Australian Government

Australian Fisheries Management Authority

Torres Strait Finfish Fishery: Coral Trout and Spanish Mackerel Biological Sampling 2021-2024

AFMA Project Number 2020/0814

Final Report: June 2024

This report should be referenced as:

Trappett A.G., Langstreth J.C., and O'Neill M.F., 2024. *Torres Strait Finfish Fishery: Coral Trout and Spanish Mackerel Biological Sampling 2021-2024,* Torres Strait AFMA Project Number: 2020/0814. Department of Agriculture and Fisheries, Queensland Government.

This publication has been compiled by A.G. Trappett of Fisheries Queensland, Department of Agriculture and Fisheries.

Enquiries and feedback regarding this document can be made as follows:
Email: info@daf.qld.gov.au
Telephone: 13 25 23 (Queensland callers only) (07) 3404 6999 (outside Queensland) Monday, Tuesday, Wednesday and Friday: 8 am to 5 pm Thursday: 9 am to 5 pm
Post: Department of Agriculture and Fisheries GPO Box 46 BRISBANE QLD 4001 AUSTRALIA
Website: daf.qld.gov.au

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Acknowledgements

The authors acknowledge the Traditional Owners of the Country where this research was carried out and recognise their continuing connection to land, sea country and culture. The authors pay our respects to their Elders past, present and emerging.

Many thanks to all the island communities, Native Title Prescribed Body Corporates (Mer Gedkem Le, Ugar Gedkem Le Zeuber Er Kep Le, Masigalgal Corporation, Erubam Le Traditional Land and Sea Owners) for allowing us access to visit communities and to Torres Strait Island Regional Councillors Cr. Aven Noah, Cr. Hilda Mosby, Cr. Jimmie Gela and Cr. Rocky Stephen for hosting the project team in community while conducting this research and for providing research samples.

The authors recognise and thank the project team comprising of project partners:

- Huge thank you to all the community members, commercial Torres Strait Spanish Mackerel fishers, fish buyers and fish processors that have assisted the project through collecting biological data and offering support including: Amina Ghee, Harry Ghee, Issac Ghee, Jermaine Ketchell, Samuel Mye, Kenny Bedford, Rock Gela, Dennis Passi, Allan Passi, John Tabo Jr, James Zaro, John Zaro, Jimmy Wailu, Appie Thaiday, Sabu Tabo, Billy Bourne, Pau Stephen, Akasha Stephen, Seri Stephen, Dan Sailor, Les Pitt, Kenny Bedford, Bert Matysek, Grahame Hirakawa, Tony Shibasaki, Harry Nona, Simon Naawi, Paul Lowatta, Gavin Mosby, Hilda Mosby, Tenny Elisala, Benny Dau, Egon Stewart, Mick Boylen, Keith Dellow and Jo Dellow, Ian McCarter (Dugong Adventures) and many others.
- Many thanks to Senior Ranger Barry Pau from Erubam Rangers for his support provided to the sampling program and advice on working in communities through 2019 to present.
- Thank you to Jermaine Baker and team at Meriba Ged Ngalpun Mab on Erub for your support and advice on working in community.
- Chris Boon, Nat Couchman, Georgia Langdon, Selina Stoute, Emma Freeman, Kayoko Yamashita (Australian Fisheries Management Authority, AFMA), Quentin Hirakawa (Torres Strait Regional Authority, TSRA) for support with operational parts of the project, Malcolm Pearce, Jason McGilvray (Queensland DAF) who provided an advisory and project steering role as well as provided a review and comments on the draft report.
- Thank you to DAF Fisheries Queensland staff: Peri Subritzky and Olivia Whybird for their assistance in reviewing this report and thanks to Cassandra Peters for assistance with fish ageing, Shirin Hyatt, Susin Churchill and Brayden Jarvis for their support with the data collection, sampling, and laboratory processing.

The authors acknowledge and thank AFMA for funding the project and reporting through the Torres Strait Scientific Advisory Committee, in collaboration with additional funding and support from TSRA and DAF.

Ethical clearance and oversight were granted for this project by the PZJA Torres Strait Scientific Advisory Committee and managed by the Committee's Research Secretary at AFMA Ms. Lisa Cocking.

Acronyms and traditional names

Acronyms and Terms

AFMA	Australian Fisheries Management Authority
CDR	Catch Disposal Record issued by AFMA for mandatory recording of harvests by licenced fish receivers (TDB02)
DAF	Department of Agriculture and Fisheries, Queensland
FL	fork length
JL	jaw length
n	number or count of samples
PBC	Prescribed Body Corporate (see RNTBC)
PZJA	Protected Zone Joint Authority
RNTBC	Registered Native Title Body Corporate (see PBC)
Sunset	Sunset licence holder/sector leasing annual access to commercially fish
TIB	Traditional Inhabitant Boat sector (commercial fishers)
TL	total length
TSFFRAG	PZJA Torres Strait Finfish Fishery Resource Assessment Group
TSRA	Torres Strait Regional Authority
TVH	Transferrable Vessel Holder

Traditional names

Erub	Darnley Island community
Maizab Kaur	Bramble Cay fishing grounds, approximately 50km NNE of Erub.
Masig	Yorke Island community
Mer	Murray Island community
Ugar	Stephen’s Island community
Waiben	Thursday Island community

Summary

Annual fish age-length sampling is essential to monitoring trends and patterns in the recruitment, abundance, and cohort strengths of key commercial Torres Strait finfish stocks. These data are needed to support stock assessments and sustainable fisheries management.

This report summarises the *Torres Strait Finfish Fishery Coral Trout and Spanish Mackerel Biological Sampling Program 2021-2024*, identified by the Torres Strait Protected Zone Joint Authority (PZJA) as a key data need for the Torres Strait Finfish Fishery.

The report includes appropriate findings from previous biological sampling research funded in 2019-2020 financial year on Torres Strait Spanish Mackerel (Langstreth et al. 2020) and during 2020-2021 financial year for Spanish Mackerel and coral trout species (Trappett et al. 2021). The report describes the sampling program designed and employed following on from the method developed in these prior studies.

The program collected coral trout and Spanish Mackerel frames from both Traditional Inhabitant Boat (TIB) and non-traditional commercial (Sunset) fishing sectors. Many fishers and community members assisted to collect samples from fish frames and measure the lengths of fish from commercial and traditional catches. Participation of Traditional Owners and Traditional Inhabitants was fostered by holding community workshops. The program worked closely with key fishers and fish receiver businesses and provided one-on-one training and communication which focused on opportunities for local involvement in sampling and data collection.

Spanish Mackerel

Declines in Torres Strait Spanish Mackerel catch rates and biomass estimates evident in previous stock assessments have driven a need to collect updated biological fish age-length information. A sampling program was employed to collect length measures and to collect frames from both Traditional Inhabitant Boat (TIB) and Sunset (primarily non-indigenous fishers leasing temporary access to fish) sectors to allow the study of length, sex and to determine an age at length relationship. These data inform the model of the population formed during stock assessments. The stock assessment provides an estimate of stock abundance using these data, which is then used to set a sustainable level of fishery harvest.

Updated biological sampling of Torres Strait Spanish Mackerel was re-commenced in 2019-2020, following a gap in sampling since 2005-2006. This was implemented to address a long-term need identified by the PZJA for updated fish age-length information. These data add to the historical fish age and length data collected during previous sampling programs (2000-2001 to 2002-2003 and 2005-2006).

Spanish Mackerel sampling conducted since the commencement of monitoring in the 2019-2020 financial year:

- 11,008 Spanish Mackerel were measured from 307 individual commercial catches
- Sampling was conducted in five separate areas of the fishery, including at Maizab Kaur (Bramble Cay) where most of the fishery harvest occurs.
- A large proportion of the fishing effort was annually sampled for lengths, ranging from 24 to 75% by fishing season.

- Length structures sampled in this study were consistent in structure to those reported from older on-board surveys.
- Otoliths were collected from a total of 2,052 Spanish Mackerel with 2,025 interpreted for age allocation.
- Fish ranged from 0 to 13 years in age with most fish being two years old.
- A strong cohort of fish (sharing the same birth year) were able to be tracked through the years of sampling, evident as a large proportion of the harvest being 2-year-olds in 2020-2021, 3-year-olds in 2021-2022 and again present as 4-year-olds in 2022-2023.
- Genetic samples were collected from a total of 3,813 Spanish Mackerel.

Coral trout

A data need identified by the PZJA for the Reef Line fishery was to expand the 2019-2020 biological sampling program for Spanish Mackerel to the collection of coral trout biological information for 2020-2021. A coral trout sampling program was employed to collect length measures and to collect coral trout frames from TIB and Sunset sectors to allow the study of length, sex and to attempt to determine an age at length relationship per species. An additional objective of the program was to collect and report on species composition of commercial catches noting that a key challenge for the stock assessment of Torres Strait coral trout is the 'basket' of four coral trout species harvested by Torres Strait fishers and reported in catch reports as a grouping of 'coral trout'.

Coral trout sampling conducted since the commencement of monitoring in the 2020-2021 financial year:

- 1,356 coral trout (all species) were measured from 70 catches.
- Otoliths were collected from a total of 416 coral trout with 377 aged.
- Six areas of the fishery were sampled including the key fishery areas in eastern Torres Strait where commercial harvest occurs.
- Common Coral Trout and Passionfruit Coral Trout were found to reach a maximum age of 13. Barcheek Coral Trout were overall generally of a younger age with a minimum of 1 and a maximum of 10 years of age.
- Most coral trout aged in the study were between 4 and 7 years of age.
- Sunset sector was found to have a much higher proportion of Common Coral Trout over the other three target species in their catches sampled compared to TIB sector which generally had equal proportions of Common Coral Trout and Passionfruit Coral Trout sampled across the study.

Project outputs and outcomes

Key outcomes from this project were the successful design and implementation of a biological sampling program that was able to deliver a large volume of accurate, representative data from remote fishing locations. This was achieved through building and maintaining strong working relationships with Torres Strait fishers, fish receivers and other stakeholders.

Key outputs were provided to support annual Spanish Mackerel stock assessments and the research findings also supported the 2023 coral trout stock assessment update. For the first time this research was able to identify a strong recruitment pulse (cohort) of Spanish Mackerel evident in the annual age structure in this stock. This research was able to provide the first updated age-data for Torres Strait coral trout species (including Barcheek and Passionfruit Coral Trout species) since 2005.

While not a succinct objective of the project, substantial extension of the project's outputs and outcomes to communities and stakeholders was achieved through:

- meetings held during sampling trips to communities to share results and updates,
- project updates provided to PZJA advisory group meetings, and
- communications strategy that included a webpage, video explanations of the project, community notices, project flyers and SMS messages sent to fishers.

This extension helped in building the capacity of fishers and interested community members in engaging with collaborative science and management of their fish stocks.

In additional to key project objectives, the project has supported the AFMA funded CSIRO Close Kin Mark Recapture (CKMR) Pilot Study (Williams et al. 2022) by providing a large volume of Spanish Mackerel genetic tissue samples for analysis. The analysis of these samples supported the pilot study's objectives which included confirming stock connectivity assumptions using population genetics. Correct stock definition is a key assumption for any stock assessment model. Since 2021-2022 the project has aimed to collect 1,000 Spanish Mackerel genetic samples per sampling season (financial year) to support future genetic research projects.

Project challenges and future recommendations

Ongoing annual fish age-length sampling is critical to monitor trends and patterns in the recruitment, abundance, and cohort strengths of key commercial Torres Strait finfish stocks. These data are needed to support stock assessments and management action to set sustainable catch limits. This information also plays a key role in understanding the impact of the changing climate on the biology of these fishes including how stock recruitment may change relative to sea surface temperature.

A key challenge for the project lies in converting general support and interest into active participation from fishers, including fishers consistently filling out length measures and providing fish frames for study. Continued partnerships with key stakeholders, regular community engagement and feedback of project results will continue to build and promote trust to support effective working relationships over time between communities and researchers.

Future research needs include building on the spatial and temporal coverage of sampling, particularly outside of the main Spanish Mackerel fishing ground of Maizab Kaur and from the TIB sector. This is to test for any differences in length or age structure in other areas of the fishery as most of the stock assessment information and sampling was from Maizab Kaur from the commercial Sunset sector.

Given that most data from the TIB sector have been acquired while project staff have been working in community, future monitoring should look at options to spend more targeted time in community while catches are occurring or investigate hiring a research assistant from within community to collect samples.

Future monitoring of Torres Strait coral trout species requires more samples to provide more detailed trends in length and age structure. Due to a lower level of fishing effort for coral trout relative to Spanish Mackerel, the project has not been able to acquire as many samples for the species basket as might have been expected. This issue is exacerbated by the tally of samples acquired being divided between the three main coral trout species commonly harvested (Common, Barcheek and Passionfruit Coral Trout).

Fisheries Queensland also recommends that future work on collecting biological data for Spanish Mackerel and coral trout species in the Torres Strait move from a short-term research-based funding model to routine monitoring program through an ongoing agreement for service.

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Objectives

The objectives of the project included:

- Continuing from previous contracts for biological data collection in the Torres Strait, reviewed design of a cost effective and efficient sampling program to collect the required fishery dependent biological data from fishers (ageing data and length data for Spanish Mackerel; ageing data, length data and catch composition for coral trout species) for informing the assessment of stock status and catch limits for Spanish Mackerel and coral trout species in the Torres Strait.
- Engagement with Traditional and non-Traditional fishing sectors to collect fish length data. Collect and process fish specimens and conduct ageing of fishes sampled as per existing standardised ageing protocols and quality assured methodologies.
- Collection of age, sex, length-frequency data along with genetic samples for Spanish Mackerel.
- Collection of age, sex, and length-frequency data, and species composition for coral trout species.

Introduction

The Torres Strait Finfish Fishery (TSFF) is made up of two sub-fisheries; the Torres Strait Finfish (Reef Line) Fishery, mainly targeting coral trout species (P*lectropomus* spp.), and the Torres Strait Spanish Mackerel Fishery targeting Spanish Mackerel (*Scomberomorus commerson*). Under the Protected Zone Joint Authority (PZJA), the Australian Fisheries Management Authority (AFMA) is the lead agency for management of Torres Strait stock of Spanish Mackerel and coral trout species with Queensland's Department of Agriculture and Fisheries - Fisheries Queensland providing scientific support. These fish species are iconic fishes with cultural significance for Torres Strait communities and represent an important economic opportunity and food source, with recent commercial harvests in the order of 20-40 t for coral trout species and 50-100 t for Spanish Mackerel.

Two commercial sectors, the Traditional Inhabitant Boat (TIB) and non-traditional sector (Sunset licence sector), target Spanish Mackerel and coral trout species. Fish catch and catch rate data from these two sectors provide data for the stock assessments for these species. While this study focuses on commercial fishing sectors, other sectors of the fishery in Torres Strait waters include recreational, charter and traditional subsistence fishers.

The Torres Strait Reef Line Fishery is a multispecies line fishery predominantly targeting coral trout (*Plectropomus spp.*). The target species are:

- Common Coral Trout (*Plectropomus leopardus*)
- Barcheek Coral Trout (*Plectropomus maculatus*)
- Passionfruit Coral Trout (*Plectropomus areolatus*)
- Bluespotted Coral Trout (*Plectropomus laevis*)

The TSFF Spanish Mackerel Fishery is a line fishery targeting Spanish Mackerel. Spanish Mackerel are a large pelagic, predatory fish which are commonly targeted by fishers during breeding aggregations (Thurstan et al. 2016). The Torres Strait commercial fishery for Spanish Mackerel has periods of focused harvest, e.g. Spanish Mackerel is taken mostly between

September and November at a known breeding aggregation at Maizab Kaur (Bramble Cay). Peak coral trout species harvests are reported following the monsoon in the first half of the calendar year. Commercial harvests are mostly taken from eastern Torres Strait. Spanish Mackerel harvests are concentrated on north-eastern waters around Maizab Kaur.

In 2008, the Australian Government funded a 100 per cent buyback of Transferrable Vessel Holder (TVH) fishing licences, such that the catch entitlements in the fishery since are 100 per cent owned by the TIB sector. As a condition of the buyout, the Protected Zone Joint Authority (PZJA) agreed that the Torres Strait Regional authority (TSRA) would hold and lease out temporary licences until the TIB sector could increase its catch to the full allocation.

The TSRA manages the leasing out of fishing licences each fishing season on behalf of traditional inhabitants of the Torres Strait. The TIB sector has many licenced operators (>200) harvesting a small amount of catch. The non-traditional Sunset sector harvests most of the catch and consists of a small number of operators accessing the fishery through a temporary annual 'sunset' licence which is leased from the TSRA. These operators target Spanish Mackerel spawning aggregations around Maizab Kaur during August to December and, to a lesser extent, target other fishing grounds for coral trout around eastern Torres Strait waters. The sunset sector is regulated to prohibit fishing within ten nautical miles of each of the eastern Torres Strait communities of Masig, Ugar, Erub, and Mer which drives some spatial differentiation in the use of the fishery by sector.

Concerns around declines in Spanish Mackerel catch rates from 2010 to 2018 (see O'Neill 2024) have driven a need to collect age-length information for this species. This data is to support future stock assessment investigations, with these assessments informing management decisions on sustainable levels of catch. Biological sampling of Torres Strait Spanish Mackerel has been conducted annually since 2019-2020 financial year (Langstreth et al. 2020; Trappett et al. 2021) to address this need for updated fish age-length information. Data from these surveys adds to the historical fish age-length data collected during 2000-2001 to 2002-2003 (DAF data, O'Neil et al. 2024) and in 2005-2006 (Begg et al. 2006).

Coral trout biological sampling was added to the current research program in 2020-2021 and augments historical research performed by Cooperative Research Centre (CRC) through James Cook University from 2004 to 2006, sampling the spatial and temporal nature of commercial catches in the Reef Line Fishery in eastern Torres Strait (Williams et al. 2008).

This sampling program was designed and employed to collect length measurements and fish frames from both traditional inhabitant and non-traditional commercial fishing sectors. Many fishers and community members assisted to collect data and tissue samples from fish frames and measure the lengths of fish in commercial catches.

We report here on three financial years of results from the current study (2021-2022 to 2023-2024) which builds on the previous two years of data collection (2019-2020 and 2020-2021), creating a five-year continuous time series for Spanish Mackerel and four-year continuous time series for coral trout species. Where appropriate, reporting on the 2019-2020 and 2020-2021 data has been included from the previous reports to help examination of trends through time.

Methods

Industry and Community Engagement

The sampling program used in this study relied on the cooperation of community leaders, commercial fishing sectors, and community members to voluntarily allow access to their catches and to assist with data collection. The program operated by engaging community leaders (Elders, Torres Strait Island Regional Councils (TSIRC) Councillors, and Registered Native Title Body Corporate (RNTBC) Chairperson and members), explaining the project objectives and seeking permission to access community and work with community members.

Trappett et al. (2021, pp. 13-14) provides an overview of the ethical oversight provided by the PZJA and the cultural protocols followed by the project team in delivering this research (TSRA 2011; Nakata 2018). This included ensuring free prior informed consent was obtained for the acknowledgement, attribution, and citation of local traditional knowledge and fisheries data.

A summary of Catch Disposal Records (CDRs) provided by AFMA enabled the program to see where finfish were being harvested in notable quantities and to plan community engagement and sampling activities accordingly. The program has focused on sampling in the communities reporting the most catches (Erub and Mer) while also aiming to include as many communities as possible in the study (Table 1). This was achieved by liaison with community leaders and industry members on PZJA advisory groups and in collaborating with AFMA and TSRA on joint travel to communities to take opportunities to present the research.

In 2019-2020, 2020-2021 and 2021-2022 financial years, the program held initial community engagement workshops generally timed to coincide with the start of the Spanish Mackerel fishing season. To be respectful to the people and country, both land and sea, on which this research was conducted, the project made sure to focus on sharing with communities what the research was aiming to achieve, what data would be collected, how it would be used and securely stored and how individual data would not be reported, i.e. fishers' commercial business would remain anonymous. During the workshops, the project team also sought advice from community members about when would be the most appropriate time to be invited back to work with fishers on sampling.

The workshops were followed up around six weeks later by sampling trips collaborating with community fishers and fish receivers who retained frames to support the program. Sometimes an additional sampling trip was possible, before the monsoon set in, late in the calendar year. Community notices were posted for each of these visits to advise community members of who was attending and their business in community (example shown in Appendix 1). Prior to visiting the program sought permission to visit from the community elders including the PBC Chairpersons and TSIRC Councillors.

Appendix 2 details the community visits and sampling trips by project staff/ the project team conducted in communities since the 2019-2020 financial year. The table also includes meetings attended by project staff where updates on the project were given to our stakeholders. These meetings also allowed the project team face-to-face opportunities to liaise with fishers and community leaders about the project, provide additional sampling equipment, and provide training on length-measurement procedures.

Table 1. Overview of project days spent in Torres Strait communities to discuss the project or conduct catch sampling by fishing season (*note flights to Mer & Erub airstrips were suspended in late 2022 meaning the project could not visit to sample as planned).

