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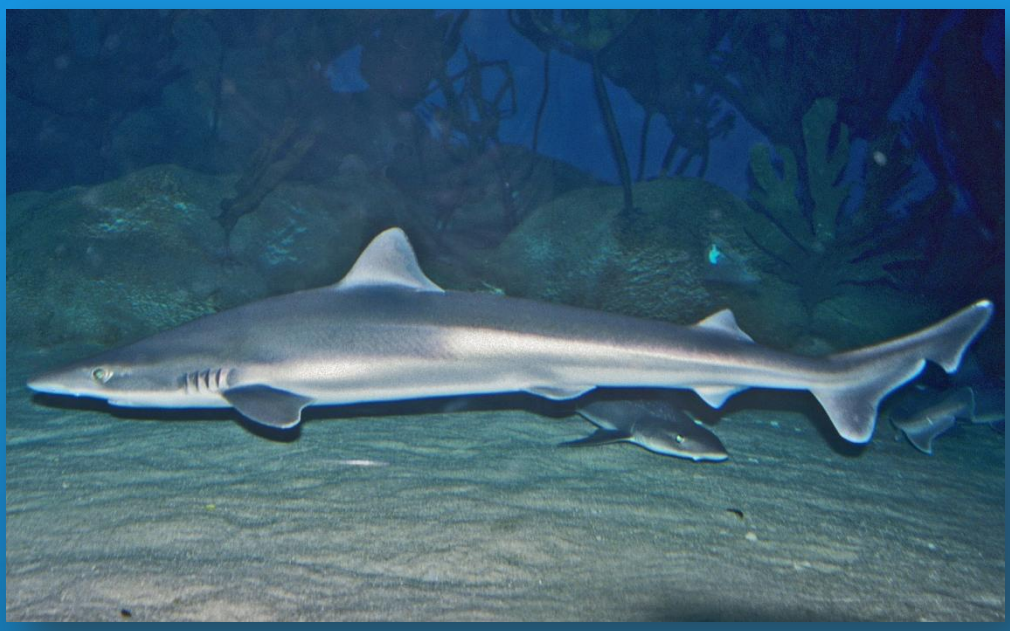
Determining the most suitable index of abundance for school shark (*Galeorhinus galeus*) stock assessment: review and future directions to ensure best recovery estimates



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April 2013

Final Report to the Fisheries Research and Development Corporation
FRDC TRF Shark Futures 2011/078

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OBJECTIVES:

1. Identify key scientists able to provide advice regarding suitable indices of abundance for school shark;
2. Organise a 2-day workshop to foster discussion about an index of abundance for the Southern and Eastern Scalefish and Shark Fishery school shark stock;
3. Discuss the limitations of the current stock assessment for school shark and the perceived discrepancies between model output and field observations;
4. Consider and assess alternative indices of abundance for school shark to input into the stock assessment model.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED TO DATE

Several recommendations resulting from the workshop have been taken up by the Shark Resource Assessment Group (RAG), which will lead to an improved stock assessment, based on a more accurate index of abundance. A review of the rebuilding timeframe was also recommended and the Shark RAG has determined that this will be completed for the revised recovery plan due in 2013. Combined, these will improve confidence in the stock assessment, and enable better monitoring of how school shark stocks are changing against the objective of the rebuilding strategy. This will allow the condition in the SESSF WTO related to the recovery of the school shark stock to be accurately evaluated.

In 2007, the biomass of school shark (*Galeorhinus galeus*) was estimated at 9–14% of original pup production levels, leading school sharks to be considered overfished and being listed as Conservation Dependent under the *Environment Protection and Biodiversity Conservation Act* (1999). The rebuilding strategy ensuing from this listing requires school shark stocks in the area of the Southern and Eastern Scalefish and Shark Fishery to recover to the limit reference biomass level (B_{20}) within a biologically

reasonable timeframe, and having reached B_{20}, rebuild school shark stocks in the area of the Southern and Eastern Scalefish and Shark Fishery to the target biomass level (B_{40}) within a biologically reasonable timeframe. Management measures in the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) to implement the rebuilding strategy and reduce catch levels have altered the fishing pattern so that the traditional catch-per-unit-effort (CPUE) index of abundance can no longer be relied on as an index of stock size for school shark.

A two-day workshop was organised to foster discussion about developing a new index of abundance for the SESSF school shark stock; to identify the potential issues leading to discrepancies between model output and field observations; and to assess alternative indices of abundance for school shark to input into the stock assessment model. The workshop was attended by 18 participants including Shark Resource Assessment Group (RAG) members and chair, the South East Management Advisory Committee (SEMAC) chair, the Australian Fisheries Management Authority (AFMA) fisheries branch director, the AFMA SESSF manager, scientists, modellers, and gillnet, trawl and auto-longline industry representatives.

The suitability of available datasets as indices of abundance was assessed, with the first-shot survey and the SESSF trawl fishery-independent survey being the most promising. Coefficients of variation (CV) were, however, large so that the scope for reducing the CV to a suitable level should be assessed prior to use in the stock assessment. Fixed-station surveys were highlighted as having potential, but are unlikely to be viable on an annual basis due to their high cost. Fixed-station surveys are a possible longer-term solution (e.g. every 10 years).

A rebuilding timeframe of one generation time plus 10 years is not biologically achievable, even in the absence of any fishing mortality. Therefore, feasible timeframes need to be calculated. It was recommended that the minimum unavoidable bycatch of school shark from the SESSF be used as the total allowable catch, provided this allows recovery of the stock. The rebuilding timeframe should be the time associated with this level of catch. In the meantime, there should be:

a) Ongoing development of the stock assessment by the Shark RAG, based on a more accurate index of abundance and taking account of other important aspects (e.g. movement); and

b) Development of an alternative monitoring program for the school shark stock using a 'Tier 5' type of assessment, with standardisation of the reported catch-per-unit-effort time-series from gillnet and trawl sectors being compared to suitable reference points.

KEYWORDS: School shark, stock assessment, index of abundance.

1 ACKNOWLEDGMENTS

Workshop participants are thanked for their time and contribution during the two-day meeting. Erik Raudzens helped with the logistic of the workshop organisation. Nick Rayns is thanked for the effective chairing of the workshop, while André Punt provided constructive comments and valuable insight into the history of the school shark model throughout the preparation for the workshop. 2011/078 Tactical Research Fund: Shark Futures - determining the most suitable index of abundance for the school shark (*Galeorhinus galeus*) stock assessment: review and future directions to ensure best recovery estimates is supported by funding from the FRDC on behalf of the Australian Government.

2 BACKGROUND

School shark (*Galeorhinus galeus*) is a commercially fished species that is primarily caught in the Gillnet, Hook and Trap (GHAT) sector of the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF). This species is also caught in various state fisheries across its range (Western Australia, South Australia, Victoria, Tasmania, and New South Wales). In 2000, the responsibility for the management of school shark in South Australia, Victoria and Tasmania was transferred to the Commonwealth with the signing of the Offshore Constitutional Settlement (OCS). Following the signing of the OCS, complementary management arrangements were introduced in the participating states to limit the take of school and gummy shark (*Mustelus antarcticus*) by state-only licence holders. For example, South Australian state-only licence holders are entitled to take no more than a combined total of five school or gummy shark in any one day from internal or coastal waters.

School shark were historically targeted on longlines, but the GHAT is now primarily a gillnet fishery that targets gummy shark, with school shark taken as bycatch. As a key commercial species caught within a Commonwealth fishery, the management of school shark falls under the Commonwealth Government Fisheries Harvest Strategy Policy; an overarching policy for sustainable commercial fisheries management that is based on a series of biological reference points (DAFF, 2007). While school shark is no longer targeted within the SESSF, the Harvest Strategy Policy considers that it is a key commercial species because it has previously been targeted and was historically considered a significant component of the fishery.

Since 1992, school shark stocks have been assessed as overfished in Australia. In 1997, maximum gillnet mesh size was reduced from 200 mm to 165 mm to prevent targeting of adult school shark, reducing catches from about 1,000 to 400 tonnes per annum. The current total allowable catch (TAC) system was introduced in 2001 for school shark and gummy shark to eliminate the targeting of school shark and manage the landings of school shark caught incidentally by fishers targeting gummy shark. The TAC for school shark was steadily decreased from 434 tonnes on introduction to 240 tonnes in 2007 (McLoughlin, 2007). A TAC of 240 tonnes was the level estimated at the time to be the unavoidable incidental catch from the gummy shark fishery, and was considered by the Shark Resource Assessment Group (Shark RAG) to be

sufficient to promote recovery of school shark (Shark FAG, 2002). Since then, the best available estimate of unavoidable bycatch is around 156 tonnes, and the school shark TAC was progressively reduced to 150 tonnes in 2012. The estimated unavoidable bycatch was based on Dr Neil Klaer's (CSIRO) report *Species associations and companion TACs in the SESSF* (Klaer and Smith, 2008), and Dr Haddon's analysis for Shark RAG in November 2009 and January 2010 (SESSF school shark workshop minutes).

In 2007, stock size of school sharks was estimated at between 9–14% of original pup production levels (McLoughlin, 2007), leading school sharks to be considered overfished and listed as Conservation Dependent under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. Under such a listing, a stock rebuilding strategy was developed and implemented as a condition of the SESSF Wildlife Trade Operation (WTO) accreditation. The objectives of this rebuilding strategy state that school shark stocks in the area of the Southern and Eastern Scalefish and Shark Fishery have to recover to the limit reference biomass level (B_{20}) within a biologically reasonable timeframe, and having reached B_{20}, rebuild school shark stocks in the area of the Southern and Eastern Scalefish and Shark Fishery to the target biomass level (B_{40}) within a biologically reasonable timeframe (AFMA, 2008). The ratio of maximum sustainable yield to the adult population was estimated by the Shark RAG to be approximately 4–5% (Punt and Pribac, 2001). The stock assessment model suggested that the school shark stock was unlikely to recover to the reference biomass level within the necessary timeframe leading to the TAC for incidental take of the species being progressively reduced to 150 tonnes, well below the sustainable yield estimated by the Shark RAG. Current models still suggest that, at this level of catch, school shark stocks will not rebuild within the period required of one generation time plus 10 years (Thomson and Punt 2009).

Since the newer goal set to rebuild the stock within a generation time plus 10 years is much more ambitious than the previous objective to rebuild the stock, TAC reduction has been necessary. Some members of the fishing industry have misunderstood that this reduction is implemented because rebuilding is not thought to be occurring, although the actual aim is to achieve faster rebuilding. This misinterpretation has led

some to deem the apparent signs of rebuilding as contradictory to the need for TAC reduction.

