# Fishing for knowledge

## Robustly and ethically documenting fishers' local ecological knowledge of the marine environments in Western Australia

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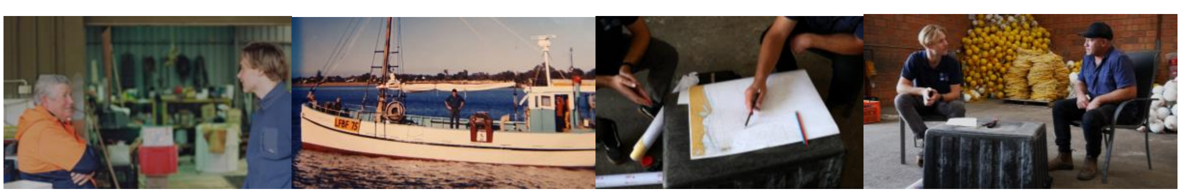

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# Contents

# EXECUTIVE SUMMARY

Fishing For Knowledge is a multi-year project funded through the Australian Governments' Our Marine Parks Grant program to explore the ecological knowledge held by Western Australian (WA) professional fishers (aka commercial fishers). The project had three main aims:

1. To understand the nature of professional fishers' knowledge
2. To understand the depth and breadth of fishers' knowledge
3. To identify principles for engaging with fishers' knowledge

The research approach involved extended (multi-hour) interviews with 36 professional fishers in WA, identified by their peers as being key knowledge holders. The knowledge of these fishers reflects experiences and observations made in 14 different fisheries across 3,500 km of coastline (Figure 1) across multi-decade careers as skippers of commercial fishing vessels. Extended interviews allowed a depth of understanding of professional fishers' knowledge that could not be gained through quantitative approaches (e.g., surveys).

**Aim 1: Understand the nature of professional fishers' knowledge**

The interviews highlighted that fishers' knowledge consisted of practical knowledge gained through direct observation and experience on-the-water and theoretical knowledge in which fishers theorise about causality behind their observations. Experimentation was also widely used amongst fishers to validate their interpretations.

A fundamental throughline in the interviews was the importance of context. What fishers were knowledgeable on and their knowledge itself was shaped by the gear, target species, geographic extent, time in the industry, whether they are part of a multi-generational fishing family and management settings.

**Aim 2: Understand the depth and breadth of fishers' knowledge**

Professional fishers in WA were highly knowledgeable on a diverse range of topics. Fishers discussed 32 discrete topics, falling broadly into nine categories including (amongst others): target species ecology, habitats and fishing grounds, non-target species including rare and threatened species and technology creep. Many fishers shared knowledge on topics beyond their target species, highlighting the broad basis of their knowledge, and the potential to engage with fishers' knowledge on a wide range of scientific and management questions.

As illustrative examples of fishers' knowledge, and with permission of the fishers interviewed, we present five case studies of fishers' knowledge in WA on a range of topics including: impacts of the 2011 marine heatwave on ecosystems in the South West, dynamics surrounding the sardine fishery following major fish kills, target species stock health and historic trends, mackerel aggregation sites, and grey nurse shark life histories and aggregation sites. As well as providing information of direct relevance to management, these case studies highlight the depth of knowledge fishers have, and the potential for fishers' knowledge to extend current scientific understanding.

**Aim 3: Principles for incorporating fishers' knowledge into research and decision making**

The interviews demonstrate the potential for knowledge exchange between professional fishers of WA and managers of marine ecosystems, including Parks Australia. The knowledge accumulated within the professional fishing industry of WA is substantial, wide-ranging and highly valuable for management. Fishers also expressed interest in sharing their knowledge and being involved in knowledge co-production (e.g., partnering with scientists to conduct research).

To help facilitate engagement with fishers' knowledge we have synthesised five principles. These principles are based on the interviews with WA professional fishers and reflect some of their key concerns expressed by fishers as well as insights about the nature of fishers' knowledge.

**Principle 1 Respect fishers' knowledge:**
Scientists and managers engaging with fishers' knowledge should ensure they frame their research in a way that respects the knowledge fishers hold.

**Principle 2 Contextualise fishers' knowledge:**
Fishers' knowledge is shaped by context (gear, geographic location, management settings). Interpreting fishers' knowledge requires that it is contextualised.

