Debe Mekik Le Consultancy

Developing an approach for measuring non-commercial fishing in Torres Strait in order to improve fisheries management and promote sustainable livelihoods.

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Disclaimer

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Definitions and acronyms

Definitions

Arakwal	Traditional Owners of Byron Bay
Bus route survey	A survey where a monitor travels around a circuit incorporating several access sites according to a predetermined schedule of travel between sites and waiting times at sites. Designed for situations having a high number of access sites.
Catch	Marine species captured during fishing.
Census survey	A survey conducted on the full population.
Commercial catch	The catch from fishers that is used for commercial profit, mostly from wild fisheries.
Commercial fishing	Fishing activity that is undertaken with the goal of selling catch for commercial profit.
Creel survey	An in-person survey where a monitor interviews a fisher about their fishing experience and can also inspect the catch. Traditionally, the survey is conducted on-site at access points along the coastline.
Customary management	Decisions, policies and actions that influences the activities of Traditional Inhabitants on marine resources and habitats at the individual, clan, community or nation level.
Diary survey	Survey in which catch information is recorded by fishers in a dairy—which is periodically reported via mail or via telephone interviews.
Equity	The quality of being fair or impartial between individuals or groups (social equity), for example w.r.t. social policy and public administration
Fishing logs	Fishers' recordings that characterise their catch and the associated circumstances and methods.
Gender equity	The concept of gender equity refers to fairness of treatment for women and men, according to their respective needs. This may include equal treatment or treatment that is different but which is considered equivalent in terms of rights, benefits, obligations and opportunities.
Gimuy people	Traditional Owners of Cairns area
Kaurareg	Traditional Owners of Thursday Island and surrounding districts
Kulkalgal	Traditional Owners of central island cluster of Torres Strait
Landing point survey	A fishing survey conducted at coastal landing sites to collect information that characterise the catch and the associated circumstances and methods
Larrakia	Traditional Owners of the Darwin region
Non-commercial fishing	Fishing for non-commercial purposes (e.g. sustenance, customary purposes, recreation). In the Torres Strait this includes Traditional fishing, recreational (non-indigenous) fishing, and the fishing charter sector fishing.
Off-site reporting	Fisher reporting fishing data after completion of the fishing trip(s), such as from their residence and often not same day as the fishing event; e.g., via telephone, diary log or computer.
Quandamooka people	Traditional Owners of Moreton Bay
Recreational fisher	Non-Indigenous person, 5 years old or older who went recreational fishing at least once in a 12-month period.*
Recreational fishing	The capture of fish, crustaceans or other aquatic taxa for non-commercial purposes* Note: for the purposes of this report, this does not include Traditional fishing.
Standard error (SE)	Estimate of how variable sample means are at estimating the true population mean (Technically, the SE of a statistic is the approximate standard deviation of a statistical sample population.

Self-reporting	Fisher reports fishing data largely independently, often using tools/proformas supplied by monitoring agency.
Stock assessment	Process for determining the status of key species by collating and assessing the best available information and matching it against clearly defined criteria.*
Sustainable catch	Number (weight) of fish in a stock that can be taken by fishing without reducing the stock biomass from year to year, assuming that environmental conditions remain the same.
TIB fisher	Traditional Inhabitant fishing commercially under a Traditional Inhabitant Boat, or TIB licence
TIB licence	Traditional Inhabitants in Torres Strait require themselves and their vessel to be licenced under a Traditional Inhabitant Boat, or TIB licence to fish commercially (for sale). TIB licences are endorsed for specific fisheries (e.g. Spanish mackerel, Reef line and Tropical rock lobster).
Traditional fishing	The Torres Strait Treaty describes Traditional fishing as "the taking, by Traditional Inhabitants for their own or their dependants' consumption or for use in the course of other traditional activities, of the living natural resources of the sea, seabed, estuaries and coastal tidal areas, including Dugong and Turtle" (Torres Strait Treaty 1985)
Traditional Inhabitant	The Torres Strait Treaty defines a Traditional Inhabitant, in relation to the Australian jurisdiction, as "persons who (i) are Torres Strait Islanders who live in the Protected Zone or the adjacent coastal area of Australia, (ii) are citizens of Australia, and (iii) maintain traditional customary associations with areas or features in or in the vicinity of the Protected Zone in relation to their subsistence or livelihood or social, cultural or religious activities" (Torres Strait Treaty 1985).
Traditional Owner	People who can trace their descent back to an ancestor alive at the time of annexation by the relevant colonial power (Arthur 2004)
Torres Strait traditional fishery	Broadly, the participants, gear, habitats and species that are subject to Traditional fishing in the Torres Strait. In Torres Strait this includes up to ~200 species, including dugong and turtle (which are also treated separately as a sub-fishery with specific management arrangements) and also including some species that make up commercial fisheries (such as the Torres Strait Torres Strait Spanish Mackerel Fishery, the Torres Strait Finfish (Reef Line) Fishery (both sub-fisheries of the Torres Strait Finfish Fishery), and the Torres Strait Tropical Rock Lobster Fishery).

*from QDAF survey reports

Acronyms

AFMA	Australian Fisheries Management Authority
AW	Alinytjara Wilurara
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FWCMP	Far West Coast Marine Park
EFMA	Erub Fisheries Management Association (Erub)
GBK	Gur A Baradharaw Kod (Peak PBC body for Torres Strait PBCs)
IPA	Indigenous Protected Area
KAIA	Kos and Abob Industry Association (Ugar)
LSMU	Land and Sea Management Unit
MCA	Multi-criteria assessment
MDWFA	Mer Dauer Waier Fisheries Association (Mer)
NRIFS	National recreational and Indigenous fishing survey
PBC	Prescribed Body Corporate
PAC	Project Advisory Committee
PI	Principal Investigator
PNG	Papua New Guinea
PZJA	Protected Zone Joint Authority
QDAF	Queensland Department of Agriculture and Fisheries
RNTBC	Registered Native Title Body Corporate
SARDI	South Australian Research and Development Institute
TEK	Traditional Ecological Knowledge
TIB	Traditional Inhabitant Boat
TRL	Tropical Rock Lobster
TSRA	Torres Strait Regional Authority
TSSAC	Torres Strait Scientific Advisory Committee
TVH	Transferable Vessel Holder (also known as Sunset licence holder)
YLM	Yalata Land Management

Executive summary

Key messages:

1. Information about the catch of non-commercial (Traditional and recreational) fishing in Torres Strait is important for sustainable management of current and future commercially important species in Torres Strait, but also for the sustainability of other species important to Torres Strait islander culture and health.
2. Non-commercial catch monitoring is strongly supported by Torres Strait Island community leaders and consultative representatives. General community support is uncertain, but indications are that it is positive and growing.
3. A successful monitoring program will need high levels of trust and a strong sense of ownership by local Torres Strait Islanders. In this regard, the main requirements are:
   - the value proposition – a shared understanding and agreement of the value of monitoring for management at all levels
   - transparency – implementation, analysis outputs and data use to be adequately communicated
   - simplicity – data collection and data stream to be conceptually straight forward
   - security – high data stream security and local control over data dissemination.
4. An assessment of several possible monitoring methods, based on stakeholder needs, feasibility and gender equality suggest that fisher self-reporting using a monitoring App may be the most effective method for collecting data on non-commercial catches by Traditional Inhabitants and recreational (non-Indigenous) fishers.
5. Complimentary household surveys should also be carried out, initially at least, to validate early-stage survey results and provide additional social data.
6. Importantly, this approach appears to be relatively gender equal - women are as likely to perceive the benefits and feel empowered to provide their catch data as men, and they have widespread access to smart phones and/or alternative data provision methods.
7. Implementation of all key phases of the monitoring program should be overseen by Traditional Inhabitants and include equitable representation for gender, region (e.g. island clusters) and other key groups.
8. Implement the monitoring program in a staged way (e.g. begin with pilot program at small number of communities and focus on basic catch data requirements to start with) which will help Traditional Inhabitants understand and become familiar with any new proposed process and minimise risks to ongoing use and uptake.

Access to marine resources by Indigenous Australians is not only important economically, but also culturally and spiritually. This is particularly so for the communities of Torres Strait, which have some of the highest consumption rates for marine species in the world. In order to sustainably manage marine species in Torres Strait, estimates of catches from all sectors of the fishery are needed. Processes for measuring the catches from commercial fishing are in place. However, the Traditional and recreational non-commercial fishery sectors currently have inadequate or no ongoing catch monitoring. Catch estimates for the non-commercial fisheries will allow more accurate estimates of the total harvest and hence, better informed management decisions that reduce the risk of over-exploitation and ensure the protection of Torres Strait Islander livelihoods. This report outlines an approach for a non-commercial fishery monitoring strategy in Torres Strait by reviewing past and

new and emerging approaches, canvassing stakeholder needs and assessing a range of potential approaches for possible implementation.

Objectives

The overarching goal of any future non-commercial catch monitoring strategy is to *Reduce the risk of declining marine populations by monitoring catch trends and including reliable estimates of non-commercial catches into population assessments*. The specific project objectives to help achieve this are:

1. Review of past and current non-commercial catch sector survey approaches in Torres Strait and more broadly
2. Review stakeholder needs for the collection and delivery of non-commercial catch sector information over the longer-term
3. Facilitate the establishment of a cost-effective Project Oversight Committee (PAC) to guide project delivery
4. Deliver an approach, or options, for collecting and delivering non-commercial catch sector data that is appropriate for management and stakeholder needs.

Review of past and current non-commercial catch sector survey approaches

Various approaches for monitoring Traditional and recreational catches have been applied in Torres Strait, although none on an ongoing basis. The outcomes and learnings from these approaches (successful and otherwise) and others elsewhere in Australia were reviewed as input into the design of an effective, ongoing data collection program.

Traditional fishing

We reviewed past approaches, outputs and learnings from previous Traditional fishery catch monitoring programs in Torres Strait, and in Australia more broadly. We found 14 studies that have been carried out in Torres Strait, dating from 1976 to 2018. Most of the monitoring programs were short-lived, and none currently operate. Six of the 14 studies were focussed on the catch of dugong and turtles. One study was focused on the Traditional Inhabitant commercial (TIB) fishery and their non-commercial (Traditional) component. The remaining seven studies focussed on the broader marine catch of the targeted communities.

The approaches that have been applied to monitoring the Traditional fishery catch in Torres Strait have primarily included creel surveys (observers recording the catch at landing points), fisher interviews, and catch logs. All studies involved an independent external researcher, usually scientists or PhD students, with the majority also involving dedicated trained monitors. Most studies were based on monitors carrying out creel surveys, and/or fisher or household interviews, with most yielding useable catch estimates. Self-reporting programs (e.g., using catch logs) had variable results, with some studies resulting in low returns by individual fishers or an unwillingness to participate.

Five Traditional fishing studies focused on other Australia Indigenous communities were also reviewed. Four of these were primarily based on fisher or household interviews, while two included catch logs. Only one study included a creel survey. The Indigenous survey associated with the National Recreational and Indigenous Fishing Survey (NIRFS) was the most extensive national survey and reported total numbers of 45 marine species or species groups.

The review classified the studies into four survey type (creel surveys—periodic and census; interviews; and self-reporting) and collated information on their strengths and weaknesses. We also

characterised their level of community involvement, which ranged from negligible to significant. However, none of the studies appeared to divulge significant control to local community stakeholders nor did there appear to be any significant community-based data interpretation or use.

Most studies concluded that engaging a wide range of local stakeholders was essential to implementing community-based monitoring. A good communication strategy was also seen as essential for fostering trust and building a shared understanding of the benefits and costs of the monitoring program and for providing ongoing feedback to the community about survey results, which can generate interest and foster participation and support. Project managers must also be ready to take feedback on board and act by adapting sampling approaches to suit local stakeholder wishes. Due to the highly variable nature of marine species landings, considerable sampling effort is required to get reasonably precise estimates of the catch for a community.

Recreational fishing

Recreational fishing, for the purposes of this review, is defined as non-commercial fishing by non-Indigenous fishers. This sector has been monitored by QDAF throughout Queensland and including Torres Strait. However, sample sizes are not considered adequate for an accurate representation of the catch of this sector in Torres Strait.

We found a wide range of approaches have been used in Australian recreational fishing surveys in the past and a range of new and emerging approaches and technologies also being applied. Most surveys targeted smaller local areas and mainly used intercept surveys which collected information in person, such as telephone, access point, roving creel, door-to-door or on-site fisher counts. Whereas broader-scale surveys (e.g., State-wide) used remote methods such as phone surveys, diary-based surveys or combinations of remote methods (Complemented surveys). The review defined each of the previous recreational fishing survey types and their approaches used and collates information on the strengths and weaknesses of each.

A common conclusion at the completion of previous monitoring projects was that any attempt to implement a non-commercial monitoring program will require strong cooperation and engagement of stakeholders at all levels, but particularly at the fisher and local community level. The review also notes that, despite a long history and multiple studies, monitoring the recreational catch is equally if not more challenging than monitoring the traditional catch.

Most attempts (and certainly the most successful ones) have used some type of complemented survey design; usually either a telephone-diary survey or a telephone-access point survey. However, the largest challenge was consistently estimating the full recreational fisher population to estimate total effort and extrapolate sample outputs.

Review of stakeholder needs

Designing a successful Traditional-fishery monitoring program in the Torres Strait requires addressing the needs and issues for all stakeholders. The failure to address a broad range of stakeholder needs will put the success of any future program at risk. We separated the needs into two overarching categories – ‘Data needs’ and ‘Program requirements, constraints and risks’ and assessed these for the following stakeholder groups:

- Traditional Inhabitants
- Fishery managers
- Stock assessment scientists
- National stakeholders

In order to obtain detailed stakeholder needs information we completed a range of activities:

1. Pre-project consultation with Traditional Inhabitants
2. Review of past monitoring program assessments as a guide to help ensure that a comprehensive list of data needs, approaches and issues will be considered, and their learnings incorporated, during any monitoring program design
3. Summaries of statements from recent PZJA meetings where non-commercial fishing data has been discussed
4. Questionnaires (via e-mail), face-to-face, and/or remote consultation (phone, video call) with Traditional Inhabitants, fishery managers, current assessment and research scientists
5. Incorporation of learnings from previous and current Traditional fishery monitoring projects relevant to National stakeholders
6. Project team workshops
7. PAC feedback and comments during virtual meetings and review of draft reports.

Pre-project consultation with Traditional Inhabitants included responses from 13 of the targeted stakeholders (21%), with 11 being supportive (85%) of the proposed project, one against and one uncertain. Most of the community stakeholders recognised the importance and benefits of collecting data on the non-commercial fishery catch and two suggested their community would be interested in being involved in the pilot program. Two main concerns expressed were: 1) that (some) community members will think that information may be used to restrict their catch/access to the fishery; and 2) that recreational fishers may not be included in the monitoring.

Recent PZJA TSSAC, FFRAG and FFWG meeting records included statements that show strong support for a new data collection program for non-commercial fishing sectors, including guidance on key issues that will be important for program success.

Stakeholder needs from all sources were collated, summarised and assigned a priority from 1 to 3 to indicate their importance to achieving the objectives of the monitoring program for Torres Strait. The priority 1 and 2 program needs were categorised into design criteria used to assess a range of Traditional-fishery monitoring options.

(i) Data needs

Traditional Inhabitants identified five data needs:

- Annual catches of all fished species in the community
- Seasonal patterns in catches
- Location of catches (reef scale)
- Disaggregation of catch, effort, use by key demographic and other groups (e.g., women, children, TIB fishers)
- Household social and economic data

Fishery managers identified six data needs:

- Annual (accurate, comprehensive, and representative) estimates of the non-commercial catch of Tropical rock lobster (TRL), Spanish mackerel and coral trout (four species)
- Annual catch of all other species in the Traditional fishery (potentially ~200 species)
- Location of catches (logbook zones)
- Catch and catch use by Traditional Inhabitants (TIB fishers, women, children etc)
- Conversion ratios for fishery products through processing chains

- Economic information on the revenues and costs of fishing, and value chains.

Stock assessment scientists identified ten data needs:

- Annual (and seasonal) non-commercial catch (including discards) of commercially fished species such as Spanish mackerel, coral trout (4 species separately recorded), and TRL that are comprehensive, representative, and accurate
- Annual (and seasonal) catch (including discards) of non-commercial species that are comprehensive, representative, and accurate
- Fishing effort and gear type
- Marine species size/weight/age and sex information
- Location of catches (logbook zones)
- Fishers' observations on catch tends and fishery biology and ecology
- Data should be complimentary and comparable to other sectors of the fishery
- Abiotic parameter measurements (e.g., water temperature, turbidity, wind strength etc)
- Post-harvest value chains analyses, by species
- Provision of fish frames, otoliths, or tissue samples for aging, genetic or seafood contaminants studies.

National stakeholders identified three data needs:

- Improved data on Aboriginal and Torres Strait Islanders fisheries resource use
- Information of monitoring program implementation, utility and limitations
- To improve government policy.

Each of these needs are described in more detail and prioritised. The highest priority needs were then used in the design of a monitoring approach.

(ii) Program requirements, constraints, and risks

Traditional Inhabitants identified eight program requirements, constraints, and risks:

- Program is socially and culturally acceptable to Torres Strait Islander communities
- Monitoring program should be co-designed with communities
- Data management responsibility sits with communities or their representative leadership/bodies
- Data is held in a secure database
- Follow ethical principles, e.g., protection of identity of individual fishers
- Data provision needs to be technically easy and uncomplicated
- Provision of data by fishers should take up the least amount of time
- The monitoring program should include capacity building and/or employment opportunities for community members.

Fishery managers identified five program requirements, constraints, and risks:

- Program needs to include trust building based on shared aspirations, recognition of past experiences, transparency regarding how the data will be used and managed, legitimate local control, and information security
- Program needs to be affordable, and cost be proportional to data accuracy and precision (risk-catch-cost trade-offs)
- Approach needs to be logistically feasible, and relatively straight forward to implement

- Overall program must meet implementing agency OH&S guidelines
- The program should minimise environmental harm, including minimising greenhouse gas production.

Stock assessment scientists identified three program requirements, constraints, and risks:

- Data collection should be accompanied by comprehensive ethics agreements to ensure an ethical and culturally appropriate way to collect, securely store and use the Traditional fishery catch information
- Co-development of monitoring programs should occur with the community, perhaps as part of broader co-management strategies
- Communication material is sufficient to inform, educate and increase capacity (e.g., provision of training and species guide to minimise misidentification).

National stakeholders identified two program requirements, constraints, and risks:

- Program is socially and culturally acceptable to Torres Strait Islanders
- Formal agreements covering all aspects of the monitoring program must be developed and ratified.

Each of these program requirements, constraints, and risks are described in more detail and prioritised. The highest priority program requirements, constraints, and risks were then used in the design of a monitoring approach.

While the above needs and issues analysis was focused on the Traditional fishery, many of the same issues apply to recreational (non-Traditional Inhabitant) fisheries. In this sense, we have some confidence that the Traditional-fishery monitoring program assessment will also be suitable for monitoring recreational catches in Torres Strait. This has the major advantage of not having to develop and roll out separate programs for each of these two sectors.

Establishment of oversight committee

A Project Advisory Committee (PAC) was establishment to provide a cost-effective approach for guiding project delivery. The PAC was formulated with the following membership:

- Councillor Francis Pearson (Poruma Island Traditional Owner; TSIRC Councillor, Protected Zone Joint Authority (PZJA) consultative Traditional Inhabitant representative)
- Jon Tabo (Murray Island Traditional Owner; PZJA consultative Traditional Inhabitant representative)
- John Morris (Masig Island Traditional Owner; PBC Chair)
- Councillor Rocky Stephen (Ugar Island Traditional Owner; TSRA Member, STIRC Councillor, PZJA consultative Traditional Inhabitant representative)
- Frank Loban (James Cook University, Badu Island Traditional Owner, Zendath Kes Fisheries Interim Director)
- Natasha Stacey (Charles Darwin University, Indigenous fisheries and livelihoods researcher)
- Stephan Schnierer (Southern Cross University, Indigenous fishery researcher)
- AFMA executive officers (Georgia Langdon/Lisa Cocking)
- TSRA Fishery Program representative

This membership provided expert assessment by two key stakeholder groups: Traditional Inhabitants and subject matter experts. Five Traditional Inhabitants represented different Torres

Strait communities and the two subject matter experts are national experts in Traditional fisheries, Traditional fisheries monitoring, Indigenous livelihoods and natural resource management.

The PAC was engaged through two (remote online) workshops, where the project methods and outputs were described, followed by feedback and group discussion. Feedback and additional information were also received through requests for comments on draft outcomes, by way of the draft written report.

The PAC deliberations resulted in several changes to project outcomes and made recommendations on the implementation of a specifically designed pilot program.

Assessment of monitoring approach options

Potential options for monitoring the non-commercial catch in Torres Strait were selected based on information from (i) the outcomes of a review of approaches; (ii) consultations with local stakeholders; (iii) the expert views of the PAC; and (iv) the project team assessments. The project team scored each of the options against the needs of key stakeholders in Torres Strait in a multi criteria analysis (MCA). This produced a score for each option and illustrates their strengths and weakness. This process resulted in a ranking of options and recommendations for a preferred candidate monitoring approach.

Six potential options were formulated to assess an acceptable non-commercial catch data monitoring strategy in Torres Strait. These reflect previously used monitoring strategies in Torres Strait, but also incorporate potentially suitable features from the range of monitoring methods. They were also moderated or refined to incorporate the needs of any future program based on stakeholder needs; then reviewed by the PAC.

Potential monitoring methods assessed by the MCA:

No.	Title	Description
1	Self-reporting via monitoring app	Reporting of daily catch and other information when fishing. Self-reporting (fisher level) via an App tool linked to a central secure database.
2	Self-reporting via catch datasheet	Daily reporting of catch and other information. Self-reporting (fisher level) using a catch data sheet which is then sent to a central location for entering into a secure database.
3	Self-reporting via periodic catch datasheet	Periodic reporting of catch (e.g., for previous month) and other information. Self-reporting (likely at household level) using catch data sheets is then sent to a central location for entering into a secure database.
4	Embedded observers via catch datasheets	Periodic reporting of catch (e.g., for previous month) and other information. Information collected by an embedded community-based observer collecting information from households.
5	Creel surveys by roving observers	Daily reporting of a temporal sample (e.g., quarterly for 5 days) for each community by independent observers based on roving (bus route) periodic sampling. Creel (landing point) survey of daily catch and other information.
6	Creel surveys by periodic roving observers	As above, but only done on every 2 to 5 years.

Fourteen high priority stakeholder needs were categorised into five high-level criteria groups: cost, benefit, feasibility, cultural considerations, and sustainability. Each of the criteria were then characterised with respect to their metric range, whether mandatory or not, and with criteria weighting estimates (based on proportion of priority 1 needs plus expert assessment). The criteria were then scored from 1 to 5, and reviewed by the PAC. Criteria group scores were calculated as the weighted average of the criteria scores in that group. The standard deviation in raw scores was also calculated to indicate the criteria's influence on the final option rankings.

The monitoring strategy option with the highest score from the MCA was *Self-reporting via a monitoring App*, followed by *Self-reporting via periodic data sheet* and *Self-reporting via daily data sheet.* Although a census of all fishing and catches is the aspirational goal, no matter which monitoring option is used, it is very unlikely that 100% coverage will be achieved. The assessment of (and accounting for) selection bias and measurement errors will be important to help improve the accuracy of catch estimates. Obtaining estimates of the catch using different methods will indicate possible biases in the different approaches, and allow for adjustment, correction, or initiate changes in the primary data collection method. For example, if self-reported catch information is used as the primary method to estimate catch, a periodic structured interview survey, may also be used to validate the fisher records and provide additional information (e.g., an estimate of socio-economic characteristics and summary catch data). To this end a parallel, complimented survey approach should be initiated early and broadly applied, with the possibility that it can be reduced or even eliminated once the primary data gathering strategy has been tested, modified and well established.

Based on these outputs, and the consideration of the project team and the PAC, we make a series of recommendations for implementing a non-commercial fishery monitoring program in Torres Strait. We focused on the Traditional fishery – it being the largest, the most diverse, and most important (from a food security and cultural point of view) of the non-commercial fisheries in the Torres Strait. This also came with the realisation that (i) the monitoring program for the Traditional fishery would likely be adaptable to the recreational fishery in Torres Strait, and, (ii) running two separate programs would be more difficult for a variety of reasons (cost, equity, data compatibility etc).

The development and implementation of a monitoring App will allow most fishers to directly provide daily catch data, and also provide useful information back to fishers and community members in almost real time. It should produce more data than other survey methods due to its ability to be used in real-time by most fishers. This data should also have relatively high accuracy of key parameters due to having accompanying photographic information of catches. This system should be linked electronically to a secure database that has transparent and robust security and permission protocols. Other benefits of using an App-based approach are discussed.

Note that the Traditional fishery catch also includes catch from TIB commercial operations that is not sold i.e. kept by fishers for home consumption, community sharing or barter. In this case, the catch of the TIB fishers will be recorded in two separate catch recording systems - the animals being sold commercially are being recorded in the FRS, and the rest being recorded in the new non-commercial catch sector monitoring program.

An important aspect in the design of the program will be data security and access. Data security, where an individuals' data is not disseminated without their written approval, will be paramount. Access to data and data summaries will need to be tightly controlled and negotiated. This is a critical aspect of the program that will need to be co-designed with Traditional Inhabitants early in the implementation phase.

Gender (and age) equity should be a primary consideration during the design and implementation of the monitoring program. Female fishers can be underrepresented in monitoring programs where there is a majority working-aged, male dominance of both commercial and intensive fishing effort. Women will often fish a different suit of species and use different methods than men (e.g., gleaning), therefore it is imperative to sample them proportionally to get a true presentation of the catch. In addition, the application of species specific, spatial and other management strategies can impact on women, and therefore, the unique social role of women's fishing disproportionately. Disaggregated data on fishing effort and catch will be required for equitable and socially beneficial management at all levels.

A range of other important considerations for the implementation of non-commercial fishery monitoring program are also discussed in detail, including consideration of AFMAs risk-cost-catch trade-off approach, consultation and engagement requirements between Traditional Inhabitants, managers, scientists and other key relationships. A summary implementation strategy is also presented along with a summary of the benefits of such a program and a series of key project recommendations.