Financial year	Mer	Erub	Ugar	Masig	Waiben
2019-2020	0	1	1	1	0
2020-2021	3	3	1	0	1
2021-2022	5	5	0	0	1
2022-2023*	2	2	0	0	1
2023-2024	4	4	1	0	2
Total	**14**	**15**	**3**	**1**	**5**

Several fishers and community members took the opportunity to visit DAFs Northern Fisheries Facility in Cairns and were provided a laboratory tour and demonstration of processing techniques applied to fish samples being provided from their fishery. The tours included practical demonstrations of measuring fish frames and removal of otoliths, preparation of otoliths for ageing, and ageing fish under a microscope. DAF has also provided a similar experience for PZJA Torres Strait Finfish Fishery Resource Assessment Group (TSFFRAG) and PZJA Torres Strait Scientific Advisory Committee members.

All non-traditional sunset sector fishers holding any coral trout or Spanish Mackerel catch allowance were briefed by the project team on the objectives of the research program and asked to assist. Some vessels were able to provide significant assistance to the program and provided large numbers of frozen fish frames or heads, as well as measuring their catches at the end of a fishing session. Samples were shipped to the laboratory for processing via the local barge service. All freight costs, and sampling and packaging supplies were covered by the projects budget.

Data Collection

Sampling design

The program's objective is to gather comprehensive data about the length, sex and age of fish retained in the commercial fishery. An additional objective for the coral trout species is to gather data on the species composition of sampled catches. Appendix 3 details the field and laboratory sampling protocol for Spanish Mackerel and coral trout species data collection methods. An overview is provided here.

The number of catches sampled, and the quantity of biological data collected varies by year. Sampling is heavily influenced by the amount of fishing occurring, participation from fishers and processors, logistical considerations regarding access to the fish, community access (remote locations, travel restrictions during COVID etc.). The form in which fish are sold to mainland buyers e.g., whole, gilled, and gutted, filleted, significantly influences what data can be collected. The crewing/staffing available to vessels and/or fish processors is another factor which can influence the amount of data collected. All these factors vary between fishing seasons and seem to be pronounced in Torres Strait, which is characterised by long distances from markets, smaller businesses (relative to the mainland), remote fishing locations, and seasonal effects of monsoon weather.

For commercially caught fish (TIB and Sunset sectors), data are gathered through voluntary cooperation from commercial fishers and fish processors. These businesses facilitate data collection by providing program staff access to fish within the supply chain or by measuring or supplying samples from their own catches.

While the main objective of the program was to gather information on commercially retained fish, data from community catches (subsistence and recreational) was also collected to provide further information on the age at length of fish to increase sample sizes. Collecting data from community catches also involves voluntary cooperation to allow program staff to measure fish at boat ramps, access fish processors, or working with fishers in providing samples of their own catches.

The primary sampling unit is the “catch”, which comprises fish from an individual fishing session on a single day or spanning several days, by one fisher or multiple fishers working together. Ideally these catches are ‘representative’ meaning that the length frequency of the samples that were measured matched that of the fish that were harvested during that catch i.e. the samples were not graded by size prior to being measured. The program is designed to collect data from the fishery by setting targets for the number of commercial catches to be sampled. For commercially caught Spanish Mackerel, the desired target is 50 different catches with around 1,500 fish to be measured. Around 400 to 500 otoliths per fishing season are required to form the age at length relationship. A similar target was applied for coral trout species initially. Following advice from the PZJA TSFFRAG (November 2019[1]) based on the level of harvest, this target for coral trout species was scaled down to 1,000 fish to be measured from representative catches (no minimum level of catches was advised) and 300 otoliths collected for age interpretation to attempt to build age at length relationships.

Samples acquired from non-representative catches supplied during community sampling (e.g. Traditional non-commercial (subsistence) or recreationally caught fish) were used by the program to support determining the age at length relationship and for collecting tissue samples from Spanish Mackerel in support of CSIRO’s genetic analysis on close-kin mark-recapture (Williams et al. 2022). This provided all community members with an opportunity to participate in the research program.

Catch details including fishing sector (commercial, Traditional etc.), catch date, fishing method and location was recorded for each catch. Location was reported to one of 21 unique bioregions as used in the AFMA Catch Disposal Record[2] (Figure 1). This level of spatial recording preserves the confidentiality of the exact fishing location while enabling the data collected to be aggregated to a suitable and comparable spatial scale.

Appendix 4 shows an alternative map with these bioregions/reporting regions labelled with traditional names for communities and sampling sites referred to in this report.

[1] https://www.pzja.gov.au/sites/default/files/2023-01/pzja_ffrag_5_outcomes_oct_31-1_nov_2019.pdf

[2] https://www.afma.gov.au/sites/default/files/2023-02/torres_strait_catch_disposal_record-tdb02_updated_080819.pdf

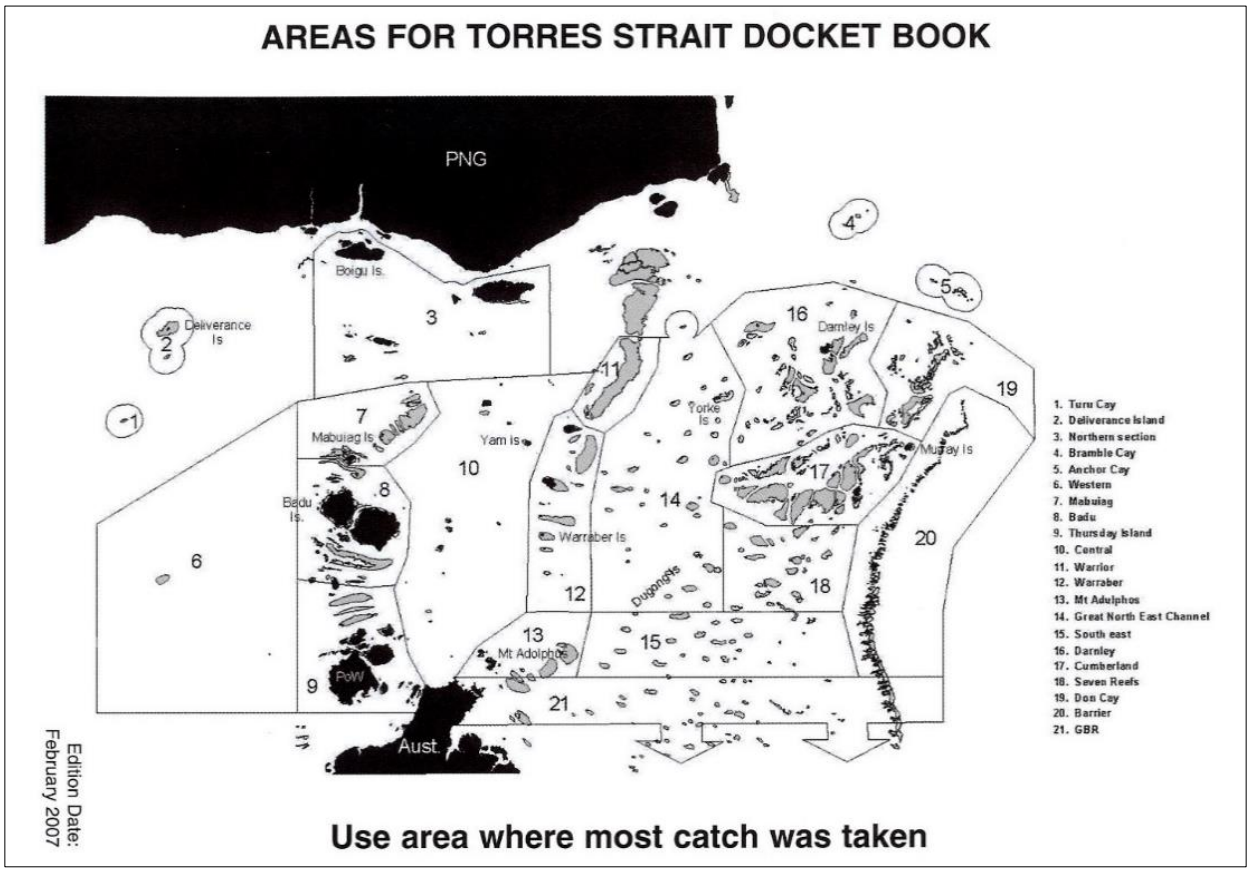

Figure 1. Reporting areas for the Torres Strait docket book used by fishers to record the location of their sampled catch. Map sourced from the 2019 Torres Strait Catch Disposal Record book (TDB02).

Fish size was recorded as Fork Length (FL) (nose to caudal fork) and where possible also total length (nose to end of tail) and jaw length (tip of the upper jaw to the end of the maxilla). Note that Passionfruit Coral Trout was an exception and were only measured as Total Length (TL) due to their square shaped tail. Alternative measurements were converted to FL using stock-specific equations.

Where a catch was identified as size biased (for example**,** the catch may have been graded or some large or small fish removed), it was flagged for exclusion from analysis that requires representative length frequency data. The project was careful to examine catch data from the Reef-Line fishery as some operations advised that certain coral trout species were marketed whole and not supplied to the study as frames for data collection. Additionally, some species were retained whole**,** when landed**,** under a certain size and filleted over a certain size due to market demand, for example Common Coral Trout and Passionfruit Coral Trout under 2.2 kg were retained whole by one business for ‘plate’ size fish and frames from this portion of the catch were not supplied to the study.

When a catch was very large, only a subsample of the catch was measured by project staff, or fishers were sometimes only able to supply a proportion of a catch’s frames to be sampled for otoliths. The proportion of the whole catch measured was recorded and scaling was used to convert the data to account for subsampling.

Where possible, gonads were examined macroscopically (without the aid of a microscope), relying on colour, structure, and texture of the gonad, along with reference photographs to

determine sex. The sex of fishes was classified as male, female, transitional (in the process of changing from female to male in the case of coral trout species) or unknown.

Most data for the study were collected onboard by fishers measuring commercial catches of Spanish Mackerel and sex was not recorded. Some fishers collected and provided whole fish frames, with attached gonads, allowing project staff to determine the sex of the fish. Some fishers removed heads from fish frames at sea after identifying the sex of the fish. These were supplied in bags that had been labelled by the fishers with sex information.

Samples of muscle tissue from each individual Spanish Mackerel sample were collected using a gene tagging tool specially designed by CSIRO to minimise contamination between samples and to facilitate high-throughput DNA sequencing (next-generation sequencing). Tissue samples were taken from the fleshy portion at the dorso-posterior of the fish's head, placed in a two-millilitre vial filled with 98 % ethanol, labelled with a unique sample number, and stored in the laboratory freezer. Samples were later sent to CSIRO laboratories in Hobart for archiving and future processing and analysis (see Williams et al. 2022 for further detail).

Fish Ageing

Otoliths (fish ear bones) were used to estimate the age of a fish by taking counts of annual growth rings (Fisheries Queensland 2024). Each year, the program aimed to collect otoliths from retained fish. Spanish Mackerel were aged using images of whole otoliths (Fisheries Queensland 2022, in prep) and coral trout were aged using images of thin sections of the otolith (Fisheries Queensland 2020). A trained reader examined the image of the whole otolith (Spanish Mackerel), or section (coral trout species) using a microscope and assigned an increment count, an edge type (new, intermediate, or wide) and a readability score.

Age was calculated based on capture date, increment count, edge type, the expected timing of new increments being formed and the assumed common birthday of all fish in the stock based on knowledge of peak spawning times (Fisheries Queensland 2020). Each year, readers underwent refresher training and testing on a reference collection of otoliths, before undertaking the current year's otolith reading.

Data analysis

Length and weight conversions - Spanish Mackerel

The primary measure used to record length was Fork Length (FL). However, if a whole fish or a whole fish frame was collected, multiple length measures were taken to allow conversion factors to be calculated and used when the primary measurement could not be taken. Individual fish weight was calculated using sex-specific total length-weight conversions for Torres Strait Spanish Mackerel developed by Begg et al. (2006) (see Table 7, page 24). FL to Total Length (TL) and Jaw Length (JL) to FL conversions were calculated from all five years of available multi-measure data combined (Table 7, page 24).

Jaw length to fork length conversion – Spanish Mackerel

As most of the samples supplied to the project in 2021-2022 to 2023-2024 were fish heads rather than whole frames it was important to review and update the JL to FL conversion. A quadratic model (Table 7, page 24) was used to convert between JL and FL.

The model is described as $FL = \beta0 + \beta1 \times JL + \beta2 \times (JL^2)$ where:

β0 = intercept
β1 = Coefficient for Jaw Length
β2 = Coefficient (base) for JL^2

Appendix 5 shows the model fit to data and model standardised residuals. The model was based on data from fish with available multi-measure data pooled across years and analysed by sex (males: n = 275, females: n = 346, pooled: n = 665).

Total length to fork length conversion – Spanish Mackerel

A linear relationship was used to covert between FL and TL for pooled data across years (2019-2020 to 2023-2024) and sex (Table 7, page 24).

Total length to weight relationship - Spanish Mackerel

Non-linear least squares regression models from Begg et al. (2006) were used as a length-weight relationship in this study (Table 7, page 24), given that no fish weights were measured (all samples were provided for study as heads or frames following filleting). Note this formula uses TL.

Length structures – Spanish Mackerel and coral trout

Individual fish counts were scaled to the percentage of the catch to account for any subsampling. Individual adjusted lengths were allocated into a two-centimetre length class. The sum of scaled counts was then used to calculate the proportion of fish within each length class.

Length structures were pooled by sex and calculated for each sector. Due to data being collected from a low number of primary vessels for each sector (less than five vessels), data was also pooled across sector within each fishing season for reporting purposes to ensure confidentiality of potentially commercially sensitive information from individual vessels was protected.

For coral trout species, sufficient samples enabled length structures to be produced for Common Coral Trout, Passionfruit Coral Trout and Barcheek Coral Trout species only.

Age allocation and growth parameters – Spanish Mackerel

The number and proportion of each otolith edge type for Spanish Mackerel was reviewed across five years of data and summarised to determine the distribution of each edge type across each month sampled and across the fishing season. This identified the seasonal trend in the formation of annual bands and confirmed that one band was formed annually. This information was used to allocate each fish into an age group (Table 2, page 19). Age group (or cohort), which is expressed in whole years, was the maximum age a fish would reach during the sampling season.

Table 2. Adjustment of otolith increment count to age group based on capture month of Torres Strait Spanish Mackerel. Increment represents that the increment count was used as the value for age group. Increment + 1 represents that 1 year was added to increment count. *Fish with an age of zero and edge type of intermediate sampled in October were given an 'Increment +1' modification to calculate age group.

Capture month	New	Intermediate	Wide
July	Increment	Increment + 1	Increment + 1
August	Increment	Increment + 1	Increment + 1
September	Increment	Increment	Increment + 1
October	Increment	Increment*	Increment
November	Increment	Increment	Increment
December	Increment	Increment	Increment
January	Increment	Increment	Increment
February	Increment	Increment	Increment
March	Increment	Increment	Increment
April	Increment - 1	Increment	Increment
May	Increment - 1	Increment	Increment
June	Increment - 1	Increment	Increment

Spanish Mackerel growth is extremely rapid in the first few years of life, with annual growth in the first year averaging 93 cm TL (Begg et al. 2006). To adjust for growth of individual fish over the sample period, fish length was adjusted to the length at a nominal birthdate. Spanish Mackerel may have a protracted spawning season in the Torres Strait, between August and March (McPherson 1993). The nominal birth date assigned was 1st November as the middle of the 'expected' peak in the estimated spawning season.

Adjusted length was calculated using the von Bertalanffy growth equation defined as:

$L_t = L_\infty (1 - \exp^{-K[t-t_0]}) + \varepsilon$ where:

- L_t was the length at age *t*,
- L_∞ is the asymptotic mean length,
- K is the growth coefficient,
- t is the age of fish when captured,
- t_0 is the theoretical age of fish at which mean length is zero, and
- ε indicates that residuals are assumed to be distributed normally about the fitted growth curve.

Growth coefficients from the individual age at length data from 2019-2020 to 2023-2024 were modelled using R program software packages '*FSA'* and '*fishmethods'* utilising the '*vbStarts*' and '*growth'* functions to fit non-linear least square regression models to male, female, and pooled sex data. Growth coefficient outputs from the models were then used to adjust fish length and are provided in Table 8 (page 24) with further results outputs provided in Appendix 5.

Note that values of t_0 are negative due to the nature of the fishery dependent sampling conducted that does not sample undersized fish and is biased away from 0+ and 1+ age groups. These growth model parameters are used for the adjustment of length within the sampling season and are not used as inputs into the stock assessment model.

Age-length key – Spanish Mackerel

For Spanish Mackerel, age-length keys were generated for combined sexes for each year sampled using adjusted length allocated within a 2 cm length class and age group. The count of fish in each two-centimetre length class was determined for each age group. From these, the proportion of fish in each length class was calculated for each age group to construct the age-length key. All length classes in the length frequency sampled were matched with fish ages in the age-length key.

Age structures – Spanish Mackerel

Age structures were constructed using the pooled-sex 2 cm adjusted fork length structure from both commercial sectors (TIB and Sunset combined) and the constructed age-length keys described above. Individual fish can then be assigned to an age group using this age-length key. To calculate the age structure of the fishery, the number of fish caught within each 2 cm length bin were divided between the appropriate ages according to the proportions of the age-length key. This was done by multiplying the proportion of ages within that length bin of the age-length key[3]. The proportion of fish in each age group were then calculated to develop the age structure for each year.

For Spanish Mackerel, annual age structures with pooled sex were produced (2019-2020 to 2023-2024). For coral trout, an age structure was produced for each species from data pooled across all years sampled (2020-2021 to 2023-2024).

Age structures – coral trout

An age-length key was not able to be formed for coral trout species due to insufficient numbers of samples to accurately produce a species-specific age at length relationship. Therefore, a fishery age structure was not produced as per Spanish Mackerel. Instead, the project was able to provide an overview of the proportions of aged coral trout found at each age class by species across the study.

[3] For methodology see example 5. pp-57 of http://www.fao.org/3/W5449E/w5449e.pdf

Results

Data summary – Spanish Mackerel

From 2019-2020 to 2023-2024, the length measurements of 11,008 Torres Strait Spanish Mackerel were recorded from 307 individual commercial catches (Table 3). Fish measured represented 12,739 fish when subsampling was accounted for. All catches were sampled at greater than or equal to a 20 % subsample and were considered representative of the entire catch.

Table 3. Sample sizes of Spanish Mackerel length and age information collected during 2019-2020 to 2023-2024. Total samples sizes are provided for each data type as well as the number of representative lengths and catches per fishing sector (TIB and Sunset).

Data type	Total number	TIB	Sunset
Lengths (sub-sampled)	11,008	169	10,839
Lengths (scaled)	12,739	180	12,560
Catches (representative commercial) *	307	13	294
Whole weight sampled**	107,729	1,439	106,289
Whole weight reported***	249,837	18,513	231,234
Per cent of harvest sampled****	43%	8%	46%
Otoliths collected	3,981	206	3,775
Otoliths aged	2,025		
Sex data from representative catches	2,431		
Genetic samples	3,820		

** Representative commercial catches are those with greater than 20 per cent sub-sampling from Sunset and TIB sectors only.*
*** Whole weight of sampled fish calculated from fork length*
**** Commercial landings source: AFMA Catch Disposal Records*
***** Represents per cent of the whole fish weight sampled compared to the total harvest estimate for the 2019-20 to 2023-24 fishing years combined.*

Most fish lengths measured were from the Sunset sector (98 %) with 169 fish (2 %) from the TIB sector. Most of the commercial harvest is taken by the Sunset sector (ranging from 89 % to 94 % between 2019-2020 to 2023-2024, with the remainder taken by the TIB sector.

The proportion of the commercial fishery sampled was estimated to range from 24 % to 75 % by year based on annual estimates of total whole fish weight sampled (ranging from 13 t to 33 t) (Table 4).

Figure 2 details the number of lengths, catches and otoliths collected for analysis. The figure also shows the seasonal distribution of sampling achieved through the months of each year. Note most harvest in the fishery occurs late in the calendar year prior to the wet season.

