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A Progress Report on the Shark Research Plan

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Abstract

There have been several areas of progress under the Shark Research Plan since the last meeting of the WCPFC Scientific Committee in August 2010. Stock status analyses are reported in a separate series of papers leaving this paper to focus on progress with data compilation and research planning. This paper describes improvements in shark data in terms of additional ad hoc and regular data provision by WCPFC members and characterizes the current shark data holdings. Two initiatives to access and analyze valuable datasets not held by the WCPFC or the SPC-OFP are also described. The results of a project involving the compilation of meta-data for Pacific shark tagging studies into a public access database (STAGIS) are presented. Plans for the upcoming stock assessments of silky and oceanic whitetip sharks are detailed.

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:

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

Initial work on shark assessments under the SRP is reported in other papers presented to SC7 (Clarke et al. 2011a, Clarke et al. 2011b, Clarke 2011, Lawson 2011 and Walsh and Clarke 2011). This paper outlines progress with shark data improvement, research and further assessments under the SRP in three main areas:

- Provision of shark data to the Western and Central Pacific Fisheries Commission (WCPFC) for use in further assessments and access to datasets held elsewhere (Section 2);
- Creation of the shark tagging information system (STAGIS), a meta-database of tagging studies (Section 3); and
- A proposed approach to the upcoming silky and oceanic whitetip shark assessments (Section 4).

The SRP is designed to be completed in mid-2014. Funding has been provided by WCPFC for one position to support the implementation of the SRP. One year's funding was approved in December 2009 and a further two years' funding was agreed by WCPFC in December 2010. Due to delays in the initial recruitment, funding is available through mid-2013. Dr Shelley Clarke will be replaced by Joel Rice as SPC's Shark Assessment Scientist at the end of August 2011.

2. Provision and Access of Shark Data

The quality and quantity of data are key factors determining the effectiveness of any stock status analysis. Due to the historical lack of shark reporting on the logsheets of most fleets, analyses of the WCPFC and SPC-OFP data holdings conducted to date under the Shark Research Plan have been based only on observer data. Observer data have been limited to <1% coverage of the longline fishery in recent years, most of which is concentrated in Exclusive Economic Zones (EEZs), but coverage is set to rise to 5% in June 2012. Observer coverage of the purse seine fishery was raised from 13-16% in recent years to 100% as of January 2010, but the purse seine fishery's shark catch is estimated to be only 8% of the total longline and purse seine shark catch (Clarke et al. 2011b, Lawson 2011). As there are important gaps and biases in observer datasets (e.g. skewed coverage by area and fleet), it is important not to lose sight of the need to secure other sources of data to supplement analyses based on observer data. The following two sections describe shark data received by the SPC-OFP, most of which are on behalf of the WCPFC, over the past year which are now available for analysis (Section 2.1), as well as data that were temporarily accessed for analysis over the past year but are not available for analysis on an ongoing basis (Section 2.2).

2.1 Data Provision for Key Shark Species

After review of SPC-OFP shark data holdings and identification of data gaps for the SRP in July 2010, shark logsheet data were provided by three WCPFC members and cooperating non-members (CCMs) in advance of WCPFC7 in December 2010:

- Australia provided missing operational level shark logsheet data for all key species from their longline and troll fisheries for 2007-2009 in September 2010;
- New Zealand provided missing operational level shark logsheet data for all key species from their longline fisheries since 2000 in December 2010;
- Japan provided aggregate (5x5 degree) catches of blue, mako and porbeagle/salmon sharks for 2007-2009 in December 2010.

In February 2011, the WCPFC rules for "Scientific Data to be Provided to the Commission" were revised to specify provision of annual catch estimates and operational level catch and effort data[2] from longline and troll (in number), and from purse seine and pole and line (in weight) fisheries for blue, silky, oceanic whitetip, mako, thresher, porbeagle[3], and hammerhead sharks (winghead, scalloped, great and smooth) sharks (WCPFC 2011). Size data are also required for those species for which stock assessments will be undertaken, therefore size data should be provided for sharks as they are for tunas and billfishes.

These new data provision rules applied to CCMs' annual data submissions which were due on 30 April 2011. Tables showing the current WCPFC data holdings from longline fisheries for blue, mako, oceanic whitetip, silky and thresher are provided in Annex 1 and on the following website:

[2] Operational level data shall be provided unless provision is subject to domestic legal constraints, in which case until such constraints are overcome, aggregated catch and effort data and size composition data shall be provided.

[3] South of 20^{o}S only, until biological data shows this or another geographic limit to be appropriate.

WCPFC Data Catalogue

http://www.wcpfc.int/wcpfc-data-catalogue

These tables will be enhanced and updated periodically to reflect new submissions and can be found on the website shown below. Current shark data holdings for the other gear types (purse seine, troll and pole and line) are very small and similar summary formats have not yet been developed.

The following points were identified in a review of the current shark data holdings:

- Logsheet shark data holdings were substantially increased with submission of aggregated data for all key species (2008-2010) by Chinese Taipei and aggregated data for blue, mako and porbeagle shark (1994-2009) by Japan.
- Six CCMs – EU (Spain), Indonesia, Kiribati, Nauru, Philippines, and Palau -- have not provided any shark catch and effort data for any species in any year[4]. Three of these CCMs are among the top twenty countries reporting Pacific shark catches to the FAO in 2009. One of these was the top Pacific shark capture production country on the FAO list for 2009 (FAO 2011).
- Five other data providers –the Marshall Islands, Niue, Papua New Guinea, Senegal and some US vessels based in SPC member countries (US-MC)—did not provide any shark catch and effort data for any species in 2010.
- The largest number of CCMs submitted catch records for mako sharks (21 CCMs), followed by blue sharks (16 CCMs), oceanic whitetip and thresher sharks (8 CCMs each) and silky sharks (5 CCMs).
- Ten CCMs submitted operational level data for at least some shark species in 2010: Australia, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, New Caledonia, New Zealand, Samoa, Tokelau and Vanuatu. Another three CCMs submitted operational level shark data in other years.
- Average annual reported catches[5] were 22,851 t of blue, 1882 t of mako, 631 t of oceanic whitetip, 691 t of silky, and 642 t of thresher sharks.
- Chinese Taipei reported the largest average annual catches of blue, mako, silky and thresher sharks whereas China reported the largest average annual catches of oceanic whitetip sharks. Japan reported the second highest average annual catches of blue and mako sharks.