1 Background

Fishing in Torres Strait is critically important to the regions cultural, social and economic fabric, and has been for millennia. The Traditional fishery (marine species fished by Traditional Inhabitants for consumption and/or cultural purposes) is important to Torres Strait Islander communities for food and physical health, and is also important socially, culturally and spiritually, with Torres Strait having among the highest seafood consumption rates in the world (TSRA, 2016; Harris et al., 1995; Busilacchi et al., 2013b). There are also Traditional Inhabitant commercial fisheries (the Traditional Inhabitant Boat, or TIB sector) and non-Traditional Inhabitant commercial fisheries for several species (the Transferrable Vessel Holder (TVH), or Sunset licence holder sector – known as 'Sunset sector'); the most important being for Tropical rock lobster (TRL), Spanish mackerel, coral trout and beche de mer. There is also a small non-Indigenous recreational and charter fishery sector that takes a range of species, as well as PNG commercial and Traditional fisheries.

In order to assess sustainable catch levels of fished species from Torres Strait waters (Figure 1-1) management agencies require reliable data on catches taken from all sectors of the fishery (noted above) to accurately estimate their impacts of marine populations (e.g. Torres Strait Finish RAG). More accurate estimates of fishing impacts will better inform management decisions, reduce the risk of over-exploitation and improve protection of Torres Strait Islander livelihoods.

While catch reporting mechanisms are in place for the TIB and Sunset sectors, the non-commercial fishery sectors (i.e. Traditional, recreational and charter fishing) have inadequate or no ongoing catch monitoring[1]. The Traditional fishery sector has been monitored at times in the past, and the recreational fishery sector is monitored within the State-wide QDAF program. Charter fishing is the smallest of the sectors and has had no monitoring to date.

Various catch census and survey approaches for the Traditional and recreational fishery catches have been applied in Torres Strait and more broadly in Australia. The learnings from these approaches (successful and otherwise) are critical to the design of an effective, ongoing data collection program. Monitoring the Traditional fishery catch has not been an easy undertaking in the past (Henry and Lyle 2003). Although there have been several programs to estimate the Traditional fishery catches (Section 2), the most recent (successful) program was in 2005 (Busilacchi et al., 2008). This lack of recent information is most likely behind the assessment in the most recent Torres Strait *State of the Environment report card* which lists the Traditional fishery trend as “Uncertain” and confidence in the assessment only medium (TSRA, 2016).

Current assessments of the commercial fishery sectors (TRL, Spanish mackerel, coral trout and beche-de-mer) are based on fisher-recorded data and provide information on population status of the range of species involved, as well as sustainable catch levels. However, these assessments lack up-to-date information from the non-commercial fishery sectors. Instead, estimates from these sectors are used to try and manage the total catch from all sectors. These estimates are based on extrapolations from previous surveys and expert opinion within management fora (e.g., Resource

[1] Although Traditional fishing, as defined by the Torres Strait Treaty, includes dugong and turtle, consideration of future monitoring approaches in this report does not include these species. They are considered a sub-fishery of the Traditional fishery and have their own specific management arrangements, including monitoring, through the Dugong and Turtle Management Project (TSRA, 2016). However, learnings from established Dugong and Turtle monitoring programs will be considered during implementation of any future non-commercial fishery monitoring program.

Assessment Groups and Working Groups). A monitoring program for the non-commercial fishery sectors will strengthen fishery stock assessments and management for all commercial fishery sectors that have a non-commercial fishery sector component. Just as importantly it will provide communities with opportunities to use their own data sets for planning at the community level.

The lack of monitoring for species in the non-commercial fishery sectors means that if there are substantial changes in population sizes for species that are important to either (i) Traditional fishery catches and/or (ii) ecosystem functioning, they may go largely undetected. Such changes could impact Traditional Inhabitants' ability to catch marine species and/or create increasing change in the coastal marine ecosystems (Fulton et al., 2019). A monitoring program will identify these changes over time and their extent, and also be useful for tracking the size and composition of the non-commercial catch sector, and any changes that may be due to potential impacts of related fisheries, climate change and other external drivers (e.g., Delaney et al., 2017). This information will allow Traditional Inhabitants and other stakeholders to contribute to appropriate decisions about how to best manage their interactions with the culturally important species involved.

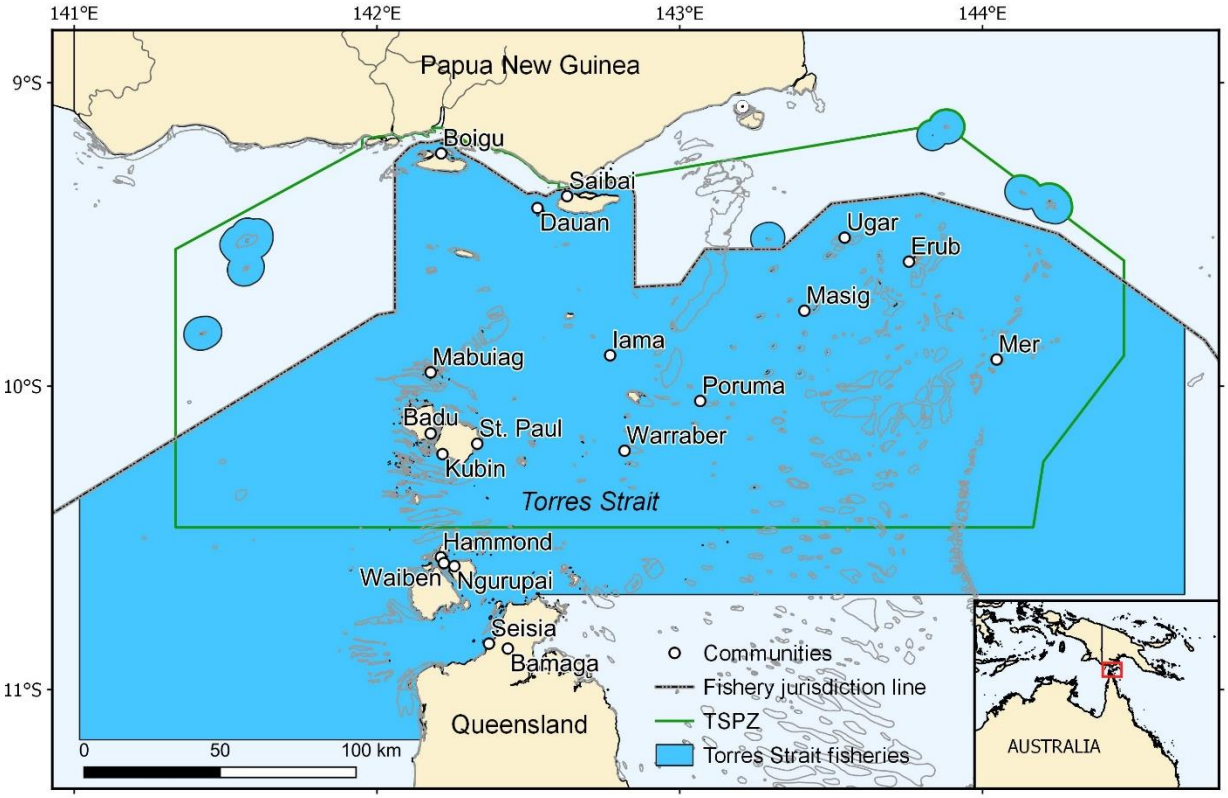

Figure 1-1. The Torres Strait Fishery area.

1.1 Project Objectives

The overarching goal of any future non-commercial catch sector monitoring strategy is to *Reduce the risk of declining marine populations by using reliable estimates of non-commercial catches*. If achieved, this will help to ensure that marine species will be available in adequate numbers to consistently fulfill the needs of Traditional fishing into the future. The specific project objectives to help achieve this are:

1. Review of past and current non-commercial catch sector survey approaches in Torres Strait and more broadly.
2. Review key stakeholder needs for the collection and delivery of non-commercial catch sector information over the longer-term.
3. Facilitate the establishment of a cost-effective oversight committee to guide project delivery
4. Deliver an approach, or options, for collecting and delivering non-commercial catch sector data that is appropriate for management and stakeholder needs.

1.2 Ethics considerations

We have implemented a range of ethics processes and considerations to ensure that consultation, information collection and project outputs both represent and protect the views of individuals. To this end, the project has been guided by a tailored Ethics Statement using the *GERAIS priorities for ethical assessment* (Appendix 1).

This statement was developed as part of a broader ethics approval process that includes seeking prior and informed consent for various levels of information handling and dissemination. Approval for ethics documentation was requested from the TSRA and project Advisory Committee. Traditional Knowledge (TK), in particular, was only used with the express permission of the Traditional Inhabitants.

1.3 Approach

We used the following broad approach (also see Figure 1-2):

i. reviewing past and potential new approaches,
ii. outlining the needs and issues of various stakeholder groups,
iii. assessing a range of options, and
iv. recommendation for the most appropriate approach for Torres Strait.

The project focused on the non-commercial catch from the Traditional and recreational sectors (excluding dugong and turtle), with an emphasis on the commercially important species, including TRL, Spanish mackerel, coral trout. However, we also investigate the opportunity for monitoring the large suite of other species of high customary value to Traditional Inhabitant communities.

A Project Advisory Committee (PAC) was also engaged (Section 3.3) to provide expert feedback on project ideas and results as well as other expert-based information to help guide the project to conclusion. Experts engaged included Torres Strait Traditional Inhabitants and experts on Traditional fishing practices and monitoring.

Detailed descriptions of the methods for each of the project components and their results are described in the sections following.

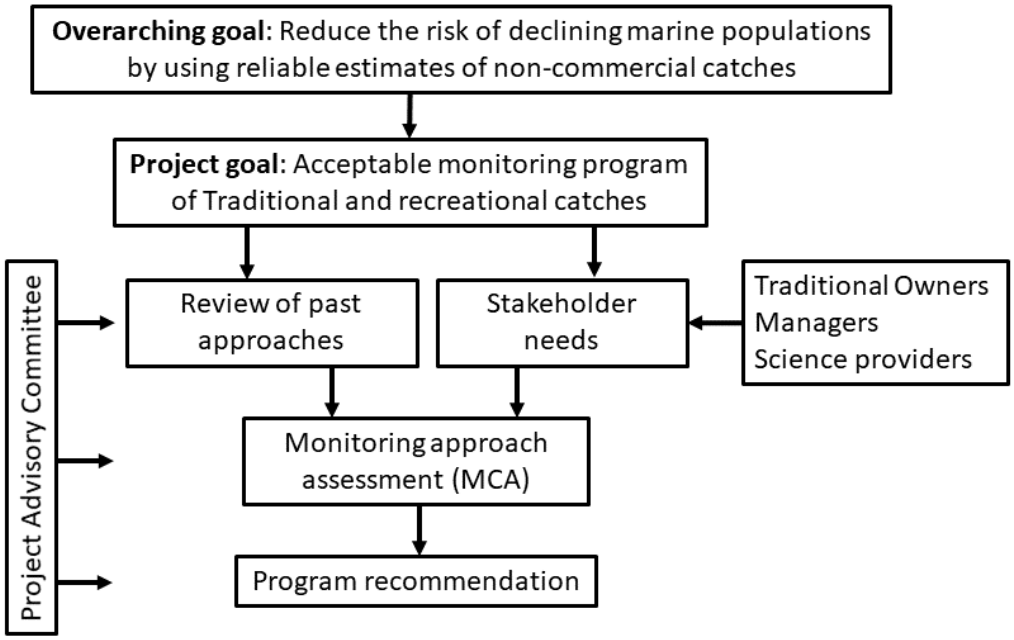

Figure 1-2. Conceptual overview of the project approach for assessing an acceptable non-commercial fishery monitoring program for the Torres Strait. MCA = Multi-Criteria Analyses.

2 Review of past non-commercial catch sector survey approaches

The objective of this component of the project is to review and characterise past approaches to monitoring the catch of non-commercial marine fishery resources relevant to Torres Strait. The non-commercial catch in Torres Strait consists of two main sectors—Traditional fishing by Traditional Inhabitants and recreational fishing by non-Traditional Inhabitants. PNG traditional fishers are included in the traditional fishing review. Charter fishing also occurs in Torres Strait, but effort is negligible and is not specifically included in the review. The outputs of this review will provide a baseline of information to support the design and evaluation of data collection approaches for a future non-commercial fishery catch monitoring program in Torres Strait.

2.1 Traditional fishing

Traditional fishing (Box 1) is an important component of the life for Indigenous communities in Torres Strait (TSRA, 2016; Harris et al., 1995; Busilacchi et al., 2013b) and coastal regions of Australia (Coleman *et al*., 2003). Estimates of the size of the Traditional fishery catch are important for assessing the sustainability of the marine species caught (along with catches from the commercial and recreationally fished sectors), and to support community adaptation and resilience (Davies *et al*., 1999; Butler *et al*., 2013, Butler *et al.*, 2020). Most species in the Traditional fishery catch are, by definition, Traditional only, due to prohibition (e.g., dugong and turtle) or lack of a market/purpose. However, the Traditional fishery catch can also include some species caught in commercial fisheries (e.g., TRL, Spanish mackerel, coral trout) and invertebrate (e.g., Tropical rock lobster) species.

We reviewed past approaches, data and learnings from previous Traditional fishery catch monitoring programs in Torres Strait, and in Australia more broadly. This included review of published studies, reports and discussions (face-to-face or remote) with a range of stakeholders involved in previous monitoring programs. The review describes their key features, strengths and weaknesses and will inform an assessment of monitoring options for possible future use.

2.1.1 Torres Strait studies

We found 14 separate Traditional fishery catch monitoring studies that have been carried out in Torres Strait, dating from 1976 to 2018 (Table 2-2). Most of the monitoring programs in this review were short-lived, and none currently operate. Six of the 14 programs ran for one year, six for two or three years, and two for five years or more. The longest observer-based Traditional fishery catch monitoring program was the AFMA/CSIRO project that carried out 5 years of monitoring between 1994 and 2001 (Skewes *et al*., 2004) – this could also be seen as an extension of the CSIRO Traditional fishing project that ran from 1991 to 1993 (Harris *et al*., 1995; Dews *et al*., 1993).

Six of the 14 studies were focussed on the catch of dugong and turtles (Table 2-2). These are species with high conservation and cultural value and have attracted significant interest (Kwan *et al*., 2006; Grayson *et al*., 2010; Marsh *et al*., 2015). One study was focused on the Traditional Inhabitant commercial (TIB) fishery (and its Traditional component) (French *et al*., 1914). The remaining seven studies generally included the broader marine catch of the focus communities, including species that are the basis of broader commercial fisheries – Spanish mackerel, coral trout and TRL (Table 2-2). Of these seven broadly focussed studies, two were focused on PNG communities and five in Australia. Only one of the broader fishery studies – Harris *et al*. (1995) – attempted to include all communities in the TSPZ (Table 2-1).

Of the 14 Torres Strait studies, Erub I was included in the monitoring the most frequently (7), followed by Mabuiag and Masig Is (6). The remainder of communities/islands have been monitored

four or five times apart from Hammond and Thursday Is, which have only been monitored once (for dugong and turtle) (Table 2-2).

Four of the 14 studies were carried out by independent researchers, three by university aligned PhD students, one by a university-based consultant, five by the CSIRO and one by AFMA. The amount of resources required to carry out the studies varied according to the number of communities included, and the demands of the monitoring approach (Table 2-2). They were funded by a variety of agencies, including the Torres Strait Research fund under the PZJA, Torres Strait CRC, CSIRO, the ARC, universities and several other conservation and philanthropic agencies.

Box 1: Definitions of Traditional fishing in Australian jurisdictions

Traditional fishing

There has been an ongoing dialogue about the terms and descriptions used for Indigenous community non-commercial fishing. Below are the definitions from the Torres Strait Treaty, and Queensland and Australian Commonwealth government agencies.

Torres Strait Treaty

The Torres Strait Treaty describes **Traditional fishing** as *'the taking, by Traditional Inhabitants for their own or their dependants' consumption or for use in the course of other traditional activities, of the living natural resources of the sea, seabed, estuaries and coastal tidal areas, including Dugong and Turtle'* (Australian Treaty Series 1985 No. 4)

Queensland Government (Department of Agriculture and Fisheries)

Under the Fisheries Act 1994, **Traditional fishing** applies in Queensland when:

- the taking, using, or keeping of the fisheries resources is for the purpose of satisfying a personal, domestic, or non-commercial communal need of Aboriginal or Torres Strait Islander people, and
- it is carried out in accordance with the Traditional laws and customs of native title holders or Traditional Owners of the area being fished, and
- those Aboriginal or Torres Strait Islander people, by their laws and customs, have a connection with the land or waters (Fisheries Act 1994; https://www.daf.qld.gov.au/business-priorities/fisheries/traditional-fishing

Commonwealth Government (Department of Agriculture, Water, and the Environment)

The National Indigenous Fishing Technical Working Group defines **Customary fishing** as '*fishing in accordance with relevant Indigenous laws and customs for the purpose of satisfying personal, domestic, or non-commercial communal needs'* (NNTT, 2004).

Torres Strait Ranger Program

An extensive ranger program has existed in Torres Strait since about 2009, and now there are 13 Ranger groups in 14 communities across the region (TSRA, 2016). They currently carry out a broad range of on-ground activities to help implement the TSRAs' Land and Sea Management Units (LSMU) strategy, including natural resource management, cultural heritage site protection, implementation of dugong and turtle management plans and Traditional Ecological Knowledge (TEK) recording and management (TSRA, 2016).

Dugong and Turtle Management Project

The Dugong and Turtle Management Project supports the sustainable and culturally appropriate management of dugongs and marine turtles in Torres Strait. It includes the formulation and implementation of community-based Dugong and Turtle Management Plans, and the collection and storage of dugong and turtle catch data, as well as nesting, breeding and foraging activities across Torres Strait. This data is collected and used in line with community agreements, and, at this stage, communities have chosen not to release any outputs or information. We have, therefore, not included the dugong and turtle catch monitoring associated with this program in our review. However, it is likely that involvement of stakeholders from this program would be useful in any future design and implementation of a Traditional fishery monitoring project.

Traditional Ecological Knowledge (TEK) Project

In most Torres Strait communities (all except for 2), Torres Strait Islander Rangers and local Traditional Inhabitants collect and store a range of environmental and cultural information in a locally implemented TEK database that only the community can access under the management of the PBCs (TSRA, 2106). The TEK Project supports participating Torres Strait communities to "utilise a TEK database for the collection, protection and controlled sharing of cultural and natural resource information whilst ensuring adherence to cultural protocols" (TSRA, 2016). Similarly to the Dugong and Turtle Management Project (see above), a lack of published information means we are not able to include the TEK Project within this review. However, the involvement and learnings of implementors and other stakeholders from the TEK project would be critical in any implementation of a Traditional fishery monitoring project.

Objectives and approaches used

Most Traditional fishery catch monitoring studies had high-level objectives related to the sustainability of high conservation species (dugong and turtle) and improving understanding of the Traditional fishery in a broad sense. However, some studies made the connection between the project outputs to more specific management and adaptive management objectives at various scales (e.g., Grayson, 2011). Only one study had a specific objective related to a local community concern - investigating the interaction between the trawl fishery and the Traditional catch on Masig (Poiner and Harris, 1984).

The approaches that have been applied to monitoring Traditional catches in Torres Strait have primarily included creel (landing point, or bus route) surveys, fisher interviews, and fishing logs (either fisher or household based). Most studies involved dedicated monitors doing creel surveys or carrying out fisher or household interviews. Four studies involved fisher or household self-reporting. One used paper fisher logs of dugong and turtle catches and reported high return rates (Grayson, 2011). But others using electronic logs focused on TIB finfish fishers (French *et al*., 2014), paper logs from households (Murphy *et al*., 2019) and school-based reporting (Busilacchi 2008; Skewes *et al*., 2004), with all reported low returns by individual fishers or unwillingness to participate.

All studies involved an independent external researcher; except for the AFMA school-based program which was managed by an AFMA officer. The level of involvement of local community members in project data collection ranged from negligible (e.g., Poiner and Harris, 1991), to being a significant portion of the project staff (e.g., Grayson, 2011). However, the majority did not include significant local involvement, such as regular activity by local monitors.

Catches were usually recorded down to the species level (e.g., Harris *et al*., 1995, Figure 2-1). However, they were not always reported as separate Traditional and commercial (TIB) fishery catch for each species (although the methods outlined in the study reports indicate that the data was collected in a way that would allow this - Table 2-1) (Harris *et al*., 1995; Busilacchi, 2008).

Table 2-1. Annual catch estimates (t/yr) for Traditional fishery catch monitoring studies that measured the whole catch (Australian studies only). (SM = Spanish mackerel; CT = Coral trout; TRL = Tropical rock lobster).

Traditional fishery Catch estimates (t/yr)	1984 – 1986 Masig (Poiner and Harris, 1991)	1991 – 1993 TSPZ (Harris *et al*., 1995)	2005 – 2006 Erub, Masig and Mer (Busilacchi, 2008; Busilacchi *et al*., 2012)	2014 Erub (French *et al*., 2014)
Total catch	49.7	847.0	223[6, 8]	5.7[9]
Commercial	15.9	184.8	46[8]	
Traditional	14.0[1]	662.2	177	
SM – Total	20.1	14.2	9.2	0.9[9]
– Commercial	10.2	-[5]	5.5[7]	
– Traditional	9.9	-[5]	3.7	
CT – Total	3.0[2]	1.9	28.0	3.9[9]
– Commercial	1.4[2]	-[5]	23.0[7]	
– Traditional	1.6[2]	-[5]	5.0	
TRL – Total	6.2	131.8	-[8]	0.6[9]
– Commercial	2.7[3]	121.2	-[8]	
– Traditional	3.5[4]	10.6	-[8]	

[1] An additional 20 t was traded, used for pig food or wasted.
[2] Coral trout included in "reef fish" category
[3] Tails only
[4] Heads only
[5] Estimated commercial (TIB) catch was 14.1 t/yr – mostly "Spanish mackerel fillets and Coral trout".
[6] Catch estimates done separately for Traditional only and TIB.
[7] Busilacchi, unpublished data
[8] TRL TIB fishers were not included in the monitoring
[9] Catch is for freezer and TIB fisher records combined (most marine species sold to freezer).

2.1.2 Australian case studies

We found five Traditional fishing studies focused on Indigenous communities in Australia (Table 2-3). Four of the five approaches were primarily based on fisher or household interviews, while two included multi-species catch logs (Saunders and Carne, 2010; Schnierer, 2011). Only one study included creel surveys, and even then, they were limited to collecting information on species size (Rogers *et al*., 2014).

The Indigenous survey associated with the National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003; Coleman *et al*., 2000; 2003) was the most extensive survey, and included 44 Indigenous communities across northern Australia (none in Torres Strait). It is still one of the few main sources of information used by fisheries management agencies to develop strategies addressing Indigenous fisheries (Steven *et al*., 2020). The catch was reported as total numbers for 45 marine species or species groups, including mackerels (4,222/yr), coral trout (7,875/yr) and lobsters (14,224/yr).

Table 2-2. Summary of past Traditional fishery catch monitoring projects in Torres Strait.

No.	Date	Islands/ places sampled	Species monitored	Survey type	Resources required	Reference
1	1976 (Sept) - 1979 (Mar) (Nietschman)	Mabuiag, Badu and Kubin	Dugong	Independent observer; Creel (landing point) surveys and interviews; Census.	1 fte, external researcher (1) + operating	Nietschmann, 1984
2	1983 - 1986 (Johannes and McFarlane)	13 islands in TSPZ (all except Warraber)	Dugong	Independent observer; Interviews; Periodic sampling.	2 fte, external researchers (2) + operating	Johannes and McFarlane, 1991
3	1984 (Nov) - 1986 (Sept) (CSIRO)	Masig	All marine species (75 species)	Independent observer; Creel (landing point) surveys and interviews; Periodic sampling.	1 fte, external researcher (1) + ~$50 k operating	Poiner and Harris, 1991
4	1987 (Johannes and McFarlane)	Boigu	All marine species	Independent observer; Individual fisher interviews.	1 fte, external researcher (1) + operating	Johannes and McFarlane, 1991
5	1991 (June) - 1993 (May) (CSIRO)	14 islands within the TSPZ	All marine species (208 species)	Independent observers; Creel (landing point) survey and interviews; Roving (bus route) community sampling.	2.5 fte external researcher + $40K operating per year	Harris *et al*., 1995; Dews *et al*., 1993
6	1990 - 1999 (AFMA-Schools)	14 islands within the TSPZ	Dugong and turtles	Community self-reporting (school based); Catch calendars; Census.	0.25 fte AFMA Officer + operating per year	Skewes *et al*., 2004
7	1994, 1996, 1998, 1999 and 2000/01 (AFMA/CSIRO)	14 islands within the TSPZ	Dugong and turtles (primarily)	Independent (local) observers (1 or 2); Creel (landing point) survey and interviews; Roving (bus route) community sampling.	2.5 fte, external researcher (0.5), local monitors (2) and + $50K operating per year	Skewes *et al*., 2004
8	1995 (Baines)	Daru Island (PNG)	All marine species	Independent observer; Creel (market) survey and interviews.	1 fte, external researcher (1) + operating	Baines, 1995

No.	Date	Islands/ places sampled	Species monitored	Survey type	Resources required	Reference
9	1998 (Jan) – 1999 (Oct) (JCU - Kwan)	Mabuiag	Dugong	Independent observer (embedded researcher); Creel (landing point) survey and targeted (fisher) interviews; Census.	1 fte, external researcher (1) + ~$25k operating per year	Kwan, 2002; 2010; Kwan *et al*., 2006
10	2005 (Apr) - 2006 (Nov) (JCU - Grayson)	Hammond Island and Thursday Islands	Dugong and turtles	Community (hunters) self-reporting supported by local observers; Catch log sheets and targeted (fisher) interviews; Census.	3.25 fte, external researcher (1), local monitors (2), TSRA liaison officer (0.25) + operating per year	Grayson, 2011; Grayson *et al*., 2006; 2010
11	2005 (May) - 2006 (May) (JCU - Busilacchi)	Erub, Masig and Mer	All marine finfish species (62 species)	Independent observer (embedded researcher); Creel (landing point) survey and interviews; Periodic sampling.	1.5 fte, local monitors (0.5) and external researcher (1) + ~$25k operating per year	Busilacchi, 2008; Busilacchi *et al*., 2012; 2013a; 2013b
12	2012 (Sept) - 2013 (Oct) (CSIRO)	Torres Strait treaty villages and Daru (PNG)	All marine species	Independent (local and external) observers; Creel (landing point and market) surveys and interviews; Periodic sampling.	6 fte, external researcher (0.5), other external (0.5), local monitors (5) + operating	Busilacchi *et al*., 2014
13	2014 (Jan - Oct) (Utas)	Erub	TIB catch (5 species categories)	Community (fisher, community freezer) self-reporting; Electronic log sheets on smartphone (fisher) and tablet (freezer); Census.	0.5 fte, external researcher (0.5) + operating (including App development, phones plus prepaid credits, travel for training etc)	French *et al*., 2014
14	2018 (CSIRO)	Erub	All marine species	Community (household) reporting supported by an embedded local observer; Catch log sheets and interviews; Census.		Murphy *et al*., 2019

Table 2-3. Summary of selected Traditional fishery catch monitoring projects in Australia.