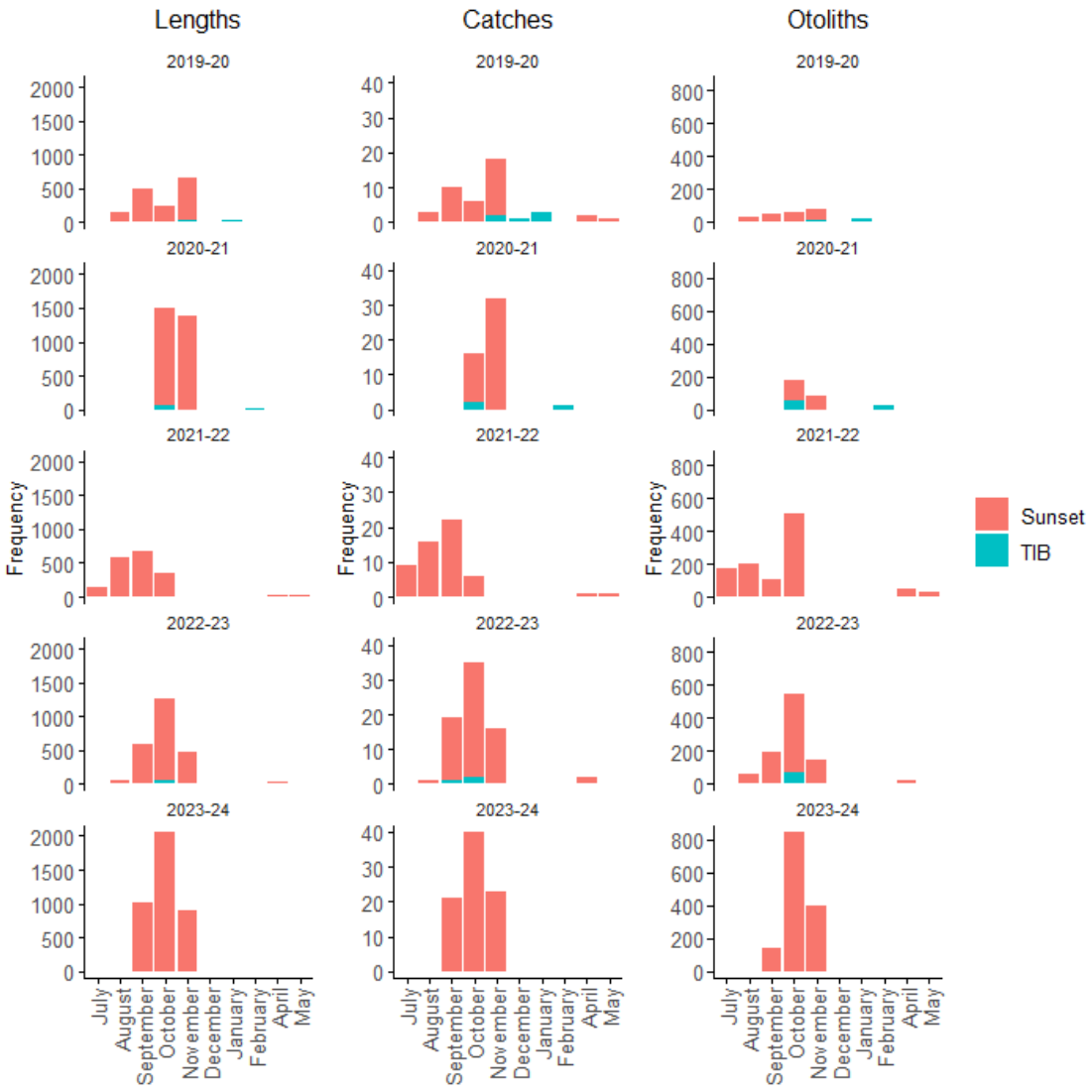

Figure 2. Monthly distribution of samples of Torres Strait Spanish Mackerel showing the measured frequency of lengths, catches and otoliths sampled from commercial representative catches by fishing sector, month and by year.

Table 4. Annual whole fish weight sampled, commercial harvest, and proportion of the fishery sampled during 2019-2020 to 2023-2024. This is calculated from the weight of fish measured (weight estimated from a length-weight conversion) as a proportion of the commercial fishery harvest per year

Financial Year	Total whole fish weight sampled (kg)	Harvest (from CDRs) (kg)	Proportion of fishery sampled (%)
2019-2020	13,647	56,550	24
2020-2021	24,062	31,942	75
2021-2022	15,070	47,320	32
2022-2023	20,896	50,833	41
2023-2024	33,445	57,349	58

A total of 3,813 fish had genetic samples taken (Table 5). These have been sent to CSIRO Hobart for sequencing and inclusion in any future genetic studies such as Close Kin Mark Recapture population analysis, which is an identified research priority for the fishery.

Table 5. Torres Strait Spanish Mackerel genetic samples collected during 2019-2020 to 2023-2024 and sent to CSIRO.

Financial Year	Number of genetic samples
2019-2020	128
2020-2021	292
2021-2022	969
2022-2023	1,030
2023-2024	1,394
Total	**3,813**

Across all years of the study, most of the sampling (96 %) was from Maizab Kaur, which is a known breeding aggregation for Torres Strait Spanish Mackerel (Figure 1, Table 6, Appendix 4). This location represents the main concentration of fishing catch and effort in the fishery. The minority of the sampling of commercial catches (4 %) was conducted within four other sampling regions as defined in the AFMA Catch Disposal Record and detailed in Table 6.

Spanish Mackerel samples were sampled from other fishery users in addition to the two commercial sectors (TIB and Sunset). Additional Spanish Mackerel samples (n = 24) were obtained from the Traditional sector being fish taken for subsistence by members of Erub and Mer communities. Recreational Spanish Mackerel samples (n = 63) were also donated to the project from Erub and Waiben communities.

Table 6. Spatial spread of sample sizes of representative Commercial Spanish Mackerel length information collected during all years combined across the Torres Strait docket book reporting areas (map of areas shown in Figure 1).

Reporting Area	Area, Reefs, Communities	Lengths (sub-sampled)	Lengths (scaled)	Catches	Sex data
CDR Zone 4	Maizab Kaur (Bramble Cay)	10,473	12,197	272	526
CDR Zone 16	Erub, Ugar, Au Meri Reef, Kebi Meri Reef	227	243	16	129
CDR Zone 14	Masig, Poruma, Great North-East Channel	151	151	9	3
CDR Zone 17	Mer, Hibernia Passage, Cumberland Passage	89	89	7	1
CDR Zone 15	South-east Torres Strait, Atub (Dugong Islet)	60	60	3	0

Table 7 (below) details the results of updated conversion equations calculated using data from 2019-2020 to 2023-2024 available data.

Table 7. Equations and source of Torres Strait Spanish Mackerel length and weight conversions used in data analysis. FL: fork length. TL: total length, JL: jaw length, W: weight.

Conversion	Equation	Source
Jaw Length (mm) to Fork Length (cm)	Male: $FL = -388.7065 + 16.9734 \times JL + 0.9565219 \times (JL^2)$ Female: $FL = 13.740 + 9.913 \times JL + 0.9860846 \times (JL^2)$ Unknown: $FL = -174.504 + 12.64393x\ JL + 0.9753584 \times (JL^2)$ Pooled: $FL = -51.95306 + 10.87157 \times JL + 0.9827502 \times (JL^2)$	Calculated from 2019-2020 to 2023-2024 Torres Strait data
Total Length (cm) to Fork Length (cm)	Pooled: $FL = (TL - 36.6) / 0.938$	Calculated from 2019-2020 to 2023-2024 Torres Strait data
Fork Length (cm) to Total Length (cm)	Pooled: $TL = 0.938 \times FL + 36.6$	Calculated from 2019-2020 to 2023-2024 Torres Strait data
Total Length (cm) to weight (kg)	Male: $W = 4.224e-6 * (TL^{3.068})$ Female: $W = 2.960e-6 * (TL^{3.148})$ Pooled: $W = 2.718e-6 * (TL^{3.165})$	Begg et al. (2006)

Table 8 (below) details the results of the review of the growth parameters used to calculate adjusted length within the sampling season. This review used data from 2019-2020 to 2023-24.

Table 8. Torres Strait Spanish Mackerel sex-specific von Bertalanffy growth parameters used to calculate adjusted length. The overall standard error of the observations for each sex are provided. Standard errors for each parameter estimate are provided in brackets.

Sex	Total n	L_∞	K	t_0	Standard Error
Female	661	177.12006975 (17.31379960)	0.08449171 (0.02148493)	-6.85907654 (1.01565563)	7.196134
Male	611	109.6325002 (1.51219266)	0.3614444 (0.03834002)	-2.5151018 (0.33328460)	5.315446
Pooled	2,025	134.976942 (3.6561495)	0.164044 (0.0178035)	-4.655811 (0.4153098)	7.369837

Length structures – Spanish Mackerel

Torres Strait Spanish Mackerel sampled from commercial catches during the study ranged in length between 61 cm and 163 cm FL (calculated from a jaw length to fork length conversion). Most fish (75 %) were between 90 cm and 104cm FL (Figure 3), with an average fish length of 97 cm FL for all years combined.

Average fish lengths from the measured sub-samples of fish were similar between the commercial sectors at 95 cm FL for TIB sector (n = 218) and 98cm FL for Sunset sector (n = 9,471).

Length structures sampled from 2019-2020 to 2023-2024 (Figure 3) were similar in structure to those reported from the on-board surveys conducted by DAF from 2000-2001 to 2002-2003 (O'Neill et al. 2024) and by James Cook University in 2005-2006 (Begg et al. 2006). These earlier studies share similar shaped length distributions with most fish lengths (75 %) measured between 86 to 107cm FL (2000-2001, n = 900; 2001-2002, n = 909; 2002-2003, n = 612; 2005-2006, n = 744) with an average fish length of 96 cm FL for all years combined.

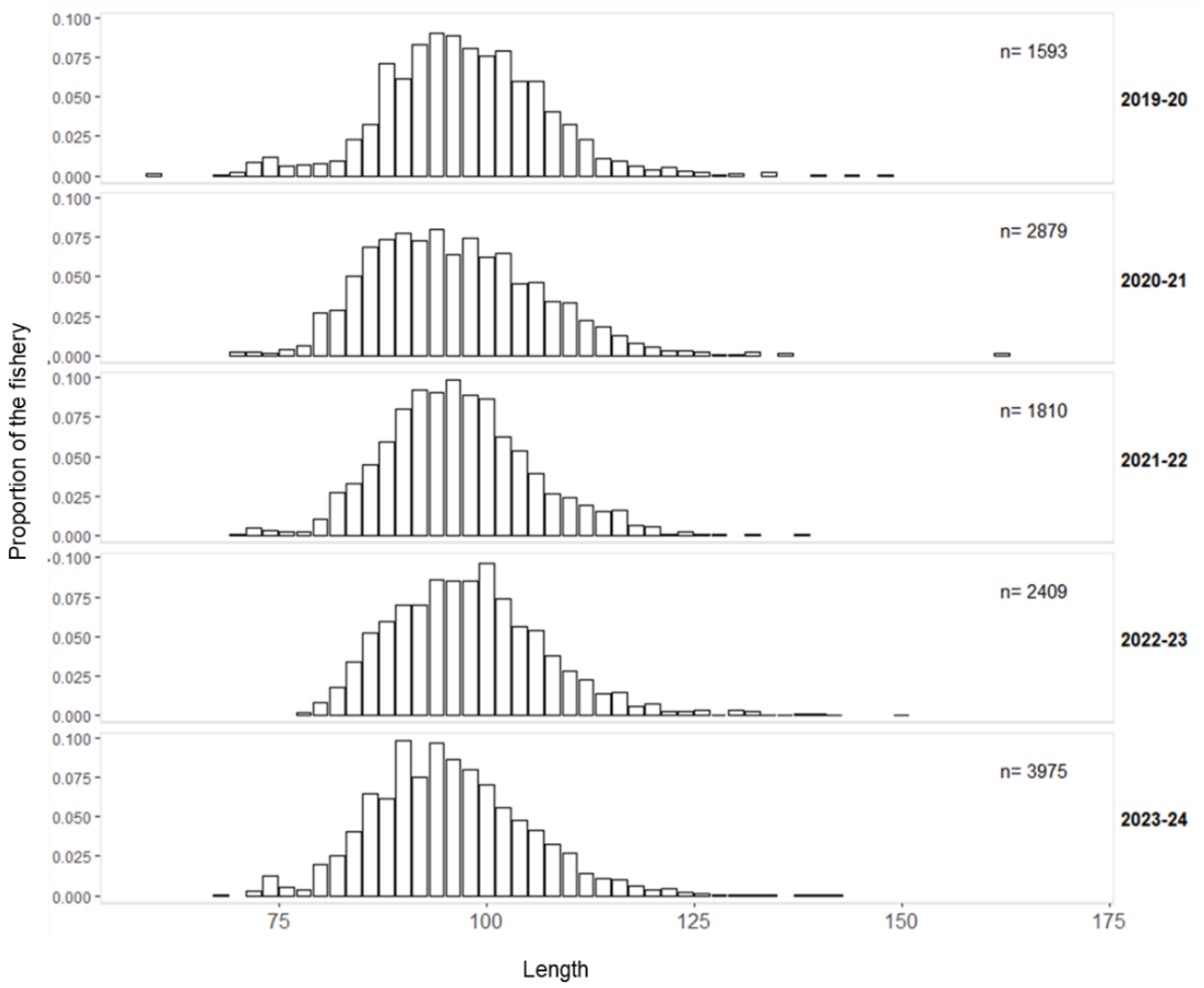

Figure 3. Length structure of the commercial Torres Strait Spanish Mackerel harvest by year. TIB and Sunset sectors combined. N-value is the number of fish scaled to account for subsampling. Fork length class is adjusted length and displayed here in 2 cm bins.

Sex ratio – Spanish Mackerel

Across all years of the study, sex data (male / female) was able to be determined from 60 % of the Spanish Mackerel frames sampled. This determination ability varied annually from 10 % to 90 %. Sex ratios were biased towards females, particularly in the larger length classes. A breakdown of the sex ratios by length class demonstrates a change from a male to female bias as length increases (Figure 4). This follows similar sex ratio by length class trends in earlier Torres Strait sampling (Begg et al. 2006; O'Neill et al. 2024), although the smallest and largest length classes with small sample sizes were difficult to compare. This bias is likely to be influenced by sex-specific growth rates (McPherson 1992).

Sex ratio in the harvest is reported to vary with lunar cycle, with more males recorded over the first quarter and full moon periods and equal ratios over the new moon and last quarter periods (Mackie et al. 2003). Fish sampled for sex information were collected across the lunar cycle. However, this temporal variability could be investigated with additional years of sampling.

Spanish Mackerel display sexual dimorphism with males growing slower and achieving smaller maximum size and weights compared to females (McPherson 1993). This is likely due to factors such as females investing more into growth to increase their size which increases chances of reproductive success; a larger body means larger gonads and, therefore, more egg production. Understanding these population dynamics is an important consideration in stock assessments which must consider how factors such as maturity, fecundity and recruitment distribution influence the population model (O'Neill et al. 2024).

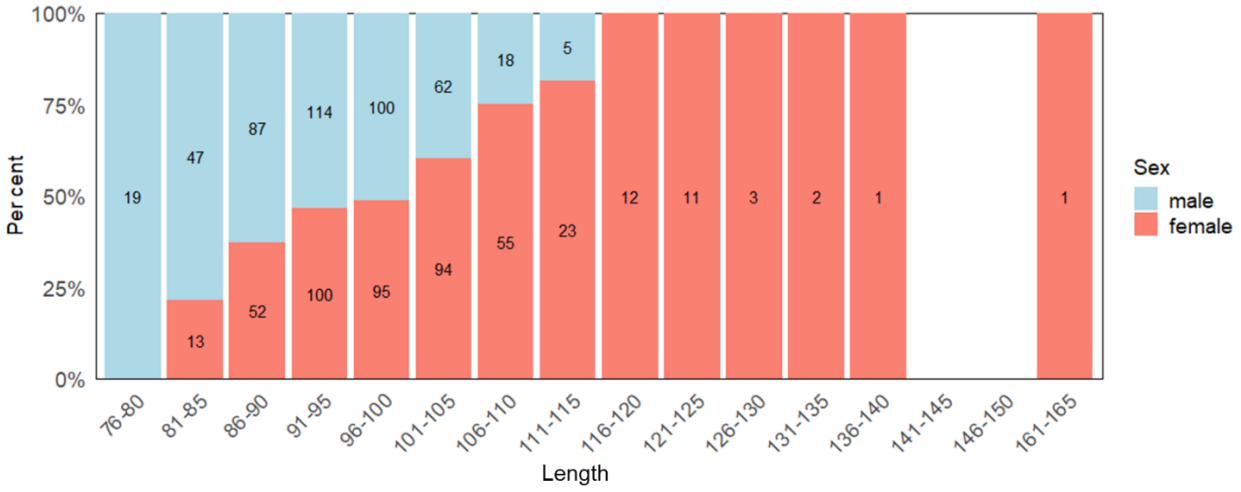

Figure 4. Sex ratio of Torres Strait Spanish Mackerel 2019-2020 to 2023-2024 within 5 cm length classes (adjusted fork length). Numbers on the bars represent sex-based sample sizes within each 5 cm length class.

Fish ageing – Spanish Mackerel

Otoliths were collected from a total of 2,052 Torres Strait Spanish Mackerel and interpreted for increment count, edge type, and readability. For each year's process of assigning ages to the otoliths, 200 fish were re-aged for increment count. Standard bias, precision, and edge classifications were tested for overall agreement between the two interpretations. Increment counts were tested for bias and precision, and edge classification was tested for overall agreement within each category.

Quality control measures for all interpretations fell within acceptable levels documented in the DAF ageing protocol (Fisheries Queensland 2024). IAPE was the index of average percent error in ageing across fish re-aged for increment count. Acceptable levels for Torres Strait Spanish Mackerel ageing, for a pass criteria were: IAPE ≤ 6 and edge % correct ≥ for new 70 %, intermediate 50 % and wide 50 %.

Across the study, age information could not be collected from 27 fish due to otolith breakages or very low readability (Table 9). Ages could be attributed to 2,025 fish in total.

Table 9. Ageing results for each read of Torres Strait Spanish Mackerel by year. Pass criteria were: IAPE ≤ 6 and edge % correct ≥ for new 70 %, intermediate 50 % and wide 50 %.

Ageing	2019-2020	2020-2021	2021-2022		2022-23	2023-24
Number of otoliths examined for ageing	256	306	400	56	504	530
Number of otoliths aged	254	299	394	55	500	523
Number of otoliths re-aged	200	200	200	55	200	200
% increment agreement	92	88.5	82.5	100	88.3	86.9
IAPE increment count	1.2	3.4	3.8	0.4	2.3	3.1
% agreement news	90.7	87	93	97.6	93.9	94.2
% agreement intermediates	73.5	83	59	NA*	73	NA*
% agreement wides	90.5	73	50	NA*	62	74.1
Number of news	170	142	246	43	325	420
Number of intermediates	58	108	78	5	106	48
Number of wides	26	49	70	7	69	55
Number unreadable	1	6	2	0	4	6
Number of processing errors	1	1	4	1	0	1

**NA scores mean less than 20 of some edge types were re-interpreted in the second read so, as per the ageing protocol, a pass mark was not calculated for these edge types (second 2021-2022 read and the 2023-24 read).*

Fish interpreted for age ranged in length between 58 cm and 163 cm FL and in age from 0 to 13 (**Error! Reference source not found.**). Male fish were generally smaller and younger than the females sampled.

The results indicate that the male Torres Strait Spanish Mackerel sampled have a smaller average size than females (94.17 cm FL compared to 101 cm FL) and attain a smaller maximum size and age compared to females (120 cm FL and 10 years old for males compared to 163 cm FL and up to 13 years old for females).

Table 10. Summary statistics of length and age for male and female Torres Strait Spanish Mackerel from 2019-2020 to 2023-2024 combined, all observations, including non-representative catches from all sectors.

Data type	Female	Male	Unknown
Minimum FL	58	68	60
Maximum FL	163	120	150
Average FL	101	94	97
Median FL	99	94	96
Minimum age	1	1	0
Maximum age	13	10	11
Sample size (n)	1,241	1,190	7,345

Length and age data allow comparison of the range of sizes that male and female fish were at each age group across seasons (Appendix 6). More female fish of larger size classes were available for sampling for age compared to males, which did not exceed 10 years of age or 120 cm in length. The highest proportion of age group sampled for both male and female fish was the 2+ age group (184 and 188 samples for female and males respectively).

Ageing results for all years of the study combined (2019-2020 to 2023-2024) are illustrated in Figure 5. showing the variation in length (adjusted fork length) at age of all fish aged (n = 2,025). Generally, the distribution of lengths of fish in ages 1+ to 7+ have an Inter Quartile Range (IQR) clustered around the mean of the observations. Above this age (>8+ age group) there is greater variation in the age at length but also fewer samples to produce a clear trend in variability.

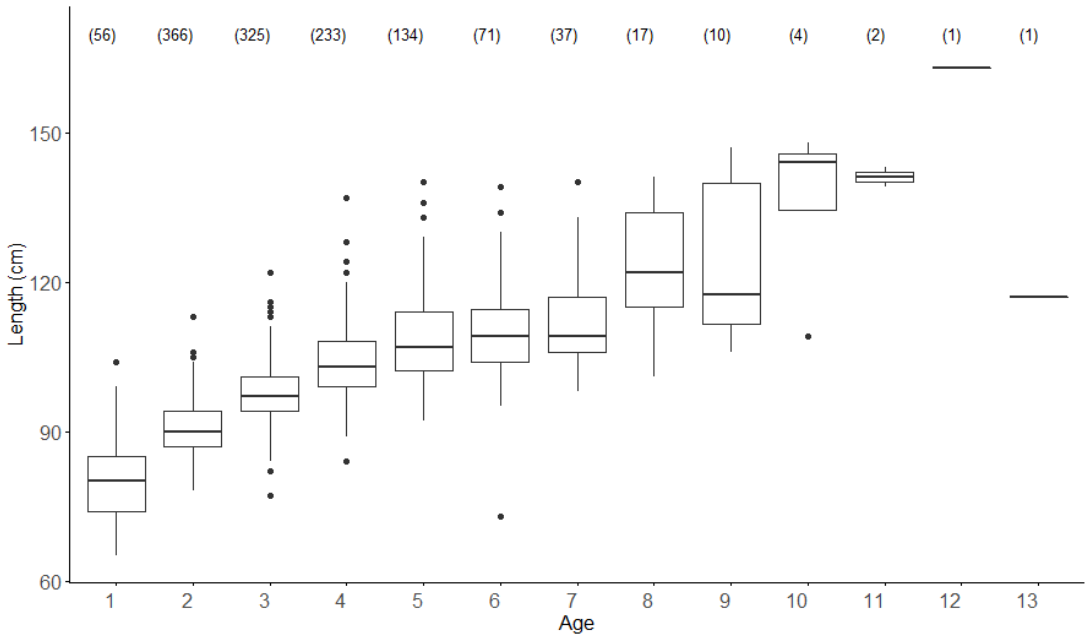

Figure 5. Ageing results box plot from all years combined, showing the fork length (adjusted length) range by age group. Total sample size (n) is 2,025. Boxes are the Inter-Quartile Range (IQR) which represent the middle 50 % of the range of the IQR, dots are 'outliers' and lie outside of 1.5 times the IQR range.