3 NEED

Management of the school shark stock aimed at reducing catch levels has altered the fishing pattern so that the traditional catch-per-unit-effort (CPUE) index of abundance can no longer be relied on as an index of stock size. The stock assessment model is therefore unable to be used to provide up-to-date information on the productivity of the stock. As a result, it cannot be reliably identified whether stock rebuilding is occurring at a different rate than predicted. Such uncertainty associated with the school shark assessment has to a significant extent hampered the South East Management Advisory Committee's (SEMAC) management arrangements for this species. A valid index of abundance that will reveal current trends in stock status is required.

4 OBJECTIVES

Specifically, the objectives were to:

1. Identify key scientists able to provide advice regarding suitable indices of abundance for school shark;
2. Organise a two-day workshop to foster discussion about an index of abundance for the SESSF school shark stock;
3. Discuss the current stock assessment for school shark and the perceived discrepancies between model output and field observations;
4. Consider and assess alternative indices of abundance for school shark to input into the stock assessment model.

5 METHODS

The project was carried out in four phases to ensure efficient running of the workshop and that practical outcomes were reached.

Phase 1: Identify key scientists able to provide advice regarding suitable indices of abundance and attend the workshop (Objective 1).

Phase 2: Appointment of a meeting chair and organisation of a consultation process with all stakeholders (Objective 2).

Phase 3: Development of assessment criteria and preliminary assessments of the main alternative datasets potentially suitable as indices of abundance (Objective 4).

Phase 4: Two-day workshop to foster discussion about potential alternative indices of abundance for the SESSF school shark stock assessment and other related issues (Objectives 2–4).

5.1 Phase 1

The identification of the key scientists and main stakeholders was first undertaken by the project principal investigator (PI) based on members of the Shark RAG, and authors from current literature and documents about the SESSF and the issues of risk assessment for bycatch of data poor species. The list of potential workshop participants was then forwarded to key scientists and stakeholders selected for their knowledge of the issue which the workshop aimed to address. The list of proposed participants was sent to Dr Colin Simpfendorfer (Shark RAG chair, scientist), Robin Thomson (scientist undertaking the school shark stock assessment and Commonwealth Scientific and Industrial Research Organisation (CSIRO) representative), George Day (SESSF manager and Australian Fisheries Management Authority (AFMA) representative), and Ian Knuckey (scientist with collaborations with industry stakeholders). The industry representatives selected by this group of people (Anthony Ciconte, David Stone, Brian Bailey, Stephen Brockwell and Kyriakos Toumazos) were contacted to ensure that the key industry associations and stakeholders were represented. This workshop was not meant to be an open meeting.

5.2 Phase 2

Following advice from the Fisheries Research and Development Corporation (FRDC), the Shark RAG chair, and AFMA, the AFMA Fisheries Branch Director, Dr Nick Rayns, was nominated to chair the workshop. Once the chair had been appointed, a consultation process was organised to ensure effective chairing of the workshop and that practical outcomes would be reached (Appendix 4).

5.3 Phase 3

As an outcome of the consultation process with scientific participants, it was recommended to develop assessment criteria to objectively assess the suitability of alternative datasets as indices of abundance. These indices were first developed by the project PI in consultation with Dr Robin Thomson who currently undertakes the school shark stock assessment and Dr Colin Simpfendorfer (Shark RAG chair), and were then forwarded to all industry representatives. These criteria were used to complete a dataset summary following a template provided by the project PI. Each dataset summary was provided to the participants of the workshop a week prior to the meeting to present background information and ensure preliminary knowledge of the datasets that were going to be discussed.

5.4 Phase 4

A two-day workshop was organised with relevant scientists and stakeholders to consider and assess alternative indices of abundance for school shark to input into the stock assessment model. The first day was designed to introduce the aim of the workshop, the issues that have led to the need for this workshop, and to assess the suitability of alternative datasets. The alternative datasets or methods which were assessed were:

- Fixed-station surveys;
- Great Australian Bight (GAB) Trawl Fishery-Independent Survey (FIS);
- SESSF Trawl FIS;
- First-shot surveys;
- SESSF and Integrated Scientific Monitoring Program (ISMP) records;
- Catches from New Zealand; and
- Catches from the recent auto-longline trials.

The first part of day one was used to obtain an overview of the issues encountered with the school shark stock assessment from the perspective of AFMA, the Shark RAG chair, CSIRO, and industry, and discuss the issues related to the intrinsically slow reproductive potential of school sharks and how this impacts on the ability to monitor recovery. During, the second and largest part of day one, each alternative dataset was reviewed and discussed based on the summaries provided (when available) and presentations carried out by the person who collected or analysed the data. Considering the complexity of the Australian school shark stock, time was also allocated to allow discussions about the movement of school sharks and its likely impacts on the stock assessment. Day one ended with a summary of the discussions that took place and the identification of the points of focus for day two.

Day two was divided into four topics based on the outcomes of day one:
1) Harvest strategy policy and how it impacts the management and TAC allocation of school shark catches.
2) Following day one's reviews and discussions, what is the best alternative index of abundance for the Tier 1[1] assessment?
3) Until sufficient and reliable data becomes available for Tier 1 assessment, how should the school shark catches be managed?
4) What evidence do we currently have to suggest that school shark stocks are recovering?
At the end of day two, industry members and scientists independently reflected on the meeting and discussed the main outcomes to provide a final position on the issue.

Following the school shark workshop, some time was allocated during the first day of the Shark RAG meeting to summarise the outcomes of the workshop and provide final recommendations.

[1] The SESSF Harvest Strategy Framework uses a three tier approach designed to apply different types of assessments and cater for the different amount of data available for different stocks. Tier 1 represents the highest quality of information available (i.e. a robust quantitative stock assessment) and Tier 4 the lowest. The previous Tier 2 analysis, which applied to species and/or stocks which have a less robust quantitative assessment, is no longer being used.

6 RESULTS/DISCUSSION

6.1 Phase 1

Twenty people were identified as being relevant to achieving the goals of the workshop and invited to attend (Table 1).

Table 1. List of relevant people invited to attend the school shark workshop

Scientist / Stakeholder	Relevance to the workshop
Dr Nick Rayns	AFMA Fisheries branch director and workshop chair
Dr Charlie Huveneers	Workshop principal investigator and South Australian representative
Mr George Day	AFMA SESSF manager
Dr Colin Simpfendorfer	Shark RAG Chair and scientist
Dr Robin Thomson	Shark RAG scientist member and scientist undertaking school shark stock assessment modelling
Dr Malcolm Haddon	Scientist contributing to the school shark stock assessment models and estimation of unavoidable bycatch
Dr Miriana Sporcic	Scientist contributing to the school shark stock assessment models
Dr Terry Walker	Shark RAG scientist member and principal investigator of the fixed-station surveys
Dr Jeremy Prince	Shark RAG scientist member and principal investigator of first-shot survey trials
Dr Rory McAuley	Shark RAG scientist member and Western Australian representative
Dr Ian Knuckey	Scientist and principal investigator of the GAB trawl and SESSF trawl fishery-independent survey, and the auto-longline trials
Dr André Punt	Scientist, previous Shark RAG member and chair and former scientist undertaking school shark stock assessment modeling
Dr Malcom Francis	Scientist from National Institute of Water and Atmospheric Research (NIWA), New Zealand who has undertaken several studies on school sharks including analyses of catch data, movement, and stock structure
Mr David Stone	Shark RAG industry member and Sustainable Shark Fishery Inc. Executive Officer
Mr Kyriakos Toumazos	Shark RAG industry member
Mr Simon Boag	Trawl fishery industry member and Executive officer of the South East Trawl Fishing Industry Association (SETFIA)
Mr Anthony Ciconte	Gillnet fishery industry member and Southern Shark Industry Alliance Executive Officer
Mr Steven Brockwell	Shark RAG industry member
Mr Brian Bailey	Shark RAG industry member

Out of these 20 invitees, Mr Anthony Ciconte, Dr. Rory McAuley, and Dr André Punt could not attend, and Dr Robin Thomson attended via phone conference. Mr Michael

Miriklis attended the workshop on behalf of Mr Simon Boag to represent SETFIA and the trawl industry. In addition, Mr Steve McCormack (SEMAC chair) attended the first day of the workshop and Mr John Jarvis (trawling industry member) attended the second afternoon of the workshop to provide some information from the southeast trawl industry perspective.

6.2 Phase 2

As part of the consultation process, the workshop chair (Dr Nick Rayns) and SESSF managers (Mr George Day and Mr Brad Milic) met with CSIRO scientists (Drs Malcolm Haddon, André Punt, Miriana Sporcic and Jeff Tuck) on 30/07/2012. During the meeting, Dr André Punt described the current school shark assessment model and how it was altered in 1996 due to the change in school shark targeting. Dr Punt noted difficulties with school shark data after 2000, because school shark was no longer targeted in any part of the fishery. Dr Punt indicated that a model including CPUE may provide indications of trends, but that the reliability of the CPUE data is questionable if the fishery targeting level changes (as has happened for school shark). The proposed potential alternative indices of abundance were also discussed. Although most of the datasets were worth considering, and some could be long-term solutions for the stock assessment model if correctly implemented, there was unlikely to be any alternative index of abundance readily available.

A phone meeting was organised between the workshop chair (Dr Nick Rayns) and SESSF manager (Mr George Day) and the other scientists participating in the workshop (Drs Charlie Huveneers, Malcolm Haddon, Ian Knuckey, Terry Walker and Malcolm Francis) on 21/08/2012. The assessment criteria for the suitability of alternative datasets as indices of abundance were discussed to ensure that the relevant characteristics were going to be considered during the workshop. It was also suggested to produce a summary for each dataset based on the assessment criteria and provide them to the participants prior to the workshop.

Finally, the workshop chair (Dr Nick Rayns) met with industry representatives (Mr David Stone, Shane Duggins and Graeme Cottee) by telephone on 24/08/2012. Industry members discussed their observations of increased numbers of school shark, particularly juveniles. Changes in fishing behaviour to avoid school shark catches and

the potential impact on the stock assessment model were discussed. Alternative assessment approaches such as the 'first-shot survey' and close kin surveys were raised for further consideration at the workshop.

6.3 Phase 3

Following consultation with the scientific participants of the workshop, the below criteria were developed to assess the suitability of each dataset as a potential alternative index of abundance:

- *Length of time series*: How long has the dataset been collected for and is data collection likely to be continuing?
- *Frequency of data collection:* How often is the data collected, or was it part of a one-off survey?
- *Consistency throughout data collection:* Have there been any changes in the way the dataset has been collected (e.g., management changes, fishing practices, targeting behaviour)?
- *Spatial extent of dataset:* What is the geographic range sampled by the dataset?
- *Size & sex distribution:* Does the dataset account for sex and size aggregation of school shark and specific life stages?
- *Variance of the data:* What is the error/variance (low, medium or high) in the school shark abundance estimates (e.g., as a result of sample size, number of stations, numbers of sharks caught, measurement error, fisher behaviour)?
- *Incorporation within the stock assessment model:* Assess the ability to incorporate the dataset as an index of abundance into the stock assessment model.
- *Flexibility of the dataset or model:* Can the dataset or the model be modified to enable the use of the dataset as an index of abundance within the model?
- *Costs:* What are the estimated costs associated with collecting this dataset?