No.	Date	Islands/ places sampled	Species monitored	Survey type	Resources required	Reference
1	1996 (Roberts)	Three communities in northern Queensland	All marine species	Independent (local and external) observers; Interviews (fishers); Census.	3.5 fte, external researcher (0.5), local monitors (3), + operating	Roberts *et al*., 1996
2	2000 (June) - 2001 (Nov) (National Rec and Indigenous Fishing Survey – Comm/DAFF)	Northern Australia's coastal areas and catchments (Kimberley region of WA, throughout the NT and the west and east coasts of Qld north of Tully. (not Torres Strait)	All aquatic organisms in the "non-commercial" catch.	Independent (local and external) observers; Household interviews; Random stratified sample of communities and dwellings; Periodic (bimonthly) sampling; Previous 7 days catch recorded.	21 fte, Indigenous Fishing Survey Manager (1), State Managers (WA and Qld) (1), consultant staff (1), Field Supervisor (1), an Aboriginal Liaison officer (0.5), Office Manager (0.5), regional (local) interviewers/guides (16), Plus operating	Henry and Lyle, 2003; Coleman *et al*., 2000; 2003
3	2008 (Feb) - 2008 (June) (NT DoR)	Groote Eylandt	Focus on sharks. rays, fish, crabs, green turtles and dugongs.	Community (Household) reporting supported by rangers; Catch log sheets reporting previous weeks catch; School based collection point; Census.	5 fte, external researchers (1), Anindilyakwa Sea Rangers (4) + operating	Saunders and Carne, 2010
4	2009–10, 2010–11 and 2011–12 (SARDI)	Yalata Indigenous Protected Area (IPA), Far West Coast Marine Park (FWCMP)	Mulloway, *Argyrosomus japonicus*	Independent (local and external) observers; Interviews and limited creel surveys (fishers) at landing sites; Census.	3 fte, external researchers (0.5) (SARDI), local monitors (Natural Resources Alinytjara Wilurara (AW) and Yalata Land Management (YLM) staff and volunteers) (2) + operating	Rogers *et al*., 2014
5	2010 (FRDC - Schnierer)	Tweed River Catchment	Traditional catch	Independent (local and external) observers; Interviews (reporting on previous 12 months); Community reporting (cultural fishing logbook); Focus group interviews.	3 fte, external researcher (1), Indigenous community liaison officers (2) + operating	Schnierer, 2011

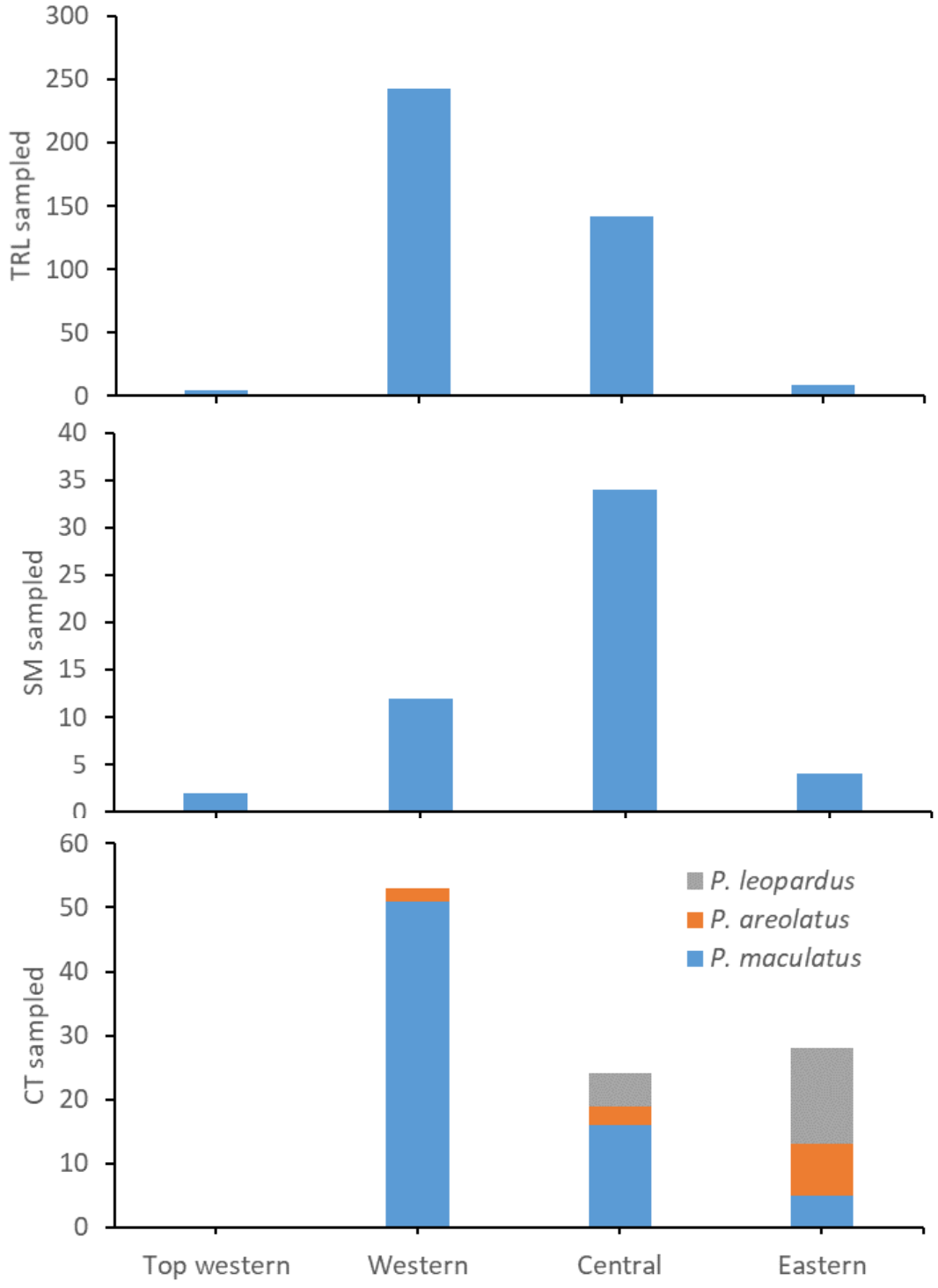

Figure 2-1. Number of individual animals sampled in 1991-93 for TRL (*Panulirus ornatus*) – TRL (top); Spanish mackerel (*Scomberomorus commerson*) - SM (middle); and coral trout (*Plectropomus* spp., 3 species) – CT (bottom) (Harris *et al.*, 1995). [Note that only 3 of 4 coral trout species are identified in this data set – *P. areolatus* also occurs in the catch (Williams et al., 2008)]

Table 2-4. Summary of common Traditional fishery catch survey approaches used and their strengths and weaknesses.

Survey type	Strengths	Weaknesses
1. Creel surveys. Census survey.	Provides the most accurate species-specific catch data. Size and other biological data can also be collected.	Labour intensive and expensive. Can be difficult to implement if landing sites are dispersed.
2. Creel surveys. Periodic sampling (e.g., monthly or seasonally)	As above (but lower accuracy). Lower cost than census survey.	Low sample effort can result in uncertain catch estimates. Biases can occur due to unrepresentative sampling.
3. Fisher or household interviews.	Moderate costs. Can also provide valuable auxiliary data.	Depends on peoples' perceptions and memories. Can have a low participation rate.
4. Fisher/household self-reporting.	Can provide high quality data if fishers respond. New technologies can make this option easier.	Fishers may not participate or lose interest. Requires significant support by competent local observers. Paper returns can be very difficult to manage.

Creel surveys

Creel surveys are based on independent observers' recording of fishers' information, usually at the landing site. They are considered the benchmark for monitoring the Traditional catch, especially for multispecies fisheries, as they provide the most accurate species-specific catch estimates. Most studies in Torres Strait included creel surveys, usually in combination with fisher or household interviews (Table 2-2). Generally, it was acknowledged that using these two approaches at the same time was advantageous in that they provided a broader range of information on fishery catches, fishing techniques, fishing effort and trends; and allowed for some cross-validation of catch estimates (Harris *et al*, 1995; Busilacchi, 2008; Grayson, 2011). Interviews also collected ancillary information and provided feedback to adapt the monitoring program (Harris *et al*., 1995; Busilacchi, 2008). However, there are a range of disadvantages in using creel survey approaches, including high cost, accessibility, and potential for bias without a robust sample design (Table 2-4).

Interview surveys

Surveys based solely on Interviews (fisher or household) can be a low-cost way of estimating catches and obtaining information about fishing patterns and trends as it does not require monitoring of catches be external observers (e.g., creel surveys). They have also been applied in situations where creel surveys are not possible due to scale (Coleman *et al*., 2003) or highly dispersed landing sites (Rogers *et al*., 2014; Schnierer, 2011). However, interviews rely on the fishers recall of past catches and their perceptions of the current state of their fishery which contain significant biases (Griffiths et al., 2014). These data can require careful treatment as recall and perceptions are open to various biases. Also, unless communities have a high level of confidence in the program, participation rates can be low (Murphy *et al*., 2019) (Table 2-4).

Self-reporting

Studies that rely on fisher or household self-reporting can be a very efficient and cost-effective way to gather Traditional fishery data (Grayson, 2011; Saunders and Carne, 2010). However, they have had problems with low levels of fisher cooperation and data reliability (Skewes *et al*.,2004; French *et al*., 2014; Murphy *et al.*, 2019). Using individual fisher logs and a focus on a small number of dedicated fishers supported by well-trained local monitors can be successful (e.g., such as Grayson, 2011). However, the challenges to getting individual fisher logbook returns has been well illustrated in Torres Strait by the difficulty in monitoring TIB fishers catch at an individual level using vessel logbooks for fisheries such as the Torres Strait Beche-de-mer (sea cucumber) fishery (Plaganyi *et al.*, 2019) (Table 2-4).

2.1.3 Discussion

The factors that most studies identified as key for conducting a successful monitoring program included:

i. a high degree of local community involvement at all stages of development;
ii. engaging key local community people (representative influencers);
iii. effective information flow to all local community members; and,
iv. sufficient resources to maintain adequate sampling levels.

The level of involvement by local community members in monitoring programs has been summarised by Danielsen *et al*., 2009 and a summary presented in Table 2-5. In projects we reviewed, the level of community involvement ranged from negligible, to being a significant portion of project staff (Table 2-2, Table 2-3) (Categories 1 to 3; Table 2-5). However, none of the studies appear to have devolved significant control to local stakeholders (e.g., program oversight, data control); nor did there appear to be any significant local data interpretation or use (Category 4; Table 2-5). We have no knowledge of any current (formal) autonomous marine catch monitoring at the community level existing in Torres Strait (Category 5; Table 2-5), although by its very nature this could be happening without external knowledge.

None of the projects appeared to address social equity issues regards their application, either by implementing strategies to ensure representation by women and or age groups, or in terms of investigating gender of age-based differences in resource values or catch fate.

Table 2-5. Categories of Traditional fishery monitoring in Indigenous communities based on levels of local involvement and control (modified after Danielsen *et al*., 2009)

Category of monitoring	Primary data gathers	Primary users of data
1. Externally driven, professionally executed	Professional researchers	Researchers and external agencies
2. Externally driven with local data collectors	Professional researchers, local monitors	Researchers and external agencies (with some potential limited local adoption)
3. Collaborative monitoring with external data interpretation	Local monitors with professional researcher advice	Local people and professional researchers (with potential local adoption)
4. Collaborative monitoring with local data interpretation	Local administrators and monitors with professional researcher advice	Local people (and potential external agencies)
5. Autonomous local monitoring	Local administrators and monitors	Local people

Most studies had a high involvement by external scientists. Interestingly, some of the more comprehensive monitoring programs (at least for a limited number of communities) have been carried out by PhD students (Kwan, 2002; Busilacchi, 2008; Grayson 2011). One advantage of PhD students is that they usually have a strong incentive, drive and determination to carry out and complete high-effort surveys; often requiring long hours and arduous surveillance of landing sites, and willingness to be embedded within communities (Kwan, 2002; Busilacchi, 2008).

There is some evidence that Torres Strait Islanders may prefer an outsider to carry out Traditional fishery monitoring (Busilacchi, 2008). Although an outsider without sufficient community engagement will have problems with trust and cooperation (Murphy *et al*., 2019). There is also broad support for collaborative arrangements and for the engagement of local islander monitors (Busilacchi, 2008, Grayson, 2011). The engagement and training of locally recruited fishery monitors has the additional benefit of providing capacity building and facilitating community awareness. However, they can be challenging to recruit and retain due to a variety of factors, including logistical (lack of funding, support, transport and training), social (community resistance, lack of confidence) and economic factors (competition for time, better employment opportunities) (Skewes *et al*., 2004; Kwan, 2002; Busilacchi, 2008; Murphy *et al*., 2019). There can also be challenges with maintaining data integrity (Skewes *et al*., 2004; Grayson, 2011 p 149).

Most studies found that engaging a wide range of local stakeholders was essential to implementing community-based monitoring. In Torres Strait, this included community leaders (e.g., TSRA, TSIRC, PBC, fishers' associations), leading fishers, commercial operations (e.g., freezer operators, CDEP, My Pathway supervisors) and schools (Harris *et al*., 1995; Busilacchi, 2008; Grayson, 2011; Murphy *et al*., 2019). Just as importantly, the project manager must also be ready to take feedback on board and act by adapting sampling approaches to suit local stakeholder wishes (Murphy *et al*., 2019).

An effective communication strategy is essential for fostering trust and building a shared understanding of the benefits and costs of the monitoring program (Grayson *et al.*, 2011; Murphy *et al.*, 2019). While the vast majority of community members recognise the importance of marine resources, and that monitoring these resources is important for maintaining fishery populations (Busilacchi, 2008; Grayson 2011), there is also some resistance to monitoring associated with the involvement of outside agencies in local issues, including the potential for a loss of control and/or access (Busilacchi, 2008; Murphy *et al*., 2019). While communities have been shown to be generally welcoming and willing to cooperate with monitoring programs in the past, there is some anecdotal evidence that communities may be more questioning as they develop more control and autonomy over their affairs and require more detailed information about data uses and ownership of monitoring data (Murphy *et al*., 2019).

Providing regular feedback to the community about survey results can generate a lot of interest and foster participation (Busilacchi, 2008). Information booklets that included species identifications and local language names can also create interest and engagement by community members (Murphy *et al*, 2019). Local communities and fishers need rapid and regular feedback of detailed information about catches to maintain interest and enthusiasm (Grayson, 2011). Whereas management agencies may only need the data on longer timescales. However, the local need should be primary (Davies *et al*., 1999). Decision making processes that use the data also needs to be clearly articulated to local community members (Grayson, 2011).

Due to the highly variable nature of marine species landings, considerable sampling effort is required to get reasonably precise estimates of the catch for a community. For dugong, at least 70 days of sampling per year would be required to get estimates of dugong catches with a Coefficient of

Variation of <20%, and 150 days of sampling for estimates with a Coefficient of Variation of <10% (Kwan, 2002; Grayson, 2011). However, dugong catches are extremely variable, and possibly a worse case sampling scenario (Kwan *et al*., 2006). The objectives of the catch sampling are an important consideration in determining sampling effort and analytical power. For example, precise catch data at the island level requires a high sampling effort for that island, whereas estimating the catch for the entire Torres Strait does not need such precision at the island level (Skewes *et al*., 2004; Grayson, 2011).

2.2 Recreational fishing

Recreational fishing (defined here as non-commercial fishing by non-Indigenous people) is a popular sport and social activity in Australia. The NRIFS (Henry and Lyle, 2003) estimated that 19.5% (3.36 million people) of the Australian population participated in recreational fishing in 2000/01. During this period, fishers undertook 23.2 million fishing events, caught 72 million finfish, and contributed $1.8 billion to the economy (Griffiths *et al.,* 2010; Campbell & Murphy, 2005; Henry & Lyle, 2003).

Since then, recreational effort has continued to increase (QDAF, 2019). In Queensland, the popularity of recreational fishing has increased from 15% of residents in 2013 to nearly 19% in 2019 (to a total of almost 943,000 people) (QDAF, 2019). These increasing participation rates, together with an increasing population in coastal regions and the increasing sophistication of fishing technologies, highlights a growing need for reliable data to inform policy development and management. In particular, it can be combined with the data from other sectors (commercial and Traditional sectors) to provide more comprehensive estimates of catch and effort for fished populations to underpin robust stock assessments and for allocating resources among sectors.

There have been two recent reviews of recreational fishing monitoring approaches in Australia. In 2010 the FRDC published the report from a large project which reviewed past approaches and new technologies (Griffiths *et al*., 2010). Then in 2014 the FRDC published the report from another large project to update the state of knowledge and information gaps across the recreational fisheries sectors (States, Territories and Commonwealth) in Australia (Griffiths *et al*., 2014). This provided an improved understanding of data sets and their deficiencies and described a framework for a national recreational fishing data portal to make summarised recreational fishing survey data available. However, the study concluded that community-based projects could not typically be integrated with the broader jurisdiction-wide surveys as they either used different survey methods or did not produce estimates of total catch and effort for discrete regions (Griffiths *et al*., 2014). This also highlighted the fragmented nature of recreational fishing data in Australia. An in-depth assessment of recreational fishing monitoring program approaches is described below.

In this study, we reviewed the published and ‘grey’ literature to identify methods that have or may potentially be used to collect catch and/or effort data from recreational fisheries in the Torres Strait. Electronic data searches were conducted using a range of search engines and the most pertinent studies have are described in the following review. Personal contact with researchers or survey companies was also made in order to access some information sources.

Due to the number of studies on recreational fishing surveys, we focused our search on the more recent literature, including the use of previous reviews. This helped focus the current review on the electronically published literature and on the more recent studies which have been designed to correct for various statistical flaws in earlier survey designs. Surveys to collect social and/or economic data, for example, were generally not included.

2.2.1 Monitoring approaches

Common past approaches

In Australia there have been a range of approaches used to survey recreational fishers. Their methods varied depending on the survey objectives and the region being targeted. Most have quite broad objectives that can include assessments of fishing effort, places fished, species fished, catch rates and effort/resources spent fishing. Most surveys targeted smaller local areas and mainly used methods to intercept fishers and collect information in person ('intercept' surveys, Table 2-6), such as access point, roving creel, door-to-door, aerial surveys, or on-site fisher counts (Griffiths *et al*., 2010). Whereas broader-scale surveys (e.g., State-wide) used remote methods such as phone surveys, diary-based surveys, or combinations of remote methods (Complemented surveys). Each of these approaches has strengths and weaknesses and we have summarised those below (Table 2-7).

Traditional intercept methods, such as roving, access point or vantage point surveys via direct observation from platforms, cars, boats, or air (Pollock *et al*., 1994) are, per replicate, expensive to collect (Wood *et al*., 2016). They also have a range of other biases that are difficult to correct for (Table 2-7). Survey designs that rely on the more well established approaches (e.g., mail, telephone, diary, door-to-door etc) appear to have diminishing effectiveness with: i) the increasing use of mobile telephones; ii) the exclusive use of landlines for internet connections (Grande and Taylor, 2010; Barr *et al*., 2012); iii) an increase in 'refusals' due to telemarketing saturation (Curtin *et al*., 2005; Groves, 2006); iv) non-contact bias (contact refusal or failure to sample, Groves, 2006); and v) other forms of survey refusal. For this reason, it is important that emerging technologies and new approaches are a key inclusion in any new assessment of recreational fishing survey design.

Table 2-6. Summary, in number of surveys, for the most common recreational fishing monitoring survey types in Australia since 1990 (based on Griffiths *et al*., 2010).

Survey type	Brief definition	Local	Regional	State	National
Mail	Questions and responses sent and received by mail	-	-	1	-
Telephone	Questions and responses received by telephone; often used with diary survey	-	2	3	-
Diary, logbooks	Fisher-completed calendar-based diary; typically, after fishing is completed; often used with telephone survey	1	2	6	-
Intercept	Survey staff intercepting fishers at specific times and places to record data relating to their fishing activities, such as number of fishers, catch and effort.	26	3	-	-
Complemented	When two or more basic survey methods are used.	8	7	9	1
Total		**35**	**14**	**19**	**1**

Recent approaches and emerging technologies

Here we also describe a suite of emerging and/or recent approaches for collecting catch and effort data from recreational fishers (summarised from Griffiths *et al*., 2010). These approaches have been

grouped into five categories, along with a brief description of their main attributes (below and Table 2-7).

Technology-based self-reporting

There have been recent successes in monitoring recreational fishing in Australia using new technologies (Table 2-7). Recent uses of remote or off-site self-reporting methods can cost-effectively sample a large number of fishers. They include online reporting, online logbooks, text message reporting and phone reporting. These are potentially low-cost methods (due to low labour and operating costs), easy to use and allow for real-time data collection to an online database. However, these types of self-reported data have significant biases. They can severely limit the usefulness of catch estimates for stock assessment due to i) the need for computing, smart phones, or internet access; ii) the prevalence of non-reporting of zero catch trips; and iii) difficulty in extrapolating the data due to unknown population sizes of potential participants (Griffiths *et al*., 2010). However, their main disadvantage is that they rely on fisher self-reported data, for which the quality and legitimacy can often not be verified without conducting follow-up surveys (Griffiths *et al*., 2010). In an international review Skov et al (2021) note that smartphone Apps that target recreational fishers are growing in abundance and are being used in several European countries. The strengths and weaknesses of self-reporting approaches are described in Table 2-7.

A notable recent example of technology-based self-reporting is the *Trachmyfish* App which uses a citizen science approach to collect data (Figure 2-2). This App records marine species reported through competitions as well as year-round. Data collection requires a smartphone device and includes taking a photo of the animal on a background ruler, as well as recording GPS location and other information. The program (run by *Infofish*) analyses data, reports aggregated summaries, and includes fishing locations reported at the region level. Importantly, the program provides analysed and mapped data back to the users. It currently has >10,000 users and has reported >44,000 marine organisms from >300 species in the past 2 years in Australia and New Zealand (Stefan Sawynok, *Infofish*, pers. comm.).

The FRDC recently funded ($1 M) a project to develop a smart-phone App for monitoring recreational fisheries: FRDC 2020-056 - *Evaluation of a smart-phone application to collect recreational fishing catch estimates, including an assessment against an independent probability based survey, using South Australia as a case study* (Crystal Beckmann (PI), University of Adelaide). This project demonstrates a high level of confidence in this form of Technology-based self-reporting within the national industry.

Community-based monitoring (citizen science)

Community-based monitoring has emerged in recent times as a community-driven method for providing information to resource managers. They have the advantage of being a potentially cost-effective way to collect data, often using one of the off-site methods mentioned above (Table 2-7). They can also increase the fishers' sense of ownership of the process and any subsequent uptake of new management measures. Recreational fishing groups, such as *Sunfish*, have undertaken numerous citizen science research projects, including one of Australia's longest running tagging programs, *Suntag*.

Stenekes & Sahlqvist (2011) review six recreational fisheries community monitoring programs in Australia and found they can: i) provide some types of biological data with reliability and over a long term; ii) encourage the fishing community to participate in research and sustainable management of fisheries. However, they had not provided an estimate of total recreational catch and fishing effort

suitable for management, nor the funding to ensure the quality and credibility of data. Other concerns from assessment scientists include that community-operated projects are unlikely to generate reliable catch estimates due to a range of significant biases, including avidity bias (over-representation of avid fishers). However, there are examples where these programs have worked successfully, with close scientific engagement, such as the CapReef program in central Queensland (CapReef, 2009) (Griffiths *et al*., 2010).

