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Strategic Planning Workshop for Yellowtail Kingfish Stock Assessment in South-Eastern Australia

Yellowtail Kingfish Workshop

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June 2021

FRDC Project No 2019/103

ISBN **978-1-76058-450-4**

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2019/103
2021

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Acknowledgments

The New South Wales Department of Primary Industries acknowledge the Fisheries Research and Development Corporation (FRDC) for providing funding for this project. The project was supported by industry members, fishery managers and scientists from each jurisdiction and several academic institutions who kindly provided their time and expertise. In particular we thank Phil Bolton for his insights and contacts in the recreational and charterboat fisheries.

Executive Summary

The New South Wales Department of Primary Industries, with funding from the Fisheries Research and Development Corporation, facilitated cross-jurisdictional and cross-sectoral discussions on aspects of the Eastern Australia biological stock of Yellowtail Kingfish. A face-to-face 2 day workshop was scheduled during the 24th and 25th March 2020 at the Sydney Institute of Marine Science, NSW; however this was cancelled due to the COVID-19 pandemic preventing travel and meetings. Nevertheless, a series of remote workshops and communications between commercial, recreational and charter fishers, as well as scientists and managers from Queensland, NSW, Victoria, Tasmania, South Australia, the Commonwealth and several relevant academics, facilitated discussion of the following project objectives.

1. Review the available data and management regimes for the Eastern Australian stock of Yellowtail Kingfish from each relevant jurisdiction
2. Review the reasons for the 'Undefined' stock status in SAFS 2018
3. Discuss appropriate spatial scales for assessment and management across the Eastern Australian biological stock
4. Identify knowledge gaps required to be filled in order to produce a defined stock status for SAFS
5. Discuss cross-jurisdictional assessment and management options for Yellowtail Kingfish

Communications determined that several major knowledge gaps relating to basic biological and life-history parameters, as well as reliable data on the recreational fishery across all jurisdictions inhibited assessment, and therefore management, of this biological stock. It was noted that this lack of information was one reason for differing management arrangements (minimum legal lengths and bag limits) between jurisdictions.

Significant progress was made on the Status of Australian Fish Stocks (SAFS) assessment, with the SAFS authors for 2020 agreeing to adopt an updated assessment based on NSW information. The weight-of-evidence considered in the assessment concluded that biomass was unlikely to be depleted and that recruitment was unlikely to be impaired, and that the current level of fishing mortality was unlikely to cause recruitment impairment. As such the Eastern Australian stock was classified as a 'Sustainable' stock, noting that until knowledge around population dynamics of the stock, in particular the distribution and movements of the spawning stock and the source of juveniles, is improved that the assessment will remain highly uncertain.

A survey of long-term, highly experienced commercial, recreational and charter fishers in NSW was done to provide feedback on data to be used in the stock assessment. Comments from these knowledgeable fishers resulted in several reconstructed catch history scenarios being used in the assessment, in addition to gathering observations on long-term changes to the fishery in terms of catch, effort, access, abundance, sizes of fish and catching efficiency.

The project also compiled tables of current and recent research done on Yellowtail Kingfish in south-eastern Australia, as well as research priorities. Common priorities across jurisdictions included basic biological and life-history information, including patterns of movement and connectivity throughout the stock, and reproductive patterns such as main spawning areas and times. These knowledge gaps were required in order to assess appropriate scales for assessment and management within and across jurisdictions.

Keywords

Yellowtail Kingfish, assessment, cross jurisdictional, cross-sectoral, management

Introduction

Yellowtail Kingfish is a high priority species for recreational fishers and the basis of an important commercial fishery in New South Wales (NSW). The biological stock structure is reasonably well understood, with genetic analyses (Miller et al. 2011) showing that the population in Western Australia is genetically distinct from the population along the eastern and southern Australian coasts (Commonwealth, Queensland, NSW, Victorian, Tasmanian and South Australian waters) and New Zealand. Tagging studies have confirmed movements between Australia and New Zealand and between South Australia and NSW (Gillanders et al., 2001). Therefore Yellowtail Kingfish are assessed through the Status of Australian Fish Stocks (SAFS) initiative at the biological stock level, being two stocks – 'Eastern Australia' and 'Western Australia'.

The 2018 SAFS assessment for the Eastern Australia biological stock of Yellowtail Kingfish was 'Undefined', due mainly to knowledge gaps around the degree of mixing throughout this stock which spans more than 3,000 km of coastline. Reasonable data for assessment exists mainly within NSW, and uncertainty around whether an assessment of that component of the stock reflected the entire stock resulted in an 'Undefined' status, with a recommendation that this uncertainty be resolved.

Assessment and management of Yellowtail Kingfish remain contentious; with widely disparate views on the status of the Eastern Australia stock. Anecdotal evidence, mainly from recreational fishers, suggests that the stock is locally depleted in places; whereas others consider the stock to have recovered substantially since the banning of pelagic "kingfish traps" in NSW in 1996, and to be an extremely healthy fishery. There are different management arrangements for Yellowtail Kingfish across different jurisdictions, and a more co-ordinated management approach may be worth considering once knowledge gaps around demographics and life-history are resolved.

The FRDC National Priority 1 from the FRDC 2015-2020 RD&E Plan aims to reduce the percentage of 'Undefined' stocks within SAFS, which also has an objective of providing a roadmap to recovery for 'Depleted' stocks. To address both of these and to promote better and more collaborative monitoring, assessment and management across all relevant jurisdictions, there is a clear need to review existing knowledge across the entire Eastern Australian Yellowtail Kingfish stock and to identify areas of uncertainty that require addressing.

Objectives

1. Review the available data and management regimes for the Eastern Australia stock of Yellowtail Kingfish from each relevant jurisdiction
2. Review the reasons for the 'Undefined' status in SAFS 2018
3. Discuss appropriate spatial scales for assessment and management across the Eastern Australia biological stock
4. Identify knowledge gaps required to be filled in order to produce a defined stock status for SAFS
5. Discuss cross-jurisdictional assessment and management options for Yellowtail Kingfish

Method

A 2 day workshop was scheduled during the 24th and 25th March 2020 at the Sydney Institute of Marine Science, NSW, which was to review the current state of knowledge, monitoring, assessment and management of Yellowtail Kingfish across the entire Eastern Australian biological stock. Participants were invited from the commercial, recreational and charter sectors, as well as scientists and managers from Queensland, NSW, Victoria, Tasmania, South Australia and the Commonwealth. Academics with recent or current research projects were invited from The University of New South Wales, the University of Tasmania and Flinders University. Unfortunately the workshop had to be cancelled just days beforehand due to the COVID-19 pandemic preventing travel and meetings.