A summary assessing each dataset against these criteria was provided for the fixed-station survey, first-shot survey, GAB Trawl FIS, SESSF Trawl FIS, Auto-longline, and New Zealand catches. All summaries were combined into one document (Appendix 5) and provided to workshop participants prior to the meeting.

6.4 Phase 4

The two-day workshop took place in Melbourne on the 3/09/12 and 4/09/12 prior to a Shark RAG meeting (5/09/12-6/09/12). The workshop was attended by 18 participants including Shark RAG members and chair, the SEMAC chair, the AFMA fisheries branch director, the AFMA SESSF manager, scientists, modellers, and gillnet and trawl industry representatives.

6.4.1 Summary of discussions

6.4.1.1 Position on the problem and stakeholder opinions

Dr Colin Simpfendorfer (Shark RAG chair) opened the workshop and saw it as an opportunity to better understand the datasets available as a potential alternative index of abundance and to reconcile the information from fishers with the output of the school shark stock assessment model.

Dr Robin Thomson (CSIRO, scientist undertaking school shark stock assessment) expressed that while it was perceived that the model does not show recovery, the output actually suggests that recovery ought to be occurring. However, the CPUE currently used in the model is becoming increasingly unreliable as an index of abundance due to changes in targeting practices. Essentially, the model is the 1997 assessment, merely extrapolated forward given the catches known to have been taken. The workshop was an opportunity to find alternative time-series of abundance or to recommend a program to collect such data, allowing a more recent assessment of the status and productivity of the stock.

The industry members (Stephen Brockwell, Kyri Toumazos, Brian Bailey, and Michael Miriklis) expressed concern that while the model suggested recovery (albeit slow), the TAC continues to be reduced. Although the model only suggests a slow recovery, the industry members provided examples of recent high school shark catches in various areas as evidence for school shark recovering at a higher rate than predicted by the model. The industry members conveyed their concerns over the accuracy of the biomass estimates. Since such estimates are based on reported landings, and changing fishing activities have made CPUE standardisation difficult, there is a need to investigate alternative datasets to be used as an index of abundance.

SEMAC and AFMA representatives (Steve McCormack and George Day) indicated that the school shark stock has become one of the most challenging to manage due to the current low level of reported landings and non-targeting, making school shark a bycatch/data-poor species. Steve McCormack emphasised that decisions at the SEMAC level are based on scientific information and that this workshop was an opportunity to advise SEMAC of the status and reliability of the school shark stock assessment and recommend the best means to move forward.

6.4.1.2 Assessment of alternative datasets

6.4.1.2.1 SESSF Fishery-Independent Gillnet Survey

Dr Terry Walker summarised information about the SESSF fishery-independent gillnet survey (see Appendix 5). Dr Walker highlighted the importance of appropriate survey designs and that given the mobility and aggregative behaviour of school sharks, traditional survey designs are mostly unsuitable.

The coefficients of variation (CV) of the 1970s and 1980s surveys were similar to those of the first-shot survey. The CV from the last survey (2000s) should be investigated further to assess whether this time series could be used as a suitable index of abundance. Reduction of the CV might be possible through incorporation of commercial catches concurrent with the surveys.

The high cost of this method was highlighted but the relative cost for school shark surveys could be reduced if they were carried out for school and gummy sharks simultaneously. Considering that three surveys have been completed since the 1970s, there should be a commitment to ensure continuity in the data. Due to the high costs, it would be impractical to do such surveys yearly, but it was suggested that they could be undertaken at longer intervals (e.g. every ten years). This would be consistent with the slow population growth of school sharks.

Although costs could be reduced by using only one gillnet size, the use of different mesh sizes is important to take into account size selectivity and ensure that juvenile school shark would also be caught. Reduced costs could also be achieved through changing the survey design from nets to hooks. Clear communication of the survey

objectives is also essential in the design and adequate participation of the industry members.

6.4.1.2.2 SESSF Fishery-Independent GAB Survey

Dr Ian Knuckey summarised information about the SESSF fishery-independent GAB survey (see Appendix 5). Due to the depth and stratum of the trawls, the data obtained from this survey is inadequate for the school shark stock assessment, as school shark are rarely caught. This survey, however, provided a successful example of a fishery-independent survey within the SESSF, thanks to careful design involving the collaboration of fishers.

6.4.1.2.3 SESSF Fishery-Independent Trawl Survey

Dr Ian Knuckey summarised information about the SESSF fishery-independent trawl survey (see Appendix 5). While this survey is not a random stratified survey, the models used are able to take data from this survey into account to produce reliable relative abundance values. Assuming that CVs less than 0.3 are considered to be suitable for an index of relative abundance, the CV of 0.33 for school shark in the FIS trawl survey suggests that this survey could be appropriate to obtain an alternative index of abundance.

As FIS trawl survey does not target school sharks and is carried out away from school shark preferred habitat; relatively small numbers of school sharks are caught at most surveyed locations (apart for the southwest Tasmanian region). Workshop participants discussed whether the CV could be further reduced if additional locations where school shark catches are more likely (e.g., southwest Tasmania, closer inshore) were surveyed. It was also discussed that the CV could be reduced through the selection of particular survey locations with the highest school shark catches. Further investigation of whether the CV could be reduced was recommended to assess if such a dataset and method are suitable as an alternative index of abundance.

Workshop participants, however, highlighted that this FIS trawl survey is spatially limited and does not encompass the whole range of the SESSF school shark catches, and that trawl fishing is an inefficient method for catching swiftly swimming school shark.

6.4.1.2.4 First-shot surveys

Dr Jeremy Prince summarised information about the first-shot surveys (see Appendix 5). This method was identified as showing the most promise for obtaining an alternative index of abundance for school sharks. The CV estimates from the pilot study were relatively high, but it was suggested that the CV could be reduced through careful selection of the data. Size-frequency is only available from the previous pilot study, but the amount of school shark caught in the first-shot could be extrapolated from the commercial reported landings to provide a longer time-series. This extrapolation could be used to estimate the CV. The first-shot survey was identified as being relatively cheap through fishers collecting most of the required information, having historic data available from records of the commercial first-shot catches, and having a potentially suitable CV.

Concerns were raised that, unless different mesh sizes are used during the first-shots, no information about juvenile school sharks would be obtained. The use of various mesh sizes was suggested for future surveys (as per the fishery-independent gillnet survey).

6.4.1.2.5 Commercial catch and ISMP data

Dr Malcolm Haddon summarised information about the commercial and ISMP data. All fishing methods show a rapid decline in reported landings between 1990 and 2000. These declines are due to a number of factors, including management regulations, and not solely to the collapse of the fishery. Since discard information was not adequately reported until very recently, the gillnet and ISMP data are unlikely to be useful as a reliable index of abundance.

CPUE standardisation and recent ISMP data could, however, be used to determine whether a trend in school shark reported landings can be detected. Such a trend can form part of a multi-method approach determining whether school shark stocks are declining and supporting some stabilisation of the TAC to allow an adequate alternative index of abundance dataset to be collected (e.g. through first-shot surveys). Based on the yearly amount of school shark reported, it was suggested that trawl landings were sufficient to warrant further investigations.

6.4.1.2.6 Auto longlining data

Dr Ian Knuckey summarised information about the data from the auto longline trial (see Appendix 5). The trial was not conducted to target and capture school sharks. As a result, insufficient school sharks were captured to calculate the CV of the data and the method's suitability as an index of abundance. However, the wide school shark size range confirmed that hook gear provide an alternative to the large range of mesh sizes used in the fishery-independent gillnet and first-shot surveys. If such change of methods took place, it would jeopardise the ability of using historic data such as the three previous fishery-independent gillnet surveys and first-shot pilot survey.

6.4.1.2.7 School shark catches from New Zealand

Dr Malcolm Francis summarised information about the school shark catches from New Zealand (see Appendix 5). New Zealand catches are managed as seven different regions by comparing the commercial catch data to the total allowable commercial catch (TACC) of about 3,000 tonnes. Although these catches are not suitable as an alternative index of abundance unless New Zealand and Australian populations are modelled jointly, the catch records from New Zealand provide an example of a school shark fishery that has caught 3,000 tonnes of school shark per year for the last 30 years without a collapse of the fishery.

Dr Francis also provided an overview of school shark movement within and from New Zealand and reported that by 1999, 20 school sharks were recaptured within Australia (eastern and western Tasmania, Bass Strait, South Australia, and Head of the Great Australian Bight). Tagging results showed that 20% of the females recaptured after 2–5 and 5–17 years were recaptured in Australia suggesting more extensive migration to Australia than previously thought.

Recent genetic analysis shows strong evidence of regional genetic structure between populations from New Zealand/Australia and Chile, but no evidence for stock structuring among Australasian populations. This suggests regional genetic differentiation across the Pacific Ocean, but genetic homogeneity between New Zealand and Australian populations.

6.4.1.3 Movement models of school shark stocks

Dr Terry Walker and Dr Jeremy Prince presented two alternative school shark movement models.

Based on tagging information and the lack of known nursery or pupping grounds in South Australia, Dr Walker proposed one stock across southern Australia with extensive movements between two regions delimited by the South Australian-Victorian border. The western region contains ovulated adults, sub-adults, and pregnant adults in winter, while pups, juveniles, and pregnant adults in spring are only found in the eastern region. According to this model, pregnant sharks in the GAB migrate to the eastern region to pup prior to returning to the western region.

In contrast, Dr Prince proposed a mosaic of stocks with other pupping/nursery grounds than off Tasmania and Bass Strait. For example, pupping/nursery grounds off South Australia and the GAB might exist but have not yet been found. The observed fishing collapses are suggested to be linked to differential fishing down of the various school shark stocks (e.g., NSW, Tasmania and South Australia, far west of South Australia).

6.4.2 Outcomes of day two discussions and recommendations summary

6.4.2.1 Harvest strategy

Under the Commonwealth Fisheries Harvest Strategy Policy the TAC needs to be set to ensure that overfished stocks rebuild within a 'biologically reasonable timeframe'.

Based on the life history traits of school sharks and the simplified model presented by Dr Robin Thomson, a timeframe of a mean generation time plus 10 years (32 years) to B_{20} is unachievable, even when fishing mortality is zero.

As a result, the rebuilding strategy needs to be reconsidered. Considering that the gummy shark fishery has unavoidable school shark bycatch, a suitable recovery timeframe should be estimated based on unavoidable bycatch and biological limits. This will reduce or eliminate discarding and avoid the need to reduce the gummy shark TAC.