**Principle 3 Avoid negative outcomes for fishers:**
Fishers' knowledge is a professional asset that has been hard earned. It is important that managers and researchers are cognisant of this and apply techniques like giving fishers final say on knowledge sharing to avoid real or perceived negative outcomes.

**Principle 4 Build long-term collaborative partnerships:**
Fishers preferred to be part of long-term collaborative partnerships in which trust is built and they can see how their knowledge is being applied.

**Principle 5 Ensure two-way knowledge exchange:**
Knowledge exchange should include both fishers and scientists/managers sharing information on an equal footing.

# 1. INTRODUCTION

Human populations around the world rely on the ocean and the ecosystem services it provides for food, livelihoods, medicine, recreation, and wellbeing (Costanza *et al.*, 1997). Our ability to optimise marine management to ensure the delivery of these ecosystem services is dependent on our knowledge of how marine ecosystems function. Whilst Australia is a world leader in marine science, critical gaps exist in knowledge of marine habitats (Lucieer *et al.*, 2019), species migration patterns (Wilson *et al.*, 2006), historical abundances (Obregón *et al.*, 2022), and environmental responses to pressures (Cheung *et al.*, 2012; Webster *et al.*, 2018) amongst many other topics. These knowledge gaps extend into the Australian Marine Parks (AMPs) which have been established under federal environmental law in Commonwealth waters. Parks Australia manages Australian Marine Parks to protect and conserve biodiversity and support ecologically sustainable use and enjoyment of the natural resources.

To fill these knowledge gaps, managers have often relied upon scientific research. In recent years, mapping of the seafloor within AMPs has progressed substantially using technology like multi-beam surveys (Case *et al.*, 2019; Przeslawski *et al.*, 2020). Similarly, new campaigns have helped characterise fish assemblages using Baited Remote Underwater Video, Drop Camera systems and Remotely Operated Vehicles (Post *et al.*, 2020; Langlois *et al.*, 2021). Whilst these efforts are laudable, there are other knowledge systems with a long history in Australia's waters that are often under-acknowledged. Aboriginal and Torres Strait Islander peoples in coastal regions possess substantial knowledge of Sea Country, drawing on a continuous oral tradition and culture spanning thousands of years (Davies *et al.*, 2020; Kearney, O'Leary and Platten, 2023).

Professional fishers also have substantial knowledge of marine systems, gaining this knowledge through direct interaction and reliance on the ocean for their livelihoods (Johannes, Freeman and Hamilton, 2008; Hind, 2014). Professional fishers spend their lives on the water and are constantly interacting with marine systems. They are natural observers of the ocean, taking note of changes that go unseen to others, and gaining unique insights into how ecosystems function (Johannes, Freeman and Hamilton, 2008). Studies around the world suggest that the knowledge fishers' accumulate is a potentially rich foundation on which to base our understanding of the ocean, and to think about ways of managing ocean health (Johannes, Freeman and Hamilton, 2008; Hind, 2014; Stephenson *et al.*, 2016). However, to date there has been only limited research on professional fishers' local ecological knowledge in Australia (Thurstan, Bey and Pandolfi, 2016; Noble *et al.*, 2020), and especially Western Australia (Shaw, Stocker and Noble, 2015; Obregón *et al.*, 2022).

From a policy perspective, the importance of Local Ecological Knowledge in addressing key knowledge gaps is increasingly being recognised. The importance of Local Ecological Knowledge is acknowledged within United Nations Convention on Biological Diversity Article 8j (United Nations, 1992), Article 7.5 of the Paris Agreement (Paris Agreement, 2015), and the Transformations document of the high Level Panel for a Sustainable Ocean Economy (High Level Panel, 2020).

With funding from the Australian Governments Our Marine Parks Grants, the Fishing For Knowledge project was established as a multi-year project to explore the ecological knowledge held by Western Australian (WA) professional fishers. While a key focus was on ecological knowledge of waters within the AMP's, the broader objectives were to assess the value of fishers' knowledge for marine management in WA, and to make recommendations about how best to work with WA fishers to further our understanding of marine environments. The project has been conducted by an interdisciplinary team of University of Western Australia researchers, with the guidance and invaluable participation of professional fishers across WA.