Subsequently the FRDC approved a variation to achieve the objectives through holding remote workshops and communications. All invited participants to the workshop that was cancelled due to the COVID pandemic were contacted via phone, and many discussions had about their opinions on the fishery and stock status.

A survey was sent to stakeholders in NSW during July 2020 that aimed to elicit expert opinion on the Yellowtail Kingfish fishery (Appendix 1). The survey asked opinions on the NSW catch history reconstruction to support the assessment, changes in the fishery through time including effort, sizes of fish, factors that may have affected the fishery such as marine parks, technological advancements, social media etc. The survey was sent to fishers identified as having a long history fishing for Yellowtail Kingfish and was done under DPI Fisheries Research Human Research Ethics approval (INT20/220281).

A virtual meeting was held on the 20th October 2020 between relevant scientists and managers from Queensland, New South Wales, Victoria, Tasmania, South Australia and the Commonwealth (absent) to discuss the Yellowtail Kingfish assessment and stock status for SAFS 2020.

A survey of recent and current research projects, as well as research priorities and knowledge gaps, was sent to original scientific workshop participants.

Results, Discussion and Conclusion

<u>Stakeholder Survey results</u>

The survey of fishers identified as having vast experience with the Yellowtail Kingfish fishery in NSW (Appendix 1) proved to be extremely valuable in developing a general description of the NSW fishery through time. The survey was completed by 6 commercial, 8 recreational and 4 charterboat fishers, as well as 2 fishery managers. The respondents as individuals had been fishing for Yellowtail Kingfish for between 14 and 60 years, for a cumulative total of more than 550 years. Fishers' experience with the fishery spanned the entire coast of NSW, from near the Queensland border to Eden on the far South Coast. General responses to sections within the survey are summarised below.

Catch history.

Most survey respondents considered that the total harvest reconstruction for Yellowtail Kingfish since the 1950s presented in the survey was reasonable. In particular there was general agreement that the increased catch seen during the 1970s and 1980s was consistent with the advent of commercial pelagic "kingfish traps" and a large increase in offshore recreational trailerboat fishing. Commercial respondents considered the reported decline in catch from that sector since the 1990s

to be mainly as a result of declines in commercial fishing effort. There was general agreement that there had been an increase in targeted fishing for Yellowtail Kingfish by the recreational sector since the 1970s - 1980s. There were suggestions that the reconstructed recreational harvest during the 1950s - 1970s was too high, as relatively few recreational fishers targeted Yellowtail Kingfish during that period and there were few boats of sufficient sea-worthiness to do so in offshore waters. Feedback from several respondents was that the more recent (post-2000) recreational harvest estimates were lower than expected, likely as a result of the recreational survey methodology used not designed to estimate the entire recreational catch, and the application of inappropriate (too small) average weights of retained Yellowtail Kingfish used in the surveys. In addition to the commercial and recreational catch reconstructions, the majority of respondents believed that there was historically, and in some instances currently, significant 'black marketing' of Yellowtail Kingfish, which was not considered in the total catch reconstruction.

Fishing Efficiency

All respondents surveyed agreed that technology had greatly improved the ability to catch Yellowtail Kingfish. Improvements in the reliability of boats since the 1980s along with improvements in fuel efficiency have allowed better access to offshore fishing grounds. Similarly, it was also unanimously agreed that availability and improvements in sounder technology since the 1980s has improved fishers' ability to find and catch Yellowtail Kingfish. Most respondents considered that improvements in fishing tackle during the last 20 years have also increased catchability, with quality lightweight specific jigging gear, heavy duty spin reels and braided fishing line all aiding in improved catching efficiency. Some fishers considered spot lock electric motors have had a small impact on Yellowtail Kingfish fishing efficiency in the last five or so years.

Both commercial and recreational fishers agreed that chart plotters had improved their ability to find and catch Yellowtail Kingfish during the last 20 years, particularly when fishing offshore away from obvious islands or landmarks. All fishers surveyed (commercial, recreational and charter), agreed that social media has greatly improved the catchability of Yellowtail Kingfish, as it has allowed greater accessibility and communication of locations and methods to the wider fishing population.

Access

Most respondents agreed that access to Yellowtail Kingfish had increased due to improvements in boats and the widespread availability of technology and information. Increased accuracy and availability of weather forecasting enabled fishers to plan ahead and had improved access to fishing grounds. Some respondents noted a decrease in access due to the implementation of marine parks sanctuary zones, restricting access to certain areas. The majority of recreational fishers believed that the improved ability to access Yellowtail Kingfish had increased harvest in that sector. There was a mix of responses from commercial fishers, some felt improved access had increased harvest in the recreational sector due to improvements in gear and technology, while others commented that the restriction of certain areas such as marine parks had decreased harvest.

Abundance

The majority of commercial and charter fisher respondents considered the abundance of Yellowtail Kingfish to have either remained steady or declined, with a decline mainly attributed to Yellowtail Kingfish becoming a more popular target recreationally. All recreational fishers surveyed considered Yellowtail Kingfish abundance and body size to have decreased through time, with excessive fishing pressure prescribed as the main reason for the changes. In contrast, some commercial and charter fisher respondents considered the average size to have increased through time. The majority of respondents from both the commercial and recreational sectors considered the number of recreational fishers targeting Yellowtail Kingfish to have increased dramatically in recent decades.

Management

The majority of recreational fisher respondents considered management changes to have led to an increase in abundance of Yellowtail Kingfish; whereas most commercial fisher respondents considered management changes to have resulted in a decrease in commercial harvest. Most respondents believed that banning "kingfish traps" and an increase in the minimum legal length had been the two major management changes that had affected harvest. Some respondents also noted the introduction of restricted areas such as marine park sanctuary zones as having a negative effect on harvest.

The majority of survey respondents believed that current management arrangements were inadequate to support the long-term sustainability of the Yellowtail Kingfish stock. Almost all individuals surveyed believed that there should be a reduction in the recreational bag limit and many recreational respondents considered an increase in the minimum legal length for Yellowtail Kingfish necessary. Many recreational fisher respondents also suggested a Total Allowable Catch (TAC) for Yellowtail Kingfish should be introduced for the commercial sector.