6.4.2.2 Providing an index of abundance for Tier 1 assessment (long-term approach)

6.4.2.2.1 Surveys

6.4.2.2.1.1 First-shot survey

- Received the most support from industry members and scientists.
- Future surveys can be compared to pilot survey (2004–05) (for length-frequency).
- Future surveys can be added to historic data from catch logbook (for catch data).
- Need appropriate design to ensure that the data obtained from such a survey are robust and can be used as an index of abundance.
- Design needs to include discussions about incentives for fishing industry (e.g., research quota, discount on levy).
- Fishing industry and management need to commit to this approach long-term (5–10 years).
- Initial CV estimates are high but previous analysis suggested that it might be reduced through appropriate selection and spatial grouping of data (Bravington et al. 2004).
- The issue regarding the ability to undertake such surveys in South Australia due to Australian Sea Lion protection needs to be considered.

6.4.2.2.1.2 Trawl Fishery Independent Survey (FIS)

- Current survey design and data might provide an additional index of abundance dataset.
- Calculated CV based on entire dataset is 0.33, but could be reduced (e.g., by focusing on winter shots from locations off western Tasmanian).
- Current catches of school sharks by this survey method are relatively low.
- The benefits from adding new trawl locations to increase catches and reduce CV might not outweigh the costs which would be incurred.
- Spatial coverage of the Trawl FIS only covers part of the SESSF (i.e., not the GAB)
- Research quota is required for this survey.
- Addition of shots not as well supported as the first-shot survey (because of costs and uncertainty of performance) but current trawl FIS could provide a suitable index of abundance and the results should continue to be monitored.

6.4.2.2.1.3. Fixed-station survey

- While the approach is valid, the costs are likely to make it prohibitive for the fishery.
- CVs obtained were relatively high but might be reduced if focused on school shark alone.
- A cheaper fixed station survey could be re-designed by focusing on school shark, but this would initiate a new data series incomparable to previous fixed-station surveys.
- Combining first-shot and fixed-station surveys is unlikely to be feasible because they are two different approaches, but should be considered.
- The use of a single mesh size, or hooks instead of various mesh sizes, would make this method logistically easier and cheaper, but would also initiate a new data series incomparable to previous fixed-station surveys.
- Although this option is unlikely to be a suitable yearly method to obtain an index of abundance, it is a possible longer-term solution to provide an alternative index of abundance (e.g., a two-year survey being undertaken every ten years).
- Research quota requirements would be higher than first-shot surveys.
- If gillnets were still to be used, there would potentially be an issue with the ability to undertake such surveys in South Australia due to Australian Sea Lion protection.

6.4.2.2.2 Fisheries-dependent data

6.4.2.2.2.1 Trawl bycatch

- Bycatch of the trawl sectors could be used as an index of abundance and is likely to be better than other sectors because they are not avoiding school sharks.
- Issues of discards affecting robustness of bycatch values as an index of abundance could be alleviated by increasing the allocated TAC, but this should be occurring across all sectors within the SESSF and should not encourage targeting.
- This would not be necessary if the TAC was set at about 200–250 tonnes, as the trawl sector would then be able to access quota. Recovery might be impacted if such catch levels are higher than the estimated unavoidable bycatch.
- Current TAC makes it very difficult for trawl and gillnet sector to lease quota.

6.4.2.2.2.2 Dr Malcolm Haddon's FRDC project

- Dr Malcolm Haddon is currently analysing catch and ISMP data under FRDC project 2011/028 "Development of robust methods to estimate acceptable levels of

incidental catches of different commercial and byproduct species" and FRDC project 2012/201 "Improve catch rate standardisations to account for changes in targeting", which can be of use as an additional dataset to investigate trends within the fishery and the stock.

6.4.2.2.3. Alternative data

6.4.2.2.3.1 Tagging

- Tagging can provide an estimate of fishing mortality, but needs to account for shedding rate, reporting rate, and tagging related mortality. All of these can be estimated.
- Tagging program would need to be well-managed with cost-benefit analysis undertaken.
- Fishing industry needs to commit to this approach long-term (5–10 years) for it to be successful.
- The main benefits of this type of data are that it would provide an alternative to indices of abundance and increase the 'portfolio' of datasets available.

6.4.2.2.3.2 Close kin analyses (genetics)

- This type of genetic analysis could be helpful in understanding abundance, but it is too early to discuss.

6.4.2.3 Impacts of movements and stocks on the output of the model

- There are still doubts and uncertainties about the stock structure of school shark.
- Although the movement of school sharks to Australia from New Zealand has previously been included in the model, there is potential to re-address this, as well as dividing the fishery into several regions in future models that Dr Robin Thomson is intending on using in 2013.
- While this is feasible, it is important to consider the cost-benefits of running such models.

6.4.2.4 Recent catches

6.4.2.4.1 Inshore trawl

Reports from commercial fishers indicated that the number of small school sharks (55–90 cm 'length' (tip of nose to base of tail), two to four year old fish of likely two

size classes) being caught between 90–500 m in traditional fishing areas has increased in the last two years. The region has experienced temperatures about 2°C colder than previous years. It should be noted that the increase of small school shark catches could be related to a change of distribution rather than a change of biomass.

6.4.2.4.2 Others

The observations from the inshore trawls are consistent with an increase in small and juvenile school sharks in Lakes Entrance, and from Danish seiners and gillnets.

6.4.2.5 Moving forward

At the end of the workshop, participants separated into two groups (industry members and scientists) to reflect on the discussions from the previous two days, and provide their views on the best means to move forward with regards to the school shark stock assessment. Groups reconvened to report on their discussion outcomes (Table 2):

Table 2. Summary of discussions that took place at the end of the workshop. Discussions were held independently by the two main groups attending the workshop.

Industry members	**Scientists**
Industry members were willing to be part, and supportive of, a process that limits the costs of research while still accounting for their observations on the water. Industry members were willing to ensure that discards are recorded	Scientists identified the need to ensure that TAC allowed all reported landings to be recorded (so that discards are either eliminated or accurately reported), but would not allow TAC to be mis-used to target school sharks.
Industry members would support a TAC of ~240 tonnes or a TAC based on the unavoidable catch estimated by the Shark RAG	Scientists recommended using the stock assessment model to determine catch levels that allow school shark stock to recover even under worst case scenarios.
	Scientists also recommended setting up a new tier (Tier 5) assessment using standardisation of the reported catch time-series from several gillnet and trawl fisheries (similar to that previously undertaken in 2009). Standardisation protocol and reference points would need to be developed by the Shark RAG. Scientists highlighted the need for the reference point to be able to respond to increases and decreases in stock size and allow for TAC to increase as unavoidable bycatch increases in response to stock size increase. If the trend goes down for longer than an agreed period, the unavoidable bycatch would need to go down.
Industry members supported a multi-year TAC (e.g., 3–5	Scientists supported the use of a multi-year TAC of at

years)	least five years to allow an alternative index of abundance to be collected and trends to be meaningful.
	Because CPUE standardisation can also be influenced by the accuracy of catch records, scientists highlighted the need to continue gathering the data that will be going into the Tier 1 assessment and to ensure that a better index of abundance is developed (see 4.4.2.2.1 and 4.4.2.2.2).
Based on discussions during the workshop, the preferred alternative index of abundance for industry members was the first-shot survey (pending appropriate design)	Based on discussions during the workshop, the preferred alternative index of abundance for scientists was the first-shot surveys and the use of ISMP data for the Tier 1 assessment
Industry members supported the design of a school shark tagging program	Scientists recognised that tagging can be valuable to improve our understanding of fishing mortality and movement, but needs commitment from the industry and proper design.
Industry members were supportive of keeping the 20% school : gummy ratio, and proposed applying it to all but the trawl sector. Catches should also be monitored to avoid targeting	Scientists were supportive of keeping the 20% school : gummy ratio
Industry members identified the need for better recording of bycatch data, and supported development of aspecial or modified log book to allow reporting of all bycatch species	

6.4.3 Outcomes of Shark RAG discussions

Due to management measures introduced in 1997, and the implementation of a 350 tonne TAC in 2001, little useable information from the school shark fishery has been available to update the stock assessment model for school shark in recent years. In particular, an informative index of abundance has not been available so that anecdotal claims from the industry of strong recovery in the school shark stock cannot be verified. Consequently Shark RAG does not accept the current results of the stock assessment model for school shark. In addition, the rebuilding timeframe is not biologically achievable, even in the absence of any fishing mortality. Therefore, Shark RAG agreed to:

1. Design a suitable means to obtain an alternative index of abundance (see workshop recommendations) and collect data over the subsequent five years towards it;
2. Prepare a rationale for treating the school shark bycatch fishery as data poor and, as a consequence, assess whether the school shark stock has been changing

using a combination of methods and evidence (e.g., standardised catch data, ISMP data, discards data when available, industry observations);

3. Estimate the level of unavoidable bycatch using a several methods and comparing the results for consistency (e.g., average landings over the last ten years, ISMP data including discards when available);
4. Recommend that the relatively rapid rebuilding timeframe of 32 years be revised to a to a more achievable timespan;
5. Revisit the rebuilding timeframe in 3–5 years once more reliable data are available (see point 1 of 4.4.3);
6. Make the recommendation that the school shark TAC should be set at the minimum unavoidable bycatch level from the gummy shark fishery (set by point 3 above), provided that level is thought to be sustainable, until an index of abundance becomes available at which time the assessment model will once again be used to set the TAC.

6.4.4 Summary of recommendations resulting from the school shark workshop (to be reported to future Shark RAG meetings)

Recommendation 1: Shark RAG to determine a suitable recovery timeframe based on unavoidable bycatch and a recovering stock;

Recommendation 2: Use historic first-shot of catch data to determine whether CVs can be reduced to suitable levels (preferably <0.2). Shark RAG to set the parameters for this work, AFMA to facilitate its implementation;

Recommendation 3: Dr Ian Knuckey to determine whether the CV for school shark in the Trawl FIS can be reduced to suitable levels (preferably <0.2);

Recommendation 4: Dr Terry Walker to determine whether the CV of school shark catches from the SESSF fishery-independent gillnet survey can be reduced to suitable levels (preferably <0.2);

Recommendation 5: Across all sectors: AFMA to educate fishers about the importance and need to record discards, and the possible implications of recording discards;

Recommendation 6: Dr Malcolm Haddon to provide a one-page summary about his FRDC project 2010/046 on bycatch species;

Recommendation 7: Dr Robert Johnson, Mr Russel Hudson, and SARDI to determine the cost-benefit of tagging data and develop a suitable tagging program;

Recommendation 8: CSIRO to assess the possible application of close-kin genetics to school shark and report back to Shark RAG;

Recommendation 9: Terry Walker and Malcolm Francis to explore implication of movements on output of the school shark model using the existing movement model;

Recommendation 10: Shark RAG to develop standardisation protocols and reference points for 'Tier 5' assessments;

Recommendation 11: Drs Robin Thomson and Miriana Sporcic to re-visit the model based on school shark life history traits to determine a more suitable recovery timeframe;

Recommendation 12: Dr Malcolm Haddon to re-assess the unavoidable bycatch based on the catch and ISMP data including discards when available; this is already being acted upon through FRDC project 2011/028 "Development of robust methods to estimate acceptable levels of incidental catches of different commercial and byproduct species" and

Recommendation 13: Dr Malcolm Haddon to undertake CPUE standardisation to assess whether the school shark stock has been declining and to set up a 'Tier 5' to use until an alternative index of abundance becomes available. CPUE standardisation is already being acted upon through FRDC project 2012/201 "Improve catch rate standardisations to account for changes in targeting".