## 2. AIMS AND OBJECTIVES

The Fishing For Knowledge project aims to document and understand how scientists and managers can better engage with and learn from professional fishers in the WA context.

To achieve this, the project had three main objectives:

1. Understand the nature of professional fishers' knowledge, including how fishers gain their knowledge, how knowledge is shared within and outside of the fishing community, and how fishers validate and use their knowledge.

   *Rationale: for managers and scientists to engage effectively with fishers' knowledge they must know where it comes from and what it represents.*

2. Understand the depth and breadth of what fishers know about marine systems in WA and how this knowledge varies across regions and fisheries.

   *Rationale: for managers and scientists to engage effectively with fishers' knowledge they must know which topics fishers are knowledgeable on.*

3. Identify principles to guide Parks Australia and other marine management agencies in engaging with and incorporating fishers' knowledge into management decisions.

   *Rationale: fishers' knowledge represents a form of intellectual property; it is often the basis of fishers' livelihoods and cannot always be shared. We identify principles that allow scientists and managers to engage with professional fishers in ways that are mutually beneficial, or at least do not compromise fishers' livelihoods.*

# 3. METHODS

The research approach for Fishing For Knowledge relied on long-form semi-structured interviews with knowledgeable professional fishers across Western Australia (WA). These interviews spanned the WA coast, with discussions of fishers' knowledge encompassing, but not limited to areas within the North-west and South-west networks of Australian Marine Parks.

## 3.1 Background

### 3.1.1 Commercial fisheries of Western Australia

Western Australia's coastline spans over 12,000 km. More than 50 professional fisheries (not including charter operators) operate across this region, many of which are small-scale (e.g., with just 1 - 2 operators in the fishery).

The Western Rock Lobster (*Panulirus cygnus*) (WRL) fishery is the state's largest professional fishery in terms of total production and Gross Value Product (GVP). Other key fisheries include demersal scalefish fisheries (predominantly targeting Snapper (*Chrysophrys auratus*) and West Australian Dhufish (*Glaucosoma hebraicum*), and the shark gillnet fishery (predominantly targeting gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*Carcharhinus plumbeus*). In addition, there are prawn trawl fisheries, a scallop trawl fishery, a mackerel fishery, abalone fisheries, an octopus fishery, a seine fisheries targeting nearshore pelagic fish, and many others. Due to the seasonality and relatively low productivity of some of the key fishery resources, fishers often hold multiple professional licences and rotate through different target species to secure income year round, particularly on the south coast of WA (Molony *et al.*, 2011).

## 4.2 Interviews

The research approach involved conducting long-form interviews with key knowledge holders in the professional fishing industry across WA. As many fishers currently operate or have previously operated across their careers in multiple fisheries, the identification of knowledge holders was at the level of individual fishers rather than fisheries. To identify key knowledge holders we used the approach recommended by Davis and Wagner (2003), using peer recommendations to identify key knowledge holders. Each fisher interviewed was asked to identify up to 10 other particularly knowledgeable fishers. Fishers were then ranked according to the number of recommendations they received, and the order of interviews was determined based on these rankings where possible (Davis and Wagner, 2003).

Interviews were one-on-one and face-to-face as per literature recommendations (Drescher *et al.*, 2013; Deshpande, Brattebø and Fet, 2019). The interview items were open ended, and fishers were encouraged to steer the conversation to allow knowledge topics and contextual information to emerge naturally. Participants were first asked broad questions about their fishing career, which were followed by a series of more in-depth questions about their knowledge acquisition and sharing. Finally, fishers were asked about knowledge topics that they felt they were particularly knowledgeable about, and which of these they would be comfortable sharing. These conversations were guided using the Interview protocol in Appendix 1.

The interviews were automatically transcribed using Otter.ai transcription software, and transcripts were manually checked by the lead author for errors and corrected for accuracy. Transcripts were then analysed using qualitative thematic coding guided by the 'theoretical' thematic analysis (Braun and Clarke, 2006). Three overarching themes were identified in interview data; (1) knowledge acquisition, (2) knowledge transfer, and (3) depth and breadth of fishers' knowledge. For key theme (1), transcripts were filtered for any passages where fishers described or inferred learning mechanisms. These passages were then used to develop a conceptual model characterising the flows of knowledge in fishers' knowledge systems, focusing primarily on the transition of knowledge from tacit to explicit forms. Key theme (2) related to knowledge transfer within and outside of the fishing community. Themes identified under knowledge transfer were within fishing-community sharing including intergenerational knowledge transfer, and fishers' knowledge transfer with western-scientific knowledge systems. The final key theme focused on the depth, breadth and contextual drivers of fishers' knowledge.