<u>SAFS Assessment</u>

Feedback from authors of the 2018 SAFS assessment (Hughes et al., 2018) indicated that an 'Undefined' status was decided upon for several reasons. Reasonable data for assessment was only available from NSW, and given uncertainties around connectivity between fish from different jurisdictions spanning more than 3,000 km of coastline, from south-east Queensland to South Australia, there existed considerable doubt about whether it was appropriate to apply the NSW assessment to the entire Eastern Australia biological stock. This was in addition to substantial knowledge gaps around movements and spawning dynamics in this region. Furthermore, while the NSW assessment was reasonably pessimistic in terms of stock status it acknowledged considerable uncertainties, including whether basing stock performance metrics mainly on commercial fishery data reflected trends in the entire stock.

Following discussions amongst SAFS authors, it was decided that the 2020 SAFS assessment for the entire Eastern Australia biological stock would use a weight-of-evidence approach based on NSW data only. Stock status considered standardized commercial catch rates, a Catch-MSY model-assisted catch-only assessment (CMSY) with Bayesian state-space implementation of the Schaefer surplus production model (BSM), Total and Fishing Mortality estimates from commercial length monitoring, Spawning Potential Ratio (SPR) analysis, and tag-recapture rates (Hughes and Stewart, 2020). Following feedback from the survey of experienced NSW Yellowtail Kingfish fishers, it was decided to run various total harvest scenarios in the catch-only models. The base-case catch history was as presented in the survey as it received majority support from experienced Yellowtail Kingfish fishers as being a reasonable approximation of the fishery. However in some catch reconstructions the recreational estimate was halved between the 1950s and 1970s; following expert feedback that the base-case estimates were too high as relatively few recreational fishers had boats of sufficient sea-worthiness in addition to limited targeting of Yellowtail Kingfish during that period. Other catch reconstructions included recreational estimates which were doubled following 2000/01; again as a result of expert feedback that the recreational fishing surveys likely under-estimated the catch considerably, due to the survey methodology used not designed to estimate the entire recreational catch and the application of inappropriate (too small) average weights of retained Yellowtail Kingfish applied in the surveys.

The SAFS authors reviewed and discussed the stock assessment done by NSW scientists (Hughes and Stewart, 2020) and agreed that for SAFS 2020 it was acceptable to apply the NSW assessment to the entire Eastern Australia biological stock, again noting some very major knowledge gaps remained unresolved and therefore acknowledging considerable uncertainty in stock status.

Research and knowledge gaps

Key knowledge gaps and research priorities for improved assessment and management of the Eastern Australia Yellowtail Kingfish stock were collated from jurisdictions (Table 1). This information was collated by a survey of recent and current research projects, as well as research priorities and knowledge gaps, sent to original scientific workshop participants, ahead of the October meeting. Common priorities across jurisdictions included basic biological and life-history information, including patterns of movement and connectivity throughout the stock, and reproductive patterns such as main spawning areas and times. These knowledge gaps were required in order to assess appropriate scales for assessment and management within and across jurisdictions.

Table 1. Yellowtail Kingfish knowledge gaps and research priorities for improved assessment and management.

Jurisdiction	Organization/s	Knowledge gap/research priority	Notes
Queensland	QDAF	Lower priority species	
New South Wales	NSWDPI	Spawning times and locations	
	NSWDPI	Source of recruits	
	NSWDPI	Movements/connectivity throughout range	
	NSWDPI	Appropriate scales of assessment and management	
	NSWDPI	Size composition of recreational harvest	
	NSWDPI	Analysis of conventional tagging data to establish movement trends, connectivity and recapture rates	
	NSW Catch sector	Validation of size at maturity	This could be an industry-based initiative
Victoria	VFA	Genetic (SNP's) with samples from Lord Howe Island	Knowledge gaps documented

	VFA	Movement characteristics (seasonal)	
	VFA	Larval and Juvenile distribution	
	VFA	Location of spawning region	
Tasmania		None provided	
South Australia	Flinders University	Movements/connectivity throughout range	
	Flinders University	Spawning times and places	
	Flinders University	Appropriate scales of assessment and management	
	Flinders University	Efficacy and relevance of MPA/No-take zones to protect spawning areas/events	
	Flinders University	Commercial and recreational sector allocation	
Commonwealth	ABARES	Lower priority species	

Current and recently completed research into Yellowtail Kingfish was compiled by scientists in each jurisdiction and several universities (Table 2). Recently completed research into the biology and fishery for Yellowtail Kingfish in Victorian waters (Green et al., 2020) has added considerably to knowledge of basic biology from NSW (Gillanders et al., 1996, 1999, 2001, Stewart et al., 2001, 2004); however there remains a very large part of the distribution of the stock that has not been studied. Likewise Champion (2020) and Champion et al. (2019, 2020) have provided new information on oceanographic habitat preference that may become informative when assessing any impact of effects of climate change throughout the distribution.

It was apparent that considerable research is also being done on movement patterns, generally through the IMOS Animal Tracking Facility utilising acoustic tagging technology. It was clear however that resourcing to fund adequate numbers of tags, as well as a lack of co-ordination across the entire distribution of the stock, may limit the potential of findings to resolve questions of importance to assessment and management at the biological stock scale.

Table 2. Current and recently completed research into Yellowtail Kingfish.

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
Queensland	IMOS Animal Tracking Facility	Current: National tracking of priority species	National IMOS acoustic telemetry network optimised to track movements of marine species (including kingfish) and define cross-jurisdictional movement to better understand stock structure	Ongoing	Funded by the Integrated Marine Observing System (IMOS) and FRDC (Project 2018-091). In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN).
	IMOS / AIMS QLD Acoustic Telemetry program	Current: Statewide coordinated, collaborative. acoustic tagging program to define movements of priority marine species for QLD	Optimise QLD IMOS acoustic receiver network. implement a collaborative, statewide, coordinated, acoustic tagging program of priority species for QLD (kingfish listed as secondary priority species). Collect multi-year, movement, connectivity, migration and residency data for these key priority species in QLD as well as across jurisdictions	3.5 years (currently funded until June 2023)	Funded by the Integrated Marine Observing System (IMOS) via the QLD Department of Environment and Science. In collaboration with QLD Department of Agriculture and Fisheries and multiple stakeholders in the region (universities, marine parks, etc).
New South Wales	NSWDPI	Current: Commercial catch monitoring	Estimate commercial catch, effort and size composition	Ongoing	Commercial licence funded plus core funds
	NSWDPI	Current: Recreational catch surveys	Estimate recreational catch (kept and released) in terms of numbers statewide	Ongoing every 2 years	Recreational licence funded plus core funds