[4] Some shark data from Korea and the Solomon Islands were submitted for 2010 but do not appear in Tables A1-A5.

[5] This figure is the sum of the average annual catches reported by CCMs from Tables A1-A5. Note that the number of years in the reporting period varies by CCM.

2.2 Access to Data on Key Shark Species Held Elsewhere

As some very useful shark catch and effort datasets exist but have not been provided to WCPFC or SPC-OFP for various reasons, efforts were made under the SRP to analyze these data under alternative arrangements. Continuing access to these datasets would be highly beneficial for the SRP and should be pursued if possible.

An important component of the shark analyses conducted thus far under the SRP was a collaboration between SPC-OFP and the National Research Institute of Far Seas Fisheries in Shimizu, Japan to jointly analyze operational level North Pacific shark data held by Japan. Dr Shelley Clarke spent eight weeks in Shimizu in January-March 2011 analyzing both the longline logsheet dataset (1993-2009) and the research and training vessel dataset (1992-2009). The product of this collaboration was an indicator-based analysis of eight of the key WCPFC shark species which is presented to SC7 as Clarke et al. (2011b).

SPC-OFP also collaborated with the United States' Pacific Islands Fisheries Science Center (PIFSC) in Honolulu, Hawaii to analyze observer data from the Hawaii longline fishery from 1995-2010. Due to domestic legal constraints, these data have been provided to SPC-OFP through 2004 but have not been provided thereafter. Dr. William Walsh of the Joint Institute for Marine and Atmospheric Research (JIMAR), University of Hawaii spent three weeks at SPC Noumea in April 2011 producing an analysis of stock status trends for oceanic whitetip and silky sharks. This paper represents a compatible analytical approach to the indicators work conducted by SPC and is presented to SC7 as Walsh and Clarke (2011).

2.3 Other Initiatives

In addition to the analytical and data-based work described above, CCM scientists worked with SPC to compile bibliographic, shark tagging and other information to support the SRP. The contributions of Drs Barry Bruce (CSIRO, Australia), Dean Courtney (NMFS-PIFSC), Malcolm Francis (NIWA, New Zealand), Suzy Kohin (NMFS-Southwest Region, US), Hiroaki Matsunaga (NRIFSF, Japan), Mioko Taguchi (NRIFSF, Japan) and Peter Ward (BRS, Australia) are gratefully acknowledged.

2.4 Data Sufficiency

As observer data are expected to remain limited, as well as skewed toward national waters, both historically and prospectively, the largest gains in compilation of new shark data are expected to derive from capturing more information from commercial logbooks. CCMs should be encouraged to identify opportunities for "rescue" of historical shark data and to either develop projects independently or in collaboration with SPC-OFP (Williams 2011). CCMs should also consider whether their existing national and/or sub-regional fisheries information collection systems are appropriate for the new shark data provision requirements. For example, logsheet formats should be reviewed to confirm that they allow and facilitate the recording of all key shark species. Procedures for handling non-species specific shark logsheet data (e.g. "other sharks" or "total sharks") should also be reviewed. The SPC/FFA Tuna Fishery Data Collection Committee is one forum that could be utilized to coordinate these issues (SPC 2011).

3. Shark TAGging Information System (STAGIS)

3.1 Introduction, Project Context and Objectives

Tagging studies provide essential information for shark species stock assessments on movement, habitat area, growth and natural mortality. At the time the SRP was approved, a comprehensive database of shark tags deployed and returned in the Pacific did not exist, and SPC-OFP did not have any substantial tag data holdings for sharks. Sources of tagging data for Pacific sharks appeared to be scattered amongst government and academic research institutes around the Pacific Rim. While the existence of some studies could be confirmed, the numbers of species tagged and tracked/recovered by each could not, and the availability of the findings in published reports or other sources was unknown. This lack of information hampered the ability of scientists to access the most relevant existing data for shark assessments and prevented clear identification of priorities for future shark tagging research. These motivations led to initiation of a project whose aim was to create a database of shark tagging studies conducted in the Pacific Ocean.

The primary focus of the STAGIS project was to compile meta-data (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.

STAGIS was launched on the SPC web site on 5 July 2011. It can be accessed at:

Shark Tagging Information System (STAGIS)

http://www.spc.int/ofp/shark/index.php

3.2 Database Description

The database was designed to hold tagging data for any species of shark found in the Pacific. It was designed around four principal tables which include all meta-data fields needed to describe shark tagging research: Species, Contacts, Studies and References.

The Species page presents a list of 60 shark species that have been studied using tags in the Pacific Ocean. Scientific and common names, as well as FAO species codes, are shown. Users can also see if the species of interest has been designated as a Key Shark Species by the WCPFC.

The Contacts section contains approximately 60 researchers who have led shark tagging activities. For each contact, the organization and country, as well as the email address, are listed. The user can access a list of shark tagging activities led by this person.

The References section contains approximately 90 references pertaining to shark tagging studies in the Pacific. Reference types include peer-reviewed papers in scientific journals, meeting papers and project reports. The full citation and abstract are listed for each reference, as well as a hyperlink which illustrates how the user can access the full reference.

The Studies section contains approximately 200 studies. Species tagged, a brief description, type of tag, oceanic region, years of deployment, and the person who was in charge of this study are listed for each study.