# 5 RESULTS AND DISCUSSION

Thirty-six professional fishers identified as key knowledge holders in their respective fishing communities were interviewed over the project duration. The knowledge of these fishers reflects experiences and observations made in 14 different fisheries across 3,500km of coastline (Figure 1). All participants had at least 10 years of experience as the skipper of a commercial fishing vessel, and several had over 50 years of experience (Table 1).

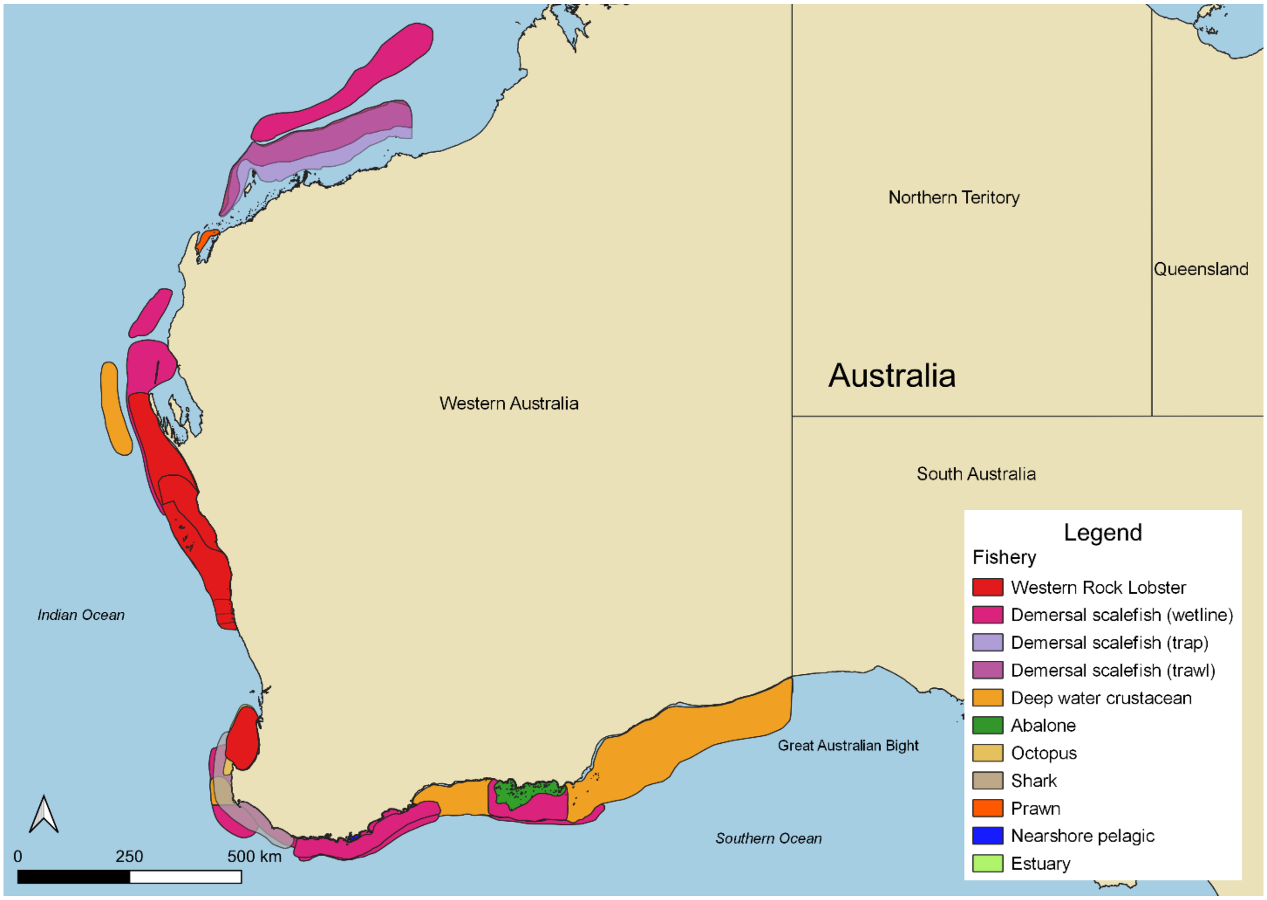


Figure 1. Approximate fishing extent of interview participants. Each polygon represents the extent of an individual fisher. Polygons representing fishers who operate in multiple fisheries concurrently have been coloured according to that fishers' primary fishery. Note, some legend entries are not visible at the map scale due to their relatively small extent. Also note, the mackerel fishery was omitted from the legend as both mackerel fishers interviewed opportunistically catch the species while targeting demersal scalefish.

Table 1. Summary of interview participants. The fishing region acronyms represent Western Australia's fisheries bioregions: NC (North Coast), GC (Gascoyne Coast), WC (West Coast), and SC (South Coast). Note, gear type was specified in the fishery column if the resource could be targeted using a number of different gears. All participants were male.

| Fisher ID | Fishing region/s | Current or most recent fishery | Years skippering | Recommendations received |
|---|---|---|---|---|
| 1 | WC (Dongara) | Western Rock Lobster | 40+ | 1 |
| 2 | WC (Dongara) | Western Rock Lobster, demersal scalefish (wetline) | 30+ | 4 |
| 3 | WC (Perth Metropolitan area, Mandurah) | Western Rock Lobster | 20+ | 2 |
| 4 | WC (Perth Metropolitan area, Mandurah) | Octopus | 60+ | 3 |
| 5 | WC (Abrolhos) | Western Rock Lobster | ~20 | 1 |
| 6 | WC (South-west Capes) | Demersal scalefish (wetline) | 20 | 3 |
| 7 | WC (South-west Capes) | Western Rock Lobster, Southern Rock Lobster, deep-sea crab | 40 | 2 |