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
	IMOS Animal Tracking Facility	Current: National tracking of priority species	National IMOS acoustic telemetry network optimised to track movements of marine species (including kingfish) and define cross-jurisdictional movement to better understand stock structure	Ongoing	Funded by the Integrated Marine Observing System (IMOS) and FRDC (Project 2018-091). In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN).
	IMOS Animal Tracking Facility	Planned: A nationally coordinated, collaborative. acoustic tagging program to define stock structure of priority Australian marine species	Implement a collaborative, nationally coordinated, acoustic tagging program of key priority species (including kingfish). Collect multi-year, cross-jurisdictional, movement, connectivity and residency data for these key priority species	3-4 years initially	Pending funding. In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN) and state Fisheries Management agencies.
	Sydney Institute of Marine Science	Planned: Satellite-tracking sexually mature yellowtail kingfish caught in NSW to reveal spawning habitats and recruitment hotspots	Describe movement patterns of large mature yellowtail kingfish caught in NSW waters. Identify critical habitats for large kingfish tagged in NSW waters via modelling of movement tracks. Identify key locations and timing of kingfish recruitment in NSW waters via larval dispersal modelling.	3 years	Pending funding. In collaboration with NSW recreational fishers and NSW DPI.
	NSWDPI	Current: Monitoring of kingfish stocking within Sydney region	Determine movement patterns from release sites and contribution to recreational catch of stocked kingfish based on tag recapture and genetic data through citizen science project. Telemetry work completed	Ongoing	Funded by NSW RFST

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
	UNSW	Recent: PhD by Stephanie Brodie	Thesis explores the ecological energetics of pelagic fish by estimating consumption rates (Chapter 2) and determining the environmental drivers of fish activity (Chapter 3) in coastal waters of eastern Australia. I also examine the oceanic habitats (Chapter 4) and forecast the seasonal distribution (Chapter 5) of two comparative pelagic predatory fish off the east coast of Australia.	2016	Funded by ARC Linkage, NSW Rec Trust, NSW DPI & CSIRO Climate Adaptation Flagship. Kingfish and Dolphinfish combined research.
Victoria	Victorian Fisheries Authority	Increasing knowledge of Victoria's growing recreational yellowtail kingfish fishery	(1) To determine whether yellowtail kingfish caught in Victorian waters are from a single or multiple stock complex using genetic markers. (2) Define population characteristics (age and growth, size structure, spawning characteristics) of Victorian yellowtail kingfish. (3) Determine the future potential of this fishery using historical recreational catch information. (4) To trial the use of satellite tags as one method to understand movement characteristics (spatial, depth, temperature preference) of yellowtail kingfish. (5) To trial otolith chemistry (stable isotope) analyses as a method for investigating yellowtail kingfish temperature preference and population structure. (6) To determine the suitability of yellowtail kingfish for marine stocking.	January 2020	Recreational Licence Funding

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
	IMOS Animal Tracking Facility	Current: National tracking of priority species	National IMOS acoustic telemetry network optimised to track movements of marine species (including kingfish) and define cross-jurisdictional movement to better understand stock structure	Ongoing	Funded by the Integrated Marine Observing System (IMOS) and FRDC (Project 2018-091). In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN).
	IMOS Animal Tracking Facility	Planned: A nationally coordinated, collaborative. acoustic tagging program to define stock structure of priority Australian marine species	Implement a collaborative, nationally coordinated, acoustic tagging program of key priority species (including kingfish). Collect multi-year, cross-jurisdictional, movement, connectivity and residency data for these key priority species	3-4 years initially	Pending funding. In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN) and state Fisheries Management agencies.
Tasmania	IMOS Animal Tracking Facility	Current: National tracking of priority species	National IMOS acoustic telemetry network optimised to track movements of marine species (including kingfish) and define cross-jurisdictional movement to better understand stock structure	Ongoing	Funded by the Integrated Marine Observing System (IMOS) and FRDC (Project 2018-091). In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN).

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
	IMOS Animal Tracking Facility	Planned: A nationally coordinated, collaborative. acoustic tagging program to define stock structure of priority Australian marine species	Implement a collaborative, nationally coordinated, acoustic tagging program of key priority species (including kingfish). Collect multi-year, cross-jurisdictional, movement, connectivity and residency data for these key priority species	3-4 years initially	Pending funding. In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN) and state Fisheries Management agencies.
	UTAS - IMAS	Current: Opportunities and impacts of range extending scalefish species: understanding population dynamics, ecosystem impacts and management needs	(1) Develop a program for ongoing collection of biological samples and data of key range-shifting fish species using citizen science initiatives engaging with the recreational fishing community. (2) Develop geographically discrete life-history parameters for key range-shifting fish species in Tasmania to inform management decisions. (3) Determine the diet composition of key range-shifting fish species to refine parameterisation of an ecosystem model. (4) Utilise the Atlantis ecosystem model framework to predict ecological impacts of increasing abundance of key range-shifting fish species in Tasmania. (5) Develop species distribution models that utilise oceanographic climate change projections to predict the future presence and persistence of the key target species in Tasmania.	2 years	FRDC funded (FRDC 2018-070), multi-species including Kingfish, pink snapper and King George Whiting. Tissue samples are being collected but it is not an objective to process them as part of this project.