These recommendations should be considered in the context of school sharks being listed as Conservation Dependent under the *EPBC Act 1999*, the legislative constraints ensuing such listing, and the School Shark Rebuilding Strategy.

7 BENEFITS AND ADOPTION

The workshop was well attended by scientists and industry representatives involved in the school shark stock assessment and received positive feedback from AFMA and the Shark RAG. The recommendations from the workshop were tabled at the Shark RAG and were forwarded to SEMAC, for its consideration.

The outcomes and recommendations of the workshop were taken up by the Shark RAG as specific actions of the RAG. This is demonstrated by the following extract from the minutes of the Shark RAG meeting (Shark RAG, 2012) which followed the workshop:

"Due to the transition from a target species to a bycatch species (up to 1997), Shark RAG does not accept the current results of the stock assessment model for school shark. Therefore Shark RAG agreed to collect alternative data over the next five years and:

- *prepare a rationale for treating the school shark bycatch fishery as data poor and use a weight of evidence approach to determine whether or not there is a decline in the stock*
- *look at the level of unavoidable bycatch using a weight of evidence such as average landings over last 10 years, ISMP, increases in discards (Dr Malcolm Haddon to re-look at unavoidable bycatch levels)*
- *increase the current school shark Rebuilding Strategy recovery time from 32 years to a more appropriate level. Based on life history this may require revisiting the rebuilding timeframe in 3–5 years once more reliable data is available.*
- *Recommend an interim TAC for school shark.*

***Action item 5**: Shark RAG to consider level of unavoidable bycatch and determine a suitable recovery timeframe based on unavoidable bycatch and a recovering stock. Shark RAG following advice from CSIRO to put together justification for a change in timeframe.*

***Action item 6**: AFMA to commence process to implement 20% school shark: gummy shark for hook methods.*

***Action item 7**: Terry Walker to circulate post-capture mortality work to Shark RAG.*

***Action item 8**: Shark RAG to set parameters for desktop study using historic first-shot catch data to determine whether CVs can be reduced to suitable levels. AFMA to facilitate the desktop study.*

***Action item 9**: Shark RAG to:*
a) Prepare a rationale for treating the school shark bycatch fishery as data poor and use a weight of evidence approach to determine whether or not there is a decline in the stock
b) look at the level of unavoidable bycatch using a weight of evidence such as average landings over last 10 years, ISMP, increases in discards (Dr Malcolm Haddon to re-look at unavoidable bycatch levels)
c) increase the current school shark Rebuilding Strategy recovery time from 32 years to a more appropriate level. Based on life history this may require revisiting the rebuilding timeframe in 3-5 years once more reliable data is available.

***Action item 10**: Shark RAG to develop standardisation protocol and reference point for 'Tier 5' assessment for school shark (to be developed later in the process; Dr Malcolm Haddon to provide data to Shark RAG)."*

8 FUTURE DEVELOPMENT

The workshop outcomes were communicated to the Shark RAG and SEMAC. The recommendations from this workshop that have been incorporated into the Shark RAG actions will be addressed through the Shark RAG process. Following the workshop and Shark RAG recommendations, the unavoidable bycatch level was calculated based on the landed catch of 2011 and amount of discard estimated by the industry representatives (20% of the catch). This level of discards was supported by data from logbooks (~14.7%), but could not be verified by ISMP data, as it does not currently provided reliable estimates of discarding for school sharks (AFMA 2012).

The Shark RAG recommended the continued use of a limit reference point of B_{20} until other rebuilding targets are examined as part of the revision of the recovery strategy. Based on a model using a revised productivity factor, the Shark RAG provided a table of catches with the associated time necessary to reach B_{20}, which SEMAC used to decide upon a rebuilding time of three generations (66 years). Both of which are subject to changes pending the review of the school shark rebuilding strategy. Following the recommendations from the workshop and the Shark RAG, SEMAC identified the development of an index of abundance as of high priority.

9 PLANNED OUTCOMES

The discussions at the start of the workshop provided representatives from the GHAT and trawl sectors with the opportunity to express their opinions and perceptions of the issues surrounding the current stock assessment. The limitations of the stock assessment model and implications of the model output were clarified.

The workshop assessed the suitability of several datasets as indices of abundance for the school shark stock assessment model and determined their advantages and disadvantages. The spatio-temporal design, costs, and feasibility of using such datasets were discussed and resulted in the first-shot survey being identified as the method most likely to provide a suitable alternative index of abundance by industry representatives and scientists. The CVs were, however, high and need to be brought down for this method to be useable.

The workshop allowed developing a collective view among sectors as to how to improve current stock assessment, and identified a strategy to increase the reliability of the stock assessments, estimate school shark biomass, and determine TAC. Once this strategy is implemented, it will allow to accurately assess if the objectives of the rebuilding strategy are met and whether this condition to retain the SESSF WTO accreditation is met. SESSF managers will increase their ability to rely on an index of abundance and become more confident of its suitability. As a result, yearly TAC will be based on more accurate and defendable model outputs.

The outcomes and recommendations from the workshop were provided to the Shark RAG and AFMA, and were used to develop the 2012 stock assessment report for school shark. Some of the recommendations from the workshop were included in the 2012 stock assessment report and contributed to the 2013 TAC recommendations.

10 CONCLUSION

- Objective 1 and 2: The workshop was attended by 18 participants including Shark RAG members and chair, the SEMAC chair, the AFMA fisheries branch director, the AFMA SESSF manager, scientists, modellers, and gillnet and trawl industry representatives.

- Objective 3: The limitations of the model due to the current input data were discussed. The implications of the model output were clarified to industry representatives to ensure that the perceived discrepancy between model output and field observations were explained.

- Objective 4: The suitability of available datasets as indices of abundance was assessed, with the first-shot survey and the SESSF trawl fishery-independent surveys being the most promising. Coefficients of variation (CV) were, however, large and the ability to reduce the CV to suitable levels should be tested prior to recommending any dataset. Fixed-station surveys were also highlighted as having potential, but are unlikely to be viable on an annual basis due to their high cost. Fixed-station surveys are a possible longer-term solution (e.g. every ten years).

  The workshop developed an approach to move forward with the issues related to the school shark stock assessment:

  The existing school shark stock rebuilding strategy specifies a rebuilding timeframe that is not biologically achievable, even in the absence of any fishing mortality. Therefore, feasible timeframes need to be calculated. Considering that the gummy shark fishery has unavoidable school shark bycatch, a suitable recovery timeframe should be estimated based on unavoidable bycatch and biological limits, provided this allows recovery of the stock. The rebuilding timeframe should be the time associated with this level of catch. In the meantime, there should be:

  a) An ongoing development of the stock assessment by the Shark RAG, based on a more accurate index of abundance and that also takes into account other important aspects (e.g. movement); and

b) An alternative monitoring of the school shark stock using a ‘Tier 5’ type of assessment, with standardisation of the reported catch time-series from gillnet and trawl fisheries and reference points.

Recommendations from the workshop were provided to the Shark RAG and were used in the 2012 stock assessment report for school shark to recommend the 2013 TAC.

11 REFERENCES

AFMA (2008) School shark stock rebuilding strategy 2008.

AFMA (2012) Shark Resource Assessment Group (Shark RAG) Meeting record (6–7 September 2012), Docklands, Melbourne.

AFMA (2012) Recommendations for total allowable catches for SESSF species for the 2013/14 fishing year.

Bravington, M., Pribac, F. and Punt, A.E. (2004). First shot Variability in school shark catch-rates from 1998- 2002. Shark RAG document 2004/01

DAFF (2007) Commonwealth Fisheries Harvest Strategy Policy and Guidelines, September 2007. Canberra: Department of Agriculture, Fisheries and Forestry.

Klaer, N. and Smith, D.C. (2008) Species associations and companion TAC in the SESSF. Report for the Australian Fisheries Management Authority (2006/814). Canberra: Australian Fisheries Management Authority.

McLoughlin, K. (2007) Shark Gillnet and Hook Sectors. *In:* LARCOMBE, J. & MCLOUGHLIN, K. (eds.) *Fishery Status Reports 2006: Status of Fish Stocks Managed by the Australian Government.* Canberra: Bureau of Rural Sciences.

Punt, A.E. and Pribac, F. (2001) An assessment of school shark for 2001. SharkFAG document: SharkFAG/01/D03.

Southern and Eastern Scalefish and Shark Fishery – school shark workshop (2010) Final minutes (20 April 2010).

Southern Shark Fishery Assessment Group (2002) Report to SharkMAC 47.

Thomson, R.B. and Punt, A.E. 2009. Stock assessment update for school shark *Galeorhinus galeus* based on data to 2008, re-analysis for SharkRAG meeting 17-18 November 2009.

12 APPENDIX 1: INTELLECTUAL PROPERTY

There is no intellectual property associated with this project

13 APPENDIX 2: STAFF

Table 3. Name, organisation, and involvement of staff

Name	Organisation	Project Involvement
Dr Charlie Huveneers	SARDI – Aquatic Sciences / Flinders University	Principle Investigator
Dr Colin Simpfendorfer	James Cook University	Co-investigator
Dr Robin Thomson	CSIRO	Co-investigator

14 APPENDIX 3: GLOSSARY

AFMA	Australian Fisheries Management Authority
CPUE	Catch-Per-Unit-Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
EPBC Act	Environment Protection and Biodiversity Conservation Act
FIS	Fisheries Independent Survey
FRDC	Fisheries Research and Development Corporation
GAB	Great Australian Bight
GABTF	Great Australian Bight Trawl Fishery
GHAT	Gillnet, Hook and Trap
ISMP	Integrated Scientific Monitoring Program
NIWA	National Institute of Water and Atmospheric Research
OCS	Offshore Constitutional Settlement
SARDI	South Australian Research and Development Institute
SEMAC	South East Management Advisory Committee
SESSF	Southern and Eastern Scalefish and Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
Shark FAG	Southern Shark Fishery Assessment Group
Shark RAG	Shark Resource Assessment Group
TAC	Total Allowable Catch
TRF	Tactical Research Fund
WTO	Wildlife Trade Operation

15 APPENDIX 4: WORKSHOP CHAIR CONSULTATION PROCESS

Background - Project Objectives

1. Identify key scientists able to provide advice regarding suitable indices of abundance.
2. Organise a two-day workshop to foster discussion about an index of abundance for the SESSF school shark stock.
3. Review of the current stock assessment and identify the potential issues leading to uncertainties regarding model outputs.
4. Consider and assess alternative indices of abundance for school shark to input into the stock assessment model.