| 8 | WC (Cervantes) | Western Rock Lobster and demersal scalefish (wetline) | 10+ | 2 |
| 9 | WC (Kalbarri) | Mackerel and Western Rock Lobster | 45 | 2 |
| 10 | WC, GC (Kalbarri, Shark Bay) | Demersal scalefish (wetline) | 35+ | 4 |
| 11 | WC, SC (Augusta) | Shark (gillnet) | 40+ | 2 |
| 12 | WC (South-west Capes) | Sardines, whitebait, herring, salmon | 40 | 3 |
| 13 | SC (Albany) | Sardine, herring, salmon | 45+ | 2 |
| 14 | SC (Albany) | Sardine, herring, salmon | 15 | 3 |
| 15 | SC (Albany) | Sardine, demersal scalefish (wetline), Southern Rock Lobster, deep-sea crab | 40 | 2 |
| 16 | SC (Albany) | Sardine, demersal scalefish (wetline) | ~30 | 1 |
| 17 | SC (Albany) | Estuary, demersal scalefish (wetline) | 30+ | 2 |
| 18 | SC (Albany) | Demersal scalefish (wetline), salmon, estuary, shark, herring | 55 | 3 |
| 19 | SC (Albany) | Estuary, demersal scalefish (wetline and trap), squid | 30 | 2 |
| 20 | SC (Esperance) | Demersal scalefish (wetline and trap) | 35 | 1 |

| | | | | |
|---|---|---|---|---|
| 21 | SC (Esperance) | Sardines, demersal scalefish (wetline and trap) | 10+ | 4 |
| 22 | SC (Esperance) | Demersal scalefish (wetline) | 10+ | 2 |
| 23 | SC (Esperance) | Abalone | ~50 | 1 |
| 24 | SC (Esperance) | Southern Rock Lobster, octopus | ~40 | 3 |
| 25 | WC (Cervantes) | Western Rock Lobster | 20 | 2 |
| 26 | WC (Dongara) | Western Rock Lobster | 55+ | 3 |
| 27 | WC (Geraldton) | Western Rock Lobster | 40 | 1 |
| 28 | GC (Shark Bay) | Deep-sea crab | 50+ | 2 |
| 29 | GC (Coral Bay) | Demersal scalefish (wetline) | 10+ | 2 |
| 30 | GC (Coral Bay) | Demersal scalefish (wetline) | ~30 | 3 |
| 31 | GC, NC (Exmouth) | Demersal scalefish (wetline), prawn | 20 | 2 |
| 32 | GC, NC (Exmouth) | Demersal scalefish (wetline), prawn | 30+ | 2 |
| 33 | GC, NC (Exmouth) | Demersal scalefish (wetline) | 30+ | 1 |
| 34 | NC (Karratha) | Demersal scalefish (trap and trawl) | 10+ | 1 |
| 35 | WC (Bunbury) | Shark (gillnet) | 50+ | 2 |
| 36 | WC (South-west Capes) | Demersal scalefish (wetline) | 30+ | 2 |