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
	UTAS - IMAS	Recent: Influence of oceanographic environment on the distribution and condition of an iconic coastal-pelagic fish within a climate change hotspot	(1) Demonstrate the utility of a marine-based habitat suitability model for quantifying historical climate-driven species redistributions while simultaneously accounting for sources of natural climate variability. (2) Quantify the temporal persistence (months per year) of suitable oceanographic habitat for kingfish within coastal bioregions. (3) Develop a robust sampling protocol for the field-based application of BIA for assessing relationships between fish condition and environmental habitat suitability. (4) Test for a relationship between oceanographic habitat suitability and the physiological status of kingfish from eastern Australia.	3.5 years	Curtis Champion's PhD thesis
South Australia	Flinders University	Current: Movement and residency	Assess residency in South Australian key areas and cross-jurisdictional movement	July 2021	As part of Tom Clarke PhD project
	Flinders University	Current: spawning behaviour	Develop and apply methods to identify spawning behaviour and location	July 2021	As part of Tom Clarke PhD project
	Flinders University	Current: genetic sample collection	Collect genetic samples from South Australia	Ongoing	Genetic samples are collected from any yellowtail kingfish captured as part of various projects
	Flinders University	Current: impact of wildlife tourism	Assess the effects of white shark cage-diving	July 2021	As part of Tom Clarke PhD project

Jurisdiction	Organisation/s	Project title	Objectives	End Date	Notes
	IMOS Animal Tracking Facility	Current: National tracking of priority species	National IMOS acoustic telemetry network optimised to track movements of marine species (including kingfish) and define cross-jurisdictional movement to better understand stock structure	Ongoing	Funded by the Integrated Marine Observing System (IMOS) and FRDC (Project 2018-091). In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN).
	IMOS Animal Tracking Facility	Planned: A nationally coordinated, collaborative. acoustic tagging program to define stock structure of priority Australian marine species	Implement a collaborative, nationally coordinated, acoustic tagging program of key priority species (including kingfish). Collect multi-year, cross-jurisdictional, movement, connectivity and residency data for these key priority species	3-4 years initially	Pending funding. In collaboration with the Fisheries and Aquaculture Research Providers Network (RPN) and state Fisheries Management agencies.

While the inability to hold a face-to-face workshop due to COVID-19 travel restrictions somewhat limited discussions, the survey of experienced fishers, collation of jurisdictional needs and video conferencing enabled the project objectives to be met.

It was clear that Yellowtail Kingfish remains a high priority species throughout its range, with management agencies eager to better understand and improve their fisheries. A limitation to improved management reported by all jurisdictions was a lack of knowledge around basic biology, life-history and fishery data. A key outcome of this project is a list of priority areas of research for improved assessment and management (see Recommendations).

The two objectives concerning appropriate scales for assessment and management, and cross-jurisdictional management options, were discussed only cursorily by relevant scientists and managers. Discussions were impacted by the inability to hold a face-to-face workshop; however the general consensus was that until key knowledge gaps were filled that there was little point in pursuing such discussions. It was noted by all agencies that disparate size and bag limit regulations existed between jurisdictions (Table 3). Discussion was had on why this may have occurred and comparable management arrangements between jurisdictions suggested as worth discussion once knowledge gaps had been filled.

Table 3. Recreational bag and size limits by jurisdiction for Yellowtail Kingfish.

Jurisdiction	Bag Limit	Minimum Legal Length
Queensland	2 (possession limit)	60 cm TL
New South Wales	5	65 cm TL
Commonwealth	N/A	N/A
Victoria	5	60 cm TL
Tasmania	5 (10 in possession)	45 cm TL
South Australia	1	60 cm TL

It is noteworthy that the only jurisdiction to have a significant commercial fishery (NSW) was also the only jurisdiction with adequate data to assess the fishery and stock status. Such data was obtained from compulsory commercial fisher logbooks and routine length-based monitoring of landings. A lack of adequate information on the recreational fishery in terms of quantities, catch rates, sizes and ages from every jurisdiction is clearly inhibiting understanding of the fisheries and stock. Importantly this work has initiated improved communications between relevant scientists from each jurisdiction that will likely lead to future collaborative studies.

This project enabled the 2020 SAFS authors to provide a defined stock status for Yellowtail Kingfish, and so contribute to the FRDC National Priority 1 of reducing the percentage of 'Undefined' stocks within SAFS. It needs to be noted however that the status of 'Sustainable' (Hughes et al. 2020) has a considerable number of caveats and considered relatively uncertain; with the overall weight-of-evidence suggesting a 'Sustainable' stock. It is anticipated that future assessments based on improved fishery, biological and life-history information will be more certain, as well as fishery performance metrics. A harvest strategy for Yellowtail Kingfish is being developed in NSW and will require support from an improved assessment.

Recommendations

The project identified the following areas of research as being essential for stock assessment and management of the Eastern Australia Yellowtail Kingfish stock:

1. A nationally co-ordinated tagging study across the entire distribution of the Eastern Australian biological stock to elucidate movement patterns and connectivity of all sizes of fish.
2. Recreational fishing surveys of high quality should be done by each jurisdiction to estimate catch, effort and size composition of Yellowtail Kingfish.
3. Identification of key spawning areas and times.
4. Identify the main source of recruits in each jurisdiction.
5. Drivers of Yellowtail Kingfish movement patterns, including habitat, prey and reproduction.
6. The size/age at sexual maturity should be updated, including sampling across the entire distribution.

Other recommendations:

1. Harvest strategies should be developed for Yellowtail Kingfish.
2. A fully-integrated population model should be developed once adequate data are available.
3. Communication between scientists and managers across all jurisdictions is essential for assessment of shared biological stocks.
4. Data to be used in assessments and management decisions should be reviewed by knowledgeable fishers.

Further development

Development of research proposals to address the recommended areas of research required for improved assessment and management of the Eastern Australian biological stock of Yellowtail Kingfish should occur as a matter of urgency. Potential funding sources and industry collaboration should be identified.

Extension and Adoption

Extension of the outcomes from this project will be straightforward. This final report will be the main source of dissemination to the general public and interested fishers. The assessment (Hughes and Stewart, 2020) and revised SAFS status will be communicated via the SAFS 2020 platform.

References

Champion, C. L. C., 2020. Influence of oceanographic environment on the distribution and condition of yellowtail kingfish (*Seriola lalandi*) within a climate change hotspot (Doctoral dissertation, University of Tasmania).

Champion, C., Hobday, A. J., Zhang, X., Pecl, G. T. and Tracey, S. R., 2019. Changing windows of opportunity: past and future climate-driven shifts in temporal persistence of kingfish (*Seriola lalandi*) oceanographic habitat within south-eastern Australian bioregions. Marine and Freshwater Research, 70(1), pp.33-42.

Champion, C., Hobday, A. J., Pecl, G. T. and Tracey, S. R., 2020. Oceanographic habitat suitability is positively correlated with the body condition of a coastal-pelagic fish. Fisheries Oceanography, 29(1), pp.100-110.