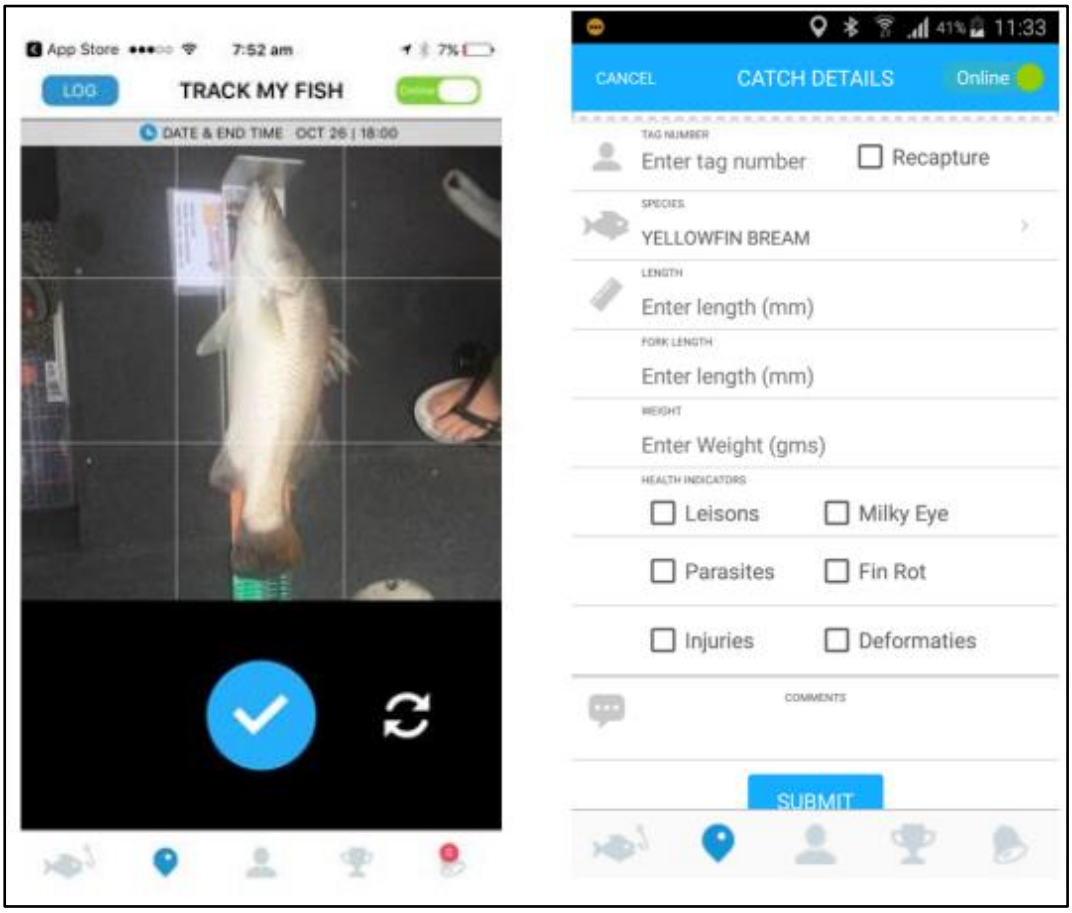

Figure 2-2. Image of a smart device screen to capture images and details using the *Trachmyfish* App (duplicated from Sawynok *et al*., 2018).

Remote surveillance

Remote surveillance approaches include aerial surveillance, remotely sensed imagery, traffic counts and remotely operated cameras. Remote camera technology is in relatively early-stage development and uses high-resolution photo-mosaic time-series imagery for monitoring patterns of human use (Wood et al., 2016). Remote surveillance approaches, such as remote cameras, are cost-effective tools for measuring effort and behaviour, and are most useful at the scale of vessel detection, including trailer-boat counts and traffic counting. Remote surveillance can be a cost effective and reliable method for monitoring fisher activity due to its ability to collect large amounts of data without a full-time, on-site human data recorder (Wise and Fletcher, 2013; Blight and Smallwood, 2015). They can also allow for better coverage of the temporal sampling frame for fishing effort compared to other methods and can provide time-stamped images. And they can improve precision

of estimates for some on-site survey designs and improve accuracy of estimates from some off-site surveys (Steffe et al., 2017). However, remote surveillance approaches are much less useful for collecting specific information on species caught, levels of effort and other specific catch information from recreational fishers. Remote surveillance is most usefully used on large commercial fishing vessels where species-specific video information can often be collected for catches of large animals such as Threatened, Endangered and Protected species (TEPs). The strengths and weaknesses of remote surveillance approaches are summarised in Table 2-7.

Expert elicitation (and Bayesian models)

According to Griffiths et al. (2010), expert elicitation approaches can overcome some key constraints of other methods and therefore may be powerful and cost-effective tools for monitoring some recreational fishing activities. They use qualitative models to analyse stakeholder expert knowledge (e.g., to quantify anecdotal or patchy data sources such as catch, effort and size composition) (Griffiths et al., 2010) (Table 2-7). They allow for the integration of different types of information into quantitative models, including scientific judgment or expert opinion of fishers, while formally accommodating and incorporating the uncertainty in the information provided (Griffiths *et al*., 2010). Successful applications of Bayesian models have been applied to a range of ecological and social situations to facilitate the use of expert knowledge (Kuhnert *et al*., 2005; McCarthy and Masters, 2005; Griffiths *et al*., 2007), including in Torres Strait to investigate factors influencing indigenous participation in the Torres Strait TRL fishery (van Putten, 2013). However, expert elicitation methods are complex in that they require a Bayesian modelling approach to guide the interpretation of anecdotal information and expert data and are usually used because high quality catch and effort data cannot be (cost-effectively) collected other ways. They are usually best for general issues only rather than specific catch information.

Chain-referral sampling and respondent-driven sampling (RDS)

Chain-referral sampling and respondent-driven sampling are non-random statistical methods that work by the researcher interviewing a randomly chosen set of initial subjects from the target population, who serve as "seeds" for an expanding chain of referrals and interviews. Subjects from each 'wave' then refer subjects of subsequent waves (Griffiths et al., 2010). They are useful where fishing members of populations are rare, hidden, or physically difficult to locate within the general population (Griffiths et al., 2010) (Table 2-7). Potential biases include the non-random selection of the first set of seed subjects (seeds) leading to 'volunteerism' bias (Erickson, 1979); and non-response bias where participants may refuse to refer the researcher to their peers or provide false or incomplete contact details ('masking' bias) (Griffiths *et al.*, 2010), which can have significant ethical ramifications in some situations (Heckathorn, 2002).

Past recreational fishing surveys in Torres Strait

The Queensland Department of Agriculture and Fisheries (QDAF) has conducted statewide surveys of non-commercial fishers in 2010, 2013/14 and 2019 (Taylor *et al.*, 2012; Webley *et al.*, 2015; Mission *et al.*, 2019). These surveys used predominantly telephone-diary combination approaches (Mission *et al.,* 2019). The method used is depicted in Figure 2-3.

Most of the estimates reported in these surveys are grouped into regional summaries and the reliability of the estimates produced is dependent on sample size and activity. While there is no intentional focus on different regions within Queensland, in practice, sampling effort tends to be positively correlated with regional population. Consequently, Torres Strait has always had a low sampling effort during this program, which has resulted in uncertain estimates for that region

(QDAF). QDAF also has a policy of not disclosing estimates that it considers to be unreliable (i.e., where the relative standard error exceeds 50% of the estimate). Due to variability and low sample sizes many of the estimates for the Torres Strait fishing region are not disclosed. For this reason, we only report the limited data that is specifically reported for Torres Strait.

The top 10 species from the 2010 and 2013/14 surveys were reported for Torres Strait (Figure 2-4). These two surveys have little overlap between the species reported, indicating high variability between years. This could be due to a number of factors relating to species regime shifts and/or fisher behavioural change. However, the reliability of the data (as explained above) is a more likely explanation given that it is limited due to low sample sizes within each survey.

The Statewide surveys also reported that the percentage of shore-based and boat-based fishers in Torres Strait was ~25% and ~75%, respectively, in 2010; and ~78% and ~22%, respectively in 2013/14. This high variability may also reflect low sample sizes, rather than a major shift towards shore-based fishing between these two surveys.

An estimated 5,776 (± 2,515 SE) fisher days were reported for Torres Strait in 2010. However, in 2013/14 the estimate is not reported due to being considered unreliable (a likely reflection of low sample sizes). There is no other data reported from Torres Strait specifically for recreational fishing, as this survey contacts households by phone and does not categorise between Traditional Inhabitants and non-Traditional Inhabitants. However, it uses the definition of relevant catches as being 'fishing for recreation or fun'; as opposed to 'fishing for food' (Traditional fishing).

The QDAF statewide surveys adopt an efficient method for obtaining statewide estimates. However, different methods are more suitable for making estimates at smaller spatial scales. The QDAF data summaries demonstrate the need for a different sampling method where estimates at smaller spatial scales are required. This appears to be the case in order to provide reliable catch and effort estimates for Torres Strait. Alternatively, a relatively large investment is required to modify the QDAF survey to include far greater samples sizes than are currently allocated. And even then, this survey would be restricted by the biases of using a telephone-diary combination approach. Further collaboration with QDAF will be needed to determine a way forward for any further comparative analyses between surveys.

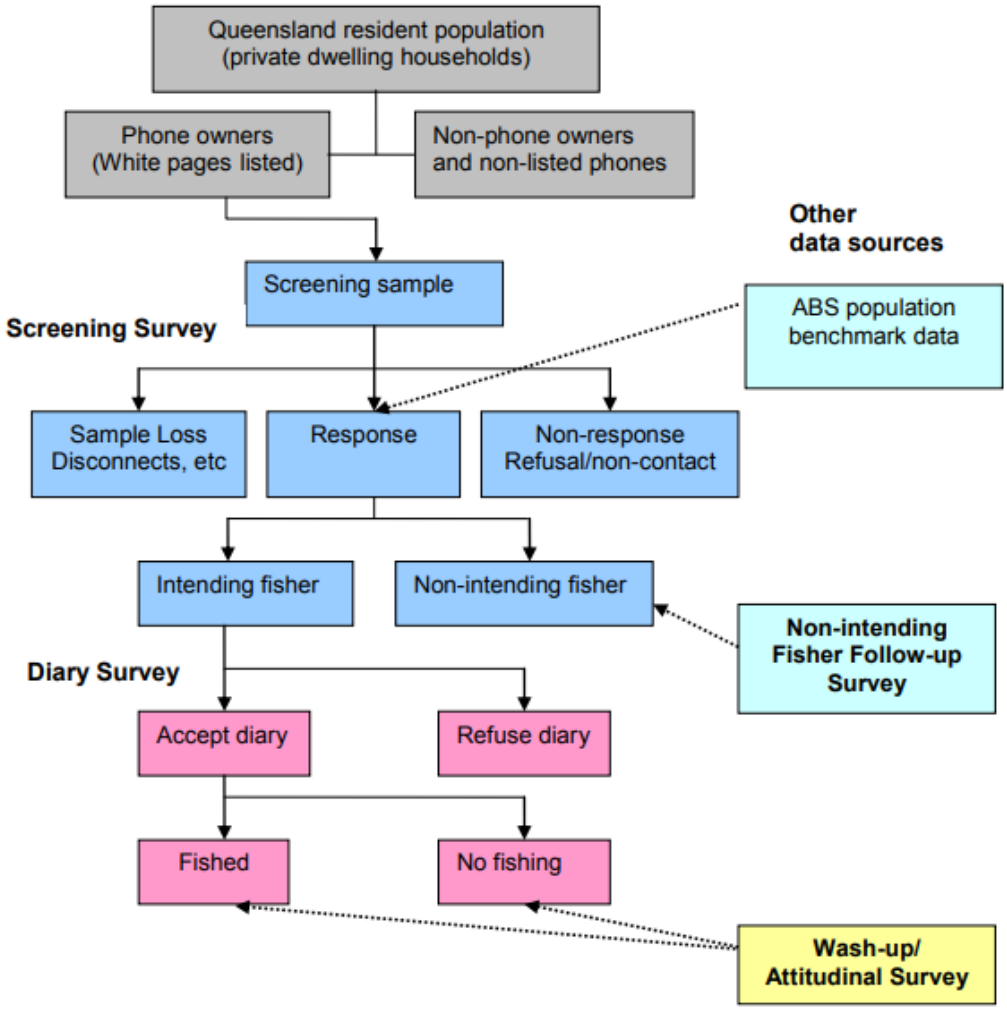

Figure 2-3. Queensland State-wide recreational fishing survey stages (2010, 2013/14). (Mission *et al.,* 2019)

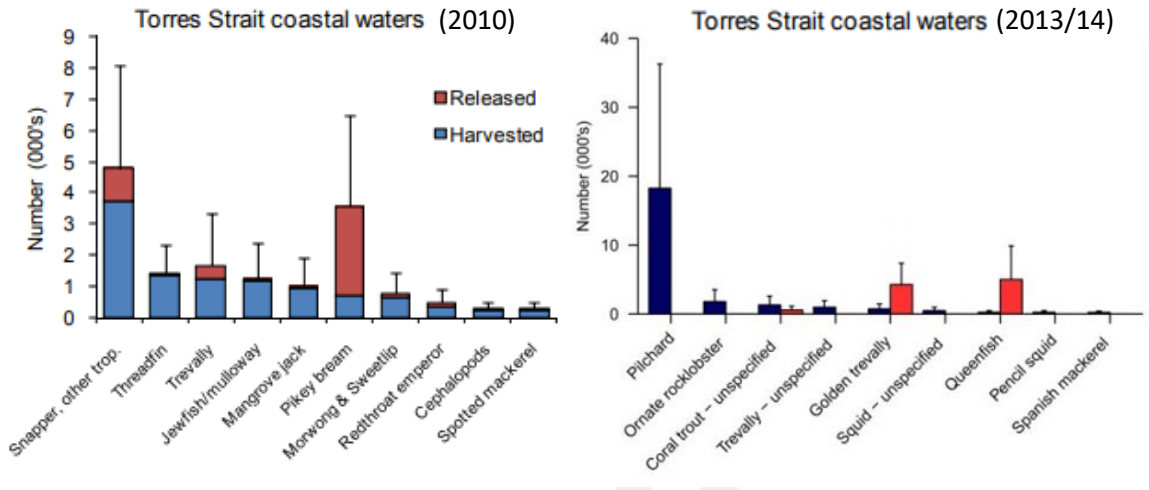

Figure 2-4. Top 10 species caught by fishing region (+SE), taken from the QDAF statewide reports (Taylor *et al.,* 2012, Webley *et al.,* 2015).

Table 2-7. Summary of recreational fishing monitoring approaches and their strengths and weaknesses.

Survey type	Brief definition	Strengths	Weaknesses
Mail	Questions and responses sent and received by mail.	Can be cost effective. Catch and effort can be recorded from fishers who also fish at night or return to private docks, jetties and moorings.	Susceptible to a range of biases (non-response, recall, prestige, rounding, and intentional deception) that often cannot be validated or corrected. Data is self-reported with little or no validation, so data reliability may be an issue. Relies on recall bias and a diminished memory of catch. Survey results are unlikely to reflect the behaviour of the wider recreational fishing community, since more motivated or frequent fishers are more likely to accurately and consistently complete diaries.
Telephone	Questions and responses received by telephone. Often used with diary survey.	As above.	As above
Diary	Fisher-completed calendar-based diary, typically after all fishing is completed. Often used with telephone survey.	As above.	As above. Labour-intensive and expensive; many species groups may need to be lumped under broader categories. Diaries can create 'false effort' as some fishers may feel obligated to fish between each monthly reporting period.
Intercept (includes access point, roving creel, door-to-door, aerial surveys and fisher counts on site)	Survey staff intercepting fishers at specific times and places to record data relating to their fishing activities, such as number of fishers, catch and effort.	Can target only groups or areas of interest. Non-response bias not likely to be a major factor (Pollock *et al.,* 1994). Can provide species-specific catch rates and size composition data. Catches can be inspected to collect accurate species and size composition data. Biological information can be recorded from retained animals (Roach *et al*., 1999).	Labour-intensive, logistically cumbersome, and potentially expensive. Generally, only representative of the daytime catch, making total head counts difficult and prone to underestimation (see O'Neill, 2000; Williamson *et al*., 2006). Fishers may use several access points over time and survey staff may not be able to survey all fishers if the number of access points is large (Malvestuto, 1996). 'Length of stay' bias - where fishers who fish for longer periods are more likely to be interviewed - is difficult to correct for (e.g., overall mean trip length

Survey type	Brief definition	Strengths	Weaknesses
		Recall accuracy of fishing effort and details of released animals can be high. Fishers can be interviewed before their trip is complete.	for roving surveys may be considerably longer than the mean trip length determined from completed trip surveys). The over-representation of avid fishers (those who participate more frequently) in a survey can also led to 'avidity bias', and fishing effort per fisher can be grossly overestimated. Interviewers may contact mainly people that are easy to find to fill their monitoring quota (and fulfill the sample design criteria).
Complemented	When two or more basic survey methods are used.	Useful for dealing with large complex surveys to estimate catch and effort, but they are also useful for correction of biases.	Requires running more than one approach in parallel and using a tightly co-ordinated and potentially complex analytical process. Many of the weaknesses of the individual methods involved may also be relevant.
Technology-based self-reporting (includes online reporting, online logbooks, reporting Apps and text message reporting)	Self-reporting using fast, digital media such as computers and smart phones.	Can cost-effectively sample a large number of fishers. Real-time data collection. Data usually instantly stored electronically. Unique ability to collect accurate temporal and spatial distributions of fishing effort and fisher behaviour.	Requires ownership of personal electronic devices. Self-reporting biases, due to the 'opt-in' strategy are likely to require verification, at least initially. Zero-catch reporting can be highly underestimated. Data extrapolation can be difficult due to unknown sampling frame. Lack of currently available useful Apps
Community-based monitoring (citizen science, e.g., through a fishing club)	Community driven data collection; usually via a range of off-site reporting methods.	Can cost-effectively sample a large number of organised and/or motivated fishers. Can create strong sense of fisher ownership and hence uptake of new measures.	Unlikely to generate reliable catch estimates due to a range of significant biases (including avidity bias). Appropriate quality assurance procedures and training are critical for ensuring the quality of data collected (Stenekes & Sahlqvist, 2011).
Remote surveillance (includes aerial surveillance, remotely sensed imagery, traffic	Uses visual recording and/or counting of patterns of human activity.	Cost-effective and reliable methods of capturing large amounts of accurate activity data, as well as a	Usually cannot collect information of species caught, levels of effort and other specific catch information.

Survey type	Brief definition	Strengths	Weaknesses
counts and remotely operated cameras)		broader representation of the temporal sampling frame.	
Expert elicitation (and Bayesian models)	Uses qualitative models to analyse stakeholder expert knowledge, e.g., to quantify anecdotal or patchy data sources (e.g., catch, effort and size composition (Griffiths *et al.*, 2010)	Can be employed to quantify anecdotal or patchy data sources. Can incorporate uncertainty into estimates.	Usually used because high quality catch and effort data cannot be (cost-effectively) collected. Relies on anecdotal information, usually best for general issues only rather than specific catch information.
Chain-referral sampling and respondent-driven sampling (RDS)	A seeded, fisher-to-fisher referral method to locate fishers and collect information to estimate population sizes, catch and effort.	Can identify and survey fishers that would normally be difficult to locate. Useful method when sampling frames do not exist.	Some biases, including the non-random selection of the initial seed subjects (volunteerism bias). Non-response bias (refusal to refer the researcher to their peers or provide false or incomplete contact details) ('masking' bias).

2.2.2 Discussion

Previous recreational fishing surveys for Torres Strait have occurred as part of a State-wide survey. These reported most information summaries for a grouped "Far North or Far North Hinterland" region and had relatively low samples sizes for Torres Strait. One feature of the State-wide surveys worth noting is their definition of recreational fishing, which is: 'fishing for recreation or fun'; as opposed to Traditional fishing: 'fishing for food'. This definition will potentially result in some Traditional Inhabitants' data being included into their recreational fishing survey, which contrasts to the definition used in this review (Section 2.1).

Regardless of jurisdiction, the common need for undertaking recreational fishing surveys is to obtain a reliable estimate of the catch for inclusion in stock assessments and other management objectives, usually relating to sustainable fishery management. In this review we describe a wide range of established and emerging recreational fishing survey approaches that have been applied in Australia, along with their strengths and weaknesses. It is likely that no single survey approach will work in all situations (Griffiths *et al*., 2010). Consequently, it is critical that any newly designed survey needs to be tailored specifically to the Torres Strait situation based on the objectives of the program and local factors.

Most state agencies in Australia have used some type of complemented survey design; usually either a telephone-diary survey or a telephone-access point survey (Griffiths *et al*., 2010). However, these designs suffer from biases, with the largest being the lack of a complete list frame (or population list) to estimate total effort or to draw a representative sample of subjects for a diary survey (Griffiths *et al*., 2010). Other issues were demonstrated in a recent survey in Victoria (Ryan *et al*., 2009), where around 60% of fishers were found to be exempt from holding a licence, while around 50% of fishers failed to provide a phone number when interviewed during on-site surveys.

In determining which method is most likely to successfully collect high quality data from recreational fishers in Torres Strait, the range of issues - including data requirements (objectives) and the methods' strengths and weaknesses - need to be critically assessed for a Torres Strait setting. This review provides a snapshot of potential methods and where available, their strengths and weaknesses. However, their assessment for application in Torres Strait will be determined through an assessment process, including use of a multi-criteria analyses and consideration by an expert Advisory Committee. Synergies with a parallel process for assessing a monitoring approach for the Traditional (non-commercial) fishing sector will also be considered.

The review outputs will form the basis for designing and assessing potential future monitoring programs. We will marry these learnings with the information collected on stakeholder needs to tailor potential future monitoring program options to assess the most likely approaches for implementing a persistent, robust, and acceptable program

3 Stakeholder needs

Designing a successful Traditional fishery monitoring program in the Torres Strait requires addressing the needs and issues for all stakeholders. The failure to address the broadest possible range of stakeholder needs will put the success of any future program at risk. We separate the needs into two overarching categories – 'data needs' and 'program requirements, constraints and risks' and assess these for the following stakeholder groups:

- Traditional Inhabitants
- Fishery managers
- Stock assessment scientists
- National stakeholders

Although the PNG National Fisheries Authority (NFA) are the main international stakeholders in Torres Strait fisheries issues, inclusion of PNG stakeholders in the needs' assessment was not within the scope of this project.

In order to obtain detailed stakeholder needs information we completed a range of activities:

1. Review of past fishery monitoring program publications as a guide to help ensure that a comprehensive list of data needs, approaches and issues will be considered during any monitoring program design (Section 2, above)
2. Pre-project consultation with Traditional Inhabitants (Appendices 2, 3 & 4)
3. Summaries of statements from recent PZJA meetings where non-commercial fishing data has been discussed
4. Questionnaires (via e-mail), face-to-face, and remote consultation (phone, video call) with Traditional Inhabitants (Appendix 6)
5. Questionnaires (via e-mail), and remote consultation (phone, video call) with fishery managers (Appendix 6)
6. Questionnaires (via e-mail), and remote consultation (phone, video call) with current assessment and research scientists (Appendix 6)
7. Incorporation of learnings from previous and current Traditional fishery monitoring projects relevant to National stakeholders (appendix 6)
8. Project team workshops
9. PAC feedback and comments during virtual meetings and review of draft reports

The collated needs for each stakeholder group were summarised and assigned a priority from 1 to 3 (Table 3-1) to indicate their importance to achieving the objectives of the monitoring program for Torres Strait. The priority 1 and 2 program needs were categorised into design criteria used to assess a range of traditional fishery monitoring options (Section 4). These design criteria and their prioritisation were also reviewed by the PAC.

Table 3-1. Description of priority levels attributed to identified design criteria.

Priority level	Description
1	Identified design criteria is a critical need for key stakeholders and critical to achieve the core objectives of the monitoring program.
2	Identified design criteria is an important need for key stakeholders and important to achieve the core objectives of the monitoring program.
3	Identified design criteria would make a useful addition to the core objectives of the monitoring program.

3.1 PZJA committee statements on non-commercial fishing data

1. Torres Strait Scientific Advisory Committee (TSSAC No 73)

In the May 2019 TSSAC noted that:

- the proposed non-commercial monitoring project should be a community-led project;
- any non-commercial catch data collection should not put TIB data collection at risk; and that this may be a matter of timing (e.g. wait until CDR rollout has happened);
- the project remains a priority, but agreed to the scoping component initially;
- collecting information about the importance of seafood to communities (and species cultural roles, catch dynamics) could guide the PZJA and other Government agencies in protecting these species for the future livelihood and culture of communities;
- the programs' data could support monitoring and predict climate change effects on these species (currently not monitored) and allow communities to better prepare and plan for future changes;
- all TIB members supported this project going forward, although collecting commercial data needs to remain the priority, and shouldn't be could put this at risk by other activities;
- the program should include "ways to rebuild confidence with communities around sharing data, given past issues where communities felt their fishing data was improperly used.

2. Fin Fish Resource Assessment Group (FFRAG No 8)

In the November 2020 the FFRAG noted that:

- the project is likely to recommend an education campaign to help communities understand why the collection of these data is important especially as part of an ecosystem based management system rather than considering a single species at a time;
- collecting data on non-commercial catches is a key issue for the fishery;
- 2021 rounds of community visits and any consultation by AFMA/TSRA should add communicating the outcomes of the non-commercial catch project to the agenda to help communities' understanding.

3. Fin Fish Working Group (FFWG)

In the November 2020 the FFWG noted that:

- it is priority at this time to develop estimates of catches taken outside the fishery and for the TAC to be reduced accordingly; and that this work should commence, further highlighting the importance of the Torres Strait Non-commercial fishery monitoring project;
- Traditional take catches have been very good; and that Spanish mackerel is an important resource for Traditional fishers;
- there were concerns by Ugar community members that Spanish mackerel being taken for subsistence and recreational fishing are significant (maybe more than the TIB catches) but are not being recorded;
- it is important to collect more accurate catch data for TIB Traditional fishing (kai kai) and that they were eagerly awaiting the outcomes of the scoping study investigating options for monitoring Traditional take catches being led by Kenny Bedford.

3.2 Pre-project consultation with Traditional Inhabitants

As part of the project proposal process, we provided a consultation plan (Appendix 2) and project summary (Appendix 3) for approval by the TSSAC/AFMA/TSRA. The original expanded proposed project summary was emailed, with a covering letter, to all current PBC Chairs and TSIRC Councillors.

We also sent the project summary and cover letter to the TSRA for dissemination to the Fishery portfolio member (TSRA), and subsequently to other TSRA officers deemed appropriate by the Fishery portfolio member.

The results of the pre-project consultation, including any comments received, were submitted as a supplementary document to the original full proposal to the TSSAC EO in May 2020, and are presented in Appendix 4. This included responses from 13 of the targeted stakeholders (21%), with 11 being supportive (85%) of the proposed project, one against and one uncertain.

Most of the community stakeholders recognised the importance and benefits of collecting data on the non-commercial fishery catch and two suggested their community would be interested in being involved in the pilot program. Two main concerns expressed were: 1) that (some) community members will think that information may be used to restrict their catch/access to the fishery; and 2) that recreational fishers may not be included in the monitoring. The messaging around these and similar concerns, as well as communicating the benefits for sustainable fisheries, will be critical to the success of the project.