## 5.1 The nature of professional fishers' knowledge

### 5.1.1 A model of knowledge creation

New knowledge can arise within local knowledge systems in a range of ways, including empirical observation, spirituality, intuition and introspection (Varghese and Crawford, 2021). Whilst many models could be applied to help understand knowledge creation in the Western Australian (WA) professional fishing industry, successive interviews suggested utility in a model that distinguishes between practical knowledge and theoretical knowledge (Figure 2). Practical knowledge describes the tacit knowledge that fishers' gain through and apply to their fishing practices. As this knowledge is tacit, fishers often found it hard to describe.

> Fisher 4: *I took [fisher name] down to the Beauvards and set pots.. and he, after about a quarter of them he said, "You haven't looked at the computer once". And I said, "Nah it's all up here mate [pointing to head]". It just becomes a natural instinct, you know.*

> Fisher 17: *I suppose it just comes down to a gut feeling*

For many fishers this tacit knowledge was often converted into a more explicit theoretical knowledge independent of fishing practices. This theoretical knowledge would often start as an explicit description of the trend that was underlying the tacit knowledge; so called practice-based theories. However, some fishers would then take this observation further and describe the causal mechanism that sits behind the observation. We refer to these deeper theories of causality as interpretive theories.

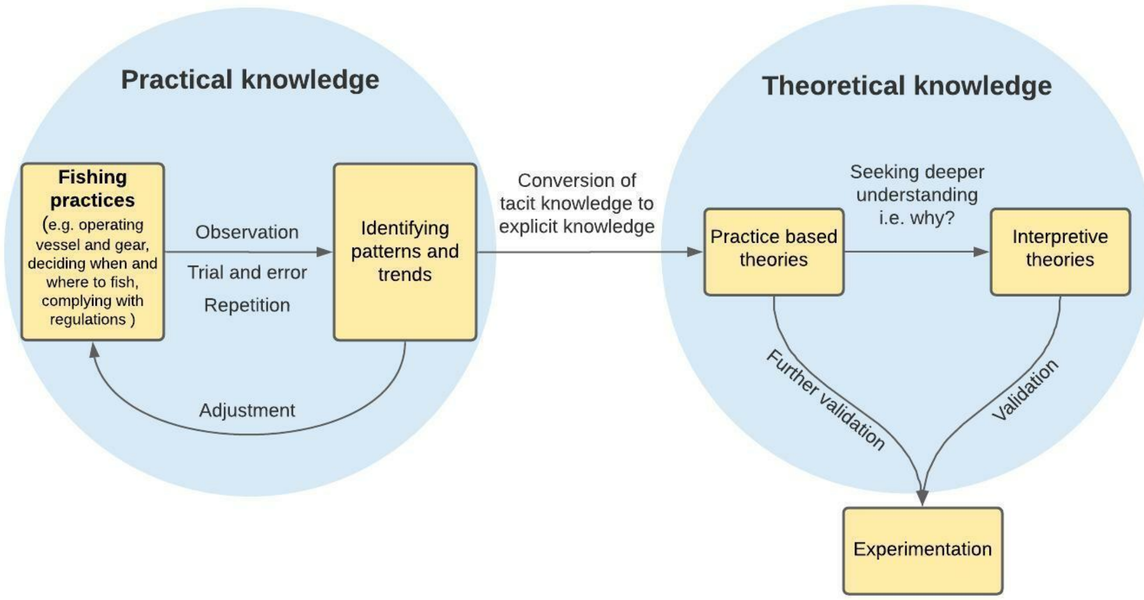


Figure 2. A conceptual model representing the mechanisms for knowledge creation in the fishers' knowledge systems of Western Australia.