Gillanders, B. M., Ferrell, D. J. and Andrew, N. L. (1996) Determination of ageing in kingfish (*Seriola lalandi*) in New South Wales. Final report to the Fisheries Research and Development Corporation, project No. 95/128. NSW Fisheries, Cronulla.

Gillanders B. M., D. J. Ferrell & Andrew, N. L., 1999. Size at maturity and seasonal changes in gonad activity of yellowtail kingfish (*Seriola lalandi*; Carangidae) in New South Wales, Australia. New Zealand Journal of Marine and Freshwater Research, 33:3, 457-468

Gillanders, B. M., Ferrell, D. J. and Andrew, N. L., 2001. Estimates of movement and life-history parameters of yellowtail kingfish (*Seriola lalandi*): how useful are data from a cooperative tagging programme? Marine and Freshwater Research, 52: 179–192.

Green, C., Hamer, P., Ingram, B., Silva, C., Strugnell, J. and Whitelaw .B, 2020. Increasing knowledge of Victoria's growing recreational yellowtail kingfish fishery. Recreational Fishing Grants Program Research Report, Project No. 14/15/Large/34.

Hughes, J., Molony, B., Dawson, A., Steer, M. and Georgeson, L. 2018. Yellowtail Kingfish (*Seriola lalandi*), in Stewardson, C., Andrews, J., Ashby, C., Haddon, M., Hartmann, K., Hone, P., Horvat, P., Mayfield, S., Roelofs, A., Sainsbury, K., Saunders, T., Stewart, J., Nicol, S and Wise, B. (eds) 2018, Status of Australian fish stocks reports 2018, Fisheries Research and Development Corporation, Canberra.

Hughes J. M. and Stewart, J., 2020. Status of Australian Fish Stocks 2020 – NSW Stock status summary – Yellowtail Kingfish (*Seriola lalandi*).

Miller, P. A., Fitch, A. J., Gardner, M., Huston, K. S. and Mair, G. 2011. Genetic population structure of yellowtail kingfish (*Seriola lalandi*) in temperate Australasian waters inferred from microsatellite markers and mitochondrial DNA, Aquaculture 319: 328–336.

Stewart, J., Ferrell, D. J., Van der Walt, B., Johnson, D. and Lowry, M., 2001. Assessment of length and age composition of commercial kingfish landings, final report to the Fisheries Research and Development Corporation, project 1997/126, New South Wales, Fisheries Final Report Series.

Stewart J., Ferrell D. J., and van der Walt, B., 2004. Sizes and ages in commercial landings with estimates of growth, mortality and yield per recruit of yellowtail kingfish (*Seriola lalandi*) from New South Wales, Australia. Marine and Freshwater Research 55, 489-497.

Appendices

Appendix 1.

Survey designed to elicit opinions from knowledgeable fishers on the representativeness of data proposed to underpin the Yellowtail Kingfish stock assessment.

Fisher assistance to support Yellowtail Kingfish stock assessment

Yellowtail Kingfish (*Seriola lalandi*) is an iconic species amongst fishers in NSW. Growing to more than 50 kgs and 190 cm in length, Kingfish are extremely important for commercial, recreational and charter fishers in NSW and as such are a priority species for NSWDPI - Fisheries. Currently the commercial fishery, which is a line fishery, is managed mainly through input controls (no quota) and a minimum legal length of 65 cm total length. The recreational and charter fisheries are also managed through a minimum legal length of 65 cm total length and a bag limit of 5 fish per person.

Yellowtail Kingfish stock status is being assessed as part of the 2020 Status of Australian Fish Stocks project. In 2018, the status was assessed as being 'Undefined', due to knowledge gaps in the assessment. To assist in the 2020 stock status assessment we are seeking input from people who have been identified as having considerable experience with the Yellowtail Kingfish fishery. The attached survey is designed to help assessment scientists in setting input parameters to the assessment that are as accurate as possible. Two of the most important inputs into an assessment are total catch (harvest) and catch rates. This survey is asking questions that can be used to help in understanding and interpreting both of these things.

Commercial landings data for Yellowtail Kingfish in NSW are available since the mid 1940s through compulsory logbooks; however estimates of any recreational harvest are lacking prior to 2000/01 when the National Recreational and Indigenous Fishing Survey (NIRFS) was done. Since that time there have been 2 more surveys to estimate recreational harvest in NSW, in 2013/14 (West et al., 2015) and in 2017/18. Total historical harvest from the NSW Kingfish fishery was reconstructed here by estimating recreational harvest prior to, and between, survey estimates. Hindcasting the recreational harvest prior to 2000/01 was done using estimates of recreational marine fishing effort as a proxy and benchmarking that against the 2000/01 survey estimates. Recreational harvest between each survey period was assumed to follow a constant trend.

Recreational harvest was estimated to have increased rapidly during the 1970s and 1980s, peaking in 1990/91 at around 300 t (Fig. 1). There was a substantial decline in recreational harvest between the surveys in 2000/01 and 2013/14 (noting that the minimum legal length was increased from 60 to 65 cm total length in 2007), and a slight increase between 2013/14 and 2017/18. It is noted that the NSW charterboat harvest is included within these recreational estimates.

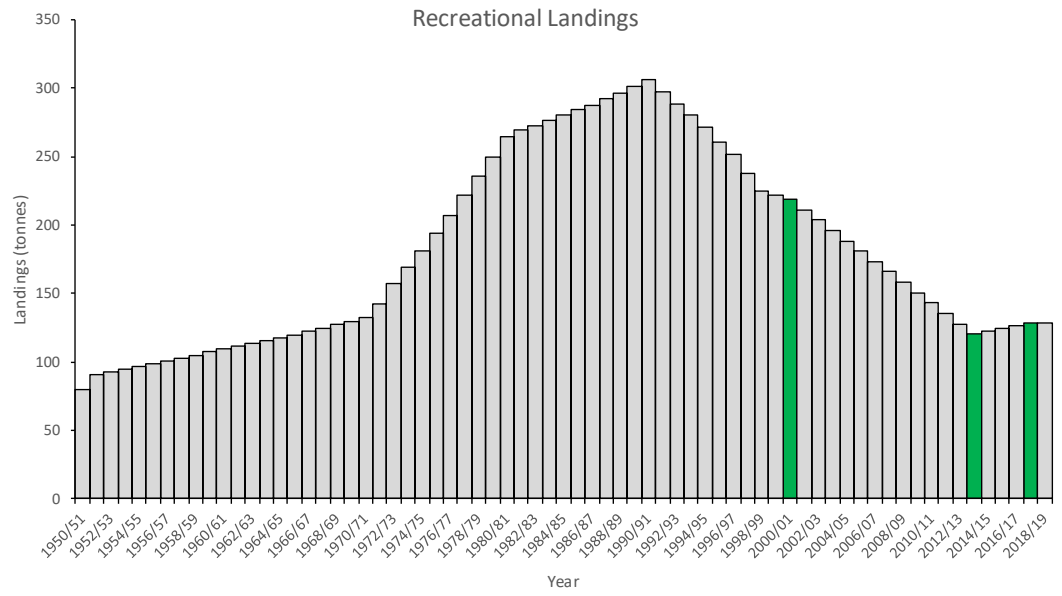

Figure 1. Estimated recreational fishing harvest of Yellowtail Kingfish in NSW 1950/51 to 2018/19. The green bars indicate actual survey estimates.