STAGIS also has export and print functions which permit users to extract the information of interest in various formats (PDF, Excel or print formats).

3.3 Data Sourcing

Notices were sent to the shark scientific community to request their assistance in populating the database. We attempted to publicize the project across this community by publishing our request in several newsletters such as the newsletters of the Oceania Chondrichthyan Society, the International Union for the Conservation of Nature and on the website www.shark-references.com. In addition, a list of researchers who may have attached tags to sharks in the Pacific was compiled through literature searches, SPC contacts and word of mouth, and these researchers were contacted individually and asked to cooperate by submitting information. Overall, the response rate was fairly high with 44% responding to the email request; however, only 17% of the contacts provided any data for STAGIS. Nevertheless, these contributions represent 45% of the data in STAGIS in terms of number of studies. To supplement the researcher contributions via email, bibliographic research was undertaken. Over 90 literature references which deal with shark tagging activities were identified, studied, analyzed and, if appropriate, entered into the database. This represents approximately 55% of the data entered into STAGIS in terms of number of studies (i.e. 109 studies).

In order to make the database as reliable as possible, particular attention was paid when entering new data into STAGIS. We strove to quality control the data by verifying the relevance of the information and avoiding duplication. For example, we identified some mistakes or inaccuracies in data provided on the response form (i.e. aberrant lengths and/or taxonomic identifications). In some cases, corrections could be made directly, but in other cases it was necessary to re-contact the contributor. A particular challenge arose from data produced through collaboration between several researchers or organizations. In such cases it was necessary to verify whether the same data had been provided by multiple researchers and thus identify and remove double-counted studies and tags.

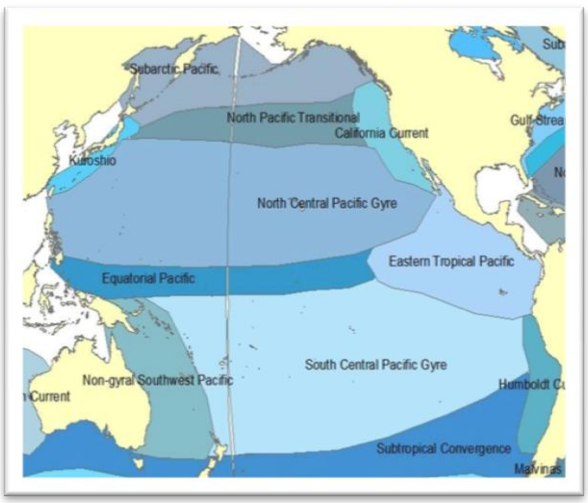
At present, STAGIS contains approximately 200 shark tagging studies. Each study, as defined in STAGIS, deals with one species and summarises the type of tag used, the oceanic region (i.e. the location of tagging if available), the time period of the tagging, the number of individuals tagged and recovered (if applicable), the range of lengths and the sex of the individuals tagged, the longest and the farthest track observed during the study, and the project leader. In total, STAGIS contains information on over 80,700 tags deployed between 1968 and the present, covering approximately 60 shark species throughout the Pacific.

3.4 Descriptive Statistics from STAGIS

STAGIS was designed to compile and hold data, rather than to analyze it. However, descriptive statistics of STAGIS's content can be used to characterize shark tagging activities in the Pacific by oceanic region, species and tag type.

3.4.1 Oceanic Region

Tags contained in STAGIS were deployed principally in the Southwest Pacific (32%), in the California Current (23%), in the Kuroshio area (20%) and in the Western Subtropical Convergence (19%; Figure 1). In terms of number of studies, research has been most active in the California Current and in the Subtropical Convergence with each region comprising 26% of the studies for the Pacific as a whole. Shark populations in regions which border developed countries as Australia, Japan, New-Zealand and USA are well-studied compared to those in other areas.



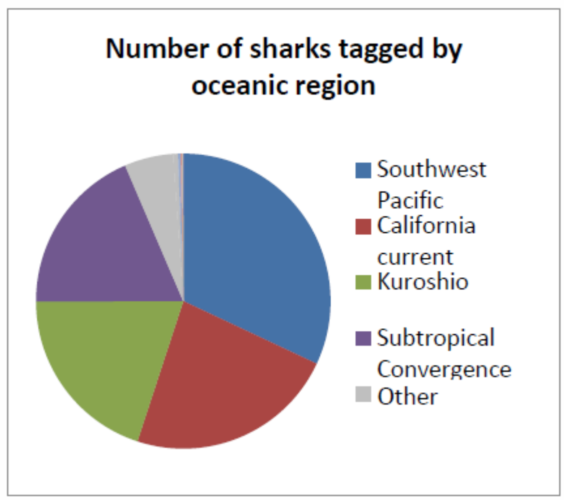


Figure 1. Map of the regions of the Pacific Ocean used in STAGIS to classify the location of shark tags (left) and the distribution of shark tags contained in STAGIS among these regions (right).

3.4.2 Species

In terms of number of tags deployed (Figure 2), the species distribution is particularly unbalanced with two species occupying more than 50% of the total distribution: blue shark (BSH, 36% of the total number of tags) and shortfin mako (SMA, 23% of the total number of tags).