Ageing results for all years of the study by sex are combined (2019-2020 to 2023-2024) are illustrated in Figure 6. The plot shows the variation between sexes including how male fish (blue) aged reached a maximum of 125 cm and 10 years old, whereas females (pink) reached a larger size (over 160 cm) and an older maximum age of 13.

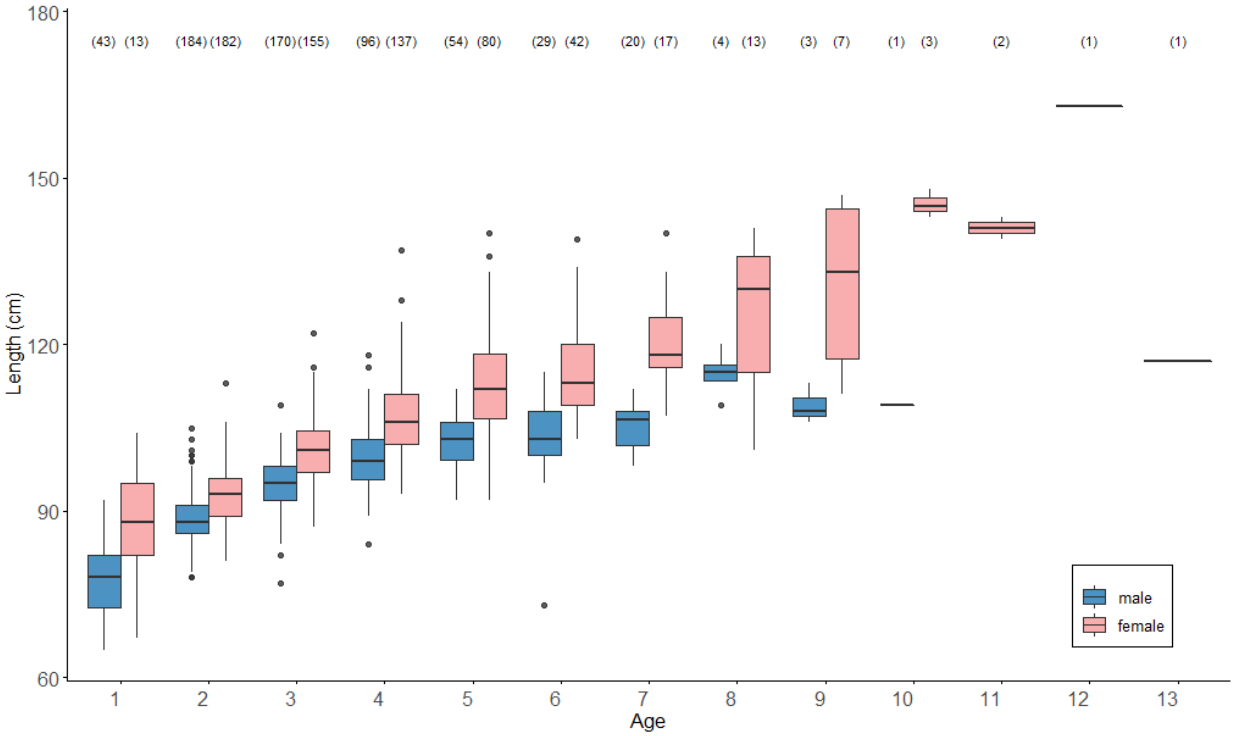

Figure 6. Ageing results by sex from all years combined, showing the fork length (adjusted length, cm) range by age group. Boxes are the Inter Quartile Range (IQR) which represent the middle 50% of the range of the IQR, dots are 'outliers' and lie outside of 1.5 times the IQR range.

Age allocation – Spanish Mackerel

Following the methodology established in the 2019-2020 financial year, the otolith edge type of Torres Strait Spanish Mackerel otoliths was determined as either "new", "intermediate", or "wide" to be able to allocate each fish into an age group or cohort. This process aims to group fish from the same spawning season (cohort) into the same age group, using information on the month of capture and the number of annual increments and otolith edge type category determined during age interpretation.

The timing for the period of opaque zone otolith formation (Figure 7, page 30) shows a peak period of new edge type (opaque zone formation) in September and October, a period of peak intermediate edge type in December through to March and a peak period of wide edge type in April. This trend is similar to that observed for Spanish Mackerel in neighbouring waters where new edge type observations peak in October for fish from east coast waters and September for fish from Queensland Gulf of Carpentaria waters (Bessell-Browne et al. 2020; Trappett et al. 2021).

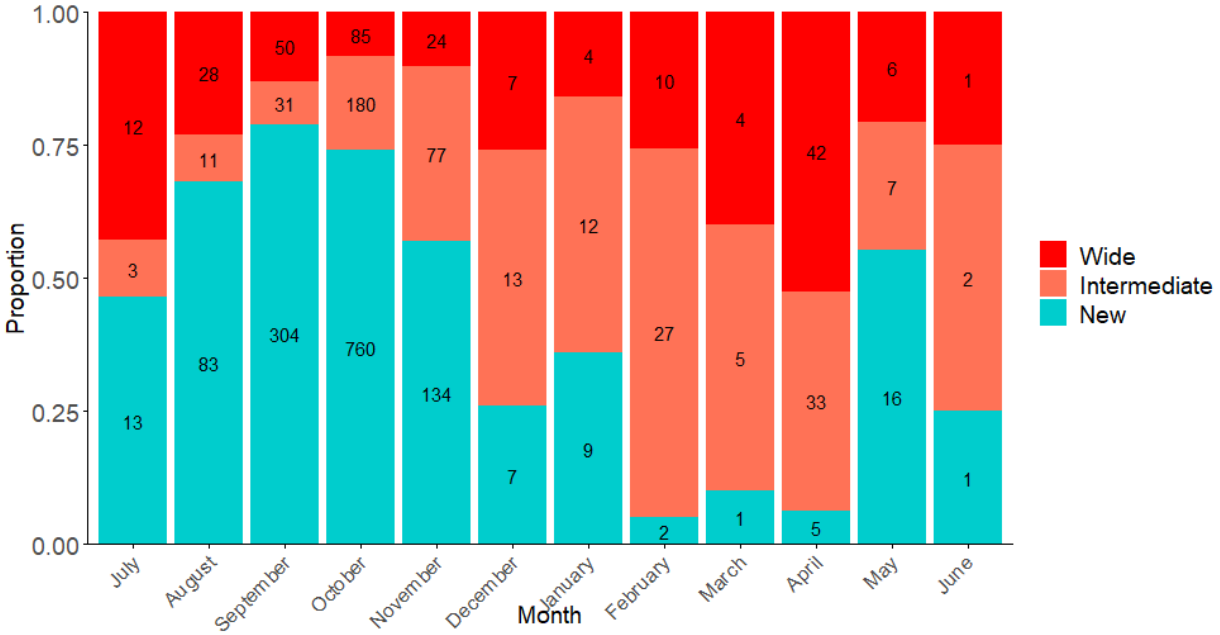

Figure 7. Proportion of edge types (wide, intermediate, new) of Torres Strait Spanish Mackerel 2019-2020 to 2023-2024 by month. Numbers provided are the sample sizes for each edge type by month.

Age-length key – Spanish Mackerel

The adjusted fork length and age group of all aged fish from 2019-2020 to 2023-2024 (n = 2007 fish) were used to construct an age-length key to convert the length structures into an age structure for the fishery (Figure 8).

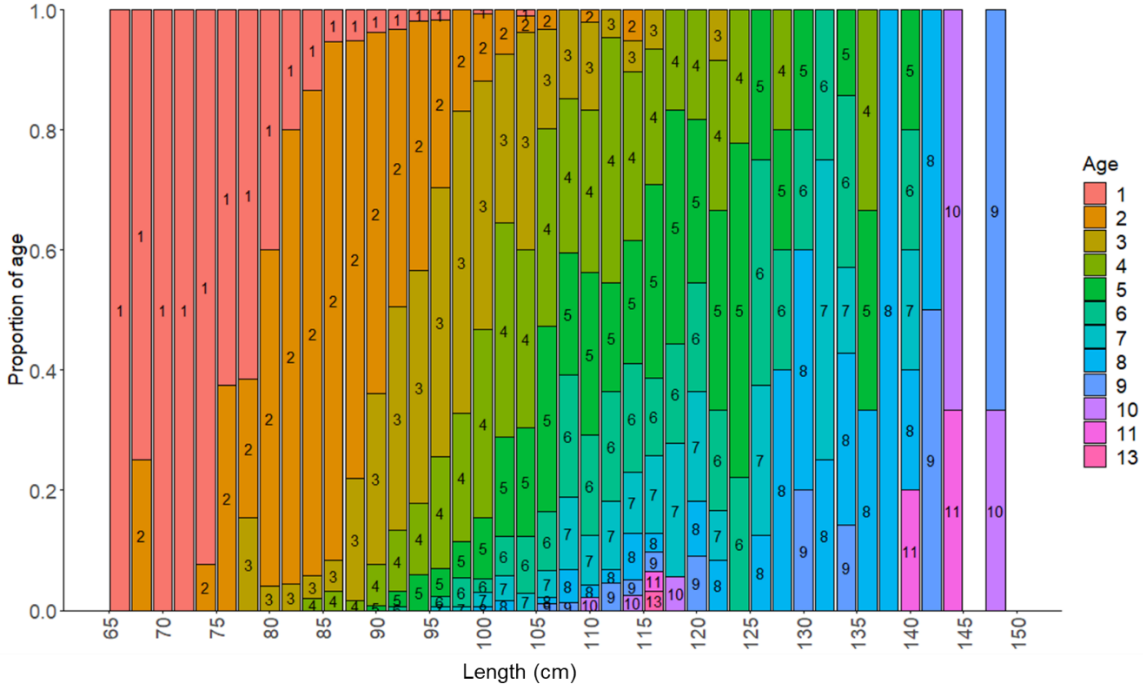

Figure 8. Plot of the observed proportional age-length key of Torres Strait Spanish Mackerel sampled from 2019-2020 to 2023-2024 combined years, using age group and adjusted fork length (cm). (n = 2,007 fish aged). Numbers shown on bars represent age group.

Fish smaller than 75 cm were generally assigned an age in the 1+ age group while fish from 80 to 90 cm FL were generally in the 2+ age group. Fish at 100 cm FL were generally in the 3+ or 4+ age group but in some cases a small number were found to range up to 6+ or 7+ years.

Age structures – Spanish Mackerel

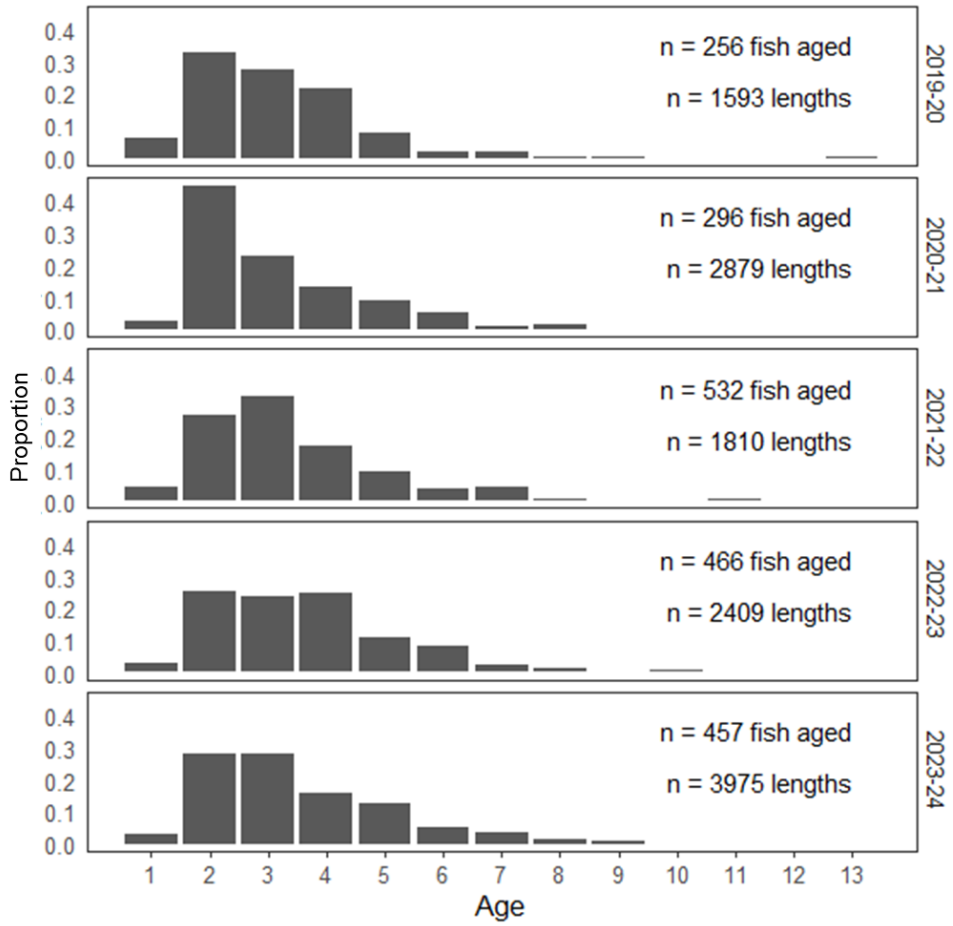

Figure 9. Annual age structure of commercial Torres Strait Spanish Mackerel harvest between 2019-2020 and 2023-2024. The X axis represents age which is adjusted age in years and the Y axis represents proportion of the commercial fishery at each age increment. TIB and Sunset sectors are combined. N-values are the number of fish represented as fish aged and fish measured per year.

The age structure of Torres Strait Spanish Mackerel fishery from 2019-2020 to 2023-2024 from Sunset and TIB sectors combined (Figure 9) shows a strong indication of increased recruitment evident in 2020-2021 with more than 40 % of the year's fishery being made up of 2-year-old fish. This age cohort can be tracked through the 2021-2022 fishing season (3-year-old fish making up 33 % of the harvest) and was still present as a high proportion of 4-year-old fish in the 2022-2023 fishery (25 %). Through the study, fish ranged between 1+ and 13+ with the catch dominated by fish in age groups 2+ to 4+, which between years comprised between 72 % to 82 % of the catch (see Appendix 7: Cohort analysis of Torres Strait Spanish Mackerel spawned in 2018

Data summary – coral trout

From 2020-2021 to 2023-2024, length measurements of 1,356 coral trout (Common Coral Trout n = 799, Barcheek Coral Trout n = 170, Passionfruit Coral Trout n = 385 and Bluespotted Coral Trout n = 2) were sampled from 70 catches. These catches were from all users of the fishery (TIB and Sunset commercial sector and the Recreational sector). Some of these catches recorded more than one species of coral trout, so in total these 70 catches allowed the program to measure 129 samples of individual coral trout species within these multi-species catches.

Otoliths were collected from 145 Common Coral Trout, 139 Passionfruit Coral Trout and 132 Barcheek Coral Trout (416 in total across all species). No Bluespotted Coral Trout otoliths were collected. To augment frames collected from the commercial sector, 199 of these 416 coral trout frames were able to be sourced from recreational (non-traditional) fishers from Erub and Waiben communities. These fish were not used as representative catches as part of the commercial fishery in the analysis; instead, these samples were able to provide age at length data.

Out of 129 catches sampled, 54 catches were from commercial sectors (TIB or Sunset) with 1,025 coral trout of all species measured from a complete fishing day or as sub-sampled catches (e.g. 80 % of the days catch). Once sub-sampling was accounted, a total of 1,213 coral trout of all species were measured from commercial representative catches. Total numbers of samples collected are described in Table 11, below.

Table 11. Sample sizes of coral trout (pooled species and years) length and age information collected during 2020-2021 to 2023-2024. Total samples sizes are provided for each data type as well as the number of representative lengths and catches per sector.

Data Type	Total	TIB	Sunset	Rec
Lengths, all measured (sub-sampled)	1,356	229	928	199
Catches (all sampled)	129	32	40	57
Lengths (commercial, representative, sub-sampled)	1,025	210	815	NA
Lengths (commercial, scaled)	1,213	211	1,002	NA
Catches (representative commercial)	54	24	30	NA
Otoliths collected	416	24	193	199
Otoliths aged	377			
Sex data (male or female)	259			

Sampled weight from commercial representative catches equals an estimated weight of 1,738 kg of all coral trout species combined (2,272 kg when scaled to account for subsampling). This represents sampling 2.3 % of the commercial coral trout harvest for combined years 2020-2021 to 2023-2024 (97,281 kg harvest of all coral trout species for TIB and Sunset sectors combined over these four fishing seasons).

Most coral trout samples in this study were acquired from either at sea length-frequency measures completed by commercial fishers in the months of March to May or were acquired late in the calendar year (September to December) during community visits to conduct sampling ahead of the monsoon period (Figure 10, page 33). Some samples were also freighted to the laboratory directly from commercial fishing vessels or community-based fishers.

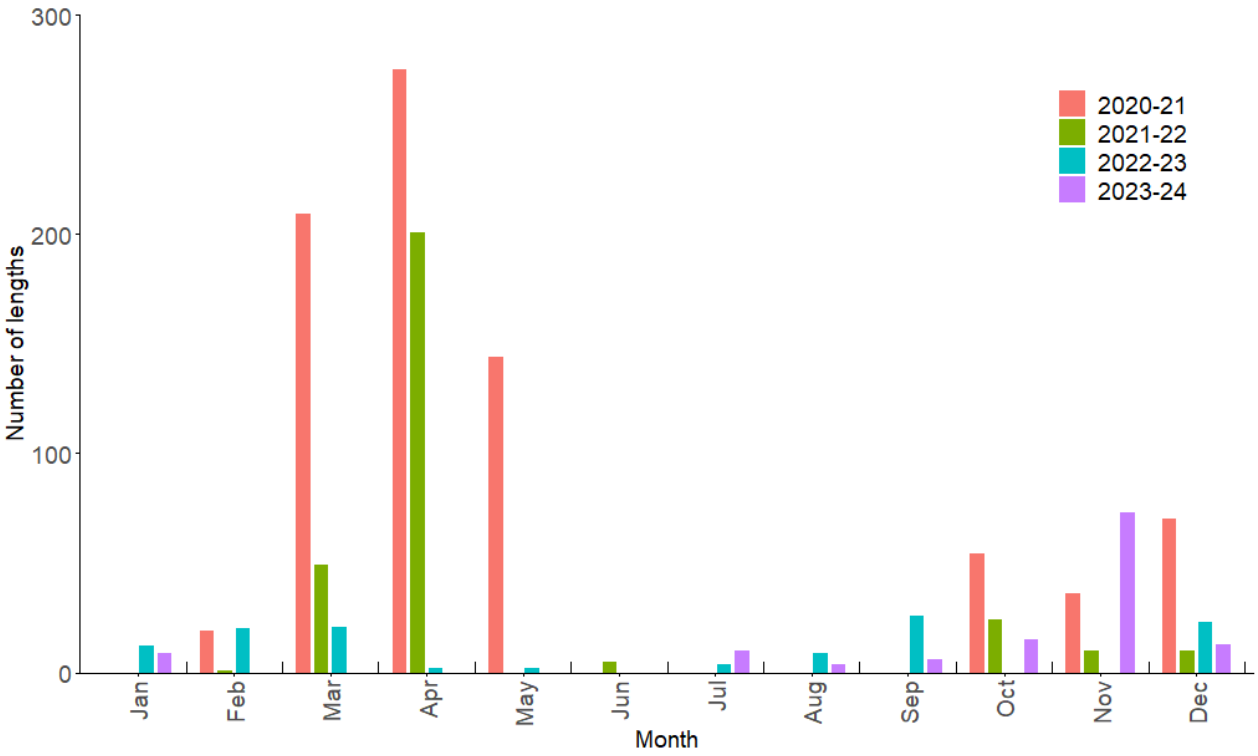

Figure 10. Number of Torres Strait coral trout lengths sampled (all species and all sectors combined) by month and year.

Coral trout samples were acquired from six areas in total of Torres Strait as described by the AFMA issued Catch Disposal Record system and presented in Table 12 below.

Table 12. Number of lengths sampled of Torres Strait coral trout by AFMA Catch Disposal Record Zone. All sectors pooled including recreational sector samples (n = 1,356).

Reporting Area	Area, Reefs, Communities	Lengths
CDR Zone 16	Erub, Ugar, Au Meri Reef, Kebi Meri Reef	637
CDR Zone 17	Mer, Hibernia Passage, Cumberland Passage	409
CDR Zone 14	Masig, Poruma, Great North-East Channel	144
CDR Zone 18	Seven Reefs	99
CDR Zone 9	Inner west area (Waiben, Muralag, Ngurapai)	62
CDR Zone 10	Central Torres Area – includes Iama community	5

Length structures – coral trout species

The observed length structure of Torres Strait coral trout species measured in the study (all sectors combined) is presented in Figure 11.