The commercial harvest of Yellowtail Kingfish increased substantially during the 1980s, but declined rapidly during the 1990s (Fig. 2). There have been numerous management changes effecting commercial fishery harvest since the 1980s, including changes to minimum legal lengths and the banning of the Kingfish traps (Fig. 3).

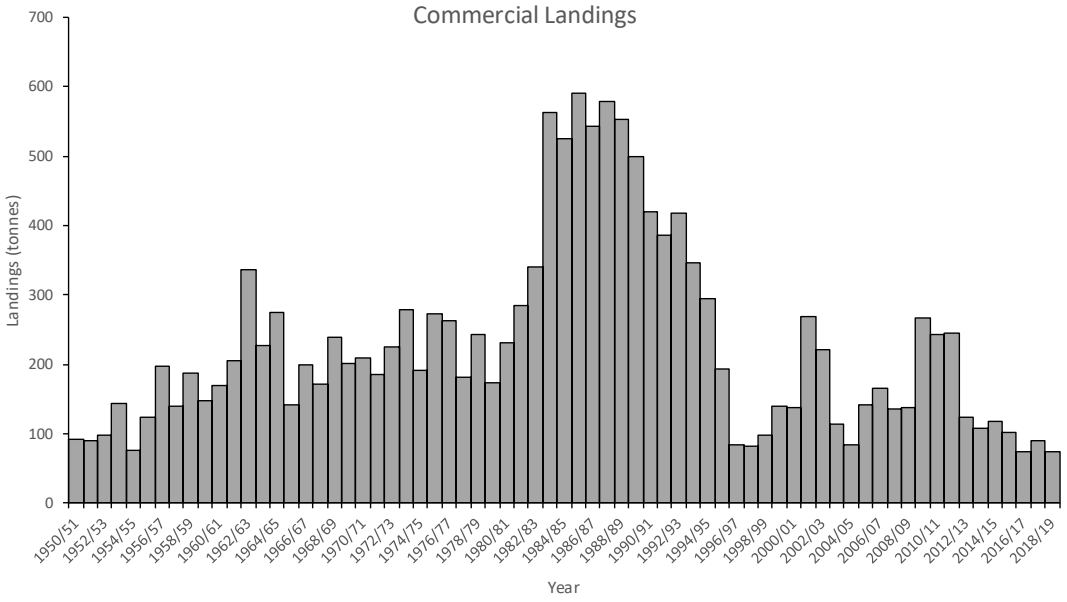

Figure 2. Reported commercial fishing harvest of Yellowtail Kingfish in NSW 1950/51 to 2018/19.

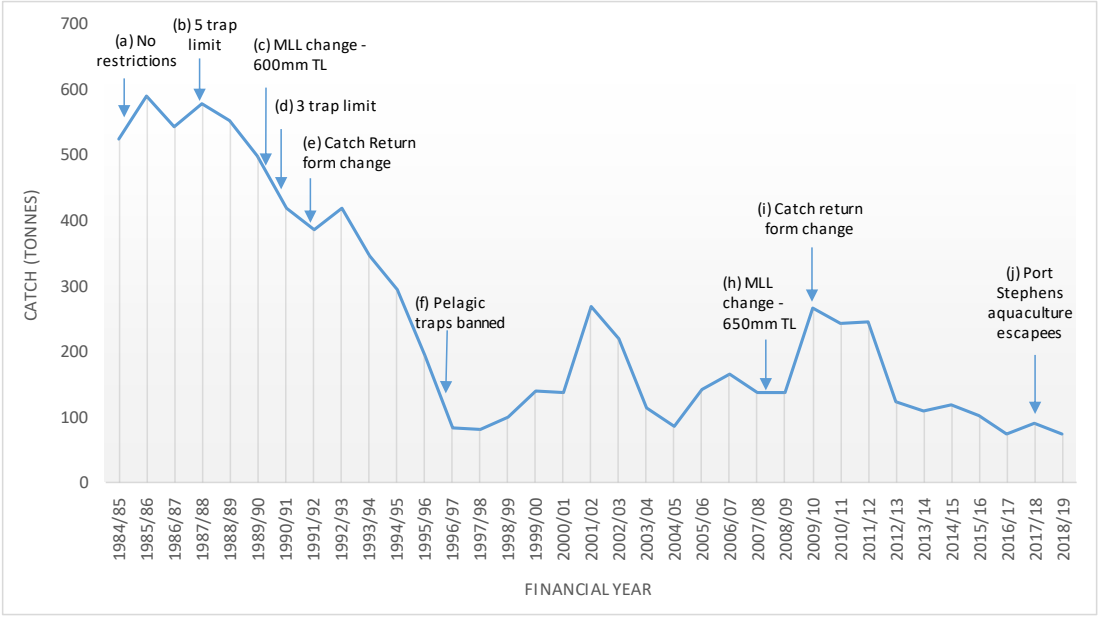

Figure 3. Various management changes effecting the commercial kingfish fishery in NSW since the early 1980s.

Combining the NSW commercial and recreational harvest estimates indicate that the fishery increased during the 1970s and early1980s, peaking at around 875 t during the mid-1980s (Fig. 4). Total harvest since the mid-1990s has been considerably lower, averaging approximately 320 t p.a. since 1995/96.