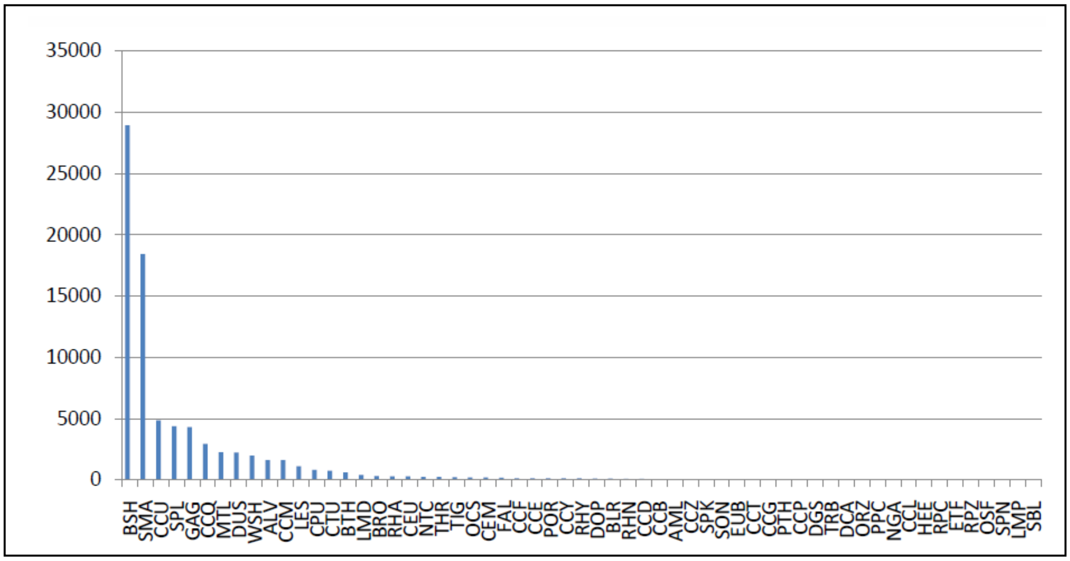


Figure 2. The number of tagged sharks in STAGIS by species. Species are identified using their FAO species code.

In terms of number of studies (Figure 3), shark tagging research has primarily focused on white sharks (14% of studies). In other words, the greatest number of studies are devoted to white sharks but the number of tags deployed in these studies tends to be small. This is at least partially attributable to lower abundances of white sharks as compared to blue, mako and other common pelagic species, many of which have been tagged with low-cost conventional tags.

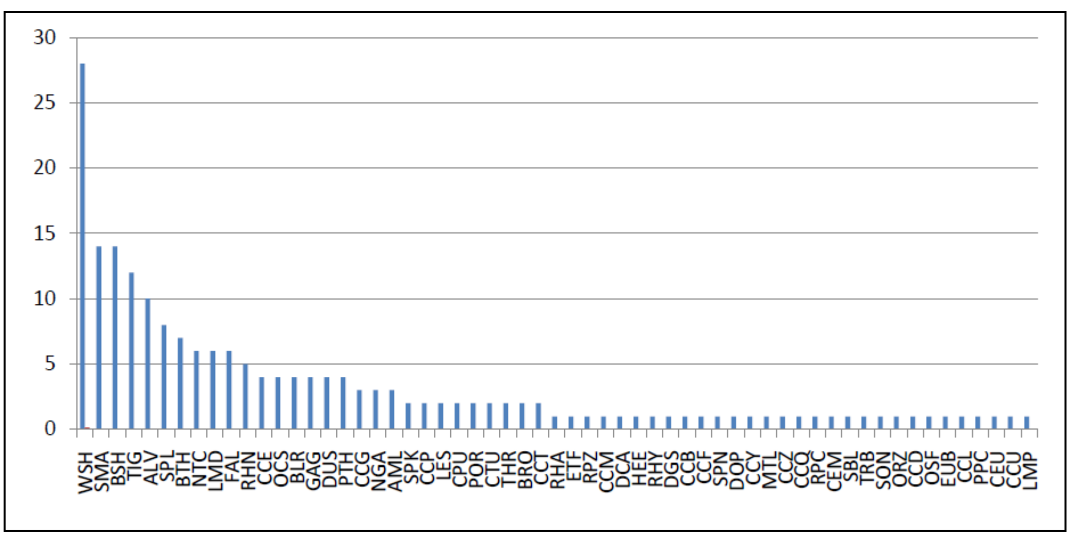


Figure 3. Number of studies in STAGIS by species. Species are identified using their FAO species code.

3.4.3 Tag Type

Studies in STAGIS are classified by four types of tag: conventional, sonic (or acoustic), archival and satellite (Figure 4).

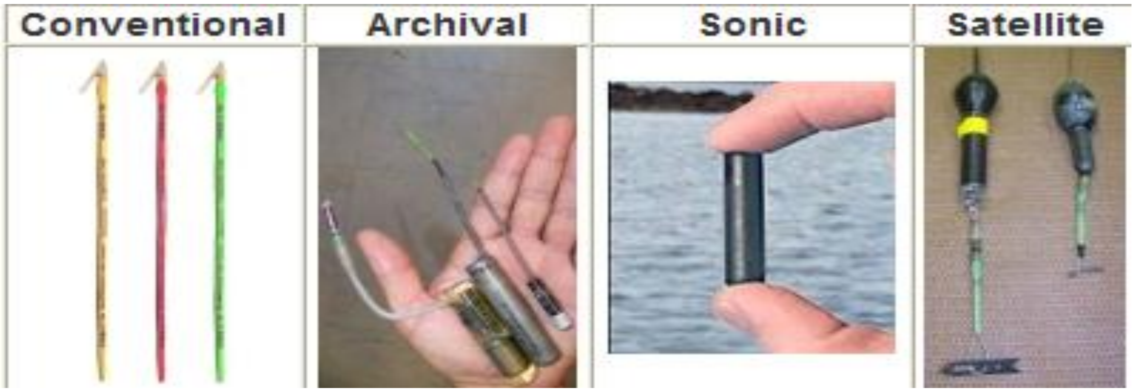


Figure 4. Examples of the different types of tags used for shark tagging.

In terms of the number of tags deployed, about 96% were conventional tags. This can be explained by the fact that this tagging method has been used for a long time, is inexpensive and is easy to deploy on large samples. In terms of the number of studies, the distribution of tag types is more balanced with 36% of the total number of studies employing conventional tags, 35% employing satellite tags, 25% employing sonic tags and 4% employing archival tags (Figure 5, left). Shark research using satellite tags is surprisingly widespread given its cost and deployment difficulties. However, satellite tags are arguably the best way to track high migratory shark species. White sharks (WSH), blue sharks (BSH) and shortfin mako (SMA) sharks are the species which have been most tagged with satellite tags according to the STAGIS database (Figure 5, right).