An assessment of the following alternatives dataset will be undertaken:
- Fishery-independent surveys (e.g., MAFFRI surveys):
- First-shot surveys
- Data from New Zealand catches
- Data from the trawl sectors
- Date from the SESSF manual longline
- Data from the recent auto-longlines trials
- Data from the potential new auto-longline fishery
- Movement models and impact of South Australian school shark nurseries

Workshop Process

Preliminary Consultation July 2012

The workshop chair will undertake preliminary consultation with stakeholder groups in July 2012. This will involve visits to Hobart, Melbourne and Adelaide July 2012. Those unable to meet with the chair will be contacted by phone. The aim of preliminary consultation will be to identify (see Table 4 for details):

- Concerns with current assessment processes (Objective 3).
- Alternative datasets and potential preliminary analyses for workshop (Objective 4).
- Presentations and papers to be considered for the workshop.

Meeting of Scientific Members August 2012

Presenters and key scientist will meet via a teleconference in early August. The objectives of the meeting will include:

- Papers and presentations
- Draft agenda
- Draft outputs from the workshop.

Workshop Meeting September 2012

The workshop is scheduled for the first week of September 2012. The objectives of the group:

- Recommendations to SEMAC and the AFMA Commission regarding whether an alternative method and/or methods of assessing an index of abundance is viable for the fishery.
- If an alternative method or methods are identified, a clear set of actions for the implementation of alternative methodologies including research costs and timeframes to be delivered to SEMAC and the AFMA Commission by the end of 2012.

Table 4. Consultation process for school shark workshop

Dates	Location	Sector	Participants	Planned outcomes
18/19 July TBA	Hobart	CSIRO	Robin Thompson Malcolm Haddon André Punt	Identify scientific issues. Discussion of current assessment processes (Objective 3). Discussion of alternative datasets and potential preliminary analyses for workshop (Objective 4). Staffing/funding availability.
18/19 July TBA	Hobart	Industry	Brian Bailey David Stone Other reps	Identify industry concerns (Objective 3).
18/19 July TBA	Hobart	State Fisheries		Identify State concerns. OCS and data sharing issues.
19/20 July TBA	Melbourne	Industry	Simon Boag Steven Brockwell Other reps	Identify industry concerns.
19/20 July TBA	Melbourne	Scientific Members	Terry Walker Ian Knuckey	Identify scientific issues. Discussion of current assessment processes. Discussion of alternative datasets and potential preliminary analyses for workshop (Objective 4).
19/20 July TBA	Melbourne	State Fisheries	None available	
30 July-3 August TBA	Adelaide	Industry Reps	Kyri Toumazos Anthony Ciconte	Identify industry concerns.
30 July-3 August TBA	Adelaide	State Fisheries/Scientific members	Michele Besley Charlie Huveneers	Identify industry/State concerns.
July-August TBA	Canberra via phone	Scientific / State members	Rory McAuley Colin Simpfendorfer Jeremy Prince Malcolm Francis	Identify scientific issues. Discussion of current assessment processes (Objective 3). Discuss historical approaches to the issue. Discussion of alternative datasets and potential preliminary analyses for workshop (Objective 4).
6-10 August	Canberra via phone	Scientific members	Robin Thompson Malcolm Haddon André Punt Terry Walker Ian Knuckey Charlie Huveneers Rory McAuley Colin Simpfendorfer Jeremy Prince Malcolm Francis	Agreement on final agenda papers/presentations. Agreement on draft outcomes/outputs.
3-7 September	Melbourne TBA	Workshop meeting	All members	Finalised outcomes/outputs agreed to.

16 APPENDIX 5: INFORMATION SUMMARIES OF POTENTIAL DATASETS TOWARDS A SCHOOL SHARK INDEX OF ABUNDANCE

16.1 SESSF gillnet Fishery Independent Gillnet Survey

Dr Terry Walker

Summary of dataset, provenance, and type of data collected

Three fishery-independent surveys with gillnets have been undertaken during 1973−76, 1986−87 and 2007−08. Catch with length-frequency and age-frequency composition were collected during all three surveys for gummy shark and during the last two surveys for school shark. Only the 2007−08 survey was designed to provide an index of abundance; the earlier two surveys were designed for gillnet selectivity trials and collection of animals for biological study. Comparisons among surveys were made opportunistically where there was overlap of fishing sites.

Length of time series

Two gillnet surveys for school shark and gummy shark data	1986−87 and 2007−08
Additional survey targeted at gummy shark only	1973−76

Frequency of data collection

Three fishery-independent surveys conducted (three cover gummy shark, two cover school shark).

Consistency throughout data collection

1973−76 survey	Mesh-sizes 2, 3, 4, 5, 6, 7, 8, and 9 inches of 250-m long gillnets.
1986−87 survey	Mesh sizes 5, 6, 7, and 8 inches of 500-m gillnets.
2007−08 survey	Mesh sizes 4, 5, 6, 7 and 8 inches of 500-m gillnets.

Spatial extent of dataset

SA, South Australia; BS, Bass Strait; Tas, South of north coast of Tasmania.

1973−76 survey	SA 16 sites, BS 126 sites; Tas 20 sites.
1986−87 survey	SA 84 sites, BS 60 sites.
2007−08 survey	SA 106 sites, BS 60 sites, Tas 21 sites.

Size & sex distribution

Species, sex, length of all sharks available (samples also aged).

Variance of the data

Varies, depending on spatial selection of sites.

Incorporation within the stock assessment model

Indices from 2007−08 survey provide adequate baseline data against which future surveys could be compared. Indices from 1986−87 survey are less adequate but have estimates of length composition and age composition of the population.

Flexibility of the dataset or model

Survey data can be readily aggregated over selected sites.

Costs

Cost of 2007−08 survey was $325K for gear, payment to fishers for changing gear, observers, laboratory ageing from vertebrae, data analysis and reporting. Selected fishers operated under research quota and were able to sell the catch.

Additional information

Planning report and survey report available.

Strengths of dataset

2007−08 survey only designed to provide index of abundance (fishing sites constrained).

Weaknesses of dataset

1973−76 and 1986−87 not designed to provide index of abundance (fishing sites not constrained).

Overall suitability of dataset as an index of abundance

2007−08 survey suitable as agreed upon by scientists and industry. Earlier surveys not suitable.

List of school shark reports and papers relevant to Workshop

Fishery-independent survey (gillnet)

Braccini, J. M., Walker, T. I., and Gason, A. S. (2009). GHATF shark survey of population abundance and population size composition for target, byproduct and bycatch species. Final Report to Australian Fisheries Management Authority. Project No. 2006/823. June 2009. iv + 123 pp. (Marine and Freshwater Fisheries Research Institute, Fisheries Victoria, Department of Primary Industries: Queenscliff, Victoria, Australia).

Punt, A. E., Walker, T. I., and Prince, J. D. (2002). Assessing the management-related benefits of fixed-station fishery-independent surveys in Australia's Southern Shark Fishery. *Fisheries Research* **55**, 281–295.

Walker, T. I., and Braccini, J. M. (2007). Fishing sites for 2007–08 shark survey. Report to SharkRAG Meeting 6–7 August 2007. SharkFAG Document 2007/04. 8 pp. (Primary Industries Research Victoria: Queenscliff, Victoria, Australia).

ISMP and other monitoring

Walker, T. I., and Gason, A. S. (2007). Shark and other chondrichthyan byproduct and bycatch estimation in the Southern and Eastern Scalefish and Shark Fishery. Final Report to Fisheries and Development Corporation. 182 + vi pp. July 2007. (Primary Industries Research Victoria: Queenscliff, Victoria, Australia).

Walker, T. I., and Gason, A. S. (2009). SESSF monitoring data management, reporting and documentation 2006/07. Final report to Australian Fisheries Management Authority Project No. R2006/812. (June 2009). vii + 177 pp. (Marine and Freshwater Fisheries Research Institute, Fisheries Victoria, Department of Primary Industries: Queenscliff, Victoria, Australia).

School shark movement

Walker, T. I., Taylor, B. L., Brown, L. P., and Punt, A. E. (2008). Chapter 32. Embracing movement and stock structure for assessment of *Galeorhinus galeus* harvested off southern Australia. In 'Sharks of the Open Ocean: Biology, Fisheries and Conservation'. (Eds Camhi, M. D., Pikitch, E. K., and Babcock, E. A.) pp 369–392. (Blackwell Publishing: Oxford, UK).

School shark fisheries of the world

Walker, T. I. (1999). *Galeorhinus galeus* fisheries of the world. In 'Case studies of management of elasmobranch fisheries'. *FAO Fisheries Technical Paper* 378/2. 24, 728–773.

16.2 Dataset described: SESSF Fishery Independent Trawl Survey

Dr Ian Knuckey

Summary of dataset, provenance, and type of data collected

The SESSF FIS was designed to provide good indices (<0.3 CV) for a range of quota species. It collects catch composition data on the entire catch (retained and discarded) as well as length frequency data on all major species.

Length of time series

Trawl Surveys are conducted during summer and winter using a 'standard' research trawl net to sample ~320 shots. Relative biomass estimates are calculated. Successful surveys have now been conducted during 2008, 2010 and 2012.

Frequency of data collection

The summer and winter surveys have been conducted during 2008, 2010 and 2012. It may be that only the winter survey continues in the future, and this may be conducted annually. This has yet to be discussed that the RAG or MAC.

Consistency throughout data collection

There is an extremely consistent sampling procedure in place and the type and amount of data collected is very consistent.

Spatial extent of dataset

The survey ranges across the shelf and upper slope from Kangaroo Island, around Tasmania (not through Bass Strait) and up to Sydney. The depth range is from 50–500m.

Size & sex distribution

Size frequency data is collected on all major species, but as yet the measuring of school shark has not been a high priority.

Variance of the data

Coefficient of variations for jackass morwong, john dory, eastern gemfish, tiger flathead, pink ling, redfish, mirror dory, and silver warehou) were good (<0.20). Reasonable CVs (0.20<0.30) were achieved for ocean perch, dogfishes, gummy shark, blue grenadier, common sawshark, ocean jacket, latchet, toothed whiptail, king dory, red gurnard, whitefin swellshark, greeneye dogfish, and stargazer.