To better understand the flow of knowledge into the professional fishing industry of WA, an illustrative example is useful. In interviews with Western Rock Lobster (WRL) fishers, a common theme was the observation that catch rates were often higher in larger swells. This knowledge is actively used by fishers who would fish in larger swells despite the risks and discomfort. As this knowledge is actively applied to fishing practices is it best described as practical knowledge. However, this knowledge also exists outside of fishing practices, and is at this stage a well-developed theory that can be used by managers to help understand trends in catch per unit effort data. As the knowledge arose from practice (practical knowledge) but is now being applied outside of practice (e.g., used by researchers or managers) this is a practice-based theory. Finally, some fishers generated theories about why lobster catches increased with swell (interpretive theories).

The distinction between tacit practical knowledge, practice-based theories and interpretive theories has important implications for the application of fishers' Local Ecological Knowledge to management. A key observation throughout this study was that practice-based theories emerged with high consensus among participants from similar contexts, whereas interpretive theories were more variable. Referring back to the swell example from above; all interviewed WRL fishers described a similar relationship between swell and catch rates, but at least 3 different interpretive theories emerged explaining why swell might increase catches (see three examples below).

Fisher 1: *When you get the low pressure systems come in, and then you've got the warm water on top, maybe, and it's getting rolled down to the bottom, is that what stirs them up [makes the lobster more active]?*

Fisher 8: *Works on the food chain, you know? Crays*[1] *don't want to be out when the fish can see them. Because then they eat them, you know.*

Fisher 4: *Get shook up a bit down there I think. Rattles em' and they move around.*

Critiques of Local Ecological Knowledge have often focussed on divergences in interpretive theories, dismissing this knowledge as anecdotal and unreliable (Gendron and Camirand, 2000; Gunn, Arlooktoo and Kaomayok, 1998). In doing so, the consistent practical knowledge and practice-based theories are often also dismissed. As such, we suggest that a more considered approach to fishers' knowledge and its value to management should distinguish between interpretive theories and practical knowledge as different forms of knowledge derived from separate (but related) knowledge creation mechanisms.

The use of experimentation by fishers within the WA professional fishing industry was also raised by interviewees suggesting its importance as a key element of knowledge creation in this context (Figure 4). Many fishers described conducting experiments, often outside of their fishing activities, to attempt to validate or gain new perspectives on the practice-based knowledge they had developed. For example, one fisher noticed that octopus catches would slowly decline with prolonged periods of trap submergence. Upon observing natural octopus habitats while diving, he hypothesised that octopus prefer cleaner habitats. He started cleaning traps more regularly, and catches remained higher thereafter.

Fisher 4: *The catch rate was starting to go down… When I was diving and you come to an occy lair, he had no slime in his hole, there was always nice shiny bits and pieces of rocks and all that stuff… So I picked up the line of 60 [traps] one day, I brought them home and I cleaned them all up, but I left the marks on the plotter. When I cleaned them all up, I took them back out and dropped them on those marks. The day I pulled them out [prior to cleaning] I got 22 occies out of 60 pots. I went back seven days later and pulled those pots that were all nice and clean and got 135… Every time we did that to a line of pots the catch rate went through the roof.*

Another fisher in the wetline fishery described keeping detailed notes of catches and a range of difference variables to detect patterns.

Fisher 6: *I keep a log of everything; the weather, the moon, the water temps, currents… yeah, the whole lot. There's patterns and it's taken a long time to get a pattern. That's why I say it's like a 10 to 12 year apprenticeship, it's more to get a pattern. You know, something you can sort of look back on in years to come. If we get a year that was similar to this year*

[1] "Crays" refers to the Western rock lobster.

> *or similar to last year and you can't find fish, you sort of go back through your diaries, and, 'oh yeah this is where they were that year, it was quite similar, so maybe we'll try that'. And they might be there. A lot of its mental now too – probably don't write it down as religiously as what I used to. Because you start getting patterns.*

Some fishers also engaged in other marine based activities such as diving and surfing, and described how the knowledge accrued from these activities helped their fishing. For example, fishers who engaged in recreational diving described how it allowed them to visualise features displayed on their echo sounders.