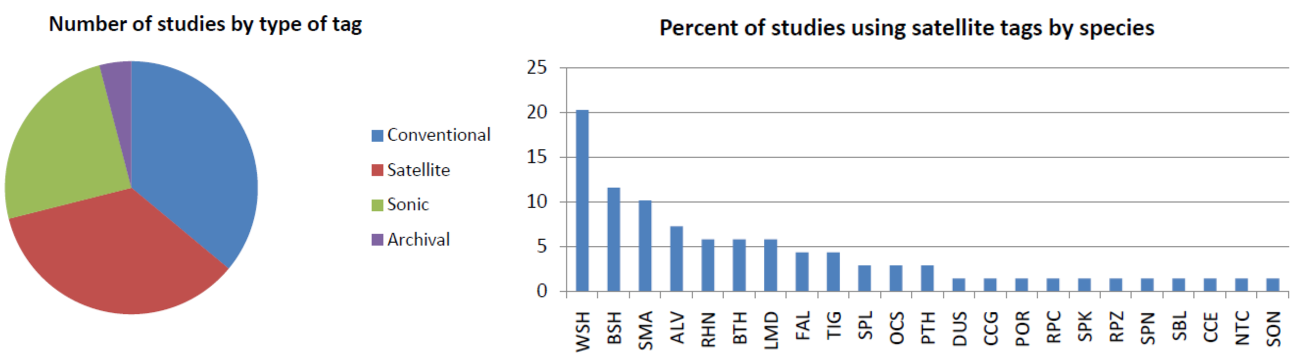


Figure 5. Relative numbers of studies contained in STAGIS by type of shark tag (left) and the number of studies using satellite tags by species (right, species identified by FAO species codes).

From Figure 6 it appears that conventional tagging is a largely outdated method, commonly used before 2000 but replaced by satellite tags over the last decade. Archival tags have also not been commonly deployed in recent years.

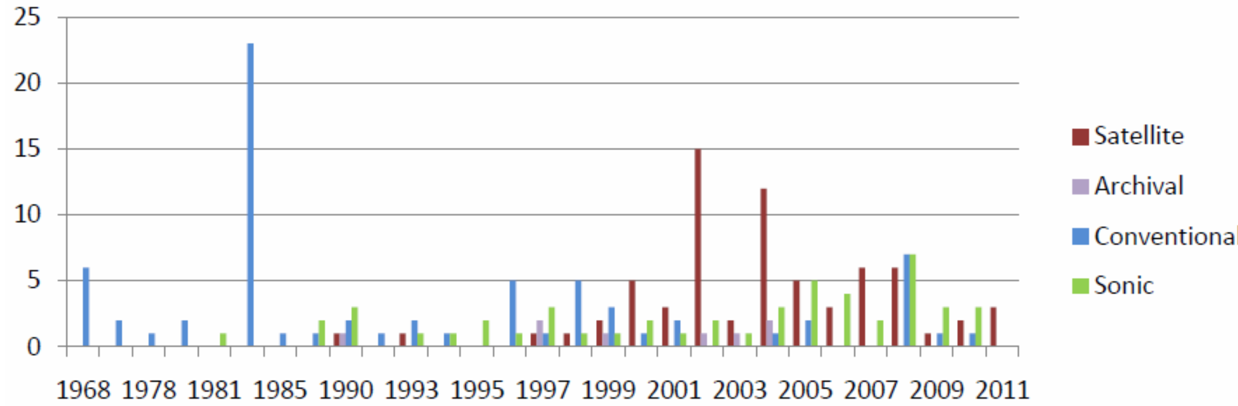


Figure 6. Number of Pacific shark tagging studies by type of tag and by year.

3.5 Conclusion

STAGIS provides a useful inventory of shark research using tags undertaken in the Pacific to date. It is hoped that STAGIS can help the scientific community of shark researchers to better understand the current status of shark tagging research in the Pacific and to more easily identify those researchers who share similar research interests. This should assist in developing collaborative projects and clearly identifying the priorities for future shark tagging research.

Despite the attempt to develop an information system which is as complete as possible, there may be omissions, inaccuracies or mistakes that have inadvertently been included in STAGIS. Users are therefore encouraged to provide feedback on the system as well as the data themselves, and to contribute new information to keep it a vibrant and useful tool.

In its current form STAGIS is a static system which does not allow direct user updating and editing. To preserve the ongoing usefulness of this system, it will need continuous updating and further development. Several areas recommended for further development are as follows:

- Add an online data capture component which would permit researchers to directly enter their data.
- Expand beyond metadata to store or link to actual tag data.
- Add a geographical component (e.g. GIS-based features) to better understand the spatial linkages and gaps between shark populations of different oceanic regions.

Other ideas for development are likely to arise from user feedback once STAGIS is launched.

4. Outlook for Stock Assessment of Silky and Oceanic Whitetip Sharks

This section outlines the intended approach for conducting the first full stock assessments for silky and oceanic whitetip sharks. It provides a schedule for the work, outlines likely sources of key data inputs, and reviews a suite of potential stock assessment modelling approaches that will be considered.

4.1 Scheduling

According to the SRP (Clarke and Harley 2010) the stock assessment for silky shark is scheduled for completion by the last quarter of 2011 and the stock assessment for oceanic whitetip shark by the middle of 2012. As the first opportunity for WCPFC review of these assessments will be SC8 in 2012, it is proposed that both assessments be undertaken in parallel, with preliminary results considered at the 2012 Pre-Assessment Workshop (PAW) that typically occurs in the first or second quarter of year, and final results presented to SC8. The SRP identifies blue and mako sharks as the next priority for assessment with these results presented at SC9. At this time it is anticipated that blue and mako stock assessments will be undertaken in parallel, following the assessment methods used for silky and oceanic whitetip sharks.