Most Common Coral Trout sampled in this study were between 41 cm to 56 cm fork length (75 % of samples) (Figure 12) with a ‘floor effect’ evident in the distribution (few samples under 40cm) which is most likely a reflection of minimum legal-size (MLS) restrictions (38 cm fork length). Both

Passionfruit Coral Trout and Barcheek Coral Trout (Figure 13 and Figure 14) displayed a more normally distributed frequency of the lengths sampled.

Only two Bluespotted Coral Trout were measured in this study (Figure 11), therefore no length frequency was able to be produced for this species.

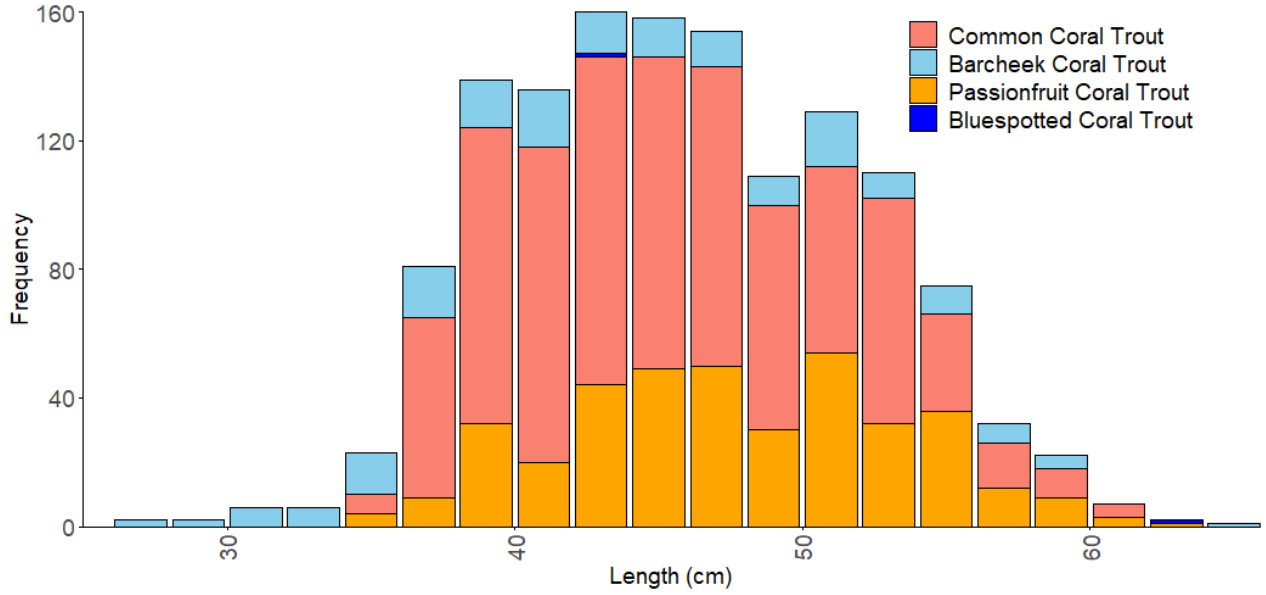

Figure 11 Observed measurements of all Torres Strait coral trout species lengths 2020-2021 to 2023-2024 (n = 1,356) binned into in 2 cm length increments. All species are FL except Passionfruit Coral Trout which is TL. Common Coral Trout n = 799, Passionfruit Coral Trout n = 385, Barcheek Coral Trout n = 170, Bluespotted Coral Trout n = 2.

TIB sector fishers can legally retain undersized coral trout (below 38 cm total/fork except for Bluespotted Coral Trout which has a 50 cm MLS) for subsistence purposes and these frames donated were included in the study. Of note were the lower size classes of Barcheek Coral Trout, ranging as small as 27 cm FL.

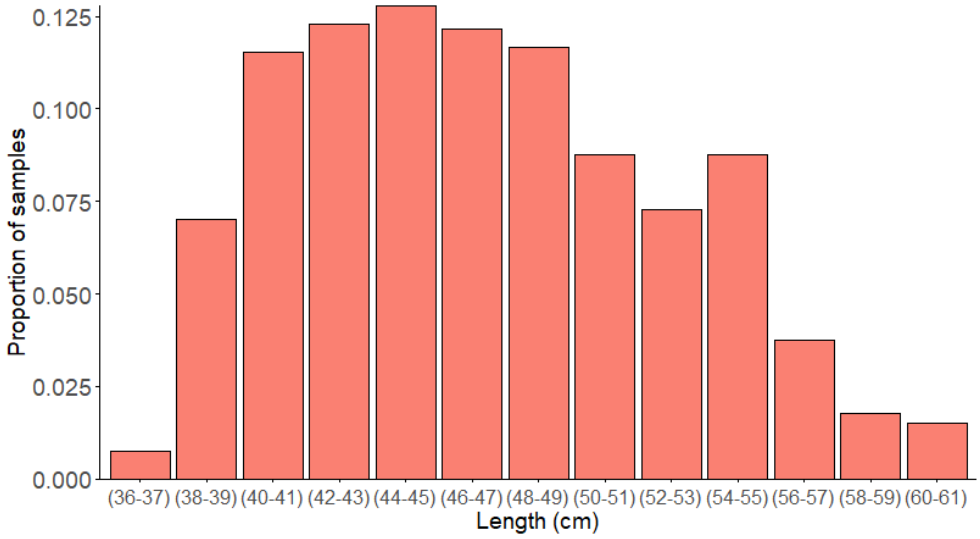

Figure 12. Proportional length frequency of Common Coral Trout 2020-2021 to 2023-2024, all sectors (TIB, Sunset and Recreational). Length is in 2 cm bins and measured in FL (n = 799).

Most Common Coral Trout lengths from commercial, representative catches were between 41 and 56 cm FL (75 %) (Figure 12). For Barcheek Coral Trout 75 % of lengths were between 40 to 57 cm FL (Figure 13) and for Passionfruit Coral Trout 75 % of lengths were between 42 to 57 cm TL (Figure 14).

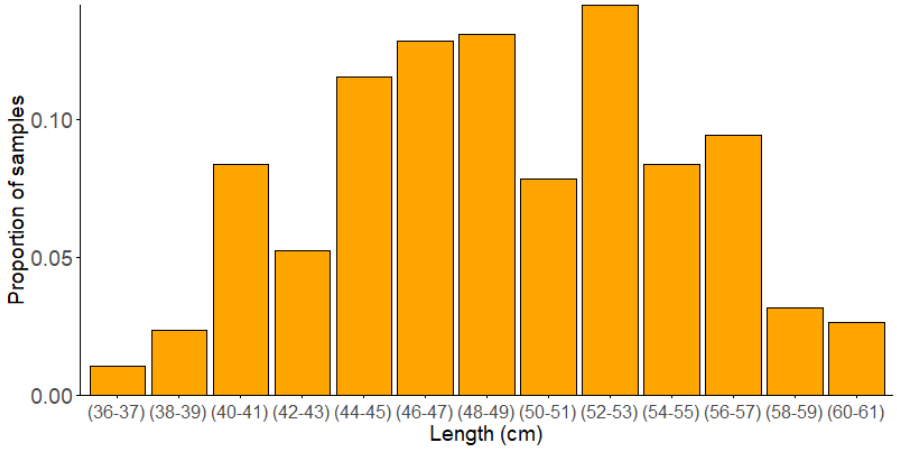

Figure 13. Proportional length frequency of Passionfruit Coral Trout 2020-2021 to 2023-2024, all sectors (TIB, Sunset and Recreational). Length is in 2 cm bins and measured in TL (n = 385).

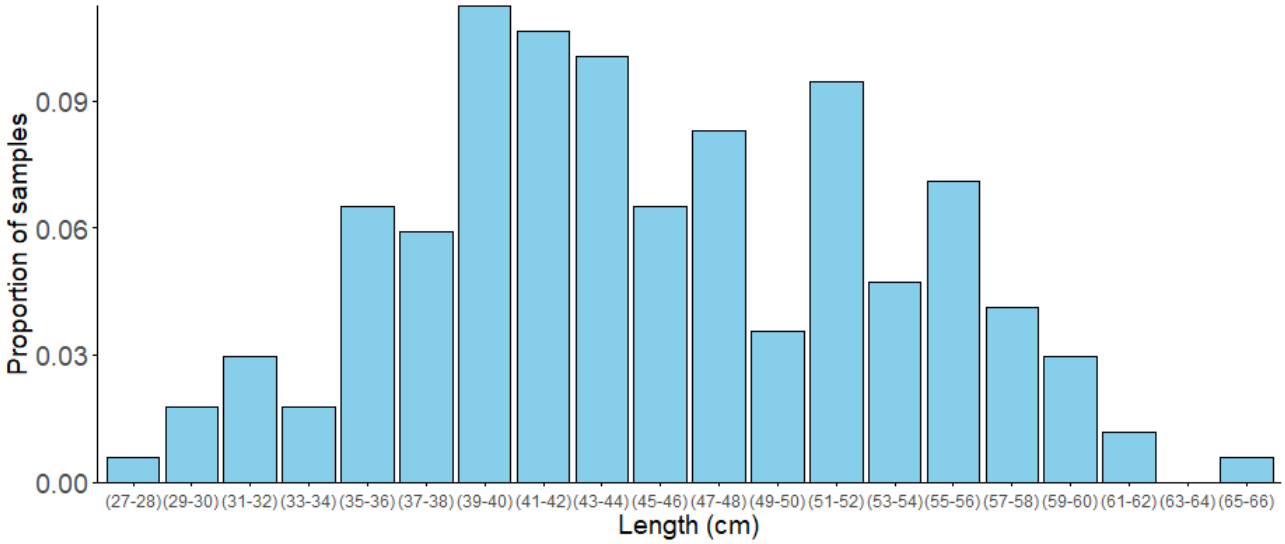

Figure 14. Proportional length frequency of Barcheek Coral Trout 2020-2021 to 2023-2024, all sectors (TIB, Sunset and Recreational). Length is in 2 cm bins and measured in FL (n = 170).

Ageing Results – coral trout

Otoliths were collected from a total of 416 coral trout from three species. Of these, 394 were interpreted for age[4] and a random subset of otoliths (up to 200) were re-read. Standard bias, precision, and edge classifications were tested for overall agreement between the two interpretations. Increment counts were tested for bias and precision, and edge classification was

[4] An additional 22 samples were received part way through the final processing of coral trout samples for reading.

tested for overall agreement within each category. Results for ageing reads are shown in Table 13 (page 36).

Quality control measures for all interpretations fell within acceptable levels defined/documented in the DAF ageing protocol (Fisheries Queensland 2024).

Across the study, age information could not be collected from 15 fishes due to otolith breakages or readability issues. Ages could be attributed to 377 fishes in total.

Table 13. Results for ageing reads of Torres Strait Coral Trout by year. Pass criteria were: IAPE ≤ 6 and edge % correct ≥ for new 50%, intermediate 50% and wide 50%.

Ageing Result	2020-2021	2021-2022 2022-2023 2023-2024
No. otoliths examined for age	90	304
No. otoliths aged	90	287
No. otoliths re-aged	90	200
% increment agreement	69	67
IAPE increment count	2.62	4.91
% agreement news	91	86
% agreement intermediates	NA*	54
% agreement wides	90	60
Count news	34	141
Count intermediates	14	62
Count wides	42	84
Count unreadable	0	14
Count processing error	0	1

Through the analysis of coral trout species age at length, increment count was used as the measurement of age. The study did not have enough samples from each month of the year to determine if there was a pattern in edge type that would allow for the adjustment of increment count. If achievable, this is a more accurate method to classify fishes to individual cohorts (age groups). Larger sample sizes per species would ideally be used in future research to calculate appropriate growth curve functions which can be used to adjust length to account for differences in capture date through the sampling season. Additional samples will enable sex-specific growth functions to also be examined.

The maximum age of Common Coral Trout and Passionfruit Coral Trout in the study was 13. Barcheek Coral Trout sampled were overall younger in age, with a lower minimum of age of 1 and maximum age of 10 (Table 14, page 37).

Table 14. Summary statistics of observed lengths with maximum and minimum age group data of Torres Strait Coral Trout from 2020-2021 to 2023-2024 combined.

Data type	Common Coral Trout	Barcheek Coral Trout	Passionfruit Coral Trout
Minimum Length	36	27	36
Maximum Length	63	68	65
Average Length	47	45	49
Median Length	46	44	49
Number aged	126	116	135
Min age	2	1	2
Max age	13	10	13
Sample size (no. lengths)	799	170	385
Minimum Weight (g) (calc)	644	260	665
Maximum Weight (g) (calc)	4,081	5,083	4,593
Mean Weight (g) (calc)	1,844	1,555	1,981
Median Weight (g) (calc)	1,781	1,251	1,823

Coral trout show large variation in age at length. Most fish aged being 3-6 years of age for Barcheek Coat Trout and 4-5 years of age for Common Coral Trout (Figure 15). Results of the age at length of the aged coral trout are presented in Appendix 6. Figure 15 also shows the range of sizes (maximum and minimum length) observed for fish aged.

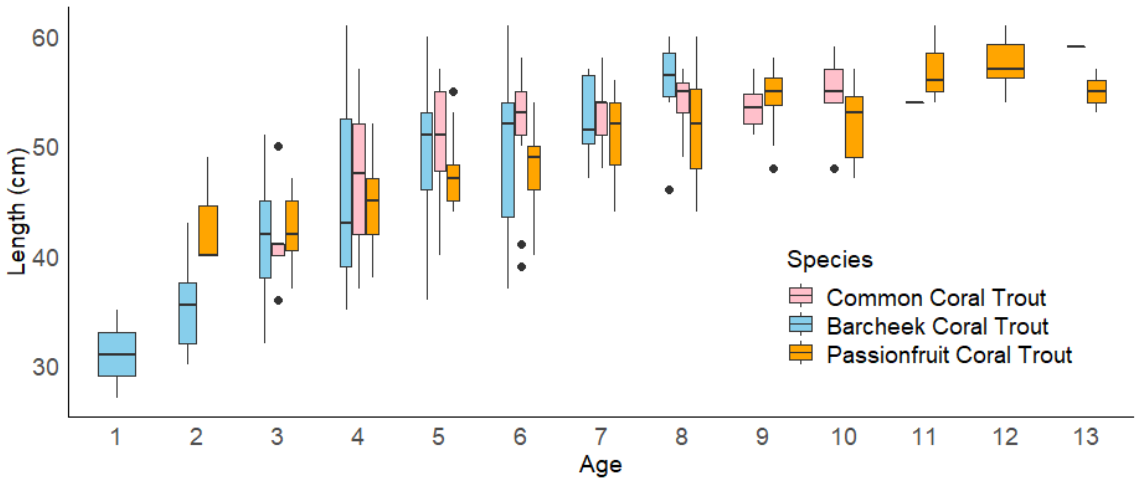

Figure 15. Ageing results box plot from all years combined, showing the range of lengths at age for aged fish (Barcheek Coral Trout FL, Common Coral Trout FL, Passionfruit Coral Trout TL) Boxes are the Inter Quartile Range which represent the middle 50% of the range of the IQR, dots are 'outliers' and lie outside of 1.5 times the IQR range.

Age structure – coral trout

Most Common Coral Trout measured in the study ranged between 4-7 years of age with the highest proportion of samples being 4 years old. Most Barcheek Coral Trout were 3-6 years of age with the highest proportion of samples being 4 years old. Passionfruit Coral Trout had a broad range of ages with most fish aged between 4-10 years of age. Figure 16 shows the proportion of the observed ages for each species of coral trout (except for Bluespotted Coral Trout for which no otoliths were collected).

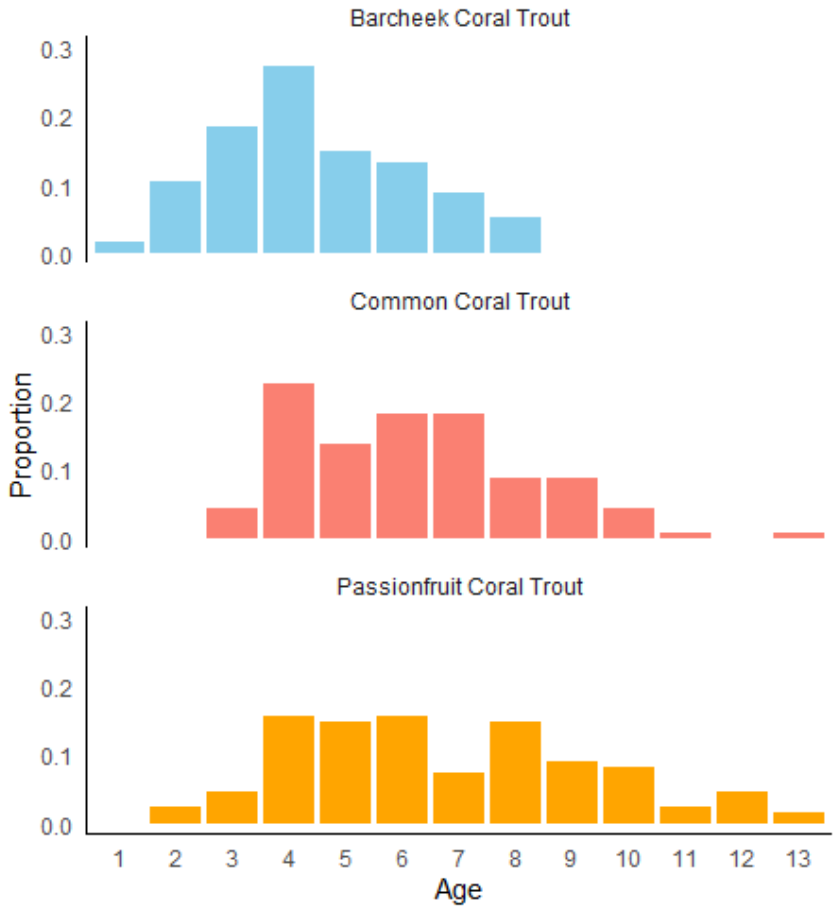

Figure 16. Proportion of sampling by age observed in length-age data for Torres Strait Coral Trout all years combined 2020-2021 to 2023-2024 (Barcheek Coral Trout n = 116, Common Coral Trout n = 126, Passionfruit Coral Trout n = 135).

For Common Coral Trout, fewer frame samples were acquired from the Sunset sector for study of age at length from fish under approximately 2.2 kg (approximately 52 cm FL (n = 31)) meaning that fewer smaller size class Common Coral Trout might have been aged then could normally be expected. This was attributed to some parts of this sector keeping some fish under this size in whole product form for supply to market meaning their frames could not be studied.

As such, further representative sampling to understand age at length from a range of size classes, and a larger sample size (n = 118 Common Coral Trout aged to date) will enable age at length keys to be formed which will permit a more accurate age structure of the commercial fishery to be produced using length frequency data from representative catches.

Sex ratio – coral trout

Sex information was determined for 62 % of the 416 coral trout sampled for otoliths (frames examined) (male n = 117, female n = 142).

Sex information was not able to be determined from most coral trout measured in the field as most coral trout length frequencies were measured at fish receiver premises and were being sold to market as whole fish or had been gutted prior to sampling.

Coral trout are protogynous hermaphrodites, beginning life as females and changing sex to males later in life (Ferreira, 1995). Through the study, although there was overlap between sizes of males and females (see Appendix 6) at age increments, most fish in smaller size classes were found to be female (Figure 17) with a pattern trending towards more males in larger size classes. The exception to this was the 61-65 cm size class where more females were observed.

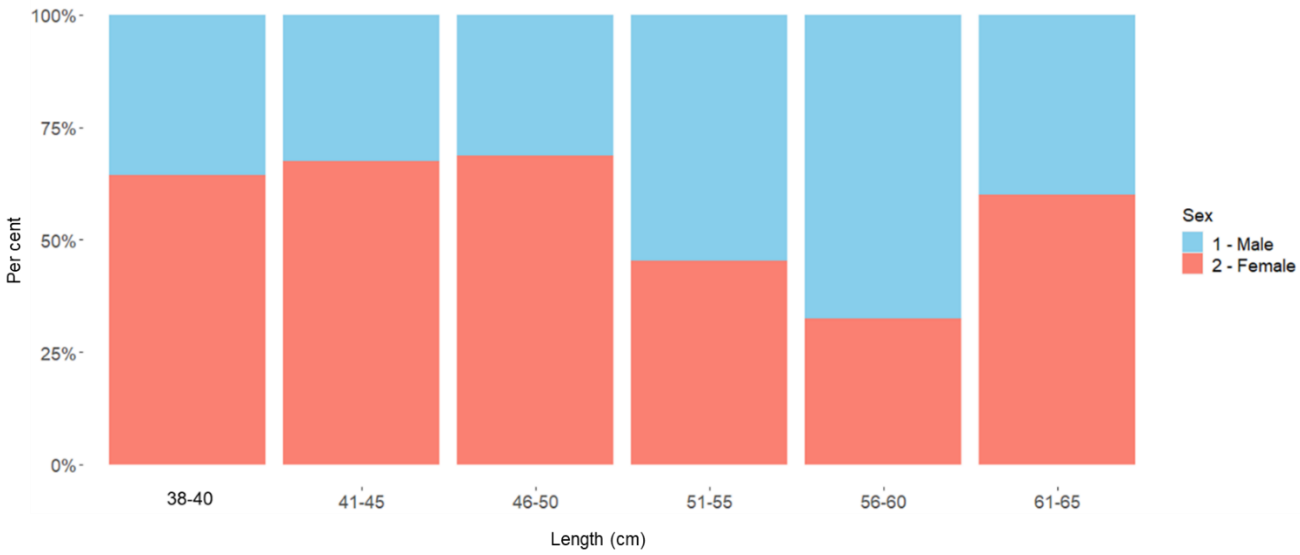

Figure 17. Sex ratio by 5cm length bin (cm) of fish above minimum legal size (38cm length), all coral trout species and all sectors combined (n = 259).