School shark achieved a CV of 0.33.

Incorporation within the stock assessment model

The limited time series of these surveys has meant that the abundance indices have not yet been incorporated into assessments. 2012 marks the third in the series and once the winter trial is completed, there is no reason that the time series of abundance indices couldn't start being used as an additional data input.

Flexibility of the dataset or model

The FIS may be able to be further modified to achieve an improved CV for school shark without undermining the design model. Some efforts were made to explore this potential during 2011, but none of the results of modified survey designs revealed a marked improvement in school shark CVs.

Costs

The annual cost of the summer and winter survey is $1.2 million. The winter survey alone is around $600k and provides the best value for money in achieving good CVs for most species and minimizing costs.

Additional information

See Table 5.

Strengths of dataset

There is already three time series of consistently collected data across a five year period. The method used can catch school shark but is probably not that efficient to do so. Value of this dataset for gummy shark and common sawshark should be considered.

Weaknesses of dataset

With respect to school shark, the greatest weakness of this survey is the spatial extent. It spans from Sydney to the South Australia border around Tasmania but does not include the important school shark grounds in Bass Strait. However, it does not extend further west into the GAB.

Overall suitability of dataset as an index of abundance

Although trawls cannot really "target" school shark, this time series of trawl surveys could well provide a reasonable index of abundance for school shark, albeit across a truncated extent of their distribution.

Table 5. Summary of data collected on major shark species from the SESSF FIS. Data from 2012 winter yet to be analysed.

Total catch of each species in each survey					
Sum of Estimated Catch: Green weight (kg)	**Column Labels**				
Row Labels	**37017001 : Gummy shark**	**37017008 : School shark**	**37023001 : Southern sawshark**	**37023002 : Common sawshark**	**Grand Total**
2008	**1443.9**	**450**	**61.5**	**2960.1**	**4915.5**
summer	172.6	241	9	960.7	1383.3
winter	1271.3	209	52.5	1999.4	3532.2
2010	**904.3**	**536.5**	**102**	**2577.8**	**4120.6**
summer	120.1	44	7	788.8	959.9
winter	784.2	492.5	95	1789	3160.7
2012	**157.3**	**342.3**	**67**	**1022.5**	**1589.1**
summer	157.3	342.3	67	1022.5	1589.1
Grand Total	**2505.5**	**1328.8**	**230.5**	**6560.4**	**10625.2**
Number of shot each species was observed in each survey					
Count of Estimated Catch: Green weight (kg)	**Column Labels**				
Row Labels	**37017001 : Gummy shark**	**37017008 : School shark**	**37023001 : Southern sawshark**	**37023002 : Common sawshark**	**Grand Total**
2008	**83**	**22**	**13**	**142**	**260**
summer	22	8	1	46	77
winter	61	14	12	96	183
2010	**83**	**31**	**15**	**143**	**272**
summer	18	3	2	33	56
winter	65	28	13	110	216
2012	**24**	**10**	**1**	**39**	**74**
summer	24	10	1	39	74
Grand Total	**190**	**63**	**29**	**324**	**606**

16.3 GABTF Fishery Independent Trawl Survey

Dr Ian Knuckey

Summary of dataset, provenance, and type of data collected

The Great Australian Bight Trawl Fishery (GABTF) targets two main species, deepwater flathead (*Neoplatycephalus conatus*) and bight redfish (*Centroberyx gerrardi*). Industry-based fishery-independent resource surveys of the Great Australian Bight (GAB) have been conducted with the primary goal of obtaining robust annual indices of relative biomass of these two main species. These indices are incorporated into formal stock assessments, which were previously hampered by input data with little contrast.

Length of time series

Trawl Surveys are conducted during February–April each year using a 'standard' research net. Relative biomass estimates are calculated using swept area calculations, avoiding the need to make assumptions regarding the catchability and efficiency of the gear. Successful surveys have now been conducted during the following years: 2005, 2006, 2007, 2008, 2009 and 2011.

Frequency of data collection

The surveys were initially conducted annually but may now be conducted biennially or triennially. At present there is no plans for another survey until at least 2014.

Consistency throughout data collection

There is an extremely consistent sampling procedure in place and the type and amount of data collected is very consistent.

Spatial extent of dataset

The survey ranges across the main GABTF fishing grounds in the GAB. Although fishing for shelf species occurs outside of these areas, the survey was restricted to depths of 120–200 m and between longitude 126º00' and 132º30'. The longitudinal range was divided into four primary strata; 126º00'–127º45'(West1), 127º45'–129º00' (West2), 129º00'–130º15' (Central1), 130º 45'–132º30' (Central2)

Size & sex distribution

The survey catches around 500–1000 kg of gummy shark and common sawshark. Catches of school shark have been very low over the years. Length frequency samples of these shark species are not generally taken.

Variance of the data

Based on the very low catches of school shark, there would be extremely high variance around any school shark estimate of abundance. A reasonable index of abundance may be able to be provided for common sawshark and gummy shark.

Incorporation within the stock assessment model

The data on the target species for the survey – bight redfish and deepwater flathead has been able to be incorporated into a Tier 1 stock assessment. It is likely that similar data could be used for assessment of gummy shark and sawshark but due to the low catch levels of school shark, it is unlikely the data would be useful for a school shark assessment.

Flexibility of the dataset or model

At the initial design stage of the GAB FIS, there was an "Inshore" stratum which spanned from depths less than 120m. This stratum was not incorporated into the final survey design as it is off the main fishing grounds and occurs over relatively rough bottom that would be likely to damage the nets. It may be that this stratum, however, could provide better catches of school shark.

Costs

The annual cost of the survey is $150–200K, the bulk of which is required for vessel charter.

Additional information

N/A

Strengths of dataset

There is a reasonable time series of consistently collected data from a method which can catch school shark but is probably not that efficient to do so. Value of this dataset for gummy shark and common sawshark should be considered.

Weaknesses of dataset

Even if the survey could be modified to cover regions that school shark are more likely to be found in, this survey currently only covers a small range in the GAB of the overall distribution of school shark.

Overall suitability of dataset as an index of abundance

It is unlikely that this dataset will provide a good index of abundance for school shark.

16.4 First-shot surveys

Dr Charlie Huveneers (on behalf of Dr Jeremy Prince)

Summary of dataset, provenance, and type of data collected

The first-shot surveys were only conducted as a proof of concept and aimed to provide 'relatively' fishery-independent length structure and catch rate data. Specifically, the following was recorded per shot:

- Length and sex of four main shark species
- Count of other species
- Record of discards

In 2004 alone, 61 first-shots were recorded and 750 sharks were measured, of those, 100 school sharks were caught in a total of nine first-shots.

Shark FAG estimated on the basis of the pilot scale fixed station surveys that 120 shots/annum could provide statistically significant catch rate data for gummy shark. It is unknown how many shots would be necessary for first-shots data to be sufficient to provide statistical significant catch rate data for school shark.

Preliminary analysis of the data collected suggested that this method could underpin stock assessment of 9–10 species.

Length of time series

The idea of using data from the first-shot of a trip collected by industry members was initially discussed during a SharkFAG meeting in September 2002. Further discussions led to a preliminary project aimed to assess the feasibility of suitability of collecting such data in 2004 and 2005. Data from first-shot surveys have not been collected since.

However, there is the ability to use catch records held by AFMA to analyse the catches from the first shot of each fishing trip. The existing log-book data does not include length frequencies but might be useful in determining the number of first-shots necessary to provide statistically significant catch rate data, and also to allow an extended time series of first-shot catch rates stretching back in time to be constructed from the existing log-book data.

Being compatible with log-book data could also allow data standardization procedures to be developed computationally, increasing the fishery-independence of indices developed using first-shot data.

Frequency of data collection

Data was collected once from the first shot of each trip.

Consistency throughout data collection

Data has only been collected once as part of a pilot study. The data was collected consistently throughout that pilot study.

Spatial extent of dataset

Data is to be collected throughout the fishery distribution.

Data initially collected during the pilot study was predominantly collected in South Australia due to the biased participation rates. Towards the end of the pilot study, participation from Bass Strait increased. Final participation was from 12 skippers: four from Victoria, two from Tasmania, and six from South Australia.

Size & sex distribution

Data intended to be collected for school shark includes sex and size making it possible to take into account school shark aggregation and sex and size biases.

Variance of the data

Variance estimation was undertaken by the CSIRO using the first-shot data in the GN01 database:

Data was highly variable. Additionally, a few shots with large catches strongly influenced the total catches. Confidence intervals of 40–70% were initially estimated. A large number of shots would need to be recorded over 10–15 years before significant trends are likely to become evident.

In the most data rich region of the fishery (EBS) approximately 100 recorded first-shots per year produced CVs of 38-47% from 1998–2002 (likely reflecting the real natural variability of school shark). School shark data could be more informative than estimated (see Flexibility of the dataset).

Incorporation within the stock assessment model

There is insufficient existing data to be incorporated into the current stock assessment framework, however, the pilot-scale project and supporting analyses suggested that if scaled up and extended through the industry as an on-going exercise it could feasibly become the basis of an additional standardized time series of size based catch rates.

Flexibility of the dataset or model

A more focused analysis should provide a way of removing variability through stratifying the school shark data. These measures could include:

- Focusing on SharkFAG's nominated core areas;
- Filtering out targeted school shark shots (i.e. the few very large catches) from the small incidental catches and the background scatter, use a different metric (i.e. median rather than mean). NB The first-shot design of this approach was designed to *a priori* filter out targeted school shark stocks, as occurring at the beginning of each trip all recorded shots would be conducted without any immediate knowledge of fine-scale local conditions;
- Stratification by depth;
- Include the level of co-incidentally caught gummy shark as a covariate in the analysis;

- Use *a priori* knowledge to account for known seasonal affects.

Costs

One of the major advantages of this type of data is the low costs incurred due to industry participation.

Additional information

N/A

Strengths of dataset

This method represents a cost-effective means of collecting data. The data collected could potentially be integrated with existing log-book data to produce a time-series that extends further back within the fishery.

Weaknesses of dataset

- Relies on operators to collect data accurately.
- Potentially a need to be independently validated.
- Potentially a large number of shots needed to estimate significant trends.

Overall suitability of dataset as an index of abundance

It was estimated on the basis of the pilot scale fixed station surveys that data from 120 first-shots were needed for gummy sharks. It is unknown how many first-shots would be required for the data to provide statistically significant school shark catch rate. The length data, which are available through this survey technique but not through the analysis of GN01 data, may provide an additional means of accounting for the variability observed in school shark catch rates.

