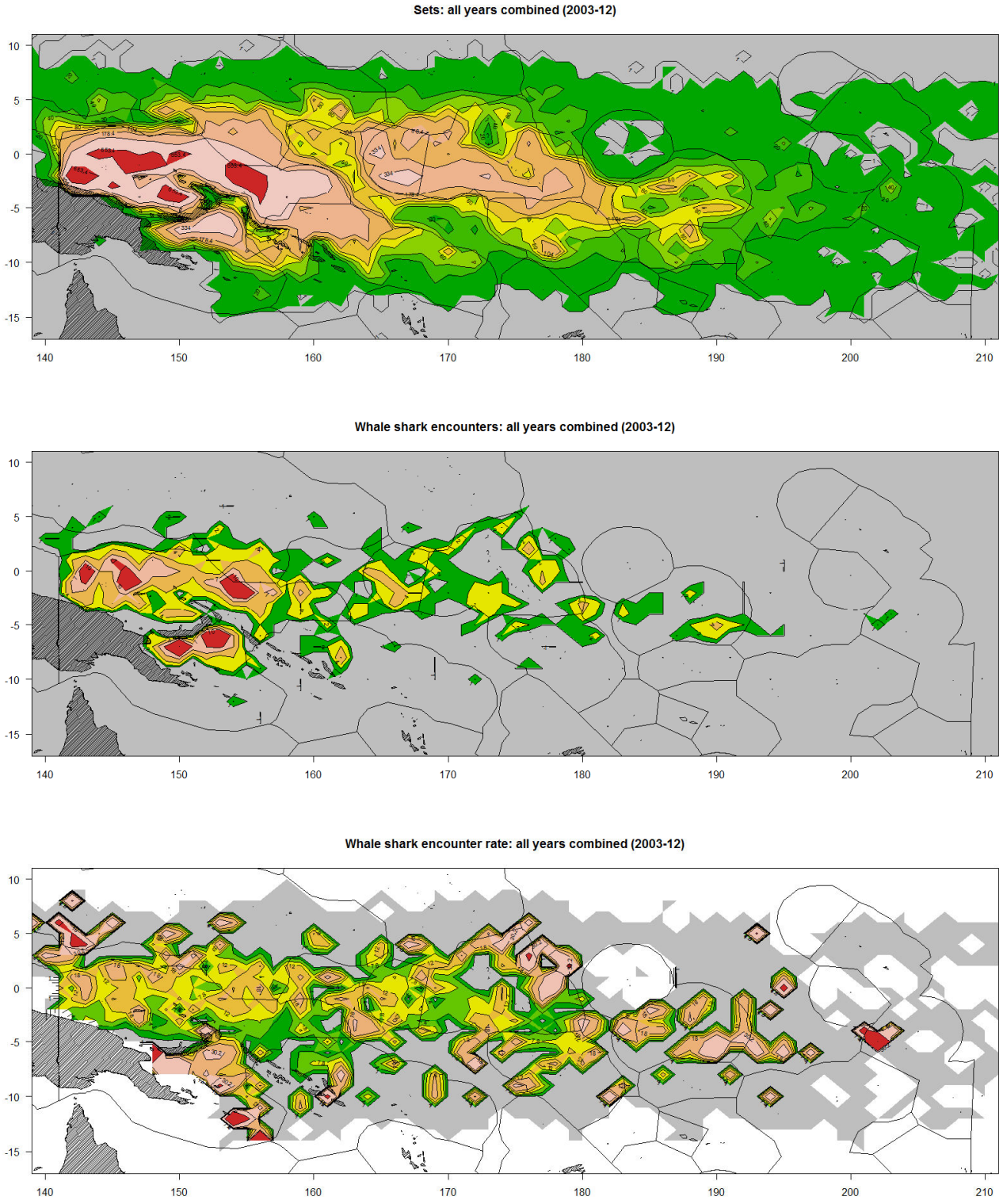

Figure 11: Contour plots based on 1 x 1 degree square data for all years combined of purse seine sets (top), whale shark records (middle – see text for criteria), and encounter rates (bottom – simply whale shark records divided by total sets for each 1 x1 degree square). Grey represents zeros, white are NA's (e.g. zero whale sharks divided by zero sets), and the scale increases from green to yellow to orange to pink to red.

Figure 12: Two examples of sharks being landed with fins naturally attached. The proposed identification guide would make it easier for port samplers and other inspectors to identify sharks landed in ways such as this.

7. Future directions for the Shark Research Plan

The Shark Research plan was adopted by the WCPFC in December 2010 with the three key work areas of 1) stock assessment; 2) research coordination; and 3) improving shark data. In 2012 the WCPFC approved the continuation of funding for this work, but the conclusions of Rice and Harley (2012) still remain "*we have found that the resources allocated to this work through the WCPFC (one full time equivalent position) where insufficient to undertake the assessments and progress the other work areas within the SRP*".