Catch composition – coral trout

The two commercial sectors using the fishery were found to have different catch compositions. The TIB sector catches a larger proportion of Passionfruit Coral Trout relative to the Sunset sector which primarily harvested Common Coral Trout in the sampled catches (Figure 18, page 40).

Results from analysing catch composition data by catch varied through the study (Figure 19, page 40). Some catches had nearly 100 % harvest of Common Coral Trout while others displayed a large proportion of Passionfruit Coral Trout or a mix of two or three species.

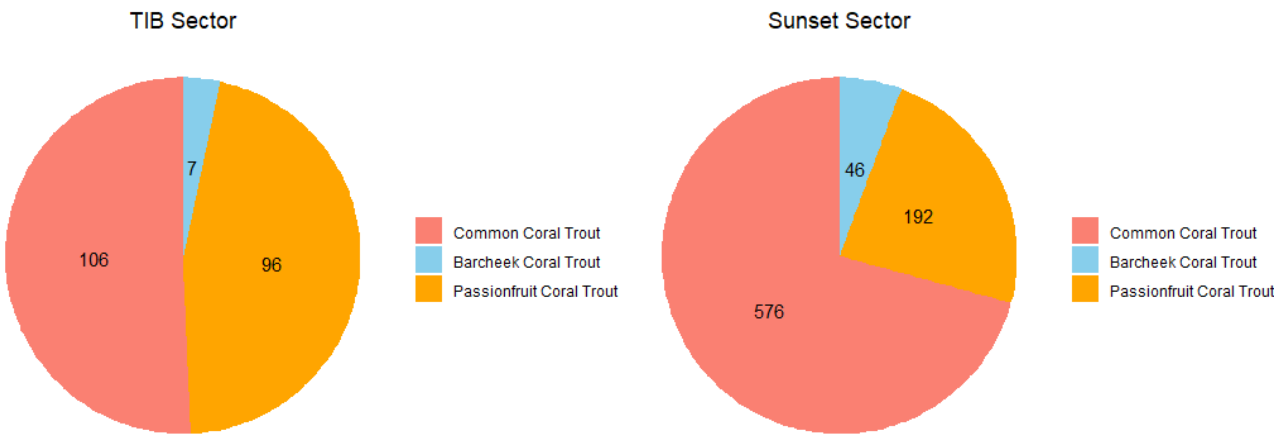

Figure 18. Overall catch composition from representative commercial catches (TIB and Sunset sectors) 2020-2021 to 2023-24 combined. N values represent number of measurements per species and by sector.

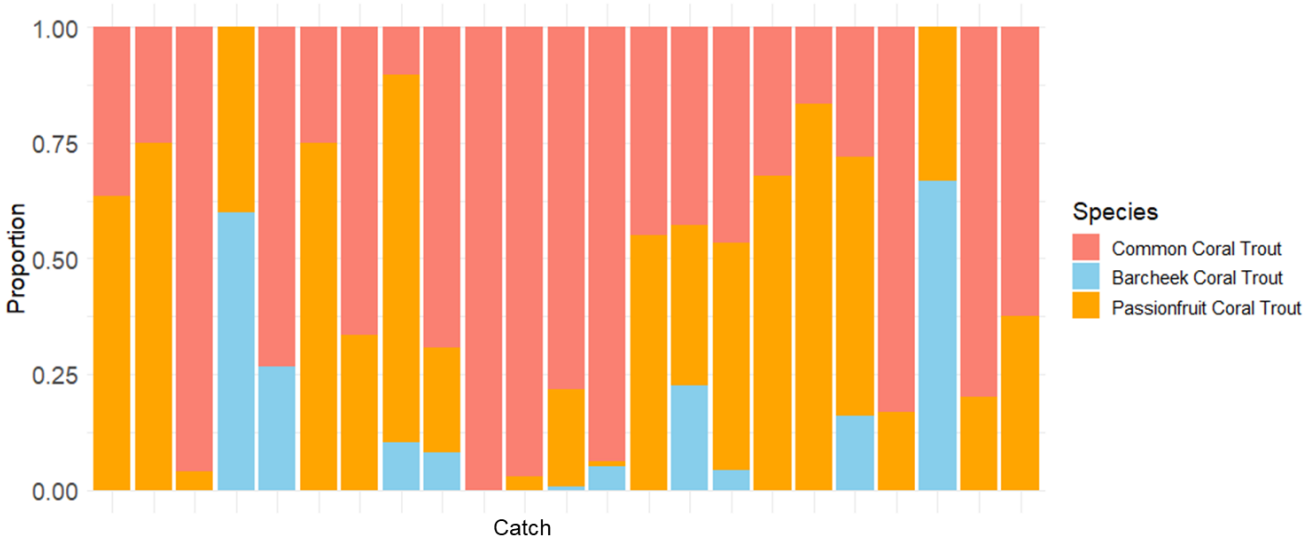

Figure 19. Proportion of Torres Strait coral trout species caught on commercial, representative catches sampled for lengths. Each bar represents a single catch and the breakdown of species caught.

Discussion

Discussion – general

The 2021-2022 to 2023-2024 biological sampling of coral trout and Spanish Mackerel project built on the monitoring data collected in the 2019-2020 and 2020-2021 projects for these Torres Strait fisheries. This project meets its objectives and provides further years of age and length-frequency data for coral trout species and Spanish Mackerel harvested form the Torres Strait. These data are now valuable for monitoring trends in recruitment, abundance and cohort strengths and have been used for Torres Strait Spanish Mackerel stock assessments. These assessments provide key information for fisheries management and are used to track changes in estimated biomass

relative to reference points and are used to set sustainable harvest levels. These data also provided stakeholders with improved knowledge of the biology of these key Torres Strait fish stocks including:

- Tracking changes in the age structure in Spanish Mackerel with a strong recruitment pulse evident in 2020-2021 (over 40% of the fishery were a cohort of two-year-olds) which carry through in the age structure of the following fishing seasons with the highest proportion of the fishery being three-year-olds in 2021-2022. This cohort of fish again appeared as a high proportion of the fishery harvest as four-year-olds in 2022-2023.
- Provide improved spread of samples to more areas of Torres Strait beyond Maizab Kaur, where most of the historical Spanish Mackerel research has occurred, and across more months of the fishing season. Fish frames were sampled from Erub, Mer, Ugar, Masig and Waiben communities. Five CDR zones/ bioregions were sampled for Spanish Mackerel and six were sampled for coral trout species. This expansion in sampling builds the base of knowledge to better capture temporal or spatial changes in these fish stocks.
- An understanding of catch composition for coral trout species and how this varies between sectors.

Using new and existing sampling strategies, the project was able to engage with all users of the fishery (TIB, Sunset, subsistence traditional fishers and recreational fishers) to collect representative length data (TIB and Sunset sectors only), collect fish frames for processing and conduct ageing of these fish sampled for otoliths to determine age at length relationships.

While time spent sampling in Torres Strait communities returned a relatively low number of samples, there were positive outcomes for communities who were able to become better engaged with science and management of their sea country. This was achieved through engaging with project staff attending their communities; 34 days working with communities since 2019-20. Additionally, tours of the DAF Northern Fisheries Facility were given to community fishers and elders, and presentations from project staff were given at PZJA advisory group meetings.

The project encountered a range of challenges in conducting the research, including:

- The logistics of storing samples in and transporting samples from remote locations. Some samples were lost due to insufficient freezer space to keep them ahead of scheduled barge services or ahead of program staff visiting community to collect them. Good feedback was received on an initiative trialled, placing a communal freezer at a fisher's residence within Mer community to address this issue.
- Communication with stakeholders in remote areas. Stakeholders have provided positive feedback on SMS updates on the project and planned sampling sent by AFMA to TIB licence holders, videos about the project produced and displayed on digital notice boards along with community notices displayed ahead of the sampling visits.
- Some fish receivers on outer islands supply whole coral trout to their buyers. Although fishing may have occurred ahead of sampling trips to communities by project staff, these samples were frozen whole awaiting shipment when staff arrived resulting in accurate length measures being recorded, nor otoliths being removed.
- Initial and ongoing participation in sampling. While vessels and businesses have indicated they were willing to participate in the research, it was challenging to convert this interest into good numbers of samples for several reasons. For example, due to staffing issues, a fishing vessel did not have an extra deck hand onboard during two fishing seasons, which

meant the skipper was unable to focus on taking length sheet measures during busy processing times.

- The closure of a prominent community-based fishing business keenly involved with the monitoring had an impact on the number of samples acquired from the TIB sector. While this business was open in 2019-2020 and part of 2020-2021, they were able to host the project while fishing was occurring, which resulted in a good number of samples. With their closure, the level of fishing effort, and therefore sampling in this community, declined.
- Food security within communities. Some fishers advised that it was hard to keep Spanish Mackerel frames ahead of the planned community sampling trips. Fish frames are a popular food source for barbeques and Spanish Mackerel and coral trout frames/heads are used for making fish soup. Some fishers also use fish frames for pet food. So, while frames may be kept frozen by fishers as research samples to assist the project, they may need to be co-opted for other more important uses in communities ahead of the project team having access to sample them.

Discussion – Spanish Mackerel

The 2021-2022 to 2023-2024 biological sampling of Torres Strait Spanish Mackerel yielded good sample sizes. The length data were collected from catches across all fishing sectors and months that were representative of the harvest of the fishery. This study produced age data which provided an age at length relationship and provided data to produce revised growth parameters.

Across the five years of this study, length structures of commercial caught Torres Strait Spanish Mackerel showed that most fish (75 %) measured were between 86 and 110 cm FL. These length structures were generally consistent with those of previous research. The fishery appears to have maintained a similar shaped length distribution over time.

Sampling in 2020-2021 commenced in October 2020, which is late in the fishing season. Due to this, the sampling did not capture the length structure of the start of this fishing season (August and September). Despite this late start, this seasons length structure also indicates a higher proportion of fish under 90cm FL relative to other years (Figure 3, page 24). This may indicate a year of good recruitment into the fishery with a higher proportion of younger fish caught in this harvest.

Age structures in 2021-2022 to 2023-2024 were dominated by the 2+ to 4+ age groups (varying from 70 to 80 % by year) and truncated from the 6+ age group, with limited numbers of older fish present in the sampling. The general age structures by year appeared consistent in structure to those from earlier sampling during 2000-2001 to 2002-2003 and 2005-2006 (Begg et al. 2006; O'Neill et al. 2024) showing few fish aged over five years. Spanish Mackerel less than two years old (0+ and 1+ age groups) were considered not fully recruited into the fishery (O'Neill and Tobin 2016; QDAF 2018) and comprised 2 % to 6 % of the commercial harvest by year.

This study was able to identify a strong cohort of two-year-old fish that were present in the 2020-2021 representing greater than 40 % of the commercial harvest. This same cohort was again apparent in the 2021-2022 fishery (33 % of the harvest) and still present in the fishery in 2022-2023 as 25 % of the harvest (Appendix 7). Being able to track a strong cohort of fish moving through the fishery provides valuable insight into the biology of this stock, including recruitment deviation and now being able to consider other factors such as environmental drivers that may influence this pattern.

The study found a maximum age for Torres Strait Spanish Mackerel of 13 years of age for females and 10 years of age for males sampled, representing no change in the maximum measured age from previous studies. The absence of older Spanish Mackerel in the fisheries within Torres Strait waters and within Queensland's zone of the Gulf of Carpentaria is of interest when comparing to age structures reported within the east coast of Queensland fisheries (Langstreth et al. 2014; O'Neill et al. 2018; Bessell-Browne et al. 2020), which recorded much higher proportions of older fish and a maximum age at 26. Reasons for this large difference in the age structures may be linked to a range of factors such as differences in available offshore reef habitats and food availability, total population size, fish movement patterns to other areas, fishing gear type, marketing, or high fishing and/or natural mortality.

Fishers have advised project staff that fish of a greater maximum size, and therefore possibly also in age, than those currently sampled by this project (164 cm FL female, 121 cm FL male) are reportedly present within the area of the fishery. Fishers from the Sunset sector do not target large Spanish Mackerel as they are harder to retrieve while avoiding depredation by sharks, harder to fillet and become a "two-person lift" out of the tenders onto the primary vessel once they have reached a certain size. This creates potential safety risks for the crew. Fishers from TIB sector advised that areas of their sea country do have numbers of larger and likely older fish as residents, but these fish have cultural significance, and these areas are not fished.

This project has improved since 2020-2021, on the spatial coverage of sample collection with the commercial fishers, with representative samples now taken from four areas of the fishery in addition to the main fishing ground of Maizab Kaur. Future sampling could improve further on the spatial coverage of the sampling program, particularly outside of the breeding aggregation at Maizab Kaur where most fishing effort occurs and 95 % of the sampling has occurred during the five years of these studies. A wider spatial range of samples would help test for any differences in length and/or age structure in other areas of the fishery and fishing sectors away from Maizab Kaur.

Enhanced sample sizes in fishery areas outside of Maizab Kaur, such as around the eastern and central islands of the Torres Strait, would improve the representation of the sex, length, and age data by better capturing the variability in catches across this area. As per 2019-2020 and 2020-2021 studies, increased sample sizes of measured catches from the TIB sector and increased participation in sampling from within each sector (greater than five boats in line with AFMA's Information Disclosure Policy[5]) would allow construction and reporting of sector-based age and length structures for comparison.

Discussion – coral trout

The updated sampling for Torres Strait coral trout species from 2021-2022 to 2023-2024 has continued to build on improving the base of biological knowledge for these key commercial and subsistence species with updated age and length-frequency data. The project provided considerations of catch composition and provided ageing data for Common, Barcheek and Passionfruit coral trout species.

[5] https://www.afma.gov.au/reporting-and-accountability/fisheries-management-policies/information-disclosure-fmp-12

Average lengths from length frequency sampling were 47 cm, 45 cm and 49 cm respectively for Common Coral Trout (FL), Barcheek Coral Trout (FL) and Passionfruit Coral Trout (TL) respectively. The highest proportion of Barcheek and Common Coral Trout species aged were 4 years of age, with most Passionfruit Coral Trout aged showing a range of ages from 4 to 8 years old. More samples will help build our understanding of these age at length relationships by species.

The project has also worked towards sampling strategies for coral trout species that can return appropriate amounts of data. Sampling for coral trout species yielded several challenges for the project, as described above in the general discussion, meaning a lower number of samples were collected than what was expected. Furthermore, the tally of the number of samples collected were divided by the three species found commonly within the basket of four coral trout species e.g. 377 fish aged meant that only 126 Common Coral Trout were aged. This smaller sample size collected has meant that an age-length key was not able to be reliably formed for each coral trout species, though building on the number aged in future years (see future research recommendations below) will enable these keys to be formed and applied to produce an age structure for the commercial fishery.

Note that no Bluespotted Coral Trout biological samples were collected during the study with only two fish of this species measured on length sheets. Given this species rarity in catches it is unlikely that enough samples will be collected in future research to be able to build a length or age frequency.

Future research recommendations

Future research on Torres Strait coral trout and Spanish Mackerel biological sampling might consider the following recommendations based on findings from this study. Survey work onboard commercial fishing boats would be ideal in future to collect length frequency data, otoliths and catch weight. Collection of length frequency measures and otoliths by an onboard staff member would reduce the burden of sample collection being taken by a small number of fishers. These fishers provided a huge effort to bag samples and measure catches to support the research. Onboard surveys, in the Reef-Line Fishery particularly, would likely result in a large amount of length and otolith samples. This survey work would likely yield a greater number of samples as those collected in four years of this study. Measurement of weight would also be able to check the assumptions used to calculate the Spanish Mackerel and coral trout length-weight relationship.

Through this project, sampling conducted by project staff at fish processors (while in operation) was a worthwhile strategy, e.g. 89 samples were acquired in 2020-2021 from a large fish processing operation and 20 samples acquired in 2021-2022 when this business was in operation. Future monitoring should look to focus the time and budget available for sampling in communities to suit when these businesses are operating, and catches are occurring, to make sure project staff are there when catches are being landed.

Future projects should ideally also look to investigate contracting a casual staff member in communities during peak finfish catching periods (e.g. dark of the moon in September, October, and November for Spanish Mackerel) to assist in sampling for the project. This person could assist fishers in completing length frequency measures and collect research samples to be sent to the laboratory for analysis. The project has discussed the potential of such roles with TSRA

regarding any capacity of the TSRA Ranger Program or TSRA Wapil Program (fishery skills and infrastructure development package) to assist in this capacity. Further consideration of integration of this monitoring program into other Torres Strait programs is recommended to help improve sample collection. Another option may be working with Meriba Ged Ngalpun Mab in the funding and creation of such a position that would have great benefits for communities in improving knowledge of data, science, and research careers.

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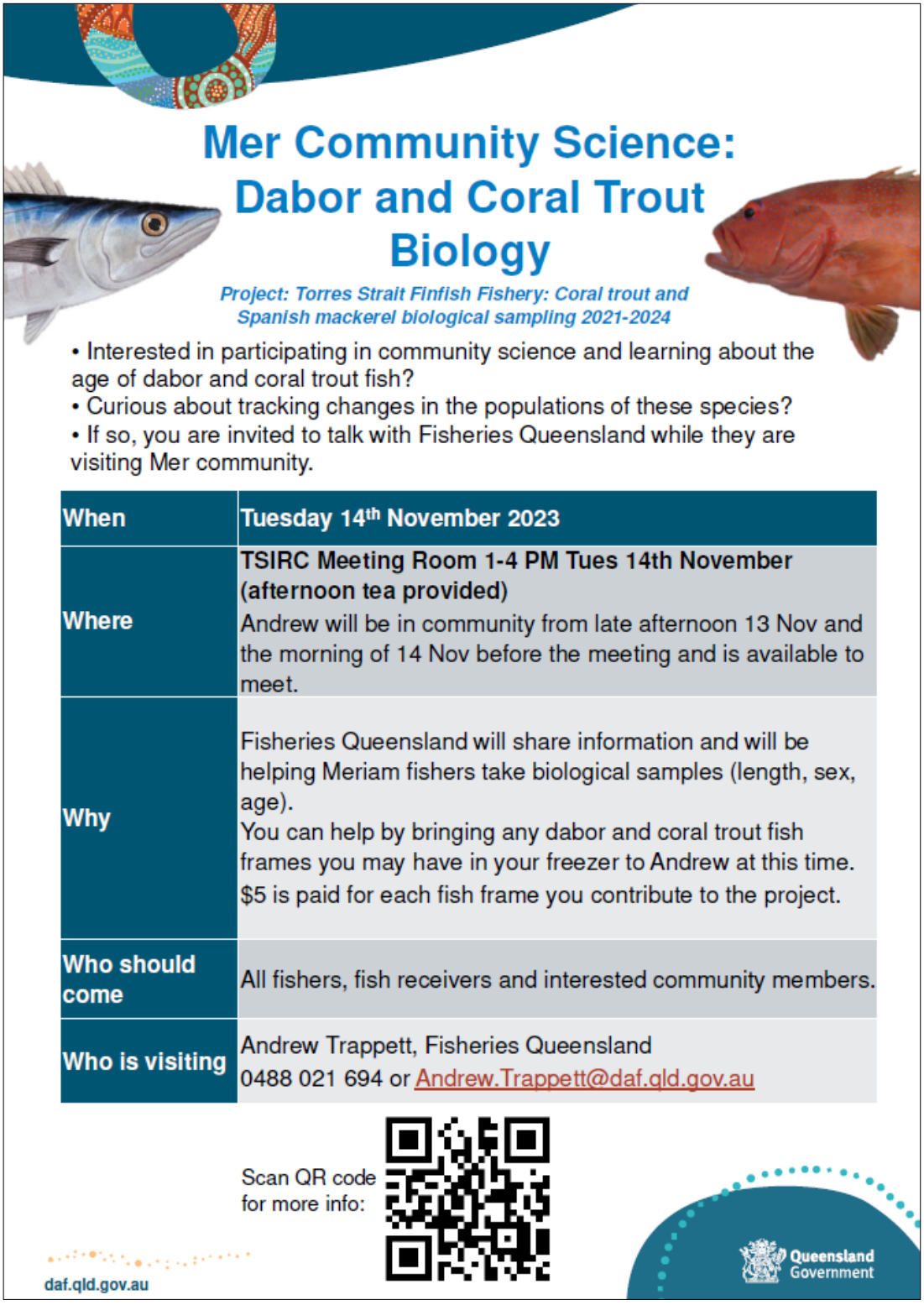
Appendices: Supplemental Information

Appendix 1: Example Community Notice



Mer Community Science: Dabor and Coral Trout Biology

Project: Torres Strait Finfish Fishery: Coral trout and Spanish mackerel biological sampling 2021-2024

- Interested in participating in community science and learning about the age of dabor and coral trout fish?
- Curious about tracking changes in the populations of these species?
- If so, you are invited to talk with Fisheries Queensland while they are visiting Mer community.