3.3 Project Advisory Committee

The Project Advisory Committee (PAC) was formulated with the following membership:

- Councillor Francis Pearson (Poruma Island Traditional Owner; TSIRC Councillor, PZJA consultative Traditional Inhabitant representative)
- Jon Tabo (Murray Island Traditional Owner; PZJA consultative Traditional Inhabitant representative)
- John Morris (Masig Island Traditional Owner; PBC Chair)
- Councillor Rocky Stephen (Ugar Island Traditional Owner; TSRA Member, STIRC Councillor, PZJA consultative Traditional Inhabitant representative)
- Frank Loban (James Cook University, Badu Island Traditional Owner, Zendath Kes Fisheries Interim Director)
- Natasha Stacey (Charles Darwin University, Indigenous fisheries and livelihoods researcher)
- Stephan Schnierer (Southern Cross University, Indigenous fishery researcher)
- AFMA executive officers (Georgia Langdon/Lisa Cocking)
- TSRA Fishery Program representative

This membership provided expert assessment by two key stakeholder groups: Traditional Inhabitants and subject matter experts. Five Traditional Inhabitants represented different Torres Strait communities and the two subject matter experts are national experts in Traditional fisheries, Traditional fisheries monitoring, Indigenous livelihoods and natural resource management.

The PAC was engaged through two (remote online) workshops, where the project methods and outputs were described, followed by feedback and group discussion. Feedback and additional information were also received through requests for comments on draft outcomes, by way of the draft written report.

The PAC deliberations resulted in several changes to project outcomes and made recommendations on the implementation of a specifically designed pilot program.

3.4 Stakeholder data needs

Here we summarise the data needs for different stakeholder groups associated with the non-commercial catch sector monitoring project in Torres Strait based on the literature review (Section 2), stakeholder consultation (Appendix 6), feedback from the Project Advisory Committee, and project team deliberations. These data needs are then distilled into design criteria that are further prioritised according to their importance for the design and implementation of future monitoring strategies in Torres Strait (Table 3-1; Section 4).

Traditional Inhabitants

Traditional Inhabitants are highly reliant on marine resources for food and income, and many of these will also have significant cultural and spiritual value. This importance is demonstrated by customary resource management that has been in place for several millennia. However, the recent advent of local and non-islander commercial fisheries, increased catch efficacy, and other global drivers (e.g., climate change, market demand) has resulted in the need for more data driven approaches to modern customary resource management. Although regional management agencies have taken an increasing role in the management of commercial species there is an ongoing aspiration among Traditional Inhabitants in Torres Strait to take more responsibility for managing Traditional and commercial fishery resources under customary management approaches.

Information on the catch of key selected species from Traditional fishing will support local decision making. For example, annual catch for culturally important species that are of local concern (e.g., rabbitfish on Erub) will allow the application of customary fishery management or other local management processes (e.g., potential Traditional fishery harvest strategies). Catch information could also underpin future development of commercial fishing where communities are not currently maximising economic benefits from local marine resources (e.g., Spanish mackerel on central island communities such as Poruma). Having information on trends in fishery catches over time will help communities see the type of changes that are occurring. This information can help communities adapt to changes in marine species availability that may be driven by management or regional drivers such as overfishing or climate change.

Seasonal patterns in fished species (e.g., based on high resolution temporal data) can also have relevance to customary management through the application of fishing seasons (e.g., ceremonial occasions, tombstone openings, holidays). Similarly, data on the location (at reef or other appropriate scale) of catches can underpin spatial fishing practices (e.g., home reefs, closed reefs) and provide assessments on whether there are regionally specific impacts from fishing or other sources.

Information on catch, effort, and behaviours (including catch use/fate) of different demographic groups (e.g., women, elders) will provide an understanding of socio-economic development needs for Traditional Inhabitants (e.g., needs that underpin sustainable community livelihoods, such as tailored support for women fishers).

The above data needs for Traditional Inhabitants and their importance (priority level) for designing a monitoring approach for Torres Strait can be summarised thus:

Data needs - Traditional Inhabitants	Priority level
Annual catches of all fished species in the community	Priority 1
Seasonal patterns in catches	Priority 2
Location of catches (reef scale)	Priority 2
Disaggregation of catch, effort, use by key demographic and other groups (e.g., women, children, TIB fishers)	Priority 2
Household social and economic data	Priority 3

Fishery managers

The primary fishery management agency in the Torres Strait is the Protected Zone Joint Authority (PZJA). The PZJA is supported by four government agencies (known as 'PZJA agencies') – the Australian Fisheries Management Authority (AFMA), the Commonwealth Department of Agriculture, Water and the Environment (DAWE), the Queensland Department of Agriculture and Fisheries (QDAF) and the TSRA.

Australia and PNG established the TSPZ with the principal purpose of acknowledging and protecting the traditional way of life and livelihood of the Traditional Inhabitants of both Parties, including their Traditional fishing and free movement. In managing Protected Zone Commercial Fisheries the PZJA must acknowledge and protect the traditional way of life and livelihoods of the Traditional Inhabitants. This includes their rights in relation to Traditional fishing; protection and preservation of the marine environment; the development and implementation of licensing policy, and fostering economic development in the TS and employment opportunities for traditional inhabitants. Consequently, PZJA needs to have sufficient understanding of the nature and extent of Traditional fishing in order to protect it whilst managing commercial fisheries and the sustainability of fished populations into the long term. This translates into having robust data from all fishing activities and sectors to ensure that the total take of any one species does not exceed its Recommended Biological Catch (RBC).

Accurate, comprehensive, and representative data from all fishery sectors (e.g., Sunset, TIB, PNG commercial[2], non-commercial fishery sectors) will allow managers to make more robust allocation decisions where there are competing sector allocations for a finite catch, whereas uncertain catch information necessitates conservative decision making and lower catch allocations to some sectors. A high priority is the annual allocation of Sunset sector licence TACs for Spanish mackerel and coral trout in Torres Strait. This allocation is important as it provides a revenue stream that supports broader economic development and capacity building, such as provision of community fishing infrastructure and other opportunities that help maintains continuity of market supply.

Improved understanding of the catches from both the commercial and non-commercial fishery sectors will provide a more accurate analysis of catch sharing between these two sectors and consequently a more accurate allocation of catch to the Sunset sector. Without accurate data, more conservative decisions need to be implemented by fishery managers, which can lead to fewer Sunset

[2] There are no current PNG commercial fisheries taking fished species in the Torres Strait, although there is provision for PNG catch sharing within the Treaty.

licences being taken up, or loss of the Sunset sector. Both scenarios reduce (i) income to the TSRA through licencing arrangements and (ii) the amount of data collected by the Sunset sector. A complete loss of the Sunset sector (a scenario that has been discussed in recent Finfish Working Group meetings for the Spanish mackerel fishery) will also have a substantial impact on the ongoing assessment of stock status, possibly leading to significantly less accurate assessments in the short to medium term.

Management agencies also have a broader responsibility to manage all Traditional fisheries and protect and promote community livelihoods and economic development. Information on the catches and status of all species in the Traditional fishery (~200 species – Harris *et al.*, 1995) will help fulfil these obligations. However, the data needs required for management of non-commercial species in the Traditional fishery catch is less certain. While a lower priority for managers than the commercial species (Spanish mackerel, coral trout and TRL), annual catch estimates for 200 or so non-commercial species will still be a high priority for Traditional Inhabitants to help describe and understand variations in marine species year biomass and impacts of exploitation and other environmental factors.

Managing for environmental sustainability in Traditional fisheries, includes management of issues related to localised depletion. This will require information on the location of catches, or other information related to spatial differences in fishery removals. For commercially fished species, this spatial information should complement other spatial data collection strategies.

Catch information differentiated by gender, age and possibly other demographic factors will provide an improved understanding of Traditional catches over time that drive seafood consumption and its value to the community. This knowledge will be important to fishery managers for implementing programs focussed on community development and vulnerability, including the contribution fishing makes to the regional economy.

Tracking fishery products through the processing chain can be important for catch data validation, maximising returns and reducing waste. Combining or comparing catch data from different sources also often requires product conversion ratios due to differential processing methods. These can be estimated by data gathered at different processing stages. Similarly, information on costs and revenues of fishing are useful for economic and non-market value analyses - key drivers of fishing effort and promoting sustainable local industries.

The above data needs for fishery managers and their importance (with priority level) for designing a monitoring approach can be summarised thus:

Data needs - Fishery managers	**Priority level**
Annual (accurate, comprehensive, and representative) estimates of the non-commercial catch of TRL, Spanish mackerel and coral trout (four species)	Priority 1
Annual catch of all other species in the Traditional fishery (potentially ~200 species)	Priority 2
Location of catches (logbook zones)	Priority 2
Catch and catch use by Traditional Inhabitants (TIB fishers, women, children etc)	Priority 2
Conversion ratios for fishery products through processing chains	Priority 2
Economic information on the revenues and costs of fishing, and value chains	Priority 3

Stock assessment scientists

Stock assessments underpin sustainable natural resource use by providing estimates of stock status and management advice to resource managers and resource owners. The degree of certainty in stock estimates impacts on recommendations for future sustainable catches, with less certainty resulting in more precautionary TACs. Accurate fishery data results in more accurate assessments which leads to potentially more appropriate management recommendations and lower risk to the fishery populations.

Robust stock assessments require fishing mortality from all sources to be considered. For commercial species that are also caught in the non-commercial fishery sectors, such as Spanish mackerel, coral trout and TRL, the biggest gap in fishery catch information is for the non-commercial Traditional take. Besides the retained catch, information on fishery discards, particularly those discarded species that have a high mortality upon release, is also important for assessing overall fishery mortality.

Stock assessments, particularly those heavily reliant on fishery-dependent data, are usually built on time series of data spanning several years at least. Therefore regular (e.g., annual), ongoing, time series of fishery dependent data is desirable. Inter-year (e.g., monthly, or seasonal) catch data can also provide important information on population status, movement patterns and ontogeny (developmental life history).

It is critical, for all the above, that marine species identification is to an appropriate level of accuracy (to species where possible). This is because different species have different life history characteristics and unique responses to management interventions. Any grouping of species or uncertainty in identification reduces the accuracy and reliability of assessment outputs. For example, stock assessments for coral trout are hampered using a coral trout 'basket' category, where four species are grouped into this one catch category, instead of each species being be treated separately.

Data integrity and reliability are critical to reliable and accurate stock assessments and other research outcomes. Data biases result in inaccurate stock assessments and potentially over-estimated TACs and overexploited stocks. Where possible, fishery datasets will benefit from data validation processes where independent data is collected for comparison and/or integration with fishery-dependent information, thereby substantially minimising potential bias.

Apart from estimates of the catch, additional information, such as fishing effort (e.g., number of hours fished) that allows for the calculation of catch per unit effort (CPUE), is usually required for robust stock assessments. In more sophisticated age-structured models (such as used for Torres Strait finfish and TRL fisheries), such high-quality data is required (standardised CPUE, age/size and sex data). Size at age can be estimated using length measurements or estimates, and/or weights and count data. More precise age and sex information could be gathered through the provision of finfish frames, otoliths, or other samples.

Fishing location is potentially important for assessing spatially patchy stocks within a fishery managed area and may also provide information to scientists on whether populations are present and differentially impacted between regions. These data can improve the accuracy of assessments by allowing for finer scale spatial population models to underpin overall regional assessments. This level of spatial detail (e.g., logbook region as per the current Fish receiver System docket books) does not need to be at the fine scale as required for customary management (i.e., reef scale), and can be negotiated, as fishers often do not want to provide exact locations of fishing.

Very often, observations by fishers (anecdotal information) on stock trends, animal movements, spawning times and areas and other aspects of fishery biology and ecology can be particularly useful to stock assessment scientists to improve the understanding of population dynamics and validate the conclusions from data driven stock assessments. The collection of such information on a regular or structured basis would have considerable utility for robust stock assessments.

Where there is an interaction between the Traditional and commercial fishery sectors, data collected should be complimentary so that the analysis can be done on a unit stock basis. This may be overcome where different data forms can be converted to match the key data being analysed (e.g., fish lengths being reliably converted to weights).

The collection of abiotic parameter measurements can be used to establish baseline measures and assess changes in patterns/environmental relationships that can be correlated with changes in stock availability and/or behaviour. While not a primary focus of the proposed monitoring program, there is the potential for local fishers to contribute to abiotic data collection as an auxiliary activity.

Following fishery products through the processing chain can be important if data is gathered at different processing stages, and conversion ratios becomes necessary for combining or comparing data from different product stages. Similarly, information on costs and revenues of fishing are useful to scientists for economic analysis - a key driver of fishing effort.

Tissue samples for genetics' studies, which could be used to investigate stock boundaries, natural mortality and/or stock connectivity, have been identified as a high priority for Spanish mackerel. They can also be used in studies looking at contaminant loads. These could potentially be collected, stored, and transported to laboratories as part of the monitoring process.

The above data needs for stock assessment scientists and their importance (priority level) for designing a monitoring approach can be summarised thus:

Data needs – Stock assessment scientists	**Priority level**
Annual (and seasonal) non-commercial catch (including discards) of commercially fished species such as Spanish mackerel, coral trout (4 species), and TRL that are comprehensive, representative, and accurate	Priority 1
Annual (and seasonal) catch (including discards) of non-commercial species that are comprehensive, representative, and accurate	Priority 2
Fishing effort and gear type	Priority 2
Marine species size/weight/age and sex information	Priority 2
Location of catches (logbook zones)	Priority 2
Fishers' observations on catch tends and fishery biology and ecology	Priority 2
Data should be complimentary and comparable to other sectors of the fishery	Priority 3
Abiotic parameter measurements (e.g., water temperature, turbidity, wind strength etc)	Priority 3
Post-harvest value chains analyses, by species	Priority 3
Provision of fish frames, otoliths, or tissue samples for aging, genetic or seafood contaminants studies	Priority 3

National stakeholders

National stakeholders of Torres Strait fisheries include national, international, and state fishery and environmental research and management agencies (NIAA, DEWE, Qld DEH, FRDC, ABARE, PNG NFA etc), and large NGOs (WWF, AMCS, QSIA). Many of these agencies will have data needs related to

the Traditional fishery in Torres Strait, mostly concerned with demonstrating sustainability of fisheries, environmental stewardship and promoting indigenous industry and economic development. In this sense, many data requirements will be similar to regional fishery management agencies (as above). However, additional information needs relate to the development and implementation of Traditional catch monitoring programs more broadly throughout Australia.

The Fisheries Research and Development (FRDC) Indigenous Research Group (IRG) are focussed on a broad initiative to improved data on Aboriginal and Torres Strait Islanders fisheries resource use, driven by sustainability, resource ownership and stewardship, and economic development goals. This is reflected in the outputs of the FRDC Project 2018-016 - *Improving data on Aboriginal and Torres Strait Islander marine resource use to inform decision-making* (Moyle et al., 2020)). This project developed a framework for improved data on Aboriginal and Torres Strait Islander fisheries resource use to help manage the challenges and opportunities that are often shared between communities. "*This framework and the ongoing development of data collection methodologies aims to facilitate the sharing of Indigenous fishing data that ensures a more holistic and collaborative approach to fisheries resource management. The sharing of these data, incorporating catch related information and Indigenous knowledge should allow an improved understanding of the needs (culturally, socially, economically) of Indigenous communities and resource managers*."

The FRDC also recently funded a relevant project in 2020: FRDC 2020-056 - *Evaluation of a smart-phone application to collect recreational fishing catch estimates, including an assessment against an independent probability based survey, using South Australia as a case study* (Crystal Beckmann (PI), University of Adelaide). This project may offer highly mutually beneficial opportunities to trial an App for non-commercial catches in the Torres Strait.

While they have developed overarching principles for Traditional fishery data collection (many of which have been included here), practical implementation of data collection methodologies that fulfill these guidelines are still in development. Learnings from the development of the monitoring program in Torres strait will have utility for these programs nationally and provide opportunity to collaborate with case studies in selected locations through the joint development and application of programs.

The above data needs for national stakeholders and their importance (priority level) for designing a monitoring approach can be summarised thus:

Data needs – National Stakeholders	**Priority level**
Improved data on Aboriginal and Torres Strait Islanders fisheries resource use	Priority 1
Information of monitoring program implementation, utility and limitations	Priority 2
To improved government policy	Priority 3

3.5 Stakeholder requirements, constraints, and risks

Traditional Inhabitants

Previous research on monitoring Traditional fishery catches and discussions with Traditional Inhabitants have emphasised that Traditional fishery catch monitoring programs must be culturally appropriate (see above), focused on local stakeholder needs, and have a high degree of local control and use. Often, Traditional Inhabitants feel that information on the Traditional fishery catch could be used against them to close or restrict access to resources, resulting in low levels of participation and cooperation.

One of the best ways to counter this issue is through the co-development of monitoring programs with Traditional Inhabitant communities and the provision of genuine local control. For example, data (e.g., higher-level summary data) should only be supplied to external agencies on an agreed basis, and with communities having veto power over access to information by outside stakeholders. Appropriate representative community groups that will take primary responsibility for managing this process will need to be identified and supported. We note here that some personal information should never be made publicly available, even to these local groups.

Regional agencies (e.g., TSRA, AFMA, Malu Lamar (TSI), Registered Native Title Body Corporate (RNTBC)) will most likely be required to take a lead role in formulating and administering the data systems needed to hold the monitoring data (e.g., based on the existing TEK database used by the Torres Strait ranger program). This should be done with the agreement of local communities and with well documented and transparent protocols in place.

To ensure confidentiality, the process for the transfer of information from the Traditional fisher to the database needs to be secure and uncomplicated (e.g., have the least number of steps). If paper forms are used, then processes need to be put in place to secure datasheets and facilitate transport to data entry points. Any data entry portal should be designed so it connects directly to secure data systems. Individual information, sensitive data, and Tradition Knowledge (TEK) must be demonstrably protected.

The monitoring program implementation should also recognise and value the time that local fishers will need to spend contributing to data collection, and that this time impost should be kept to a minimum and/or incentivised. Since this time is likely to be unpaid, the value proposition for providing fishery information will be critical.

The monitoring process should be as straight forward as possible and easy to understand and implement. Any data interface must not be too technical and/or challenging – as is generally the case with all public information elicitation programs. The simpler the better.

There is considerable scope for Traditional Inhabitant communities to benefit from employment and training opportunities that locally implemented monitoring programs can provide. This capacity building has the potential to increase local involvement, foster trust and improve data quality.

The above requirements and constraints for Traditional Inhabitants and their importance (priority level) for designing a monitoring approach can be summarised thus:

Program requirements and constraints - Traditional Inhabitants	**Priority level**
Program is socially and culturally acceptable to Torres Strait Islander communities	Priority 1
Monitoring program should be co-designed with communities	Priority 1
Data management responsibility sits with communities or their representative leadership/bodies	Priority 1
Data is held in a secure database	Priority 1
Follow ethical principles, e.g., protection of identity of individual fishers	Priority 1
Data provision needs to be technically easy and uncomplicated	Priority 1
Provision of data by fishers should take up the least amount of time	Priority 1
The monitoring program should include capacity building and/or employment opportunities for community members	Priority 1

Fishery managers

The desired (and stated) goals for management agencies in Torres Strait is to work with Traditional Inhabitants in the overall management of marine resources. Therefore, it is critical that management agencies and Traditional Inhabitants develop a trusted relationship based on shared aspirations, recognition of past experiences, transparency regarding how the data will be used and managed, and having effective local control and information security. A Traditional fishery monitoring program is at the nexus of this trusted relationship, where both parties have a legitimate stake. Building and maintaining a high level of trust will be critical to its success.

Fishery management agencies will not only be an important user of monitoring data (or at least authorised summaries of catch data) but will also likely be key contributors to the resourcing and implementation of the program. To this end, their investment will be predicated on an expectation that the program will provide information for their needs (see 3.2 Data needs) based on risk-catch-cost considerations – being the trade-off between: the risks associated with decisions based on data from the program; the quantum of catches that can be safely recommended; and the cost of the monitoring program. A costly monitoring program may not be justified in the long term if the benefits of creating demonstrably lower risk to marine species stocks or higher catches are not realised.

As key implementers of at least the technical aspects of the program the program, Fishery managers will require the approach to be highly feasible, with minimal levels of ongoing specialist technical assistance. Additionally, they will be responsible for the occupational health and safety (OH&S) of staff working on the program, as well as having a vested interest in ensuring fisher safety during any monitoring activities.

The above requirements and constraints for fishery managers and their importance (priority level) for designing a monitoring program approach can be summarised thus:

Program requirements and constraints – Fishery managers	**Priority level**
Program needs to include trust building based on shared aspirations, recognition of past experiences, transparency regarding how the data will be used and managed, legitimate local control, and information security	Priority 1
Program needs to be affordable, and cost be proportional to data accuracy and precision (risk-catch-cost trade-offs)	Priority 1
Approach needs to be logistically feasible, and relatively straight forward to implement	Priority 1
Overall program must meet implementing agency OH&S guidelines	Priority 1

Stock assessment scientists

As is the case with regional management agencies, scientific agencies and individual scientists will be required to develop relationships, protocols, and agreements with Traditional Inhabitants regarding the provision, use and dissemination of data and research outputs. This will be facilitated by current and developing ethics protocols and agreements with the appropriate cultural authority (e.g., Malu Lamar, RNTBCs) and/or individual Traditional Inhabitants. This will include obtaining internal ethics approvals implemented by most research agencies and the roll out of ethics and consultation processes in the project development phase. Current ethics agreements usually contain strict rules to ensure that data systems are highly confidential, and that personal information is not released without permission of the information provider – e.g., by only reporting large scale locational

information. This will help ensure that data and information is not misused and maintains trust and long-term participation in monitoring programs.

The co-development of data gathering protocols will also build trust between Traditional Inhabitants and scientists, and ideally will be part of a broader co-management framework (e.g., as part of a formal fishery co-management harvest strategy). The development of these broader co-management strategies could be seen as an aspirational goal by all stakeholders. These instruments could provide the platform to ensure an ethical and culturally appropriate approach to the collection and use Traditional fishery catch information by stock assessment scientists.

Trust and cooperation will also be facilitated by the provision of effective communication materials from scientific outputs. This will include dissemination of the results of research to underpin customary management and to help provide clear incentives for data collection (e.g., explaining why the data is important and will benefit communities).

The above requirements and constraints for stock assessment scientists and their importance (priority level) for designing a monitoring program approach can be summarised thus:

Program requirements and constraints – Stock assessment scientists	**Priority level**
Data collection should be accompanied by comprehensive ethics agreements to ensure an ethical and culturally appropriate way to collect, securely store and use the Traditional fishery catch information	Priority 1
Co-development of monitoring programs should occur with the community, perhaps as part of broader co-management strategies	Priority 1
Communication material is sufficient to inform, educate and increase capacity (e.g., provision of training and species guide to minimise misidentification)	Priority 1

National stakeholders

As with management and scientific agencies, national stakeholders will require that data collection and reporting is ethical and culturally appropriate, and that data outputs are only used with the permission of Traditional Inhabitants. This may be difficult in cases where there are no direct agreements between national agencies and local communities. In this case, national agencies will rely, to a large extent, on the implementing agencies protocols and processes. The provision of written agreements and data "chain of custody" protocols will be important for demonstrating that the process meets these requirements.

The above requirements and constraints for national stakeholders and their importance (priority level) for designing a monitoring program approach can be summarised thus:

Program requirements and constraints – National stakeholders	**Priority level**
Program is socially and culturally acceptable to Torres Strait Islanders	Priority 1
Formal agreements covering all aspects of the monitoring program must be developed and ratified	Priority 1

3.6 Discussion

The stakeholder needs described above were developed using information from previous monitoring programs and input from the key stakeholders of Torres Strait fisheries. Not surprisingly, it includes aspects that are important to monitoring strategies (and assessments) for almost all fisheries. However, it also includes needs and issues that are more specific to Traditional fisheries and/or

Torres Strait (e.g., the need for community level agreements). These may be best summarised by the PZJA representative fishery committees who recognise the need for data from all fishery sectors and strongly support the process to develop a cost-effective and acceptable non-commercial fishery monitoring program.

In order to recommend a successful monitoring strategy for non-commercial fishing in Torres Strait, we used the priority 1 and 2 data needs, and program requirements, constraints and risks in an assessment of potential monitoring strategies. These are described in Section 4 (below) and were subject to feedback from the PAC.

While the above needs and issues analysis was focused on the Traditional fishery, many of the same issues apply to recreational (non-islander) fisheries. In this sense, we have some confidence that the Traditional fishery monitoring program assessment will also be suitable for monitoring recreational catches in Torres Strait. This has the major advantage of not having to develop and roll out separate programs for each of these two sectors. This issue is also discussed following the assessment of different monitoring approaches (below) to test whether the above assumption holds.

4 Options for non-commercial catch sector monitoring

Here we assess a targeted range of options for monitoring the non-commercial catch sector to meet the needs of the key stakeholders in Torres Strait. The selection of potential options used information from (i) the outcomes of a review of approaches to monitoring the non-commercial catch sector of Indigenous communities in Torres Strait and more broadly (Section 2); (ii) consultations with local stakeholders; (iii) the expert views of the PAC; and the project team. We score each of the options against the needs of key stakeholders in Torres Strait (from Section 3) in a multi criteria analysis. This produced a score for each option and illustrates their strengths and weakness. This process resulted in a ranking of options and recommendations for a preferred candidate monitoring approach.

The assessment focused on monitoring the Traditional non-commercial catch sector. Recreational (non-islander non-commercial catch sector) fishing will be considered post-hoc to assess if it is possible to collect data from this sector using the same monitoring approaches selected during this initial selection process. This may require modification or additional components to the primary monitoring, or, if this is not possible, a new separate process.

Six potential options were formulated to assess an acceptable non-commercial catch data monitoring strategy in Torres Strait (Table 4-1). These reflect previously used monitoring strategies in Torres Strait, but also incorporate potentially suitable features from the range of monitoring methods assessed in Section 2. They were also moderated or refined to incorporate the needs of any future program that were described in Section 3. They were also reviewed by the PAC.

Table 4-1. Non-commercial catch sector monitoring strategy options for the Traditional fishery catch in Torres Strait.