4.2 Model inputs

The key inputs for the stock assessments will be:

- Biological parameters
- Catch
- Catch Rate
- Size data (possibly)

Through the development of stock status indicators developed to inform preliminary stock status advice on the key shark species, considerable progress has been made towards identifying key data inputs for stock assessment.

4.2.1 Biological parameters

Annex 1 of Clarke and Harley (2010) contains estimates of the key biological characteristics for silky and oceanic whitetip sharks. We intend to further review the literature and contact key regional shark researchers to ensure that the broadest suite of parameter estimates is available for consideration. Particular care will be taken to ensure that the sources of estimates are known and do not represent ‘guesses’ or predictions based on other species. It is anticipated that there will not be a single conclusive set of parameter estimates, therefore an evaluation of uncertainty in the biological parameters will be an important part of the stock assessments.

4.2.2 Catch

Catch estimates for sharks are particularly difficult to obtain due to several reporting-related issues including under-reporting, mis-identification, and reporting of aggregated shark catches. At least two sources of catch estimates will be considered in the assessment: 1) models which estimate shark catch per unit effort (CPUE) based on observer data and then make predictions across commercial effort (e.g. Lawson 2011); and 2) trade-based catch estimates (e.g. Clarke 2009). Pacific-wide estimates of silky shark from Oshitani (2000) will also be considered.

Given that it is expected that shark CPUE will vary due to many factors (e.g. year, season, flag, and area) it is unlikely that current SPC data holdings will be able to fully cover the range of likely determinants. If other important sources of shark data are made available, then these could be included in an update of the work of Lawson (2011).

As with the biological parameters, there will not be a single conclusive set of catch estimates so an evaluation of uncertainty in the catch time series will be an important part of the stock assessments. There also exist stock assessment methods that do not require absolute levels of catch and these have previously been applied to shark stocks (Cortés et al. 2006).

4.2.3 Catch Rate

Indices of abundance will be a critical input to any stock assessment and through the development of indicators (Clarke et al. 2011a, 2011b; Walsh and Clarke 2011) several potential sources of abundance indices have been examined. CPUE based on commercial logsheets are unlikely to be used in the proposed assessments. Examination of Japanese operational level data (Clarke et al. 2011a) suggest concerns in the determination of reporting rates in the key areas where these two shark species are found. This could still be the focus of further research to determine if some of this data could in fact be used to derive abundance indices. There are no other fleets operating in the tropical and subtropical areas that have been reporting species-specific catches on their logsheets, though this will improve in the future due to changes to the regional longline logsheet.

The investigation of the Japanese training and research vessel database (RTV) provides a potentially important data source for deriving abundance indices. Clarke et al. (2011a) derived standardised abundance indices for silky and oceanic whitetip for the north and tropical central Pacific Ocean. Analyses have indicated that reporting rates are generally very high, but Clarke et al. (2011a) did express some concern about a dip in the reporting rate (proportion of sets to report a shark) in the most recent years, and it is not yet known if this represents a change in reporting practices or a decrease in the abundance of sharks. It would be valuable if this data source was available for further analysis.

Walsh and Clarke (2011) constructed standardised abundance indices based on observer data held by the United States for the Hawaii-based longline fishery. It would also be valuable if this data source can be made available for further analysis.

SPC-held observer data for purse seine and longline data were analyzed by Clarke et al. (2011b). Standardised CPUE indices were developed for the longline fleet while nominal CPUE series were calculated for the purse seine fleet. These data primarily cover the equatorial distribution of the two species.

Using these data sources there will be two further pieces of work required to construct the final indices for the assessments. First, Clarke et al (2011a, 2011b) focused on using a set of consistent modeling approaches in developing the indicators for the preliminary stock status advice and acknowledged that the models used might not necessarily be the best model for a given species and region. Using the existing models and diagnostic results as a starting point, we plan to examine alternative statistical modelling approaches (within the standard suite of generalized linear and additive models) to refine both point estimates and the associated standard errors. Second, indices will need to be calculated over the region(s) that are assumed for the assessment and these will be determined as part of the assessment process but greatly informed by the work of Clarke et al. (2011a; 2011b) and Lawson (2011).

4.3 Assessment methods

Manning et al. (2009) and Clarke and Harley (2010) provide a general discussion of potential methods for conducting shark stock assessments. Whilst some assessments have been conducted using complex age structured statistical models (e.g. Harley 2002, Apostolaki et al. 2005, and Kleiber et al. 2009), most have been undertaken using surplus production models (see Bonfil 2004 and references therein) or simple age structured models.

As noted in Clarke and Harley (2010), we intend to consider multiple structural models for the silky and oceanic whitetip shark stock assessments. At least two structurally different models will be used for each species – the first will be a Schaefer(Schaefer 1954) or Pella-Tomlinson (Pella and Tomlinson 1969) surplus production model, and the second will be an age-structured model that can more explicitly incorporate the biological characteristics of each species. The age-structured model chosen will depend on the quality of the available input data, but will likely be one of the following:

- Age-structured production model (ASPM): noting that state-space and catch-free variants have recently been applied to sandbar, dusky, and blacknose shark stocks in the southeast US[6] These variants allow uncertainty in the catch series and have a biological structure for compensation than fits well with shark biology.
- MULTIFAN-CL: this was one of the methodologies applied by Kleiber et al. (2009).
- Stock Synthesis (SS): the IATTC proposes to apply this methodology for their assessments of silky and oceanic whitetip sharks and SS has recently been enhanced to allow for compensatory dynamics more similar to those thought to occur for sharks.