When	**Tuesday 14th November 2023**
Where	**TSIRC Meeting Room 1-4 PM Tues 14th November (afternoon tea provided)** Andrew will be in community from late afternoon 13 Nov and the morning of 14 Nov before the meeting and is available to meet.
Why	Fisheries Queensland will share information and will be helping Meriam fishers take biological samples (length, sex, age). You can help by bringing any dabor and coral trout fish frames you may have in your freezer to Andrew at this time. $5 is paid for each fish frame you contribute to the project.
Who should come	All fishers, fish receivers and interested community members.
Who is visiting	Andrew Trappett, Fisheries Queensland 0488 021 694 or Andrew.Trappett@daf.qld.gov.au

Scan QR code for more info:

daf.qld.gov.au

Queensland Government

Appendix 2: Table of Community Visits and Stakeholder Meetings

2019-20 sampling program community visits and meetings

Date	Activity
17 September 2019	Workshop held on Erub along with PZJA Industry Members. TSRA, AFMA, Fisheries QLD. Practical demonstration of sampling techniques.
19 September 2019	Workshop held on Masig along PZJA Industry Members. TSRA, AFMA, Fisheries QLD. Practical demonstration of sampling techniques.
9 October 2019	Workshop held on Ugar along with PZJA Industry Members. TSRA, AFMA, Fisheries QLD. Practical demonstration of sampling techniques.
1 November 2019	Project update provided to TSFFRAG 5 meeting held in Cairns.

From Trappett et al. (2021)

2020-2021 sampling program community visits and meetings

Date	Activity
27 October to 3 November 2020	Community meetings held on Erub, Ugar & Mer. Presentation of 2019-20 results, engaging with community and fishers/fish receivers and determine best time for follow up sampling in community (AFMA led visits with Fisheries Queensland invited)
5 November 2020	Presentation to TSFFRAG 8 meeting held in Cairns. Summary of the first 12 months of the project and the initial findings.
7-11 December 2020	Community visit to Erub and Mer for targeted follow-up with fishers and fish receivers actively fishing and providing samples (Fisheries Queensland led with AFMA sending an officer to assist)
15-19 February 2021	Community visit to Erub and Mer for targeted follow-up with fishers and fish receivers actively fishing and providing samples. (Fisheries Queensland led with AFMA & TSRA sending officers to accompany and assist)

From Trappett et al. (2021)

2021-2022 sampling program community visits and meetings

Date	Activity
18-19 October 2021	Community visit to Mer community, presentation of 2020-2021 results to fishers at TSIRC Hall. Sampling.
20-21 October 2021	Community visit to Erub community, presentation of 2020-2021 results to community at TSIRC Hall. Sampling.
14-16 June 2022	Attend AFMA led community meetings in Erub (15 June 2022) and Mer (16 June 2022) and conduct sampling.

2022-23 sampling program community visits and meetings

Date	Activity
12 October 2022	TSFFRAG 11 Data meeting
3-4 November 2022	Presentation to TSFFRAG meeting in Cairns.
12-15 September 2022	Sampling in Mer community 12-13 September 2022 Sampling in Erub community 14-15 September 2022
26-27 October 2022	Planned to spend the week sampling in Mer/Erub communities but flights grounded. Spent time on Waiben and Ngurupai instead.

2023-24 sampling program community visits and meetings

Date	Activity
8 June 2023	Attended TSFFRAG 13 and gave an update on the project to RAG members and observers.
28-30 August 2023	Community meeting, practical demonstration on Ugar, 28 August 2023 Waiben, sampling recreational catches 29-30 August 2023
30 Aug 2023	Attended TSFFRAG data meeting on Waiben and give a short update on sampling to RAG members and other stakeholders present.
16-20 October 2023	Sampling Mer 16-17 October 2023 Sampling Erub 18-19 October 2023 Sampling Waiben 20 October 2023
13-17 November 2023	Sampling Mer 13-14 November 2023 Sampling Erub 15-16 November 2023 Sampling Waiben 17 November 2023
29-30 Nov 2023	TSFFRAG 13 Presentation, Cairns

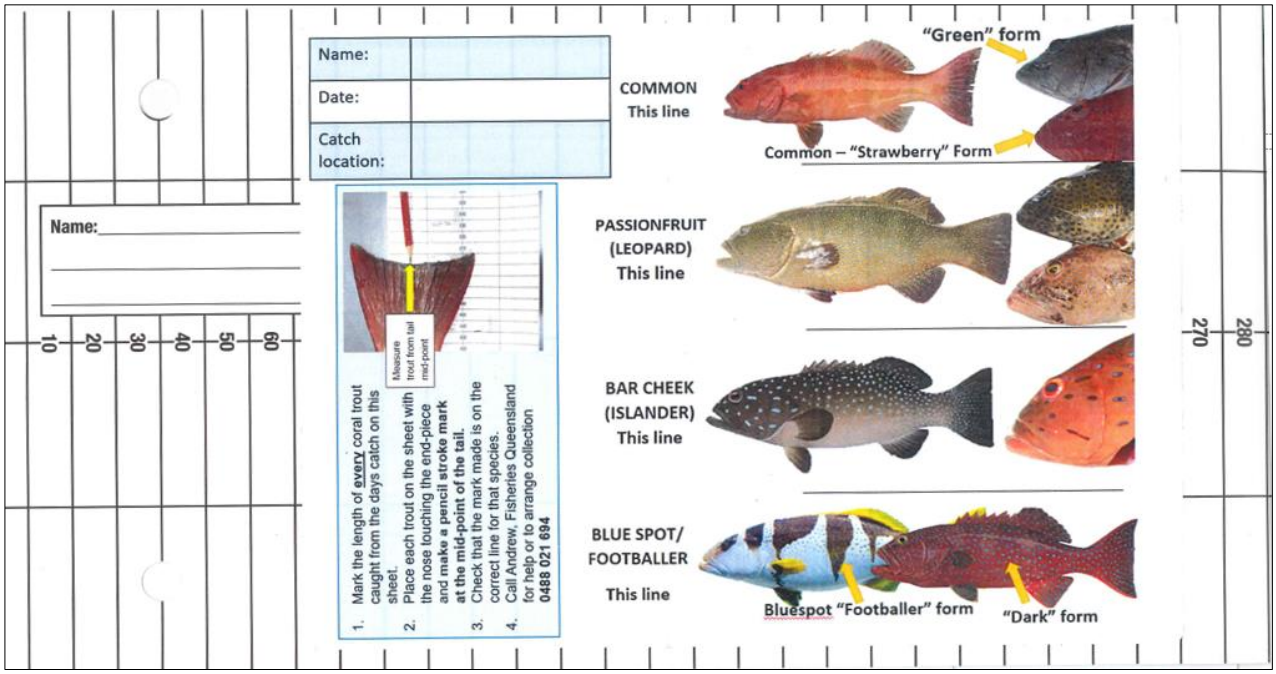
Appendix 3: Sampling Procedures

Field sampling – Spanish Mackerel and coral trout species

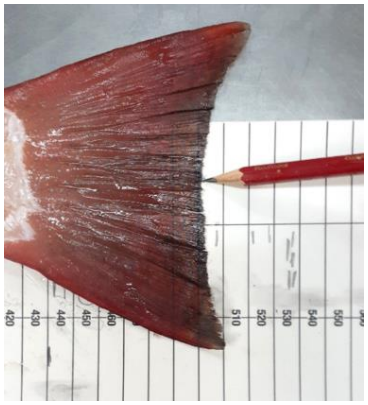
Length sampling procedures

Commercial fishers recorded the fork lengths of Spanish Mackerel from whole unbiased (ungraded) catches onto waterproof measuring sheets with measurements to the nearest 1 cm. The measuring sheets were attached to a precision built for purpose board with an aluminium end piece via two holes at one end. A percentage of the catch was recorded where fishers could not measure an entire unbiased catch. This representative length data was used to construct a length structure for the fishery.

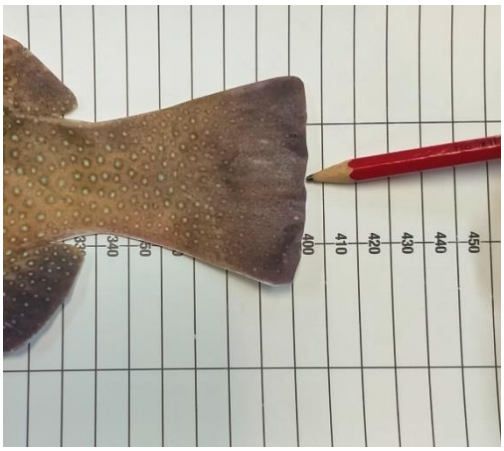
Commercial fishers recorded the lengths of coral trout from whole unbiased (ungraded) catches, as per Spanish Mackerel, using waterproof measuring sheets. Each sheet was used to record a single catch and fishers were asked to record a single species on each row of the data sheet (Figure 1). Fishers recorded the fork lengths of Common, Barcheek and Bluespotted Trout species. Passionfruit Trout was measured as total length due to their square-shaped tail. For all four species, fishers were instructed to measure to the centre point of the tail on the relevant line of the sheet (Figure 2, Figure 3).



Appendix 3, Figure 20. Example of the length frequency measuring sheet used by commercial fishers and fish receivers to collect measures of the four coral trout species noting one species is recorded per line.



Appendix 3, Figure 21. Position of fork length measurements collected for Common, Barcheek and Bluespotted Coral Trout species being the centre point of the forked tail.



Appendix 3, Figure 22. Position of total length measurements collected for Passionfruit Coral Trout species only being the centre point of the square tail.

Coral trout species identification for recording length structure was performed initially using the AFMA publication "*Torres Strait Coral Trout Identification Guide*". However, based on feedback from TIB sector fishers', amendments were made to the length-sheets to include stickers of coral trout species with useful identification features to help fishers place the correct species on the correct line of the measuring sheet for that days catch. A single page summary ID guide based on these features was also produced to aid identification (Figure 13).

Catches were defined as the fish from one morning or afternoon session or from a pooled number of dories or days, if the total number of fish caught, the proportion sampled, and the date(s) were recorded.

Sampling procedure – Age at length and sex at length

Commercial fishers collected samples of whole filleted fish frames (with gonads) and were provided with equipment necessary to do this. Fish were selected randomly by sex, and therefore the sex ratio was representative of the catch within each length class. The samples were freighted back to the laboratories at the DAF's Northern Fisheries Facility in Cairns where they were processed by DAF staff. Some fish were also processed in the field at Torres Strait Fish Receiver premises. Otoliths were removed and the sex of each fish determined.

Together with the biological material and length data, information on the catch including date caught, a general catch location and vessel name were provided by fishers with the fish samples and length data. Fishers were asked to provide position information as a general catch location that could include a reef or island name or a broader scale numbered region as per the Torres Strait Catch Disposal Record (TB02).

Lab Processing procedures - Spanish Mackerel and coral trout species

Most of the fish samples were processed in the laboratories at the DAF's Northern Fisheries Facility in Cairns. Some of the samples were processed at Torres Strait Fish Receiver premises during visits to conduct workshops in communities and to follow up with volunteer samplers and fish receivers.

To allow conversion between samples provided as a whole frame, or a fish head, all Spanish Mackerel were measured by using callipers to measure the upper jaw length (Appendix **3, Figure** 5) of each fish to the nearest 1 mm. For Spanish Mackerel fork length and total length (TL) were also measured to the nearest 1 cm.

For coral trout species fork length was measured to the nearest 1 cm for species with forked tails (Common Coral Trout, Barcheek Trout, Bluespotted Trout) and total length, to the nearest 1 cm, was used for Passionfruit Trout, which have a square tail (Figures 8 and 9). An upper jaw length (Figure 6) was taken with vernier callipers to the nearest 1 mm.

For both Spanish Mackerel and coral trout the location of the otoliths (ear bones) are in the cranial cavity and were accessed from the top of the head by making a dorsal transverse cranial incision with a saw or knife, cutting towards the back of the head (Figure 10). Otoliths were then removed using fine pointed forceps. Once removed, the sagittal otoliths were dried carefully with a tissue and stored in a 5 ml plastic vial labelled with a unique sample number. Otoliths were left in the vial for around 48 hours to allow further drying before capping with a lid.

Sex information was recorded whenever it was available. Sex was determined by macroscopically examining the gonads (Figure 4), or the residual pieces of the gonads connected to the frame. Sex was recorded as "unknown" if sex determination was not possible (Table 1).

Appendix 3, Table 1. Sex codes for Spanish Mackerel

Sex code	Features
1 – Male	gonads are creamy white, solid, small amount of milt can be extruded
2 – Female	tubular, orange and grainy
5 – Unknown	sex cannot be confidently determined (e.g. whole, gutted, degraded)

Appendix 3, Table 2. Sex codes for coral trout species

Sex Code	Features
1 – Male	gonads are often white, solid, small amount of milt can be extruded
2 – Female	gonads are tubular, orange and grainy
5 – Unknown	sex cannot be confidently determined (e.g., whole, gutted, degraded)
6 – Transitional	gonad has areas with characteristics of a female while other areas have male characteristics. Senior staff should be consulted when a transitional gonad is I identified as transitional gonad specimens can be difficult to determine

Appendix 3, Figure 4. Mackerel frames showing female ovaries (above) and male testes (below)

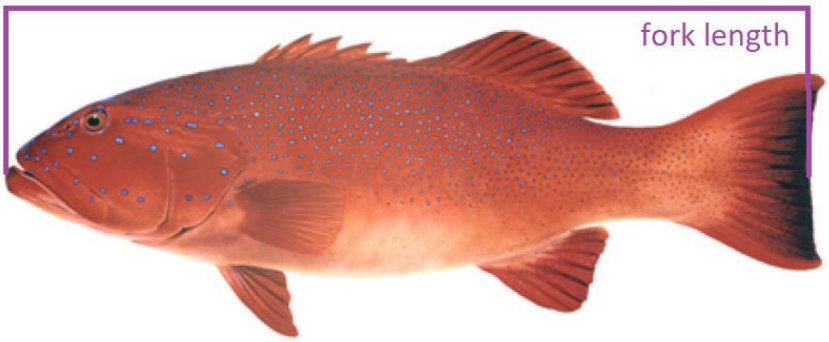
Genetic samples were opportunistically collected from Spanish Mackerel samples only during processing. For this a small piece of tissue (approximately 2 mm in diameter) was removed from the fleshy portion at the dorso-posterior of the fish's head. Each sample was placed in a 2ml vial filled with ethyl alcohol, labelled with a unique sample number, and stored in the laboratory freezer.

Ancillary data, including catch date and location, were recorded along with the biological data and all information was entered into a database and stored securely on the DAF server.

Appendix 3, Figure 5. Upper jaw length measurement of a Spanish Mackerel using Vernier callipers.

Appendix 3, Figure 6. Upper jaw length measurement of a coral trout using Vernier callipers.

Appendix 3, Figure 7. Position of fork and total length measurements collected from Spanish Mackerel.



Appendix 3, Figure 8. Position of fork length measures used for Common Coral Trout, Barcheek Coral Trout and Bluespotted Coral Trout.

Appendix 3, Figure 9. Position of total length measure used for Passionfruit Coral Trout.

Appendix 3, Figure 10. Stages of otolith extraction for a Spanish Mackerel. Coral trout otolith extraction follows the same general procedure.

Representative sampling: percentage of catch sampled

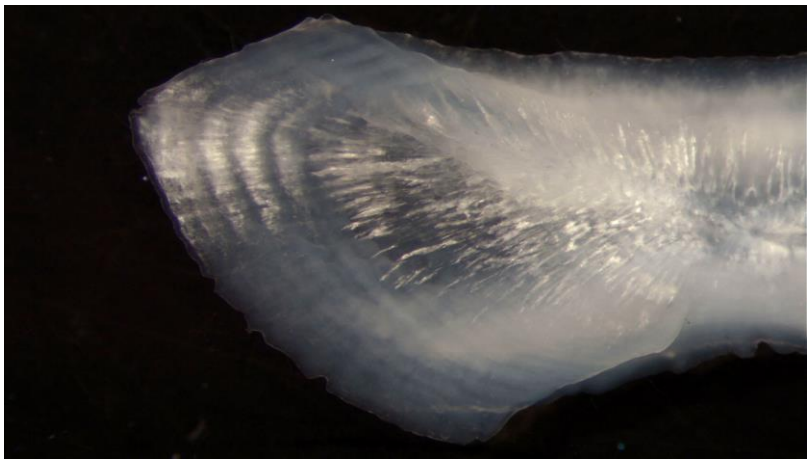
Recording 'percentage of catch' sampled identified length biased samples (0%) and/or allowed sub-sampled catches (>0 to <100%) to be scaled up to be representative of the whole catch (Table 3). In general, commercial catches that were subsampled at less than a quarter of the total catch were deemed unlikely to be representative. However, each catch was considered separately based on the total number of fish in the catch, the relative proportion of the catch to be subsampled, and the lengths of fish in the catch.

Appendix 3, Table 3. Percentage of catch sampled

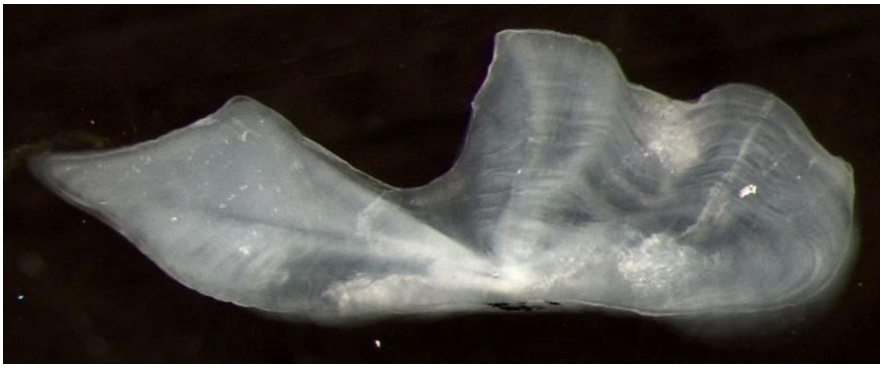
% catch sampled	Situation
100%	Representative sample - the entire catch has been sampled
~25-99%	Representative sample – the whole catch has been sub-sampled in a manner which has a representative proportion of the catch measured (a minimum of approximately 25%) and which has not been biased by fish length. The percentage of the fish that were measured (either by weight, number of fish or number of bins) is recorded together with the total catch (in same units i.e. weight or numbers).
0%	Length biased (non-representative) sample - • suspected or known bias – if the accessible fish no longer represent the lengths of the whole catch, this may be due to size grading for sale; removal of some sizes e.g. for filleting or selling whole. • duplicate - fish may have been recorded twice – once as a length and a second time as a biological sample i.e. length and age and/or sex. The length data of these catches can be used along with the age and sex information to construct age at length or sex at length relationships but not as representative lengths.

Age estimation

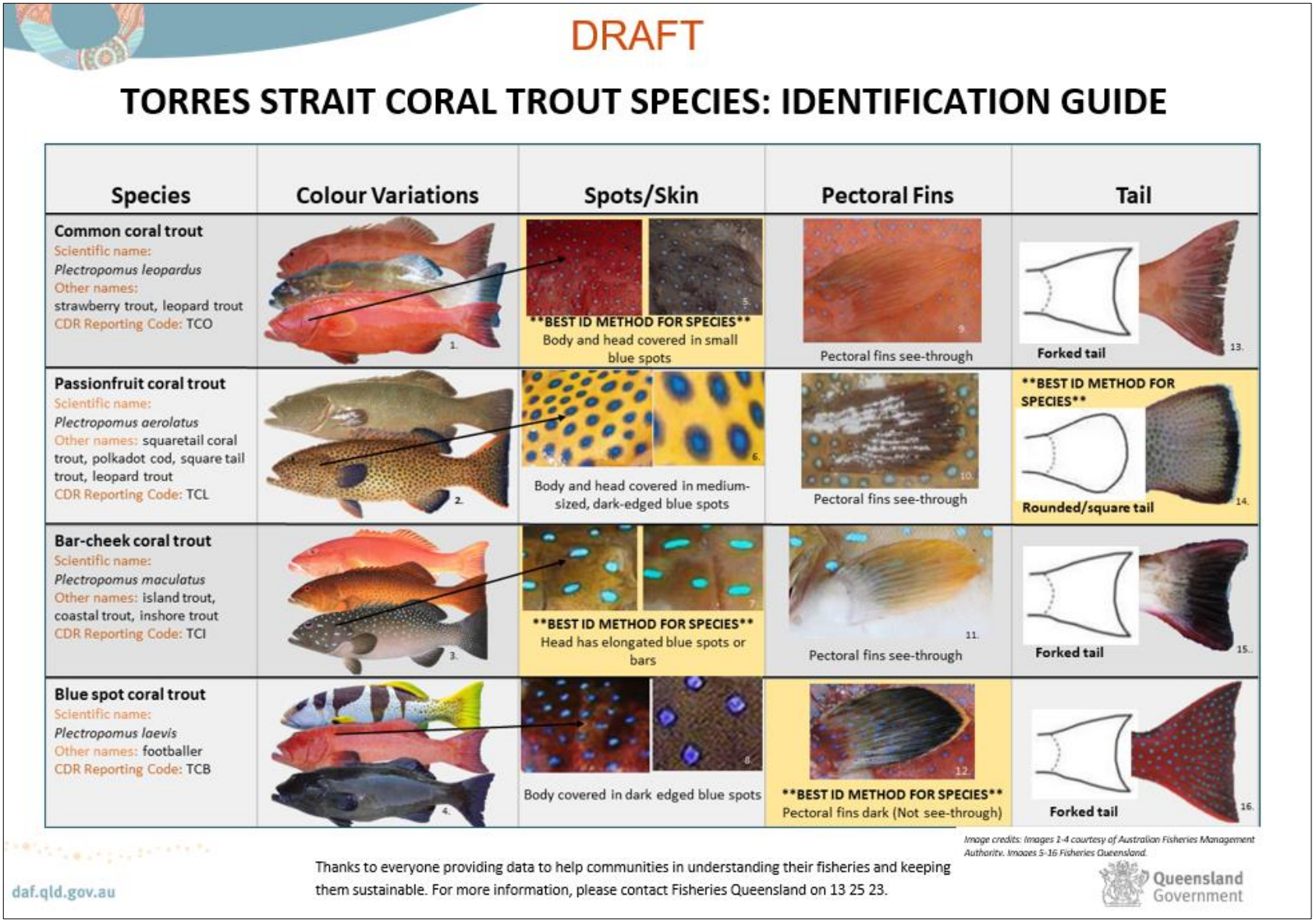
Age is estimated for each fish where an otolith is collected following the General Fisheries Ageing Protocol and the specific Torres Strait Spanish Mackerel Ageing Protocol (Fisheries Queensland, in prep). and the Torres Strait Coral Trout Ageing Protocol (Fisheries Queensland, in prep). Examples of Torres Strait Spanish Mackerel and coral trout otoliths are shown in Appendix 3, Figure11 and 12.