No.	Title	Description
1	Self-reporting via monitoring app	Reporting of daily catch and other information when fishing. Self-reporting (fisher level) via an App tool linked to a central secure database.
2	Self-reporting via catch datasheet	Daily reporting of catch and other information. Self-reporting (fisher level) using a catch data sheet which is then sent to a central location for entering into a secure database.
3	Self-reporting via periodic catch datasheet	Periodic reporting of catch (e.g., for previous month) and other information. Self-reporting (likely at household level) using catch data sheets is then sent to a central location for entering into a secure database.
4	Embedded observers via catch datasheets	Periodic reporting of catch (e.g., for previous month) and other information. Information collected by an embedded community-based observer collecting information from households.
5	Creel surveys by roving observers	Daily reporting of a temporal sample (e.g., quarterly for 5 days) for each community by independent observers based on roving (bus route) periodic sampling. Creel (landing point) survey of daily catch and other information.
6	Creel surveys by periodic roving observers	As above, but only done on every 2 to 5 years.

4.1 Multi-criteria analyses

The priority 1 and 2 design criteria that were formulated from the Stakeholder needs assessment (Section 3) were grouped and used as descriptors for 14 criteria in a multi-criteria analysis (MCA) to assess options for a Traditional (and recreational) fishery catch monitoring program. Each of the criteria were in turn grouped into five higher-level criteria groups: cost, benefit, feasibility, culture, and sustainability (Table 4-2), to ensure that standard MCA criteria were adequately represented and provide insights into the factors driving the selection of preferred options.

Note that, in addition to the design criteria stipulated above, we have also included a criterion that considers environmental sustainability, including minimising environmental harm and greenhouse gas production.

Table 4-2. Priority 1 and 2 stakeholder needs (Section 3) categorised into criteria and five high-level criteria groups: cost, benefit, feasibility, cultural considerations, and sustainability.

No.	Criteria groups / Criteria	Priority 1 and 2 Stakeholder needs
1	**Cost**	
1.1	Financial cost	• Program needs to be affordable, and costs proportional to data accuracy and precision (risk-catch-cost trade-offs) (Priority 1)
1.2	Fisher recording effort	• Provision of data should take up the least amount of time (Priority 1)
2	**Benefit**	
2.1	Traditional Inhabitant data needs	• Annual catch information for all fished species (~200 species) by the community (Priority 1) • Seasonal patterns in catches (Priority 2) • Location of catches (reef scale) (Priority 2) • Fishing effort and gear (Priority 2)
2.2	Fishery managers data needs	• Annual estimates of the non-commercial catch of commercially important species. (Priority 1) • Annual catch of all other species in the Traditional fishery (potentially ~200 species) (Priority 2) • Catch and product use/catch use by community groups (TIB fishers, women, children etc) (Priority 2) • Location of catches (logbook zones) (Priority 2) • Conversion ratios for fishery product through processing chain (Priority 2)
2.3	Scientific data needs	• Annual (and seasonal), non-commercial catch (including discards) of commercial species such as Spanish mackerel, coral trout (4 species) and TRL (Priority 1) • Annual catch of other species in the Traditional fishery (Priority 2) • Fishing effort and gear type (Priority 2) • Marine species size/weight/age and gender information (Priority 2) • Location of catches (logbook zones) (Priority 2) • Fishers' observations on catch tends and fishery biology and ecology (Priority 2)
2.4	National data needs	• Improved data on Aboriginal and Torres Strait Islanders fisheries resource use (Priority 1) • Information of monitoring program implementation, utility, and limitations (Priority 2)

No.	Criteria groups / Criteria	Priority 1 and 2 Stakeholder needs
2.5	Capacity building	• The monitoring program should include capacity building and / or economic opportunity for the community (Priority 1)
3	**Feasibility**	
3.1	Method feasibility	• Needs to be technically easy for community members to provide data (Priority 1) • Approach needs to be logistically feasible, and relatively straight forward to implement (Priority 1)
3.2	Data reliability	• Data is comprehensive, representative and accurate (Priority 1)
3.3	OH&S requirements	• Overall program must meet implementing agencies OH&S standards (Priority 1)
4	**Culture**	
4.1	Social and cultural acceptance	• Program is socially and culturally acceptable to Torres Strait Islander communities (Priority 1) • Monitoring program can be co-designed with communities (Priority 1) • Program needs to build trust based on shared aspirations, recognition of past experiences, transparency, legitimate local control, and information security (Priority 1) • Data collection should be accompanied by comprehensive agreements, including ethics and program rules (Priority 1)
4.2	TEK security	• Data management responsibility sits with communities or their representative leadership/bodies (Priority 1) • Data is held in a secure database (Priority 1) • Identity of individual fishers and fishing places/practices is protected (Priority 1)
4.3	Social equity (e.g., gender, age)	• Social equity of catch, effort and catch use information (TIB fishers, women, children etc) (Priority 2)
5	**Sustainability**	
5.1	Environmental harm	• The program should minimise environmental harm, including minimising greenhouse gas production (Priority 2)

Each of the criteria were subsequently described using the following characteristics (Table 4-3):

1. The criteria metric range. For each criteria, what is the range of values that could occur. This range of values is then scored as 1 (lowest) to 5 (highest).
2. Whether the criteria were deemed as mandatory. This identifies criteria that have a limit where the success of the monitoring program would be severely jeopardised — and for all mandatory criteria, what is the minimum acceptable score.
3. The criteria weighting – for each criteria, the weighting used for calculating criteria group option score (and ultimately the overall score). This was primarily related to the proportion of priority 1 needs within each criteria but included some expert assessment by the project team and the PAC. Note that criteria group weightings are estimated as the maximum criteria weighting of the individual criteria in that group.

Each criteria were then scored from 1 (min of range) to 5 (max of range) by the project team during a workshop in August 2020 (Table 4-4). The scores were then reviewed and moderated by the PAC at meetings in September and November 2020 (Table 4-4). Criteria group scores were calculated as the

weighted average of the criteria scores in that group. As criteria group scores were calibrated as "higher is better", some criteria scores were transformed using the formula (6 – [criteria score]) for the calculation of criteria group averages (Table 4-4).

Table 4-3. Characterisation and metrics for the assessment criteria used to score options for monitoring the Traditional catch. M flags the minimum score that is a mandatory requirement the monitoring program for selected criteria.

No.	Criteria / Criteria groups	Description	Metric range (0-5)	Mandatory (Min)	Weight (1-5)
1	**Cost**				
1.1	Financial cost	Average $ cost over first 3 years	$50k-$200k		5
1.2	Fisher recording effort	Time effort by fishers	1 min/d - 15 min/d		5
2	**Benefit**				
2.1	Traditional Inhabitant data needs	Meets data needs of Traditional Inhabitants and communities	Not met - Met	M (4)	5
2.2	Fishery managers data needs	Meets data needs of fishery managers	Not met – Met	M (4)	5
2.3	Scientific data needs	Meets data needs of stock assessment scientists	Not met – Met		4
2.4	National data needs	Meets data needs of State, Commonwealth, and other national agencies	Not met – Met		2
2.5	Capacity building	Employment and training opportunities at various levels	Low - high		3
3	**Feasibility**				
3.1	Method feasibility	How easy is the method to implement and use	Low - High	M (4)	5
3.2	Data reliability	Data is comprehensive, representative and accurate	Low - High	M (4)	5
3.3	OH&S requirements	Meets OH&S and Risk assessment requirements	Low - high	M (4)	5
4	**Culture**				
4.1	Social and cultural acceptance	Program is socially and culturally acceptable to Torres Strait Islander communities	Low - high	M (4)	5
4.2	TEK security	Security of data stream	Low - high	M (4)	5
4.3	Social equity (e.g., gender, age)	The program is representative and accessible to all members of the community	Low - high		4
5	**Sustainability**				
5.1	Environmental harm	Risk to the environment including relative production of CO_2 emissions	Low - high		2

Table 4-4. Preliminary output for multi-criteria analysis for 6 possible monitoring strategies for non-commercial catch sector monitoring in Torres Strait. (Unmet mandatory criteria are shown in yellow). The standard deviation (SD) and weighted standard deviation (SD-weighted - weighted by criteria weight) of criteria scores is also shown.

				Self-reporting, monitoring app	Self-reporting, daily datasheet	Self-reporting, periodic datasheet	Roving observers	Embedded observer	Periodic roving survey		
Monitoring strategy options->											
Criteria	Score range (1-5)	Min (0-5)	Criteria weight (1 to 5)	Score	Score	Score	Score	Score	Score	SD	SD - weighted
COST			5	4.0	3.0	4.0	4.0	3.0	4.0	0.52	0.52
Financial cost*	$50k - $200k	0	5	2	1	1	3	5	3	1.52	1.52
Fisher recording effort*	1 min - 15 min/d	0	5	2	5	3	1	1	1	1.60	1.60
BENEFIT			5	4.8	4.3	3.8	4.2	4.3	2.6	0.77	0.59
T.O. data needs	Not met - met	4	5	5	4	4	4	4	3	0.63	0.63
Fishery manager data needs	Not met - met	4	5	5	5	4	5	5	3	0.84	0.84
Scientific data needs	Not met - met	0	4	5	5	4	5	5	3	0.84	0.67
National data needs	Not met - met	0	2	5	4	4	4	4	2	0.98	0.39
Capacity building	Low - high	0	3	4	3	3	2	3	1	1.03	0.62
FEASIBILITY			5	4.3	4.3	4.0	3.3	3.7	3.3	0.46	0.46
Method feasibility	Low - high	4	5	4	4	4	3	3	3	0.55	0.55
Data reliability	Low - High	4	5	4	4	3	3	4	3	0.55	0.55
Satisfies OH&S requirements	Low - high	4	5	5	5	5	4	4	4	0.55	0.55
CULTURE			5	4.4	4.0	4.0	3.6	4.0	3.6	0.27	0.25
Social and cultural acceptance	Low - high	4	5	5	5	5	4	5	4	0.52	0.52
TEK security	Low - high	4	5	4	3	3	3	3	3	0.41	0.41
Social equity	Low - high	0	4	4	4	4	4	4	4	0.00	0.00
SUSTAINABILITY			2	4.0	4.0	4.0	2.0	4.0	3.0	0.84	0.33
Environmental harm*	Low – high	0	2	2	2	2	4	2	3	0.84	0.33
OVERALL SCORE				4.3	3.9	4.0	3.6	3.8	3.4		
MANDATORY UNMET				0	1	2	3	2	5		

* For these criteria, the criteria scores are transformed using the formula (6 – [criteria score]), for calculation of criteria group average

4.2 Results

The monitoring strategy option with the highest score from the MCA was *Self-reporting via a monitoring app*, followed by *Self-reporting via periodic data sheet* and *Self-reporting via daily data sheet* (Table 4-4). The three options using external observers scored lower, with *Embedded observers* being the best of these. *Self-reporting via a monitoring App* was also the only strategy that had no mandatory criteria unmet, followed by *Self-reporting via daily data sheets*. The *Periodic roving observes* performed the worst for unmet mandatory criteria (Table 4-4).

Two variation statistics were calculated for criteria scores. The standard deviation (SD) is a measure of the variation in raw scores, and the weighted standard deviation (SD-weighted) indicates the criteria's influence on the overall score (Table 4-4). The criteria group that had the greatest influence on the overall score (as indicated by SD-weighted) was *Benefit*, followed by *Cost* and *Feasibility* (Table 4-4). Interestingly, the criteria that made up the *Cost* criteria group had the highest individual variation. However, the two criteria, *Financial cost,* and *Fishery recording effort*, tended to counteract each other—i.e., when *Financial cost* was high, *Fishery recording effort* was low, and vice versa. *Capacity building* and *National data needs* criteria also had high scoring variation but had low influence due to their lower weightings (Table 4-4).

Culture criteria group had the lowest raw score variation and overall score influence, indicating that, whichever method was applied, the cultural considerations could be addressed to a similar extent. However, the *TEK security* criteria had the highest number of unmet mandatory scores (4) indicating the apparent practical difficulty of achieving this requirement, particularly where physical datasheets were required to be collected and transferred before entry into a secure database.

Sustainability criteria had the highest score variation, due to the significant difference in travel related greenhouse gas emissions between the various options. However, it only had a low influence on the overall score.

4.3 Complemented survey

Although a census of all fishing and catches is the aspirational goal, no matter which monitoring option is used, it is very unlikely that 100% coverage will be achieved. This means that available data will need to be extrapolated to produce an estimate for the total non-commercial catch sector in the Torres Strait. The assessment of (and accounting for) selection bias and measurement errors are important to help improve the accuracy of catch estimates from any monitoring program, but especially 'opt-in' and self-reporting methods. Selection bias can occur, for example, if the fishers that respond to the survey are the best or most avid fishers. This means that averaging up their catches to the whole population will result in an overestimate (sometimes called 'avidity bias' (Griffiths *et al*., 2010)). Similarly, some self-reporting strategies can suffer from 'prestige bias', where the catch estimate is systematically reported as larger than the true catch (Berg and Kaiser, 2017).

Obtaining estimates of the catch using different methods will indicate possible biases in the different approaches, and allow for adjustment, correction, or initiate changes in the primary data collection method. For example, if self-reported catch information is used as the primary method to estimate catch, a periodic structured interview survey, may also be used to validate the fisher records and provide additional information (e.g., an estimate of socio-economic characteristics and summary catch data). Fisher-based, self-reported survey data may also be augmented with information that can be crossed referenced with other fishers, such as estimates of coverage rates. For example, asking each respondent how many people are fishing on anyone recording day (e.g., Harris et al.,

1995), then comparing responses from different fishers may be useful in estimating the proportion unreported and/or for making a more informed estimate.

A complimented survey approach should be initiated early and broadly applied, with the possibility that it can be reduced or even eliminated once the primary data gathering strategy has been tested, modified and well established.

5 General discussion

In this study we provide a comprehensive review of possible approaches to providing an acceptable and robust approach to monitoring recreational fishing in the Torres Strait (Section 2.2). However, rather than trying to assess approaches for monitoring both the Traditional and recreational sectors separately, we have focused on assessing the Traditional fishery with a view to recommending that the same or similar approach for recreational fishing. The main reason for this approach being to keep the entire process as simple as possible, but without sacrificing too much utility of the program for recreational fishing.

The overall objective of this project was to recommend an approach to monitor the non-commercial fishery catch sectors in Torres Strait. Although the initial impetus for this project was to focus on species that are also fished commercially (Spanish mackerel, coral trout and TRL) the scope quickly expanded to the entire marine non-commercial catch sector due to its importance to Traditional Inhabitants livelihoods and communities. Similarly, both the Traditional (fished by Traditional Inhabitants) and non-traditional (recreational fishing by non-indigenous people) were also included in the scope of the project. In hindsight, this expanded scope presented a daunting undertaking. Monitoring the Traditional fishery catch and that of recreational fishers are both challenging tasks that have not been successfully (or at least routinely) accomplished in Torres Strait or more broadly.

In any case, this report does present a comprehensive review of both Traditional and recreational fishery monitoring approaches from the Torres Strait and Australia, along with their strengths and weaknesses. It also contains a thorough review of the needs of key stakeholder groups in Torres Strait in relation to non-commercial fishery monitoring, and a broad consideration of their specific issues and risks. Based on these outputs, and the consideration of the project team and the PAC, we have assessed likely options for monitoring and made a series of recommendations for implementing a monitoring program in Torres Strait.

To this end, we have focused on the Traditional fishery – it being the largest, the most diverse, and most important (from a food security and cultural point of view) of the non-commercial fisheries in the Torres Strait. This also came with the realisation that (i) the monitoring program for the Traditional fishery would likely be adaptable to the recreational fishery in Torres Strait, and, (ii) running two separate programs would be more difficult for a variety of reasons (cost, equity, data compatibility etc).

Review of approaches

The review was able to investigate and assess a wide range monitoring programs focussed on the non-commercial fishery catch of both Traditional and recreational fishers. These monitoring programs were carried out using a wide range of approaches and with variable levels of local engagement.

The Traditional fishery monitoring review was restricted mainly to the Australian scene, with an emphasis on past studies in Torres Strait. This reflects the historic recognition that fishing has a uniquely important place in the lives of Torres Strait people, and the subsequent need to understand the specific dynamics of this activity to help design monitoring programs to manage for long-term sustainability. This emphasis also reflects the fact that fishing activities in Torres Strait are unique in an Australian context, with many remote island communities having distinct Traditional cultural fishing behaviours and a hierarchical cultural setting with individual, clan, community and language group structures. The range of species fished in Torres Strait also varies with location and tradition and has a unique species mix of species not fished in other Australian locations.

A common conclusion at the completion of previous monitoring projects was that any attempt to implement a non-commercial monitoring program will require strong cooperation and engagement of stakeholders at all levels, but particularly at the fisher and local community level. The factors that most studies identified as key for conducting a successful monitoring program included:

i. a high degree of local involvement
ii. engaging key local people
iii. good communication with local community members and,
iv. sufficient resources to maintain adequate sampling levels.

The recreational fishery monitoring review took a broad look at monitoring approaches used to assess the impacts of recreational fishing in Australia. It found that, despite a long history and multiple studies, monitoring the recreational catch is equally if not more challenging than monitoring the traditional catch.

Most attempts (and certainly the most successful ones) have used some type of complemented survey design; usually either a telephone-diary survey or a telephone-access point survey. However, the largest challenge was consistently estimating the full recreational fisher population to estimate total effort and extrapolate sample outputs.

Stakeholder needs

Stakeholder needs (including data needs, and program requirements, constraints and risks) were assessed for several stakeholder groups in Torres Strait. The most important needs and issues that arose during this process were:

- provision of data that was adequate to manage the various fisheries at various levels, including socio economic and cultural aspects
- the monitoring program needs to be socially and culturally acceptable to Torres Strait Islander communities
- program implementation needs to build trust based on shared aspirations, recognition of past experiences, transparency regarding how the data will be used and managed, legitimate local control, information security and co-development approaches
- the monitoring program should be underpinned by comprehensive agreements and processes, perhaps within a broader harvest strategy framework
- the control of information dissemination should sit primarily with communities through an appropriate (and agreed) representative/leadership system
- the program should be supported with communication material that is sufficient to inform, educate and increase capacity
- any data monitoring approach needs to be logistically feasible and technically uncomplicated
- the data must be held and managed in a secure way
- program needs to be affordable, and cost be proportional to data accuracy and precision
- the monitoring program should include capacity building and/or economic opportunity for the community
- overall program must meet implementing agency OH&S guidelines.

This assessment provided a comprehensive range of needs that were then used as design criteria for assessing monitoring strategy option in Torres Strait. This approach makes direct links between meeting those stakeholder needs and the successful implantation of the program. It assumes that the failure to address these needs, especially for Traditional Inhabitants and fishery managers (that

will most likely resource and administer the program) will put the success of any future program at risk.

Assessment of approaches

A multi-criteria assessment (MCA) of monitoring strategy options scored *Self-reporting via a monitoring App* higher than other approaches. It was also the only option that had no mandatory criteria unmet. In general, options using external observers scored lower than self-reporting approaches. Periodic roving observes performed the worst for unmet mandatory criteria.

The development and implementation of a monitoring App will allow fishers to directly provide daily catch data, and also provide useful information back to fishers and community members in almost real time. This system should be linked electronically to a secure database that has transparent and robust security and permission protocols. The details relating to the design and implementation of such an App can be guided by the detailed information provided in the current reviews, assessments and discussion.

Note that the Traditional fishery catch also includes any catch from the TIB commercial sector that is kept by fishers for home consumption, community sharing or barter. In this case, the catch of the TIB fishers will be recorded in two separate catch recording systems - the animal being sold commercially are being recorded in the FRS, and the rest being recorded as non-commercial catch in the new non-commercial catch sector monitoring program.

The development an application of a monitoring App has a high feasibility. Mobile network and internet coverage in Torres Strait is widespread and reliable. Several apps have been developed that can provide examples and learnings for recreational and/or Traditional fishing (e.g., CAPReef, 2009, French *et al.* 2014, Sawynok *et al.,* 2018), and other new approaches are being developed (e.g. FRDC project 2020-056 - *Evaluation of a smart-phone application to collect recreational fishing catch estimates, including an assessment against an independent probability based survey, using South Australia as a case study* - this project may offer highly mutually beneficial opportunities to trial an App for non-commercial catches in the Torres Strait).

In addition, the implementation of a monitoring App can provide a platform for an efficient and targeted information flow back to the fisher, including: their own recorded catch data, data summaries (at an appropriate level); species information and other relevant capacity building and communication information.

It is also highly desirable to implement a complimented survey approach, where estimates of catch are made using an additional, different (and possibly less frequent) method from the primary data collection method. This would provide validation and potentially improve catch estimates. In the longer term, the validation aspect of any complimented approach could be reduced or even eliminated once the primary data gathering strategy has been tested, modified and well established. The best candidate for this complimentary method, based on the experience of other previous programs, are periodic structured interviews (e.g., 'recent recall' method), potentially done at the household level to provide additional socio-economic information about the family unit.

Data security and access

An important aspect in the design of the program will be data security and access. Data security, where an individual's data is not disseminated without their written approval, will be paramount. Access to data and data summaries will need to be tightly controlled and negotiated. This is a critical

aspect of the program that will need to be co-designed with Traditional Inhabitants early in the implementation phase.

Gender equity

Gender (and age) equity should be a primary consideration during the design and implementation of the monitoring program. Female fishers can be underrepresented in monitoring programs where there is a majority working-aged, male dominance of both commercial and intensive fishing effort (Kleiber et al., 2014; Mangubhai and Lawless, 2021). Even projects managed at the community level can lack equity in the application and return of benefits to community members because the needs of less vocal or less powerful members of the community can be overlooked (Stacey et al., 2019). As is the case with non-indigenous society, women and youth can be marginalised, reflecting the dominance of men in public positions of power and influence (Davies *et al*., 1999; Kleiber et al., 2014).

Women will usually fish a different suit of species and use different fishing methods than men (e.g., gleaning). Therefore it is imperative to sample them proportionally to get a true presentation of the catch (Kleiber et al., 2014; Tilley et al., 2021). In addition, the application of species-specific, spatial and other management strategies can impact on women, and therefore, the unique social role of womens' fishing disproportionately. Disaggregated data on fishing effort and catch will be required for equitable and socially beneficial management at all levels (Mangubhai and Lawless, 2021).

Information gathered during this project indicates that women will feel empowered to participate in data collection using a phone App approach. Based on the responses from Torres Strait Islander women interviewed for this project, it is highly likely that women would participate in a non-commercial catch recording program, particularly if they are made aware of the potential social benefit of the monitoring. This is due to their generally high social awareness, the pivotal role of non-commercial catch in household seafood consumption and their widespread use of phone technology.

There is strong anecdotal evidence of the widespread access to internet connected technology (e.g. smart phones and tablets) by Torres Strait women and youth, such as their high levels of social media usage. Information on non-commercial fish catches are already being shared on social media, particularly among women and youth. Torres Strait islander women we spoke to also indicated that alternative access to an App by anyone that did not have their own device was likely within family groups.

Much of the focus regarding gender equity will centre on the implementation process and ongoing engagement. This will need to include mechanisms to target women, youth and other potentially under-represented groups (Lawless et al., 2017; Kleiber et al., 2019; Mangubhai and Lawless, 2021). In many regards, the self-reporting approaches recommended in this report will go some way to providing an equitable platform for representative reporting. However, the complimented sampling strategy should assess gender equity as a key objective.

Consultation and engagement

The key partnership required for the successful implementation and ongoing success of the monitoring program will be between Traditional Inhabitants that will supply the data and fishery managers that will likely resource and implement the program. A primary mechanism to manage this partnership is through the Protected Zone Joint Authority (PZJA) network, who's main purpose is to manage the interests of Australian fisheries in the Protected Zone (PZJA, 2020; Butler et al., 2012).

The currently existing working groups, resource assessment groups, management and advisory committees can provide suitable fora for consultation and co-development functions related to non-commercial fishery monitoring (noting that the current focus is mostly on commercial fisheries). However, due to the commonality of issues related to monitoring and managing Traditional and recreational fisheries, there may be a need for a new consultative forum under this framework focused only on the non-commercial fisheries; noting that there is already a process and structure in place for dugong and turtle fisheries.

In addition to the PZJA network, there will likely be the need for formal bilateral agreements between communities and the implementation agency/s that will be required to outline all aspects of the program (Figure 5-1). Agreements could be with individual communities, clusters, or a single Torres Strait wide agreement. This agreement could build on existing community-based Dugong and Turtle Management Plans that have been developed with individual Torres Strait Islander communities (PZJA, TSRA, unpublished data), or standalone agreements. PNG Treaty villages could be included in this process in future versions.

Fishery scientists are another key stakeholder group that will need to develop and maintain relationships, communicate and synergise with the two other groups. The two current instruments that outline these relationships include research contracts (with managers) and ethics agreements (that outline relationships and obligations with respect to indigenous communities) (Figure 5-1). Recently implemented consultation and engagement processes that researchers are required to carry out during the research proposal phase (Nakata and Nakata, 2011; Nakata, 2018) will fulfill these requirements to a large extent.

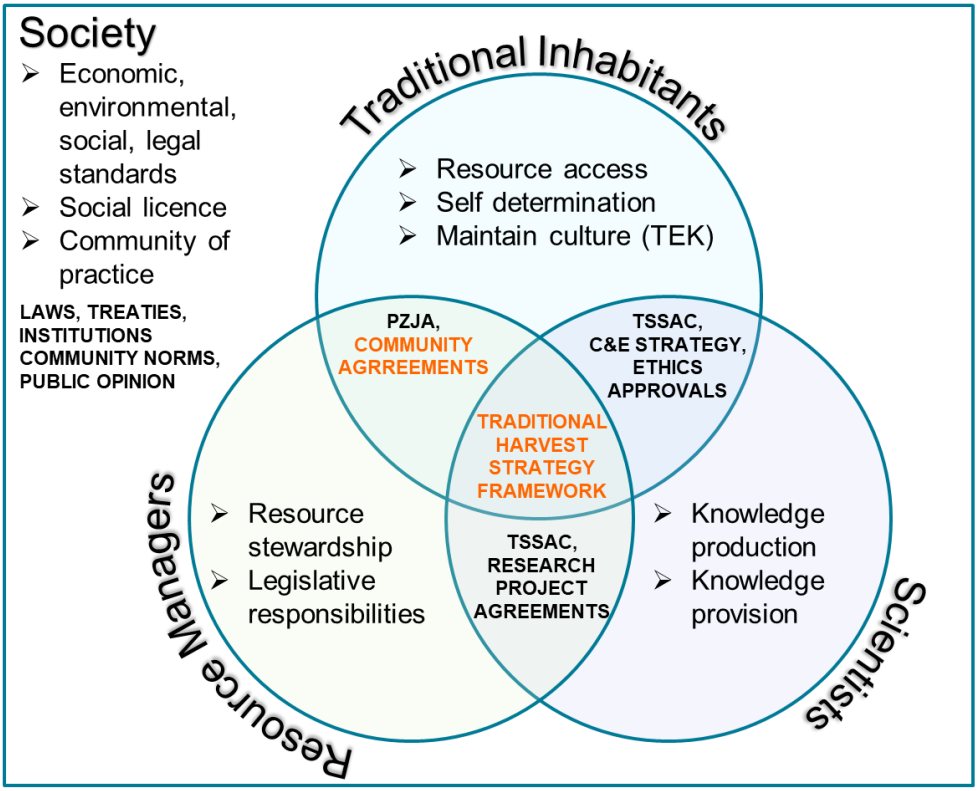

Figure 5-1. Consultation and engagement objectives, relationships and instruments (black for existing, orange for proposed) for three main stakeholder groups associated with the Torres strait Traditional fishery (PZJA = Protected Zone Joint Authority; TSSAC = Torres Strait Scientific Advisory Committee; C&E = Consultation and Engagement).