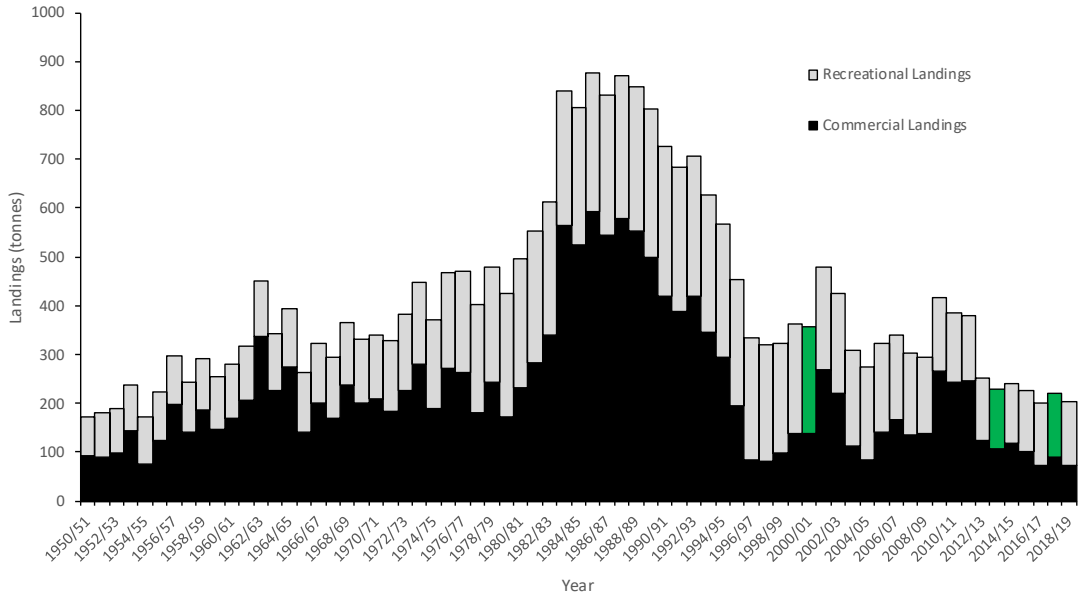

Figure 4. Reconstructed catch history for Yellowtail Kingfish in NSW 1950/51 to 2018/19.

References

West, L.D., K.E. Stark, J.J. Murphy, J.M. Lyle and F.A. Doyle (2015). Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series.

This survey is designed to obtain information on catch and fishing efficiency relating to the Kingfish fishery in NSW to support stock assessment.

Name (optional):.....

Locations (general areas within NSW) where your experiences relate to: .....

.....

.....

Fishing sector you relate to:

· Commercial · Recreational · Charter

Roughly how many years have you fished for Kingfish?

.....

Catch

In your opinion how does the current harvest (taken by all sectors) of Kingfish compare with harvest in previous decades? .....

.....

Does the catch history reconstruction here seem reasonable? If not, how would you change it? .....

.....

Does the catch increase during the 1970s and 1980s appear consistent with the advent of commercial kingfish trapping and the large increase in offshore trailerboat fishing?.....

.....

Do the relative commercial to recreational harvest ratios seem likely? If not, how would you change them?.....

.....

Do you believe that there is currently, or has been historically, significant 'black marketing' of Kingfish? If so, to what extent may that have affected the reconstructed catch history here?

.....

.....

.....

Management

Various management changes have affected the harvest of Kingfish through time, for example some commercial management changes are indicated in Figure 3. In your opinion

what are the major management changes that have affected harvest in the sector you know most about? In what way and by how much?

.....

.....

.....

.....

Fishing Efficiency

Has technology improved the ability to catch Kingfish (Y/N):.....

If Yes, which types of technology and during which years? Examples may include:

· Boats. Years/Decade: .....

· Sounders. Years/Decade: .....

· Fishing tackle (name specific items). Years/Decade: .....

.....

· Spot-lock electric motor. Years/Decade: .....

· Chart plotter. Years/Decade: .....

· Social media. Years/Decade: .....

· Other, please specify: .....

.....

.....

If you think fishing technology in general has improved catching ability, by what percentage do you think it has improved the ability to catch Kingfish? Over which time period?

· <25% · 25 – 50% · 50 – 75% · > 75% · Other, please specify…….....

Time period: .....

Access

Has the ability to access Kingfish changed? (Y/N).....

If Yes, has access increased (e.g. through better boats, boat ramps etc.), or decreased (e.g. through closed areas)?.....

.....

Has the ability to access Kingfish affected harvest?.....

If Yes, how and by how much?

.....

.....

Supplementary Questions.

The following questions are designed to provide perspective on the current fishery, and will not be used directly in stock assessment.

Abundance

Based on your experience how has the abundance of Kingfish changed?

· More · Less · Same · Not sure

Size

Allowing for the changes in size limit, over time the sizes of Kingfish harvested has:

· Increased · Decreased · Remained similar · Not sure

To what do you attribute that change? .....

.....

Fishing pressure

In your experience, the number of fishers (all sectors combined) targeting Kingfish has:

· Increased · Decreased · Not changed · Not sure

Management

Do you feel that current management arrangements support the long-term sustainability of the Kingfish stock?

· Yes · No · Not sure

If No, what do you think needs to be done?.....

.....

.....

.....

.....

.....

Thanks for your expertise in completing this survey. If requested we will contact you again with details of the stock assessment.

Appendix 2.

Project participant list

Name	Organisation
Anthony Roelofs	Department of Agriculture and Fisheries - Queensland
James Woodhams	Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
Corey Green	Victorian Fisheries Authority
Sean Tracey	Institute of Marine and Antarctic Studies
Paul Rogers	Department of Primary Industries and Regions - South Australia
John Stewart	Department of Primary Industries - New South Wales
Julian Hughes	Department of Primary Industries - New South Wales
Alistair Becker	Department of Primary Industries - New South Wales
Curtis Champion	Department of Primary Industries - New South Wales
Anne-Marie Hegarty	Department of Primary Industries - New South Wales
Caitlin Young	Department of Primary Industries - New South Wales
Antony Gould	Department of Primary Industries - New South Wales
Glen Staples	Department of Primary Industries - New South Wales
Vic Levett	NSW Charter fishers
Tricia Beatty	Professional Fisher's Association
Heath Little	NSW Commercial fishers
Greg Eden	NSW Commercial fishers
Chris Innes	NSW Commercial fishers
Charlie Huveneers	Flinders University
Tom Clarke	Flinders University
Hayden Schilling	University of New South Wales
Fabrice Jaine	Integrated Marine Observing System (IMOS)