16.5 Automatic Longline Trial

Dr Ian Knuckey

Summary of dataset, provenance, and type of data collected

This was a once-off trial to mitigate captures of Australian sea lion and other high risk species by SESSF shark operators targeting gummy shark in waters off SA. It was not designed specifically as an abundance survey; it did not have random stratified design that was aimed to be repeated in the future. Within the requirements of the survey, skippers were requested to conduct longline sets with the goal of obtaining catches of gummy shark.

A vessel fitted with automatic longline equipment was used throughout the trial. It had the capacity to store and set up to 10,000 hooks per day. Mustad longline gear was used consisting of a 9.0 mm rope mainline. Magazines were loaded with 1500 1.8mm diameter monofilament snoods of 500mm length connected to 12/0 EZ baiterTM hooks. Auto-baiting equipment was used with squid / mackerel / saury. Automatic de-hooking equipment was used but on retrieval, all non-target species were removed manually from the hooks so that their life state could be assessed accurately and they could be released if appropriate.

Length of time series

The automatic longline trials were conducted over three trips during spring / summer and one trip during winter.

Frequency of data collection

There is no plan to repeat the trials.

Consistency throughout data collection

Extensive data was collected by dual observers during the trial on catch composition and length frequency and life state of the catch. Interactions with TEP species were also recorded.

Spatial extent of dataset

The trial was only undertaken in the Commonwealth waters < 183 metres off South Australia.

Size & sex distribution

The trial was targeting gummy sharks, not school sharks. A part of the trial was dedicated to placing pop-up satellite archival tags (PSATs) in school sharks to investigate post-capture mortality and movement. Length frequency and sex data was collected on all school sharks captured. Specific information collected on school shark included:

- School shark length frequency distribution - sex by zone
- School shark CPUE (mean ±SE) - sex by zone
- School Shark vertebrae collected for ageing - sex by zone
- School Shark life state / damage

Variance of the data

The trial was not conducted to target and capture large numbers of school shark. Insufficient school shark were captured to enable calculations of the variance of the data as an index of abundance.

Incorporation within the stock assessment model

Further work needs to be done before this data could be considered as a valuable input into the stock assessment model.

Flexibility of the dataset or model

The trial could be easily altered to target school sharks. It was currently designed to avoid areas where high numbers of school sharks might be captured.

Costs

A major cost of the trials was required for vessel charter.

Additional information

As history shows, longlines are a proven method of targeting and capturing school shark.

Strengths of dataset

The data provided good information (size, sex, life-state) on the small amount of school shark that was caught but this information is limited because the trial did not target school shark. Some information on School shark survival and movement was collected.

Weaknesses of dataset

There is little information on school shark, because this species was not targeted and was therefore not a major component of the catch.

Overall suitability of dataset as an index of abundance

Overall, the use of a longline survey has significant potential as a method of collecting an independent index of abundance for school sharks. This was not well observed in the data from this trial because it was designed to avoid catching school shark.

16.6 New Zealand catches and CPUE

NZ Ministry of Primary Industries

Summary of dataset, provenance, and type of data collected

Commercial catch data are collected and summarized annually by Fishstock (7 regions) and compared with TACCs. Catch and effort data are collected from fishers' logbooks for bottom longline and/or set net by Fishstock and standardized to extract annual relative abundance indices.

Length of time series

Catch data have been collected by Fishstock since 1983-84, and for all Fishstocks combined since 1948. CPUE data are available since 1989-90.

Frequency of data collection

Data collected monthly, and summarized/reviewed annually (catches) or every 2–3 years (CPUE).

Consistency throughout data collection

Some changes have occurred but until recently were not thought to affect the CPUE series. Closures of coastal waters to set nets to protect dolphins may have invalidated some set net CPUE indices in the last 2–3 years.

Spatial extent of dataset

Nationwide.

Size & sex distribution

No. However, some size and sex data of variable quality have been collected by fishers as part of a logbook programme, and some recent observer coverage of inshore vessels may have gathered similar data.

Variance of the data

Variable.

Incorporation within the stock assessment model

Not applicable unless NZ and Australian populations are modelled jointly.

Flexibility of the dataset or model

Not applicable unless NZ and Australian populations are modelled jointly.

Costs

Unknown.

Additional information

Figures showing time series to be presented at workshop.

Strengths of dataset

Illustrates fishery of ca. 3,000 tonnes per year has been sustained for over 30 years.

Weaknesses of dataset

Fishery dependent index. Doesn't extend back to before the days of large catches, nor pre-QMS.

Overall suitability of dataset as an index of abundance

Not applicable unless NZ and Australian populations are modelled jointly.

17 APPENDIX 6: AGENDA OF SCIENTIFIC PARTICIPANTS PHONE MEETING

The main aims of the meeting are to discuss any issues related to the upcoming school shark workshop, to set criteria from which datasets will be assessed and compared, set an agenda for the workshop, and in general, to provide the Chair of the workshop, Nick Rayns, with enough background information to ensure the workshop runs efficiently and produces the outcomes set in the funding application.

The specific agenda items of this meeting are as follow:

- Brief overview of preliminary consultation undertaken by Nick Rayns

- Brief description of each dataset with a view to give a short document to each workshop attendant providing background/preliminary information about each dataset
    - Fisheries-independent surveys - Gillnet: Dr Terry Walker
    - Fisheries-independent surveys – GAB Trawl and CTS
    - First-shot surveys: Dr Jeremy Prince
    - Date from the SESSF manual longline: Dr Malcolm Haddon
    - Data from New Zealand catches: Dr Malcolm Francis
    - Data from the recent auto-longline trials: Dr Ian Knuckey
    - Data from the potential new auto-longline fishery: Dr Ian Knuckey
    - Movement models and impact of South Australian school shark nurseries: Drs Jeremy Prince & Terry Walker
    - Issue of low catch levels inherent to the attempts to avoid school shark in the SESSF: Dr Robin Thomson
    - Potential need to undertake multi-year school shark stock assessment due to the extremely slow reproductive potential of school sharks: Dr Robin Thomson

- Agenda for the workshop

- Review of criteria against which each dataset can be evaluated in terms of their suitability to be used as an index of abundance:
    - Length of time series: historically collected for the last 20/10/5 years vs. one off survey vs. no data collected yet.
    - Variance: error in the estimates (in terms of school shark abundance) are high/medium/low (as a result of sample size, number of stations, numbers of sharks caught, measurement error, fisher behaviour...).
    - Consistency throughout the time period: e.g. management changes have changed fishing practices and targeting behaviour in a way that has rendered the commercial CPUE for gillnets an unreliable measure of abundance.
    - Consistency with the model: can the dataset be incorporated into the stock assessment model?
    - Frequency of data collection: how often has the data been collected historically (e.g., twice for MAFFRI surveys) or how often would it need to be collected to be useful.
    - Costs of collecting the data - try to put a ballpark figure on it if possible.
    - Any others?

- Any other business?

18 APPENDIX 7: LIST OF DOCUMENTS PROVIDED BEFORE WORKSHOP

Braccini, J.M., Walker, T.I., and Gason, A.S. (2009). GHATF shark survey of population abundance and population size composition for target, byproduct and bycatch species. Final Report to Australian Fisheries Management Authority. Project No. 2006/823. June 2009. iv + 123 pp. (Marine and Freshwater Fisheries Research Institute, Fisheries Victoria, Department of Primary Industries: Queenscliff, Victoria, Australia).

Bravington, M., Pribac, F. and Punt, A.E. (2004). First shot Variability in school shark catch-rates from 1998- 2002. Shark RAG document 2004/01

Bravington, M., Pribac, F. and Punt, A.E. (2004). First shot Variability in gummy shark catch-rates from 1998- 2002. Shark RAG document 2004/12

Francis, M.P. (2010). Movement of tagged rig and school shark among QMAs, and implications for stock management boundaries. *New Zealand Fisheries Assessment Report 2010/3.* 24 p.

Hurst, R.J., Bagley, N.W., McGregor, G.A., Francis, M.P. (1999) Movements of the New Zealand school shark, *Galeorhinus galeus,* from tag returns. *New Zealand Journal of Marine and Freshwater Research* 33, 29–48

Huveneers, C. (2012). Information summaries of potential datasets towards a school shark index of abundance. See Appendix 5.

New Zealand school shark fishery summary. 25 p.

Prince, J. and Hudson, R. (2005). Develop or Die: Mastering Information Technology in the Gillnet, Hook & Trap Fishery. Report number R03/1403.

Punt, A.E., Walker, T.I., Tayler, B.L. and Pribac, F. (2000). Standardization of catch and effort data in a spatially-structured shark fishery. *Fisheries Research* 45, 120–145

Punt, A.E., Walker, T.I., and Prince, J.D. (2002). Assessing the management-related benefits of fixed-station fishery-independent surveys in Australia's Southern Shark Fishery. *Fisheries Research* **55**, 281–295.

Walker, T.I. (1999). *Galeorhinus galeus* fisheries of the world. In 'Case studies of management of elasmobranch fisheries'. *FAO Fisheries Technical Paper* 378/2. 24, 728–773.

Walker, T.I., and Gason, A.S. (2009). SESSF monitoring data management, reporting and documentation 2006/07. Final report to Australian Fisheries Management Authority Project No. R2006/812. (June 2009). vii + 177 pp. (Marine and Freshwater Fisheries Research Institute, Fisheries Victoria, Department of Primary Industries: Queenscliff, Victoria, Australia).

Walker, T.I. and Braccini, J.M. (2006). Development of design of 2007–08 shark survey. Shark RAG document 2006/22.

Walker, T.I., and Braccini, J.M. (2007). Fishing sites for 2007–08 shark survey. Report to SharkRAG Meeting 6–7 August 2007. SharkFAG Document 2007/04. 8 pp. (Primary Industries Research Victoria: Queenscliff, Victoria, Australia).

Walker, T.I., and Gason, A.S. (2007). Shark and other chondrichthyan byproduct and bycatch estimation in the Southern and Eastern Scalefish and Shark Fishery. Final Report to Fisheries and Development Corporation. 182 + vi pp. July 2007. (Primary Industries Research Victoria: Queenscliff, Victoria, Australia).

Walker, T.I., Taylor, B.L., Brown, L.P., and Punt, A.E. (2008). Chapter 32. Embracing movement and stock structure for assessment of *Galeorhinus galeus* harvested off southern Australia. In 'Sharks of the Open Ocean: Biology, Fisheries and Conservation'. (Eds Camhi, M. D., Pikitch, E. K., and Babcock, E. A.) pp 369–392. (Blackwell Publishing: Oxford, UK).

Walker, T.I., and Gason, A.S. (2009). SESSF monitoring data management, reporting and documentation 2006/07. Final report to Australian Fisheries Management Authority Project No. R2006/812. (June 2009). vii + 177 pp. (Marine and Freshwater Fisheries Research Institute, Fisheries Victoria, Department of Primary Industries: Queenscliff, Victoria, Australia).