This triumvirate of Traditional Inhabitants, managers and scientists will have bilateral relationships that will need to be recognised, fostered and managed (Figure 5-1). However, the development of an overarching process or agreement may be beneficial for the overall development and implementation of the non-commercial monitoring program. This could take the form of a Traditional fishery harvest strategy, which could provide the platform for all stakeholders to express their objectives, rules, and operational guidelines that could build on existing and developing fishery harvest strategies (prawn, TRL, sea cucumber, finfish; AFMA, 2011; 2019a; 2019b), and the community based management plans implemented for turtle and dugong (PZJA, TSRA, unpublished data; Butler et al., 2012); which were, in fact, envisaged as a template for other Traditionally-fished resources (TSRA, 2016).

The ranger program has also been flagged as a possible resource/partner program for the non-commercial monitoring program, as it has the potential organisational capacity and personnel to assist in the implementation of such a program. The Ranger program operational model, their infrastructure, and the community controlled TEK database could assist in implementing a Traditional fishery monitoring program in the future.

Communication strategy

Communication will be critical at the beginning, and throughout the monitoring program to build the sense of ownership among communities. This will include the reporting of information (e.g., catch summaries and other information) back to communities to assist to make customary management decisions, raise local capacity and maintain program transparency. A process for determining how and what the flow of information back to communities will look like will need to be co-developed during the initial implementation phase.

Communication material needs to be sufficient to inform, educate and increase capacity (e.g., provision of training and species guide to minimise mis-identification). The data analysis should be automated as much as possible to facilitate the timely return of information back to fishers, and provide security to program summaries and other products.

5.1 How suitable is the recommended strategy for monitoring the recreational catch?

While the outputs of the stakeholder needs and options assessment was focused on the Traditional fishery, many of the same issues will also apply to the recreational (non-islander) fishery. This includes the technical aspects of obtaining catch estimates from individual fishers, but also data security and protection of individual data. Because of this, we believe that the Traditional fishery monitoring approach outlined in this report may also be suitable for monitoring recreational catches. This has the major advantage of not having to develop and roll out different programs for each of these two sectors.

The difference between the two sectors will be mostly related to the value proposition (i.e. what are the incentives to ensure participation) and the treatment of data analysis outputs (i.e. who gets access to the catch data summaries). This will need to be addressed in the implementation phase with consultation with recreational fishers and with agreement from communities.

5.2 Assessment against AFMAs *risk-cost-catch trade-off approach* to managing fisheries

The trade-off between the cost of management, the risk to the resource and the catch benefit that a fishery gains from exploitation is known as the risk-cost-catch trade-off (Sainsbury, 2005). These

trade-offs are often unknown and likely to be non-linear (Dichmont et al., 2017). In most recent fisheries contexts, risk is couched in terms of fishery reference points — such as what are the risks associated with not achieving the target reference point or falling below the limit reference point. This information is unknown for Torres Strait non-commercial fishing.

Understanding of the *risk-catch-cost trade-off* to managing Traditional and some recreational fisheries will help with program design in relation to its alignment with management agencies. The issue is how to trade the risks associated with managing a fishery, against the costs of management and the socio-economic benefit obtained from the catch (Dichmont et al., 2017). In low economic value fisheries, such as Traditional and some recreational fisheries, there is a real need to understand the trade-off between ecological and economic risk associated with harvesting; the benefits of harvesting, and the costs associated with management (Dichmont et al., 2017). The assessment of monitoring approaches should trade these factors off in order to make an appropriate recommendation.

The MCA assessment of options carried out in this study incorporates the main components of the risk-catch-cost trade-off approach. Therefore, we consider that this assessment provides a relatively robust review of potential monitoring approaches in terms of the risk-cost-catch trade-off.

5.3 Communicating benefits

Communication of the benefits of the monitoring program outputs will be critical to engaging local fishers. Most islanders will recognise that it is important for the sustainability of commercial stocks that the catches are quantified. For the non-commercial fishery, it will be critical to clearly and fully describe the need/s for this data for all stakeholders. Some of these needs will be common across stakeholder groups (such as general sustainability concerns). However, the use of that data and management actions will differ and conflict between stakeholders in this aspect of monitoring and management will hamper any program that relies on goodwill and effort at all levels to succeed. Good communication, shared understanding, recognition of stakeholders needs and concerns, data security, information control, and finally a negotiated framework for implementing a monitoring program will be necessary for success.

If participation in a monitoring program for non-commercial catches is poor, consequences include:

- Poor return on investment from program funding
- Relatively weak or non-representative information stemming from the program
- Opportunity loss for the potential new understanding of catches and catch trends
- Opportunity loss for local cultural fishing communities to have a stronger impact in the co-development with AFMA/TSRA of fishing strategies that include their fishing areas.

The Traditional fishery is of great social and cultural value to Torres Strait islanders, including providing significant health, well being, lifestyle and economic benefits. It expresses the vital link between Traditional Inhabitants and *Zenadth Kes* (Torres Strait), and reinforces their spiritual beliefs governing their existence and responsibility for their land and sea country (Davies *et al*., 1999). It is recognised that Torres Strait islanders are acutely aware that natural resources are limited (contrary to some studies that promote a “boundless seas” attitude). This is demonstrated by countless customary and practical activities that promote sustainability (Johannes and MacFarlane, 1991; Davies *et al*., 1999). Most Traditional Inhabitants hold the view that fishing should be accompanied by some kind of monitoring, which can underpin management decision-making processes, particularly local customary management. However, this is not usually enough on its own to

convince a fisher to provide data on their catch on a long term basis due to the perceived and real risks and costs (including loss of access, effort, other disincentives and risks).

Convincing Traditional Inhabitants to fully commit to monitoring will require a deep mutual understanding of the monitoring and management context, and a framework that establishes a "bottom up" approach to monitoring and management. There also needs to be a recognition that purely customary management may also be ineffective due to increases in population growth and increasing fishing efficiency, as well as global environmental trends such as climate change. A full cooperative, co-designed, monitoring and management model, supported by capacity building programs, is required to bridge these divides – something that has rarely been achieved (Davies *et al*., 1999).

There is a primary driver for this data, being for government management agencies, particularly for non-commercial use of otherwise commercial species (Spanish mackerel, coral trout and TRL). However, there is the potential for local and collaborative management that requires accessible and credible monitoring data, especially for adaptive management that by its very nature is often rapid and local (Grayson, 2011; Danielsen, 2009). This will be a critical objective for providing the benefit and "value proposition" for prolonged provision of local catch data by community members. Outlining and communicating this "value proposition" will be important to promoting and maintaining Traditional fisher involvement and will require high levels of honesty and transparency about program drivers, approach and process, and ultimately, build local knowledge and capacity.

The community benefits (along with risks) for any proposed community-based fishery catch monitoring activity should be clearly understood to enable an informed assessment of options and appropriate support. Here we provide a high-level summary of the community benefits of a non-commercial fishery monitoring program to compliment the more detailed assessments below.

Community benefits

1. *Sustainable populations of marine species*

Accurate data on the catches of all marine species from Traditional fishing will (i) improve the efficacy of management for commercially and Traditionally-fished species. This will reduce the risk of their overexploitation and help maintain the benefits of fishing for local communities.

2. *Health and well being*

The Traditional fishery is of great social and cultural value to Torres Strait islanders, including providing significant health, wellbeing and lifestyle benefits. Knowledge of the status of traditional fishes species will help improve their local management to ensure long-term supply of these critical ecosystem services.

3. *Management of marine resources for food and culture*

Provision of ongoing Traditional fishery catch data and trend information to Traditional Inhabitants can be used to support management of marine resources at the local and regional level. Knowing whether catches are trending up or down could be critical for understanding how to manage marine resources in future. These could include supporting a better understanding of:

- the impacts of fishing on key species and on other species and ecosystems
- the impacts of climate regime shifts on population status and distribution
- the impacts of introduced pest species on endemic/Traditionally-fished species

- the impacts of terrestrial inputs from PNG and Australia on population status and distribution

4. *Healthier ecosystems*

Broad information on the full range of species catches from the Traditional fishery will underpin ecosystem level management. For example, inaccurate management resulting in heavy depletion of apex predators (e.g., mackerel, coral trout) in coastal Torres Strait waters could substantially change food web dynamics, including altering populations of some Traditionally-fished species. Resource sharing and catch allocation methods require accurate data from all sectors to ensure equitable access to catches, that for Traditional fishery sector protects a food source and associated TFK systems.

5. *Sustainable and equitable communities*

Information on fishing practices collected in a socially equitable way within communities can provide an appropriate characterisation and recognition of the contributions of different demographic groups to community health, social, and cultural wellbeing by way of their contribution of local seafood to local diets.

6. *Self determination*

Information on the Traditional fishery catch will improve the potential for customary management of marine resources which will enhance the level of self-management by Torres Strait communities. It may also build capacity for the new roles/tasks required to run and manage a non-commercial catch sector monitoring program.

New data-management agreement and processes developed in this program will form part of a new community-based monitoring program should include a data ownership model and agreement. This process will enhance current self-management of marine resources by Torres Strait Islanders.

7. *An improved understanding of recreational fishing catches*

Monitoring recreational fishing, a sector that is currently very poorly quantified, will help improve the assessment and management of commercially fished species and lead to more sustainable marine species populations and a healthier marine ecosystem.

5.4 Conclusion

Based on a comprehensive review of previous approaches, a detailed assessment of stakeholder needs, significant consultation and the assessment of a broad range of monitoring options, we have recommended a design for a non-commercial catch sector monitoring program that can deliver acceptable estimates of the non-commercial fishery catch within Torres Strait communities. This approach should also be considered for in-community recreational fishing. This monitoring data will:

- be incorporated into annual fishery assessments by the AFMA and the TSRA to account for the non-commercial fishing on selected priority fishery populations (e.g., Spanish mackerel, coral trout, TRL)
- allow more accurate allocations of catch for each of the commercial sectors
- provide the AFMA and TSRA with relatively accurate and up-to-date estimates of the catch from these sectors on the Traditional and recreational catch
- enable the assessment of change in a range of non-commercially important species that are important to Traditional fishers and their communities.

Key aspects of a successful non-commercial catch sector data collection program will include: the development of an effective consultation and engagement framework; capacity building around basic fisheries management and data use; the co-development of a data collection, storage and information dissemination model; the co-development of effective monitoring tools; strong communication strategies and community buy-in; and an adequately resourced and trained implementation team. In Torres Strait, the involvement of community organisations and leadership, along with government support will be critical to ensuring the successful implementation of a long-term, community-based monitoring program.

6 Implementation

Here we provide a way forward for implementation of a non-commercial fishery monitoring program, based on the projects' core recommendations. We recommend that the implementation take a staged approach to (i) minimised risk and (ii) simplify the early-stage processes. This allows the key data to be collected from the outset, but without overly-complex, and/or potentially off putting or confusing expectations or activities. This was a strong recommendation of the PAC. A pilot program in a limited number of communities will help fine tune and improve its functionality and acceptance to all stakeholders (Figure 6-1), before the rollout of the Torres Strait wide monitoring program. Products that help inform stakeholders of the program and its concepts, as well as provide feedback on results and success/issues, should be a non-negotiable aspect of program implementation (see below).

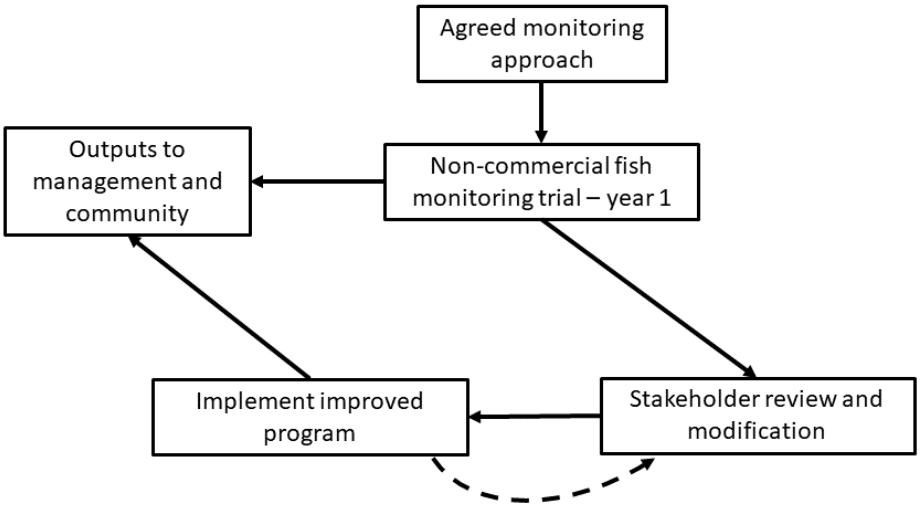

Figure 6-1. Proposed simplified approach to trialling an endorsed non-commercial catch sector monitoring strategy

The following broad recommendations act as a guide. Much of the detail should be developed with key stakeholders. We recommend a staged approach to the implementation following agreement on an approach for assessing non-commercial catches, including the following tasks. Task 1. and 2. could be packaged as a next step.

1. Community consultation and sign on:

This task would carry out a community-based consultation process to co-design and get agreement on all aspects of the monitoring approach, but particularly data collection and control, analysis and reporting. The process can provide the basis for a monitoring and data management agreement between the implementing agency and communities. An ongoing consultation and governance framework could also be designed during this process.

During this phase, particular focus should be on ensuring consultation and participation of representatives gender and age cohorts, either through targeted engagement and/or subgroup consultation. Other key groups include:

- Traditional Owner representative groups – e.g. PBCs
- Local fisher associations – e.g. EFMA, MDWFA, KAIA
- Zenadth Kes Fisheries

- Torres Strait Ranger Program
- PZJA consultative committees Fishery RAGs, WGs, SAC
- Wapil Regional Fisheries Development Project
- Fishery buyers and agents on islands

This will also require the development of a detailed and comprehensive communication and engagement strategy, including ongoing consultation mechanisms that could be built into the broader PZJA framework and involve a new dedicated forum or group focussed on the non-commercial fishery.

Task summary

- Develop comprehensive communication and consultation strategy
- Carry out initial consultation with communities:
    - Hold community workshops (at community or at least cluster level – in community)
    - Codesign of pilot program
    - Codesign of governance structure
    - Codesign of catch data collection and information feedback flow (to inform App design)
    - Codesign of complemented sampling strategy

Indicative cost: $15k-$25k plus workshop travel and operating

2. App design and development options:

There are a range of potential partners including external funding agencies and projects that may provide a cost-effective approach for monitoring App development. Examples could include:

- FRDC Indigenous Reference Group (National fisheries funding)
- QDAF (current agency monitoring Torres Strait recreational fishery catch)
- Current funded project: FRDC 2018-016 - *Improving data on Aboriginal and Torres Strait Islander marine resource use to inform decision-making* (Moyle et al., 2020)
- Current funded project: FRDC 2020-056 - *Evaluation of a smart-phone application to collect recreational fishing catch estimates, including an assessment against an independent probability-based survey, using South Australia as a case study* (Crystal Beckmann, PI; University of Adelaide)
- Partners for Indigenous Land and Sea Corporation (ILSC)

This stage would also include the design of the complemented monitoring strategy to validate the App-based data (e.g. periodic household interviews).

Tasks

- Identify and engage potential App development partners
- Identify and engage potential database designers
- Design specifications for App
    - Design data needs and data entry format
    - Specify Information feedback format
- Specifications for complemented sampling strategy
- Scope and cost App development, data base, pilot and full-scale implementation options

Indicative cost: $10k-$20k plus travel and operating

3. Develop App, database and data flow infrastructure

The monitoring program will also require the design and implement of an agency-based, central data system, including strict data security and information flow protocols. This should be based on a centralised database and automated (as much as possible) data analysis approaches. The system should be designed so that it can allow access to information to be control at the level of individuals, communities and management agencies. It could involve agreements with Traditional Inhabitants and RNTBCs to help ensure that the raw data is in safe and secure hands.

Once the database and App specifications have been developed, and potential partners identified (see above), the App and linked secure database will need to be built. This should include communication tools that will sit within the App to enhance two-way communication and capacity building – e.g., species ID guide and monitoring manual. App and database development will require the engagement of technical experts to build prototype using agreed specifications. The design of monitoring tools can benefit greatly from past or existing approaches (e.g., CAPReef, 2009, French *et al* 2014, Sawynok *et al.,* 2018), and other new approaches being developed.

Tasks

- Build App prototype (could be a modification of a currently used App)
- Build and implement database

*Indicative cost***:** Scoped in Task 2.

4. Community rollout – pilot (2 communities)

This stage will require the identification and resourcing of an implementing agency and training (if necessary) of responsible personnel.

Identifying, training and resourcing local program contacts (or champions) will also be critical to the long-term success of the monitoring program, and to help change the culture for community-based data collection.

We suggest that two communities be selected for the pilot rollout, and that the program be implemented for one year. A review of the program would then be carried out based on the outcomes of the pilot.

Tasks

- Training of implementation team
- Identify and train local champions
- Implement App and complimented sampling strategy in communities
- Summarise (and distribution of) results (one years sampling) including comparison of complimented strategy with App results
- Final report and recommendations for full-scale rollout

*Indicative cost***:** Scoped in Task 2.

5. Community rollout – full-scale

If successful, plan for Torres Strait wide implementation, based on the learnings from the pilot study, including:

- collection of feedback information from key stakeholders on success and improvement of the system (App use, data parameters collected, form of data feedback, etc)
- pilot study report back to decision making bodies on successes, limitations, way forward.

Tasks

- As per Task 4. But on all PZJA communities

Indicative cost: Scoped in Task 2.

Note that we recommend a parallel stream for each of these activities that would target recreational fishers within communities, for little additional cost.

6. Traditional fishery harvest strategy

Consider developing a new Traditional Fishery Harvest strategy for locally fished resources. This would contain the background including values and needs and begin the process for developing indicators and harvest control rules for sustainable management of the Traditional fishery.

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Appendices

Appendix 1. Statement addressing Guidelines for Ethical Research in Australian Indigenous Studies (GERAIS) priorities for ethical assessment

Research project: Measuring non-commercial fishing (Traditional and recreational fishing) in Torres Strait to improve fisheries management and promote sustainable livelihoods.

Project summary

This research project aims to review past approaches for monitoring non-commercial/Traditional catches of marine species and recommend a process and method for a long-term monitoring program to assess these catches in future. The project outputs are intended to provide the basis for instigating a trial monitoring program to collect non-commercial catch data into the future. It is largely a desktop review with some consultation with community representatives likely. An Advisory Committee, including Traditional Inhabitant representatives, will be used to help guide recommendations. There is no in-community consultation component. However, any Traditional Inhabitant representatives spoken to about the project will be provided with an approved project information sheet and invited to complete a consent form (both previously submitted to AFMA).

Statement addressing GERAIS priorities for ethical assessment

Axis	GERAIS Principle	Project team comments
Rights, respect and recognition	1. Recognition of the diversity and uniqueness of peoples, as well as of individuals, is essential	The project team is led by a Torres Strait Traditional Inhabitant and includes two other members experienced in working with Traditional Inhabitant individuals and communities. We recognise the diversity and uniqueness of Torres Strait Peoples, communities and individuals. Any future monitoring program will: Consider the inclusion of men, women, children, Traditional Inhabitants, other Indigenous and non-Indigenous community members. Take into consideration all communities across Torres Strait Provide appropriate and accessible communication material. Participation of individuals in the discussion of project ideas is voluntary and the rights of individuals to choose to participate in the research or not is recognised and

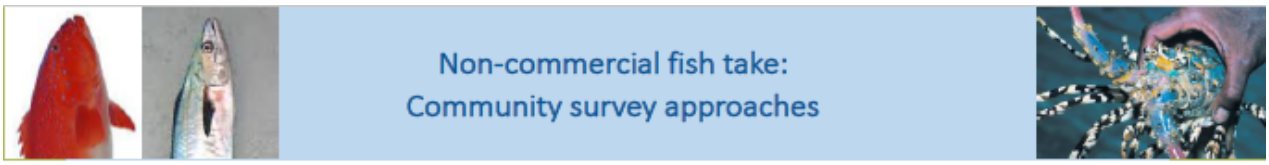
		respected. It is understood that extrapolations cannot be made from one community to another regarding their views on future fishery monitoring.
	2. The rights of Indigenous peoples to self-determination must be recognised.	Recommendations about future fishery monitoring will only be made following an appropriate level of consultation and agreement by community representatives, noting that project outcomes are only a first step towards implementation of a future program. Traditional Knowledge and sensitive commercial fisheries information will be protected through a range of mechanisms (below).
	3. The rights of Indigenous peoples to their intangible heritage must be recognised.	Any participation of individuals in the research project is completely voluntary and the rights of individuals to choose to participate, control and protect their Traditional knowledge will be recognised and respected.
	4. Rights in the Traditional knowledge and Traditional cultural expressions of Indigenous peoples must be respected, protected and maintained.	Appropriate acknowledgement of contributors will be made in any reporting and communications, including strict use of personal anonymity of views and information sources. Project staff will ensure that Prior Informed Consent is in place before any discussion/interviewing is undertaken.
	5. Indigenous knowledge, practices and innovations must be respected.	Any participation of individuals in the research project is completely voluntary and the rights of individuals to choose to participate, control and protect their Traditional knowledge will recognised and respected. We will ensure transparency around our approach for acknowledgement of contributors in any reporting and communications, including strict use of personal anonymity of views and information sources.
Negotiation, Consultation, Agreement and Mutual Understanding	6. Consultation, negotiation and free, prior and informed consent are the foundations for research with or about Indigenous peoples.	Our project will largely review past monitoring approaches and make recommendations for future ways forward for collecting and assessing data on community-based non-commercial and recreational fishing. Any views obtained or discussed about the merits of approaches for data collection will be made using an inclusive and consultative outlook and method. Project staff will ensure that Prior Informed Consent is in place before any discussion/interviewing is undertaken. The project will provide options for future monitoring accompanied by information about strengths and weaknesses and use an Advisory Committee of subject matter experts and Traditional Inhabitants to guide recommendations.
	7. Responsibility for consultation and negotiation is ongoing.	Project staff are aware of and will adhere to the Procedural Framework for Researchers in Torres Strait (Nakata 2018) and the TSRA Cultural Protocols Guide

		(TSRA 2011) when planning and conducting work with Traditional Inhabitants and Indigenous Peoples of Torres Strait. Project staff will work with and seek advice from PZJA consultative committees both during and after the timeframe for the project activity. And project staff will be available for further consultation outside these fora if required.
	8. Consultation and negotiation should achieve mutual understanding about the proposed research	Any views obtained or discussed about the merits of approaches for data collection will be made using an inclusive and consultative outlook and approach. Any recommendations for fishery monitoring methods will be made by an Advisory Committee of subject matter experts, including Traditional Inhabitants and/or Indigenous community representatives, following appropriate meeting time to ensure issues and options are discussed to the extent that all involved are clear about their detail. This will include circulation of draft project information and material prior to the meeting. The Advisory Committee will ensure an experienced Chairperson is engaged to ensure mutual understanding of the research outputs and background information relating to any recommendations.
	9. Negotiation should result in a formal agreement for the conduct of a research project.	The structure of the project governance relating to recommendations for future fishery monitoring includes engagement of an Advisory Committee of subject matter experts and Traditional Inhabitants. The committees' recommendation will be provided to PZJA consultative committees for further input and advice.
Participation, collaboration and partnership	10. Indigenous people have the right to full participation appropriate to their skills and experiences in research projects and processes.	The project team is led by a Torres Strait Traditional Inhabitant. Individual views will be welcomed and included in project assessments, although a more widespread consultation phase is planned for inclusion in later phases of the broader project program. This initial, largely desktop phase of the project, will provide options accompanied by information about strengths and weaknesses and will use an of subject matter experts and Traditional Inhabitants to guide recommendations. Project results will be reviewed by Traditional Inhabitant community representatives on the PAC and on several PZJA fishery committees.
Benefits, outcomes and giving back	11. Indigenous people involved in research, or who may be affected by research, should benefit from, and not be disadvantaged by, the research project.	The research project was identified as a high priority by the PZJA consultative committees, including TSSAC and FFRAG and FFWG (advisory groups to the PZJA made up of industry members who are Traditional Inhabitants or Indigenous representatives active in the fisheries, management agencies and scientists).