For the production models, the application of Bayesian approaches will be critical, especially in the development of priors for the productivity parameters (McAllister et al. 2001). Without strong external information, production models when fitting to CPUE series can produce estimates of key productivity parameters which might not lie in the plausible range for shark species.

4.4 Collaboration with IATTC and others

Collaboration with the IATTC was highlighted in the WCPFC shark Conservation and Management Measure (CMM 2010-07). It is our intention to construct stock assessment models that apply to the WCPO region in the first instance and then collaborate with the IATTC in the construction of a Pacific-wide assessment model. Any Pacific-wide assessment will most likely be conducted with Stock Synthesis as this is the platform that the IATTC propose to use for their assessments.

[6] http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=21

In addition to collaboration with the IATTC, we believe that these two assessments would benefit from the inclusion of abundance indices derived from the Japanese RTV and Hawaiian observer databases. Indices have been derived for these data sources, but further refinement could be of use.

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Table A1. Commission data holdings for blue shark (BSH) as compiled by SPC-OFP as of 22 July 2011. Values of average annual catch estimates are in metric tonnes. Zero catch and no reported catch are not distinguished.

		FISHERY		ANNUAL CATCH ESTIMATES			AGGREGATE DATA			OPERATIONAL DATA			SIZE DATA		
GEAR	FLAG	FROM	TO	FROM	TO	AVG. CATCH	FROM	TO	CATCH RECS	FROM	TO	CATCH RECS	FROM	TO	SAMPLES
L	AU	1985	2010	1991	2010	48	1991	2010	1,947	1991	2010	30,679	2008	2008	28
L	BZ	1995	2010				2010	2010	4						
L	CK	1994	2010				2002	2004	24	2002	2004	63	1995	2008	5
L	CN	1988	2010	2010	2010	506	2010	2010	199				1993	2008	2,783
L	ES	2004	2010												
L	FJ	1989	2010				2006	2010	31	2006	2010	80	1994	2010	2,606
L	FM	1991	2010										1994	2008	862
L	ID	1978	2010												
L	JP	1960	2010	2006	2010	8518	1994	2009	6,837				1989	2008	23,468
L	KI	1995	2008										2008	2008	7
L	KR	1960	2010										1992	2007	569
L	MH	1992	2010										2008	2008	41
L	NC	1983	2010				1996	1997	12	1996	1997	96	1996	2010	651
L	NR	2000	2004												
L	NU	2005	2010												
L	NZ	1987	2010	2000	2010	781	1989	2010	1,297	1989	2010	36,838	1994	2008	8,913
L	PF	1990	2010										1997	2010	494
L	PG	1993	2010				1998	2003	74	1998	2003	848	2001	2008	388
L	PH	1970	2010												
L	PW	1992	2004										2000	2000	1
L	SB	1973	2010										1996	2004	271
L	SN	2005	2007				2006	2007	65						
L	TO	1982	2010				2007	2007	1	2002	2007	17	1995	2010	644
L	TW	1960	2010	2009	2010	12985	1997	2010	1,092				1993	2010	1,718
L	US-AS	1988	2010	2006	2010	1	2005	2010	321				2002	2002	2
L	US-HW	1960	2010	2005	2010	12	2005	2010	1,083				1994	2004	301
L	US-MC	1991	2000										2004	2004	2
L	VU	1995	2010				2009	2009	1	2009	2009	1	2009	2010	60
L	WS	1993	2010				2007	2010	4	2007	2010	5	2001	2010	10

Table A2. Commission data holdings for mako sharks (SMA, LMA, MAK) as compiled by SPC-OFP as of 22 July 2011. Values of average annual catch estimates are in metric tonnes. Zero catch and no reported catch are not distinguished.

		FISHERY		ANNUAL CATCH ESTIMATES			AGGREGATE DATA			OPERATIONAL DATA			SIZE DATA		
GEAR	FLAG	FROM	TO	FROM	TO	AVG. CATCH	FROM	TO	CATCH RECS	FROM	TO	CATCH RECS	FROM	TO	SAMPLES
L	AU	1985	2010	1996	2010	78	1986	2010	2,053	1986	2010	25,867			
L	BZ	1995	2010				2004	2006	21						
L	CK	1994	2010				2002	2010	317	2002	2010	1,242			
L	CN	1988	2010	2010	2010	133	2002	2010	596						
L	ES	2004	2010												
L	FJ	1989	2010				1997	2010	1,116	1997	2010	8,818			
L	FM	1991	2010				2003	2010	141	2003	2010	662			
L	ID	1978	2010												
L	JP	1960	2010	2006	2010	626	1994	2010	6,746						
L	KI	1995	2008												
L	KR	1960	2010												
L	MH	1992	2010				2004	2009	41	2004	2009	128			
L	NC	1983	2010	2001	2010	22	1998	2010	263	1998	2010	1,790			
L	NR	2000	2004												
L	NU	2005	2010				2005	2007	13	2005	2007	29			
L	NZ	1987	2010	2000	2010	131	1991	2010	1,066	1991	2010	17,193			
L	PF	1990	2010				1993	2010	971	1993	2010	4,080			
L	PG	1993	2010				1997	2004	8	1997	2004	16			
L	PH	1970	2010												
L	PW	1992	2004												
L	SB	1973	2010												
L	SN	2005	2007				2006	2007	68						
L	TO	1982	2010				2002	2010	139	2002	2010	454			
L	TW	1960	2010	2009	2010	793	1995	2010	1,074						
L	US-AS	1988	2010	2006	2006	1	2005	2010	229						
L	US-HW	1960	2010	2005	2010	98	2005	2010	956						
L	US-MC	1991	2000				2008	2008	9						
L	VU	1995	2010				2002	2010	535	2002	2010	2,425			
L	WS	1993	2010				1998	2007	4	1998	2007	5			

Table A3. Commission data holdings for oceanic whitetip shark (OCS) as compiled by SPC-OFP as of 22 July 2011. Values of average annual catch estimates are in metric tonnes. Zero catch and no reported catch are not distinguished.