Therefore we believe that the future of the SRP will require both a) a medium term plan, b) the resources to implement the plan, and c) the flexibility to address emerging shark issues of importance to the Commission. We propose that the SC consider funding mechanisms to better support the SRP.

Therefore there is a need to carefully consider both the level of resources allocated to the SRP by the WCPFC and to carefully prioritize the specific work to be undertaken each year. Table 1 provides the proposed timings for assessments currently planned under the SRP, but there are many other potentially important activities that are consistent with the SRP. We encourage SC9 to carefully consider the following:

A. That the stock assessment for blue shark in the south Pacific Ocean be conducted for SC10;
B. That SPC focus on the calculation of catch and CPUE series for mako shark in the South Pacific Ocean and then determine whether it progresses the assessment for SC10 based on feedback from the 2014 Pre-Assessment Workshop (PAW);
C. That SC9 consider the value of assigning SPC resources to stock assessments for shark populations in the Northern Hemisphere given the interest of the ISC. When participating in such assessments SPC does not get access to the raw data used to generate the model inputs; and SPC does not have sufficient resources to attend the multiple ISC meetings – in particular the meetings that finalize the assessments are typically in mid-late July around the SC paper submission deadline.
D. Noting (C) above, that SC9 determine the desired level of SPC involvement with other ISC members on a stock assessment for mako shark in the North Pacific Ocean. This could also

include on what form the assessment should take, e.g., integrated age structured model or production model;

E. That stock assessments for the thresher shark complex be delayed, due to the low likelihood of success and the higher priority activities that are being undertaken;
F. That WCPFC members make all available observer and research / training data that has not previously been provided to SPC or WCPFC to support the SRP assessment work and/or provide cost-effective means for collaborative research efforts; and
G. Consider the following additional pieces of work related to the objectives of the Shark Research Plan, noting that additional funding may be required in some instances:
    i. A desktop review of relevant policy and legal documents that would inform the consideration of target and limit reference points for shark species taken predominantly as bycatch;
    ii. Conducting a standardized CPUE analysis for whale sharks using observer data from the tropical purse seine fishery;
    iii. Indicator analyses for key shark species for which assessments are not undertaken;
    iv. Application of the 'key shark species' criteria to existing species on the list (for priority setting) and to other sharks and rays taken in WCPO tuna fisheries;
    v. Contributing to a stock assessment for porbeagle shark with CCSBT (if this proceeds);
    vi. Updating and enhancing the shark tagging database STAGIS;
    vii. Expanding the distribution of shark ID guides to other longline fleets;
    viii. Development of a shark ID poster that could be distributed to longline vessels as this could have greater impact than ID guides;
    ix. Development of a identification guide to allow the identification of sharks in various processed states;
    x. Biological studies to reduce uncertainty in important life history parameters of key shark species;
    xi. Electronic tagging studies to estimate post-release mortality for key shark species; and
    xii. Undertaking a review of the SRP for the development of a revised plan.

8. References

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Annex 1: Scientific papers and reports produced under, and in support of, the Shark Research Plan (chronological order with most recent first).

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Annex 2: Collaborative research meetings undertaken through the Shark Research Plan (chronological order with most recent first)

Meeting	Comments
ISC shark working group, Shimizu, Japan (Apr 2013)	Participated in meeting, in particular the development of a Stock Synthesis model for blue shark in the North Pacific to compliment the production model also being used.
IATTC 4th annual technical meeting on sharks, La Jolla, USA (Feb 2013)	In addition to participating in the workshop, collaborative work was undertaken with IATTC and NMFS scientists in support of blue and silky shark assessment work, in particular the use of stock synthesis to conduct shark stock assessments.
Management of marine megafauna affected by fisheries bycatch, La Jolla, USA (Mar 2012)	Meeting brought together experts from across RFMOs and other fields (e.g. sea turtles, sea birds, and marine mammals) to discuss ways to assess these species groups.
Australasian mako shark workshop, Hobart, AUS (Feb 2012)	Scoping workshop to determine data availability and gaps and the potential timeline for a stock assessment for mako sharks in the South Pacific Ocean.
Joint SPC/IATTC workshop on assessment of silky sharks, La Jolla, USA (Dec 2011)	Collaborative work on stock assessment approaches using Stock Synthesis to assess silky sharks stocks in the Pacific Ocean.
ISC shark working group, La Jolla, USA (Nov 2011)	These meetings focused on the blue and mako assessments for the North pacific Ocean.
Joint workshop on Hawaiian observer data for oceanic whitetip and silky sharks, Noumea, New Caledonia (Apr 2011)	William Walsh of the NMFS PIFSC visited Noumea to work on analyses of these data that are currently not available to SPC or WCPFC.
Joint SPC/NRIFSF workshop on sharks, Shimizu, (March 2011)	Collaborative analyses of Japanese commercial logsheets records of shark catches and the research and training vessel database.