		The project will collect information that will help to ensure that future stock assessments of fished species will have the most accurate data possible from the community non-commercial fishing sector. Empowering Traditional Inhabitants and other Indigenous community members to better manage their local and regional fisheries is an identified purpose of this project work. The accuracy of this information improves stakeholder confidence in future assessments and decisions about the management of fished stocks. These assessments will, therefore, be more effective in delivering against fishery objectives designed to ensure the long-term sustainability of Torres Strait fisheries and fished populations.
	12. Research outcomes should include specific results that respond to the needs and interests of Indigenous people.	The research outcomes from this project are aimed at improving the PZJA's ability to manage fished populations in a way that ensures the long-term sustainability of those species; and hence their availability for both commercial and Traditional fishing by the Indigenous Peoples of the region. The research project was identified as a high priority by the PZJA consultative committees, including TSSAC and FFRAG and FFWG, including gaining the endorsement of the Traditional Inhabitants and Indigenous representatives on those committees.
Managing research, use, storage and access.	13. Plans should be agreed for managing use of, and access to, research results.	Plans are in place for managing use of, and access to the research results. The data and information collected during the project will be provided to AFMA for application and distribution to stakeholders. Appropriate acknowledgements of contributors and funding sources will be made in any reporting and communications. Project staff will ensure that Prior Informed Consent is in place for the acknowledgement, attribution, and citation of local Traditional knowledge and fisheries data. Confidential data and information, including any Traditional knowledge, collected during discussions with Traditional Inhabitants will remain confidential. Any information published that is sourced from individuals will be in a format that ensures that no data or information from any individual or island group may be identified. AFMA will publish the research results, making them publicly available and accessible. Information will also be summarised as feedback to stakeholders.

		The recommendations from the project for a future monitoring program will be considered by a range of PZJA committees. The implementation of an agreed trial monitoring program within Torres Strait communities will be subject to committee agreement, TSSAC approval and agreement by community leaders from targeted trial areas. Any such plans will be accompanied by a range of agreed information dissemination, such as factsheets, posters, social media stories, presentations, phone calls.
Reporting and compliance	14. Research projects should include appropriate mechanisms and procedures for reporting on ethical aspects of the research and complying with these guidelines.	Project staff are aware of and will adhere to the Procedural Framework for Researchers in Torres Strait (Nakata 2018) and the TSRA Cultural Protocols Guide (TSRA 2011) when planning and conducting work with Traditional Inhabitants of Torres Strait. The projects' governance relating to recommendations for future fishery monitoring includes engagement of an Advisory Committee of subject matter experts and Traditional Inhabitants. The committees' recommendation will be provided to PZJA consultative committees for further input and advice. Project staff will work with and seek advice from PZJA consultative committees, both during and after the timeframe for the project activity. The project will be applied as outlined in the measures described above. Any ethical issues that arise during the research project will be followed up with the appropriate individuals or organisations responsible such as AIATSIS, AFMA, TSRA, Queensland Government, community groups, or other appropriate body depending on the circumstances of the issue. An appropriate response will be formulated based on advice from these agencies. The final report will outline the process of stakeholder engagement and any other ethical aspects of the research that was conducted during the project.

Appendix 2. Consultation plan for the pre-proposal phase.



Measuring non-commercial fishing (indigenous subsistence fishing and recreational fishing) in the Torres Strait in order to improve fisheries management and promote sustainable livelihoods.

Engagement Strategy - Full-proposal phase

Consultation during the formulation of the full proposal will include management and community stakeholders from all Torres Strait communities – for although this project will only carry out pilot catch monitoring on two selected islands, the program will potentially be rolled out across all Torres Strait communities.

Stakeholders to be contacted (all Torres Strait PZJA communities) include:

- Finfish Working Group and RAG Traditional Inhabitant representatives
- GBK/PBC Chairs
- Island Councillors
- Island Fishery Associations

Initial engagement will be through email, phone calls and face-to-face meetings where possible, and include dissemination of the project flyer and a structured questionnaire to gauge support, outline any concerns and provide any insights or ideas for project activities and fish monitoring approaches.

Special consideration will be taken with any traditional knowledge collected during this (and subsequent) stages of the project. Traditional knowledge will only be used with the express permission of the traditional owners.

Engagement Strategy – Project phase

Phase 1

Communication and consultation with management and islander representative organisations will take place through correspondence and meetings with the project oversight body. [Note: costs associated with project oversight body, including any potential fee for service, have not been included in the project budget due to uncertainty of membership and potential for incorporation with established consultation processes (e.g. Torres Strait finfish working group].

Key stakeholders to be consulted during this phase will include the TSRA, AFMA, Malu Lamar and Gur A Baradharaw Kod (GBK), Councillors, PBC Chairs, PZJA working group representatives, and the CDP Provider.

Phase 2

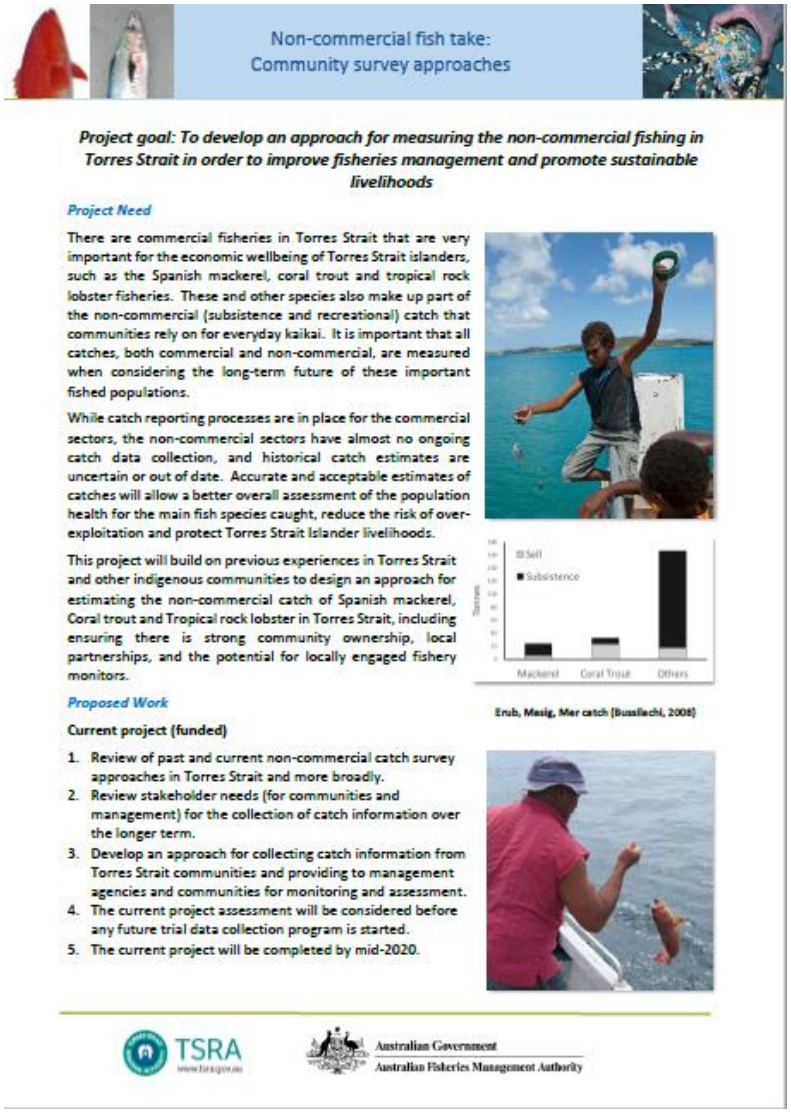
We propose to engage a minimum of two outer islands communities to pilot study the monitoring program for both subsistence and recreational fishing. Broad community consultation will occur early in Phase 2 on the two selected island communities.

This will include broad community communication and consultation, with as many people that live in the communities as possible. Targeted consultation will also be held with local PBC chairs, Councillors, TSRA Members and heads of local fishers associations. The local rangers and CDP trainers are potentially key collaborators during the pilot study phase of the project.

A range of communication engagement approaches will be used, including community notices, community meetings, household visits and direct phone conversations. Face to face meetings will be held with community representatives and leadership. We will also take advice on other approaches to inform communities about the project, such as media releases (radio and newspaper articles) and presentations at Working groups etc.

There will likely be a strong training component for locally engaged monitoring support positions (e.g. community monitors, rangers etc).

Appendix 3. Project plan - community flyer information sheet



Non-commercial fish take:
Community survey approaches

Project goal: To develop an approach for measuring the non-commercial fishing in Torres Strait in order to improve fisheries management and promote sustainable livelihoods

Project Need

There are commercial fisheries in Torres Strait that are very important for the economic wellbeing of Torres Strait islanders, such as the Spanish mackerel, coral trout and tropical rock lobster fisheries. These and other species also make up part of the non-commercial (subsistence and recreational) catch that communities rely on for everyday kaikai. It is important that all catches, both commercial and non-commercial, are measured when considering the long-term future of these important fished populations.

While catch reporting processes are in place for the commercial sectors, the non-commercial sectors have almost no ongoing catch data collection, and historical catch estimates are uncertain or out of date. Accurate and acceptable estimates of catches will allow a better overall assessment of the population health for the main fish species caught, reduce the risk of over-exploitation and protect Torres Strait Islander livelihoods.

This project will build on previous experiences in Torres Strait and other indigenous communities to design an approach for estimating the non-commercial catch of Spanish mackerel, Coral trout and Tropical rock lobster in Torres Strait, including ensuring there is strong community ownership, local partnerships, and the potential for locally engaged fishery monitors.

Erub, Masig, Mer catch (Busallachi, 2008)

Proposed Work

Current project (funded)

1. Review of past and current non-commercial catch survey approaches in Torres Strait and more broadly.
2. Review stakeholder needs (for communities and management) for the collection of catch information over the longer term.
3. Develop an approach for collecting catch information from Torres Strait communities and providing to management agencies and communities for monitoring and assessment.
4. The current project assessment will be considered before any future trial data collection program is started.
5. The current project will be completed by mid-2020.

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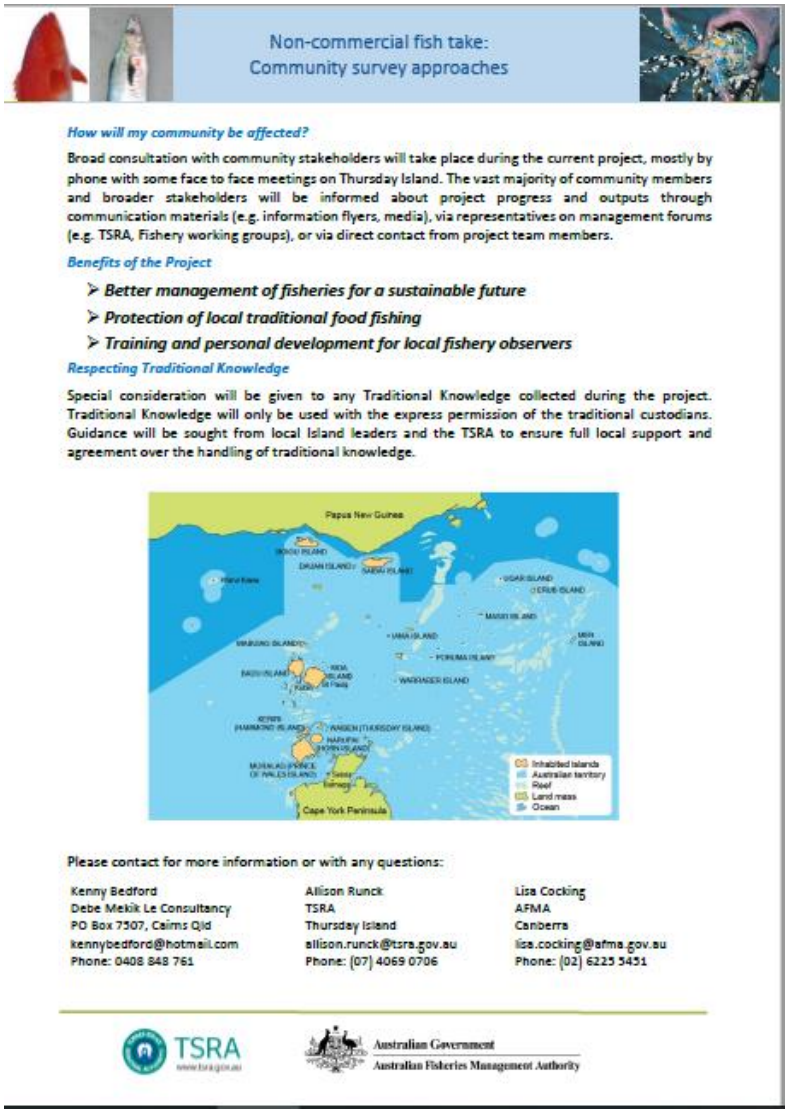

Non-commercial fish take:
Community survey approaches

How will my community be affected?

Broad consultation with community stakeholders will take place during the current project, mostly by phone with some face to face meetings on Thursday Island. The vast majority of community members and broader stakeholders will be informed about project progress and outputs through communication materials (e.g. information flyers, media), via representatives on management forums (e.g. TSRA, Fishery working groups), or via direct contact from project team members.

Benefits of the Project

- ***Better management of fisheries for a sustainable future***
- ***Protection of local traditional food fishing***
- ***Training and personal development for local fishery observers***

Respecting Traditional Knowledge

Special consideration will be given to any Traditional Knowledge collected during the project. Traditional Knowledge will only be used with the express permission of the traditional custodians. Guidance will be sought from local Island leaders and the TSRA to ensure full local support and agreement over the handling of traditional knowledge.

Please contact for more information or with any questions:

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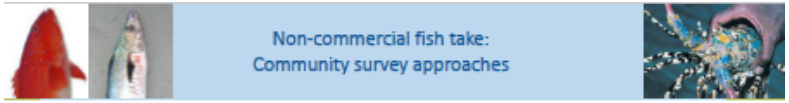
Appendix 4. Pre-project community survey information sheet



Measuring non-commercial fishing (indigenous subsistence fishing and recreational fishing) in the Torres Strait in order to improve fisheries management and promote sustainable livelihoods.

Engagement Strategy - Full-proposal phase

Consultation during the formulation of the full proposal included a broad range of community stakeholders from all Torres Strait communities – for although this project will only carry out pilot catch monitoring on two selected islands, the program will potentially be rolled out across all Torres Strait communities.

Stakeholders contacted included:

- PBC Chairs
- Island Councillors
- TSRA members
- Island Fishery Associations representatives

Note that finfish Working Group and RAG Traditional Inhabitant representatives were contacted through the respective PZJA support structures and will report directly to the TSSAC.

Initial engagement was through email, with follow-up phone calls and face-to-face meetings where possible. The e-mail included an introduction to the project, the project flyer, and requested feedback. Several telephone and face to face meetings were then held with key contacts and a structured questionnaire was used to gauge support, outline any concerns and provide any insights or ideas for project activities and fish monitoring approaches. Individual responses are shown in Appendix 1.

Special consideration was taken with traditional knowledge collected during the consultation. Any knowledge that could possibly be considered as Traditional knowledge was only used with the express permission of the traditional owner.

Summary of responses

Response group	No. surveyed	No. responses received	No. supportive	No. not supportive	Uncertain
PBC Chairs	21	9	7	1	1
TSIRC counsellors	13	2	2	0	0
Community fisher reps	9	1	0	0	1
TSRA board members	20	3	3	0	0
Total*	63	13*	11*	1*	1*

* Some respondents hold more than one position

Summary of responses

Responses from community representatives were mostly positive. Most recognised the importance and benefits of the project. Two suggested their community would be interested in being involved in the pilot program (Masig and Poruma). Two main concerns expressed were: 1) that (some) community members will think that information may be used to restrict their catch/access to the fishery; 2) that recreational fishers are not included in the monitoring.

We reiterated that recreational fishers will be included in the pilot monitoring program. Assuring community members that there is little risk to future fishery access will be important to get community support. This messaging, as well as communicating the benefits for sustainable fisheries will be critical to the success of the project.

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Engagement Strategy – Project phase

Phase 1

Communication and consultation with management and islander representative organisations will take place through correspondence and meetings with the project oversight body. [Note: costs associated with project oversight body, including any potential fee for service, have not been included in the project budget due to uncertainty of membership and potential for incorporation with established consultation processes (e.g. Torres Strait finfish working group).

Key stakeholders to be consulted during this phase will include the TSRA, AFMA, Malu Lamar and Gur A Baradharaw Kod (GBK), Councillors, PBC Chairs, PZJA working group representatives, and the CDP Provider.

Phase 2

We propose to engage a minimum of two outer islands communities to pilot study the monitoring program for both subsistence and recreational fishing. Broad community consultation will occur early in Phase 2 on the two selected island communities.

This will include broad community communication and consultation, with as many people that live in the communities as possible. Targeted consultation will also be held with local PBC chairs, Councillors, TSRA Members and heads of local fishers associations. The local rangers and CDP trainers are potentially key collaborators during the pilot study phase of the project.

A range of communication engagement approaches will be used, including community notices, community meetings, household visits and direct phone conversations. Face to face meetings will be held with community representatives and leadership. We will also take advice on other approaches to inform communities about the project, such as media releases (radio and newspaper articles) and presentations at Working groups etc.

There will likely be a strong training component for locally engaged monitoring support positions (e.g. community monitors, rangers etc).

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Appendix 5. Information request form used during consultation with Traditional Inhabitants

Non-commercial fishery monitoring project - Community views and concerns

Question 1 – Is it important for us to collect data about non-commercial catches

Question 2 - What benefits do you see in collecting and assessing non-commercial fishery catch information for individuals, families and communities?

Question 3 – What are some of the drawbacks or risks of collecting and assessing non-commercial fishery catch information from individuals or communities?

Question 4 – Do you think community members are willing to provide information on local non-commercial fishery catches? Why or why not?

Question 5 – What are the obstacles and how can we overcome them?

Question 6 – About how often would a member of your household fish for kai kai (not commercially)? – No of times per month

Name……(Optional)

Affiliation……(Optional)

Q1 – Why collect catch data
Q2 – Benefits
Q3 – Drawbacks
Q4 – Community attitudes
Q5. – Obstacles
Q6. – How often

Appendix 6. Stakeholder needs and issues – detailed information

a. Stakeholder data needs, data uses and benefits

Stakeholder	Data needs	Data uses and benefits
1. Traditional Inhabitants (community leaders, fishers, Women)	• Annual catches of all fished species in the community • Changes in fishing behaviours and effort • Fishing effort and catch by community sectors (TIB fishers, women, children etc)	• Underpin future commercial fishery for current non-commercial spp (e.g., mackerel from Poruma) • Info to underpin sustainable use of trad/local resources of various non-commercially important spp (e.g., rabbit fish), and for future trad harvest strategies for these spp • Communities can apply Traditional Knowledge and management to fishing practices • Communities can adapt to changes in marine species availability and stock status • Will provide an understanding of socio-economic development needs (e.g., needs by community sectors re sustainable livelihoods, such as tailored support for women fishers)
2. Non-Traditional Recreational fishers (TI residents, visitors)	• Annual catches of all fished species • Restrictions, minimum sizes, local protocols	• Knowledge of which species to target • Knowledge of the current status of potentially fished species
3. Resource/fishery managers (AFMA, TSRA, QDAF)	• Total catch of all individual marine species taken from outside the commercial sectors to inform fishery management decision making, e.g., total annual biomass • The ability to measure changes and trends in total catches and species composition over time • Priorities are Spanish mackerel, coral trout, TRL • The non-commercial catch of TRL is currently assumed as there is little data	• Sustainable management of marine resources, particularly of Traditional fishery resources. • Protection of community access to Traditional fishing resources • Allocation of catch shares to sunset licence holders.

Stakeholder	Data needs	Data uses and benefits
	• Total catch by geographical area to help manage any potential impacts on Traditional fishing and to assess potential stock issues • Data on number of fishers to provide CPUE data to help with fishery characterisation and future trends and assessments • An understanding of the fishing dynamics by gender, age and other factors that drive seafood consumption and its value to the community • Data that uses a risk-catch-cost approach; data that may be used as a 'proxy' for informing a risk-management approach • Data that provides economic information on the contribution fishing makes to the regional economy (QDAF) • Data on the social benefits and importance that fishing provides and means to the local community. (QDAF)	
4. Data assessment & research scientists (QDAF, Uni Qld, CDU)	• Catches/catch rates by species including: species, number, weight and location • Effort: where, when, how many days/hours, gear • Size and sex ratio of species in the catch • Seasonality of catches • Past harvest sizes by species, to help inform the status of the stock • Fishers' observations about trends, spikes/troughs in catches, observations on environment status • Role of fishers and non-fishers in communities to help understand drivers of fishing effort, or who to go for re data collection • Age data from random samples (e.g., frames, otoliths + lengths) • Independent surveys to validate catch data	• Numbers and weights provide information on mean size • Size and sex ratio can indicate health of stock and life history information • Better stock assessments for target species - especially requiring data on catch BY SPECIES e.g., coral trout group split into actual species. • Better advice for sustainable catch recommendations • Very clear and consistent effort metrics. Effort should be by hour but if by day then hopefully fish same length of time over day. Also, effort by dory. If begin using mothership then still stick to effort by dory. • Better advice for sustainable catch recommendations • Better understanding of the social and economic benefits of fishing (QDAF)

Stakeholder	Data needs	Data uses and benefits
	• Abiotic parameter measurements to establish baseline measures and assess for changes in patterns/environmental relationships • Collection of tissue samples for genetic assessments as needs arise; these can be stored for a few years if necessary to potentially inform close-kin genetics studies which would shed light on natural mortality but also importantly on stock connectivity in Torres Strait and GBR etc • Sporadic or regular tissue samples to check for contaminants • Monitoring of parasite diversity and loads to assess a range of dynamics • Record any bycatch impacts – what are the main species caught and discarded – the impacts on bycatch could have repercussions to system health • Economic information on the revenue and costs of fishing, processing	
5. National stakeholders	• Ability to demonstrate success or otherwise through data collection • Community-based data collection • Need to ensure community voices are being heard • Collecting data from a broader range of species supports a more ecosystem-based approach	

b. Monitoring program requirements, constraints and risks

Stakeholder	Program requirements, constraints	Program risks
1. Traditional Inhabitants (community leaders, fishers, others??)	• Program has to be easy contribute to, with small time and technical requirements • Local communities wish to take responsibility of local fisheries and management, therefore monitoring program should support this aspiration. • Monitoring strategies should be co-designed with the community • Clarity on the benefits to local communities • Information collected to be summarised and reported back to communities – an informed community about the need for data collection, as well as the data outputs is critical for their ability to participate in management decisions • Representative community groups are probably good options for holding/managing sensitive data. • Complete transparency about how the data will be used • Communities should have first access to information • Communities have veto power over access to information by outside stakeholders • Identity of individual fishers is protected • Database is controlled by local community, e.g., via research agreements with the community • Identification of data champions to help change the culture for community-based data collection • Needs to be easy for community members to provide data • Design so it can plug into a larger connected system to manage all land and sea resources and provide ability for a wholistic approach to management • Collect data from households rather than just individual fishers	• Community view that data will be used against them • Fisheries closed to Traditional fishing • Community participation/cooperation low due to lack of trust
2. Non-traditional Recreational	• Identity of individual fishers protected • Needs to be easy to provide data	• Local backlash against recreational fishers

Stakeholder	Program requirements, constraints	Program risks
fishers (TI residents, visitors)	• Unobtrusive	
3. Fishery managers (AFMA, TSRA, QDAF)	• Needs to be is replicable through time – including in tight funding scenarios • Frequent enough sampling to fulfil objectives • Needs to be affordable (what is the resources likely to be available?) • Needs to be logistically feasible • Needs to be socially and culturally acceptable to Torres Strait Islander communities • Trust rebuilding based on past program failures: loss of control, intrusions and data sharing issues • Resourcing – limited fund available • Must be equitable and culturally appropriate • Incentivisation to encourage engagement in the program • Transparency re how the data will be used and managed • A working harvest strategy to manage times when catch levels change • Data needs to be representative and accurate (QDAF)	• Potential backlash from communities if it goes wrong • Inaccurate data will result in unsustainable fishing, reduced access by local communities, or lost revenue from sunset licence fees.
4. Data assessment research scientists (CSIRO, QDAF, Uni Qld)	• Need to be regular and ongoing • An overlapping period of data collection between when the commercial sector data is the mainstay assessments to when the Indigenous fishing sector data becomes the mainstay assessments. This will allow the needed calibration between assessments during the period of change. • Species guide to minimise mis-identification, available to all fishers • If any tissue, genetic or other samples taken, need to ensure these are adequately labelled and stored • High quality communication materials and strategy – includes to help focus on providing clear incentives for data collection (eg explaining why TACs need be less conservative as more data become available) and also penalties (which could be converse situation of more conservative TACs) • Should be an emphasis on trust development and maintenance	• Data bias will result in inaccurate stock assessments and potentially over estimated TACs and overexploited stocks; over and underestimates of species catches, in particular • Species mis-identification; especially requiring data on catch by species e.g., coral trout group split into actual species • Very clear and consistent effort metrics. Effort should be by hour but if by day then hopefully fish same length of time over day. Also, effort by dory. If begin using mothership then still stick to effort by dory • Recognition that a proportion of community members will not want to provide information

Stakeholder	Program requirements, constraints	Program risks
	• Ensure database systems are highly confidential – e.g., measures such as only recording large scale location caught or only making this info available at end of season • Build an information database about why people will or will not be involved in providing catch information to help improve program trust and success • High levels of honesty about program drivers, approach and process • Need to take a long-term view about participation of Traditional Inhabitants • Ensure an ethical and culturally appropriate way to the collect the Traditional fishery catch information • Clarity on data infrastructure (where the information is recorded) • Need to ensure appropriate cultural authority, governance and process over the information & cultural (e.g., approval of the data during a PBC meeting) • Need for a genuine co-management approach re managing stocks • Another helpful way to communicate the benefits of shared data is to share information on local and international market prices etc so that these are transparent and fishers are more empowered about the supply chain • Data needs to be representative and accurate (QDAF)	
6. National stakeholders	*Improved data on Aboriginal and Torres Strait Islanders fisheries resource use* DRAFT Workshop 2 Outcomes Report (FRDC Project 2018-016). Some overarching principles or requirements were identified, including: • Data collected by community is owned by community. Community want to manage the data they collect. • Sharing of data by community is a choice, including what data are shared and how they are shared. • Community, at this current point in the relationship, do not want government to know about the cultural information. Government need	•

Stakeholder	Program requirements, constraints	Program risks
	to have trust in the Traditional Inhabitants and community regarding their ability to manage their resource use. • The data collection process should be driven and led by community (facilitated by Government) to create investment and ownership within the community. It should include capacity building and / or economic opportunity for the community. • Survey methods should be as simple as possible. • A formal agreement covering all aspects of the co-development of the data collection methodology must be developed and signed. **Other national stakeholders** • Validating of fisher-dependent data collected	

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