		FISHERY		ANNUAL CATCH ESTIMATES			AGGREGATE DATA			OPERATIONAL DATA			SIZE DATA		
GEAR	FLAG	FROM	TO	FROM	TO	AVG. CATCH	FROM	TO	CATCH RECS	FROM	TO	CATCH RECS	FROM	TO	SAMPLES
L	AU	1985	2010	1998	2010	10	1997	2010	1,084	1997	2010	5,301	2008	2008	5
L	BZ	1995	2010												
L	CK	1994	2010												
L	CN	1988	2010	2010	2010	532	2010	2010	180				1993	2009	687
L	ES	2004	2010												
L	FJ	1989	2010										1995	2010	943
L	FM	1991	2010										2001	2008	126
L	ID	1978	2010												
L	JP	1960	2010										1996	2005	62
L	KI	1995	2008										2008	2008	3
L	KR	1960	2010										1992	2006	230
L	MH	1992	2010										2008	2008	7
L	NC	1983	2010										1996	2010	79
L	NR	2000	2004												
L	NU	2005	2010												
L	NZ	1987	2010				2001	2008	2	2001	2008	2	1998	2008	7
L	PF	1990	2010										1997	2010	255
L	PG	1993	2010										1999	2008	1,061
L	PH	1970	2010												
L	PW	1992	2004												
L	SB	1973	2010										1996	2004	208
L	SN	2005	2007												
L	TO	1982	2010				2007	2007	1	2007	2007	2	1995	2009	424
L	TW	1960	2010	2009	2010	89	2008	2010	697				1993	2009	883
L	US-AS	1988	2010				2005	2010	269				2002	2002	5
L	US-HW	1960	2010				2005	2010	586				1995	2001	6
L	US-MC	1991	2000										2004	2004	4
L	VU	1995	2010										2009	2010	39
L	WS	1993	2010				2007	2010	2	2007	2010	4	2001	2010	9

Table A4. Commission data holdings for silky shark (FAL) as compiled by SPC-OFP as of 22 July 2011. Values of average annual catch estimates are in metric tonnes. Zero catch and no reported catch are not distinguished.

		FISHERY		ANNUAL CATCH ESTIMATES			AGGREGATE DATA			OPERATIONAL DATA			SIZE DATA		
GEAR	FLAG	FROM	TO	FROM	TO	AVG. CATCH	FROM	TO	CATCH RECS	FROM	TO	CATCH RECS	FROM	TO	SAMPLES
L	AU	1985	2010	2006	2007	2	2001	2010	123	2001	2010	247	2008	2008	12
L	BZ	1995	2010												
L	CK	1994	2010												
L	CN	1988	2010										1995	2009	2,712
L	ES	2004	2010												
L	FJ	1989	2010										1995	2010	963
L	FM	1991	2010										1995	2008	464
L	ID	1978	2010												
L	JP	1960	2010										1995	2009	171
L	KI	1995	2008												
L	KR	1960	2010										1998	2007	256
L	MH	1992	2010										2008	2008	38
L	NC	1983	2010										1996	2010	127
L	NR	2000	2004												
L	NU	2005	2010												
L	NZ	1987	2010										2007	2007	1
L	PF	1990	2010										1997	2010	105
L	PG	1993	2010										1996	2008	30,101
L	PH	1970	2010												
L	PW	1992	2004												
L	SB	1973	2010										1996	2004	362
L	SN	2005	2007												
L	TO	1982	2010										1998	2009	179
L	TW	1960	2010	2009	2010	689	2008	2010	1,029				1995	2010	5,821
L	US-AS	1988	2010				2006	2010	72				2002	2002	5
L	US-HW	1960	2010				2005	2010	103				1994	2000	3
L	US-MC	1991	2000												
L	VU	1995	2010										2009	2010	171
L	WS	1993	2010				1998	2010	26	1998	2010	59	2000	2010	2

Table A5. Commission data holdings for thresher sharks (ALV, BTH, PTH, THR) as compiled by SPC-OFP as of 22 July 2011. Values of average annual catch estimates are in metric tonnes. Zero catch and no reported catch are not distinguished.

		FISHERY		ANNUAL CATCH ESTIMATES			AGGREGATE DATA			OPERATIONAL DATA			SIZE DATA		
GEAR	FLAG	FROM	TO	FROM	TO	AVG. CATCH	FROM	TO	CATCH RECS	FROM	TO	CATCH RECS	FROM	TO	SAMPLES
L	AU	1985	2010	2005	2005	1	2007	2010	141	1996	2010	1,506			
L	BZ	1995	2010												
L	CK	1994	2010												
L	CN	1988	2010												
L	ES	2004	2010												
L	FJ	1989	2010				2002	2003	2	2002	2003	2			
L	FM	1991	2010												
L	ID	1978	2010												
L	JP	1960	2010	2007	2010	5									
L	KI	1995	2008												
L	KR	1960	2010												
L	MH	1992	2010												
L	NC	1983	2010												
L	NR	2000	2004												
L	NU	2005	2010												
L	NZ	1987	2010	2000	2010	41	2007	2010	60	1991	2010	2,009			
L	PF	1990	2010												
L	PG	1993	2010				1997	1997	1	1997	1997	1			
L	PH	1970	2010												
L	PW	1992	2004												
L	SB	1973	2010												
L	SN	2005	2007												
L	TO	1982	2010												
L	TW	1960	2010	2009	2010	563	2008	2010	560						
L	US-AS	1988	2010				2005	2010	231						
L	US-HW	1960	2010	2005	2010	32	2005	2010	900						
L	US-MC	1991	2000												
L	VU	1995	2010												
L	WS	1993	2010				1998	2000	68	1998	2000	507			