Appendix 3, Figure 11. Distal view of the left whole otolith of Spanish Mackerel from Torres Strait at 12.5 times magnification.

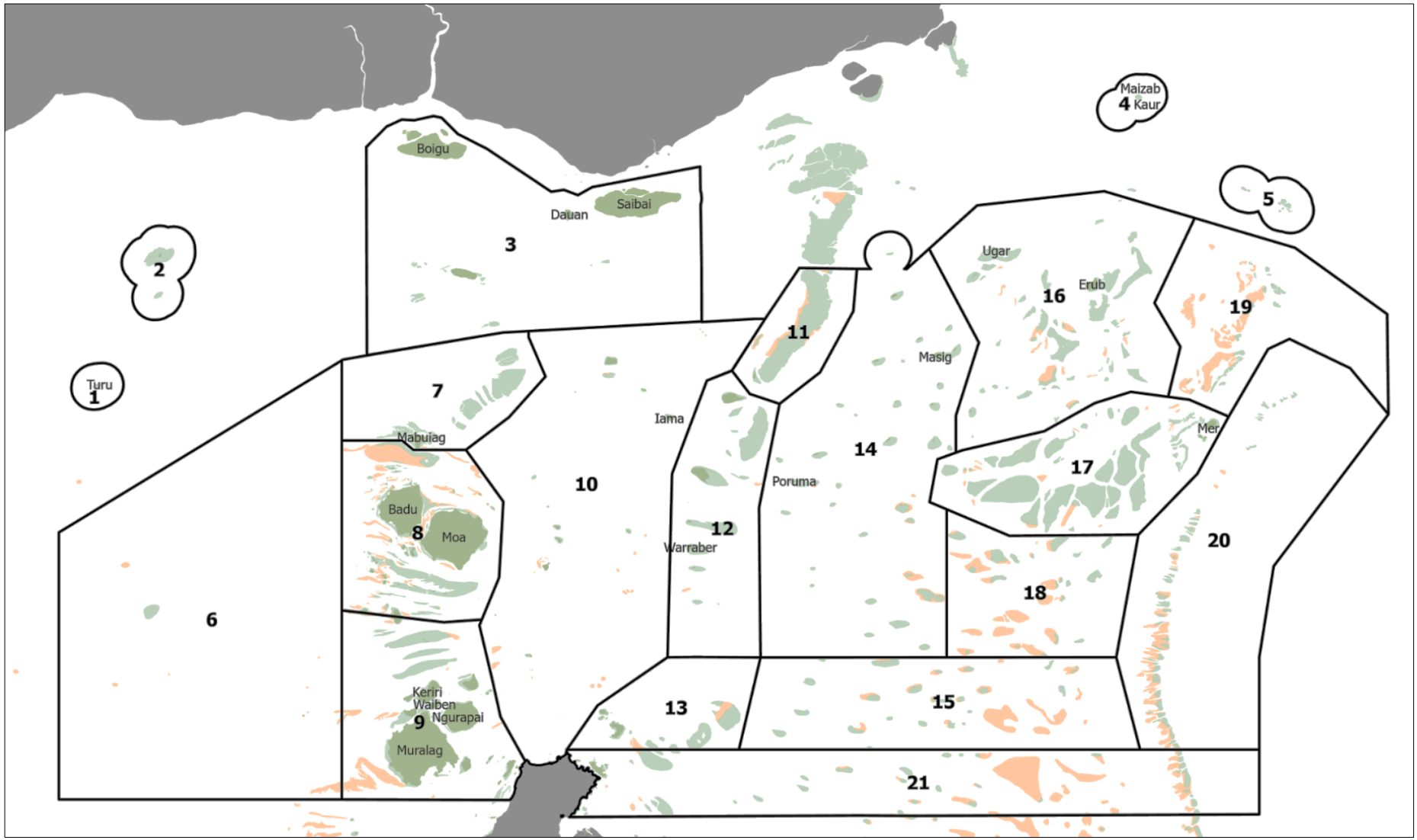


Appendix 3, Figure 12. Distal view of the left whole otolith of Common Coral Trout from Torres Strait at 2.5 times magnification.



Appendix 3. Figure 13. Species identification guide, Torres Strait coral trout species.

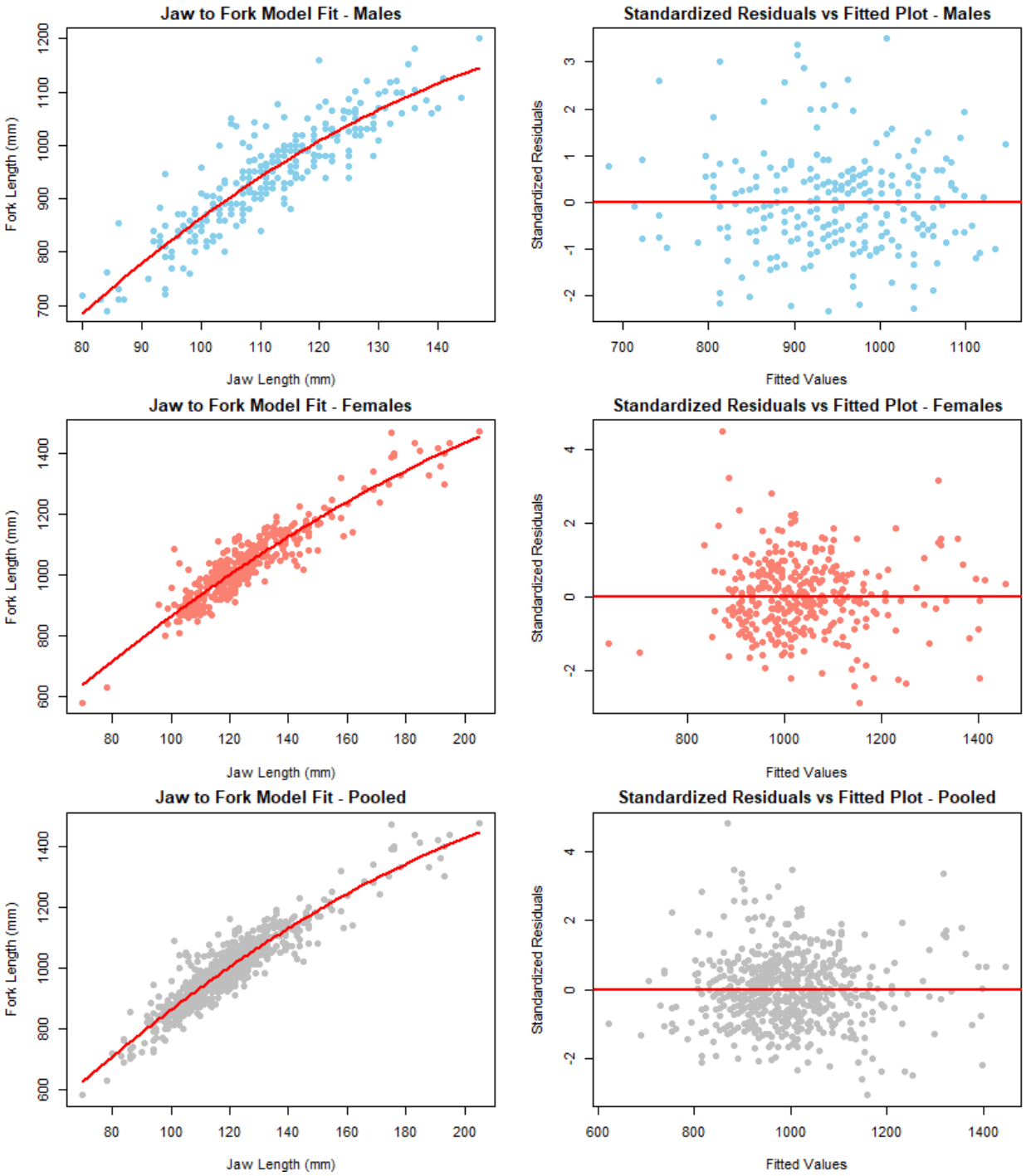
Appendix 4: Torres Strait bio-regions / reporting regions



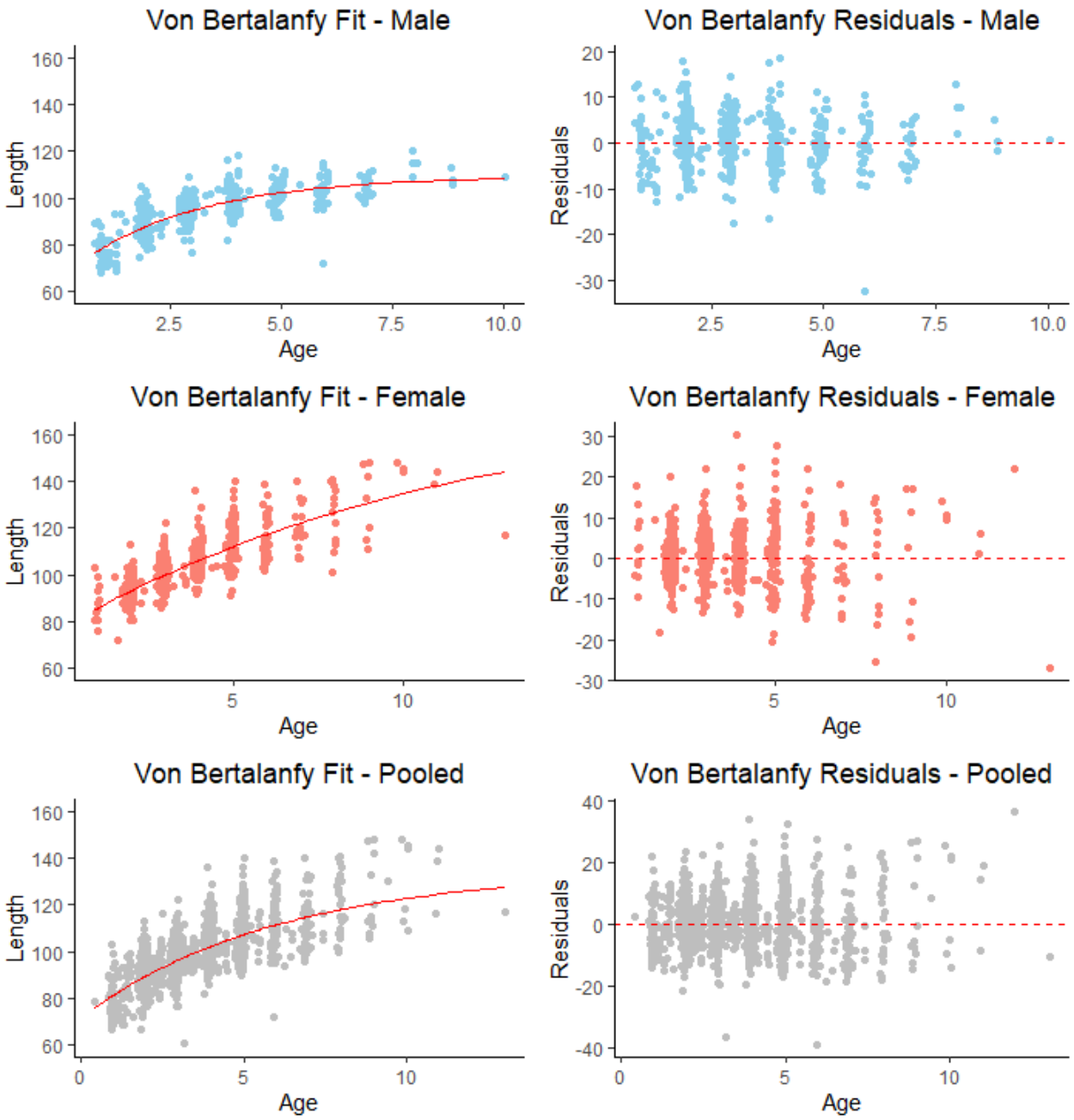
Appendix 4, Figure 1. Annotated map of Torres Strait showing the 21 bio-regions used for reporting catch and effort. Source: AFMA TBD02 Catch Disposal Record.

Appendix 5: Torres Strait Spanish Mackerel growth function

Appendix 5. Figure 1. Jaw Length to Fork Length quadratic regression conversion model, lm(fl ~ jl + I(jl^2), data = df). Pearson's R (correlation coefficient) R^2 for Males: 0.90 (n = 275), R^2 for Females: 0.93 (n = 346), R^2 for Pooled: 0.93 (n = 665).



Appendix 5. Figure 2. Von Bertalanfy growth curve model fit to data and residuals used for adjustment of length (FL) within sampling season. Pearson's R (correlation coefficient) R^2 for Males: 0.80 (n = 611), R^2 for Females: 0.81 (n = 661), R^2 for Pooled: 0.77 (n = 2025).



Appendix 6: Data summary of age at length of Torres Strait Spanish Mackerel and coral trout species

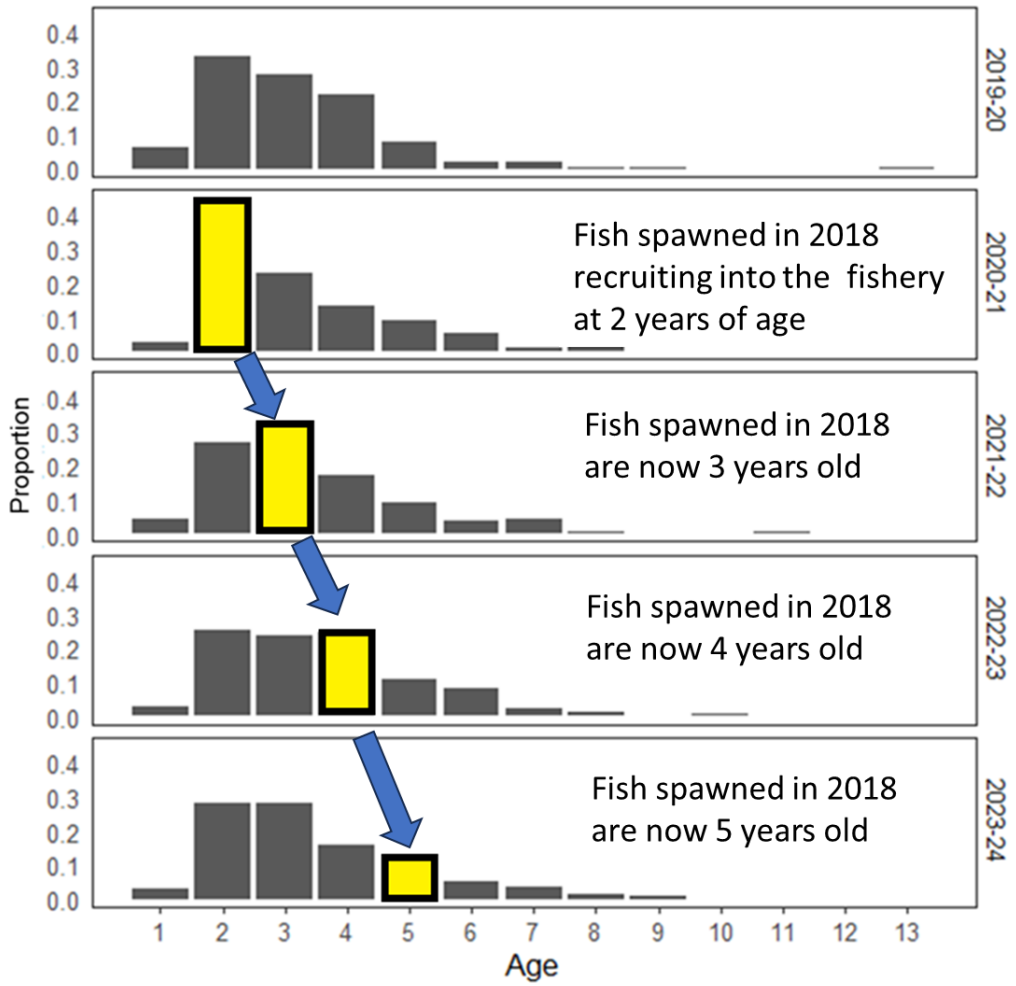
Appendix 6. Table 1. data summary of all aged Torres Strait Spanish Mackerel showing measured fork length (FL) in cm at age (age group) (n = 2,025). Showing average length and sample size for males, females and unknown sex fish aged. Numbers in brackets are the range of lengths for each sex within each age group.

Age Group	Females		Males		Unknown		Total
	Average FL Range (Min,Max)	No.	Average FL Range (Min,Max)	No.	Average FL Range (Min,Max)	No.	
0					75	1	1
1	88 (67,104)	13	78 (65,92)	43	79 (66,96)	58	114
2	93 (81,113)	184	88 (77,105)	188	89 (69,114)	235	607
3	101 (87,122)	157	95 (77,109)	171	96 (58,111)	208	537
4	107 (93, 137)	137	99 (84,118)	96	100 (86,124)	121	356
5	113 (92,140)	82	103 (92,112)	54	104 (91,127)	62	198
6	115 (103,139)	42	103 (73,115)	28	108 (92,133)	32	103
7	120 (109,120)	18	105 (98,112)	20	111 (97,131)	20	58
8	126 (101,141)	13	115 (109,120)	4	115 (100,131)	11	28
9	131 (111, 147)	7	109 (106,113)	3	122 (113,130)	2	12
10	146 (143,148)	3	109	1	116 (114,118)	2	6
11	141 (139,143)	2			116	1	3
12	163	1					1
13	117	1					1

Appendix 6. Table 2. Summary of age at length data for Torres Strait Coral Trout using measured fork (or total) of those fishes aged during 2020-2021 to 2023-2024, showing average, minimum-maximum range of lengths per age increment and by sex.

Age	Common Coral Trout		Barcheek Coral Trout		Passionfruit Coral Trout	
	Average FL Range (Min,Max)		Average FL Range (Min,Max)		Average TL Range (Min,Max)	
	Male	Female	Male	Female	Male	Female
1	-	-	-	35	-	-
2	-	-	35.3 (32,41)	34 (31,37)	-	44.5 (40,49)
3	50	40.5 (40,41)	41.8 (39,45)	44.1 (32,51)	43 (40,46)	44.5 (42,47)
4	49.3 (41,56)	48.8 (37,57)	47.8 (36,55)	44.4 (37,61)	42.5 (40,45)	45.8 (39,50)
5	54 (48,57)	48.4 (40,57)	52.4 (42,60)	50 (48,52)	48	47 (44,55)
6	52.5 (50,55)	53.4 (39,57)	54.8 (52,59)	53.6 (47,61)	48 (40,54)	49.5 (46,53)
7	54.4 (48,55)	52.5 (48,55)	52.3 (47,57)	50 (43,57)	-	50.1 (44,56)
8	54.4 (53,56)	52 (49,57)	55 (54,56)	53 (46,60)	56.5 (53,60)	51.6 (44,60)
9	54.3 (53,55)	49.5 (42,52)	-	-	55 (48,58)	53.5 (53,54)
10	57 (55,59)	42	-	40	52.4 (47,57)	49
11	54	-	-	-	57 (54,61)	-
12	48	-	-	-	58.5 (56,61)	54
13	59	-	-	-	53	-

Appendix 7: Cohort analysis of Torres Strait Spanish Mackerel spawned in 2018



Appendix 7, Figure 1. Annotated plot showing how a cohort of Torres Strait Spanish Mackerel, likely spawned in late 2018, can be seen to move through the fishery, first appearing in 2019-2020 as 1-year olds (likely not fully selected to the fishery at this stage i.e. only the larger fish of this cohort are captured by the fishing gear at this stage). In 2020-2021 these fish (highlighted in yellow) are seen to be most of the commercial fishery with over 40 per cent of the year's harvest being these fish. They again appear in 2021-2022 as 3-year-olds, 2022-2023 as 4-year-olds and in 2023-2024 as a minor proportion of the fishery harvest as 5-year-olds.