> Fisher 32: *The good thing with spearfishing, especially when you get a bit deeper, is you really get to see what your sounder looks like in the flesh.. Definitely with reading sounders, it's good. And the other thing I found it's good for is current… you know, watch fish behaviour in the flesh.*

### 5.1.2 Knowledge transfer

Knowledge transfer both within the fishing industry, and externally are important processes. In this section we explore two key themes that emerged through the interviews: knowledge transfer through multi-generational fishing families, and knowledge transfer between fishers and scientists.

#### *5.1.2.1 Intergenerational knowledge transfer*

Two broad fisher archetypes emerged from interviews that reflected the type and level of guidance fishers received upon entering the commercial fishing industry. Fishers either came from multigenerational fishing families and received considerable guidance from their predecessors, or entered the industry with no family ties. First generation fishers generally described an extremely steep learning curve during the transition from apprentice to vessel operator. A first generation abalone fisher, for example, described how his skipper taught him the bare minimum, and that most of his learning came from time spent in the water;

> Fisher 23: *He [previous skipper] took me out for two days and said this is what you do. I said ok, that's good. And I used his decky for a little while. He took me to probably the two worst places I've ever bloody dived, I never go out there anymore. So you just learnt yourself. It's just a matter of putting the effort in and just doing a lot of swimming for nothing, lots and lots of swimming. Just getting in the water every week, get a feel for where their habitat is, where they prefer to be, around an island or headland.*

In contrast, fishers with family ties to the industry often inherited highly specialised knowledge about their target species.

> Fisher 19: *I'm the fourth generation. We started here back in the early 40s, and it's just been handed down to us through the generations. So it's something that's bred into you, you learn it from an early age. Spent a lot of time out on the water and obviously with them*

> *in the shed mending and making nets and stuff, so you pick it up pretty early hey, what's going on and how you fish.*
> *Yeah both of them, my father and my grandfather. So yeah, both of them guys taught me pretty well. My grandfather was a very good fisherman, hard man. But yeah, they taught us everything that we needed to know, yeah.*
>
> Fisher 14: *The herring's the same, like, learnt from dad and pop, like, what weather patterns you can't set in. Because, you know, by the morning, the net would be out of shape and there wouldn't be any fish in it. Or it would have dragged its anchors and started to disappear on you, which you never want. So I certainly learned all of that from them.*
>
> Fisher 34: *I was fortunate enough to have done a little bit of fishing with me grandfather, quite a bit of fishing with my father, before we went out on our own. So basically, yeah, I was pretty well taught by the whole family because most.. all bar one of my uncles were also fishermen.*

Though the intergenerational transfer of knowledge allowed a great deal of knowledge to accumulate in multigenerational fishing families, some of the practical knowledge that transitioned from one generation to the next was made redundant by major shifts in fishing operations driven by environmental change, species behavioural changes, regulation changes, technological advancements, social change and market shifts.

> Fisher 14: *Pop was the first one to catch sardines in Albany, successfully. So he had a lot of experience from the, probably the late 60s through to the.. probably the late 80s, early 90s. Dad fished a lot through the 80s and 90s. But then there was a massive virus that come through in 95 and 98, that killed like 98% of the stocks, sardine stocks. Since then the fishery's changed. Because so many of the fish got wiped out, their behaviour changed, their feeding habits changed. So the fishery has completely changed. So the fishermen that fished in the 80s successfully couldn't just jump on a boat now and start up like they would have back then, they wouldn't catch anything. It's completely different. So it was probably better starting with, you know, a fresh set of eyes and ears and working it out for myself, rather than sort of lingering on what used to happen and why it's not happening anymore.*
>
> Fisher 36: *..because technology's changed. They [their father's generation] had no idea. Like they used to just go on land marks, they used to run nets out and if they ran over fish on the way home they'd fish them. Whereas we actually target them with our GPSs and stuff like that. You know, different technology. Basically advanced what they did.*

The need to respond to changing conditions makes professional fishers' knowledge in WA relatively dynamic with some transfer between generations, but also adaptation and new practical knowledge creation injected to maintain viability.

#### *5.1.2.2 Fishers' knowledge transfer with science*

Knowledge transfer between fishers and scientists in WA emerged as a key theme in the interviews, though the extent of transfer differed significantly between fishers interviewed and across fisheries. Some fishers regularly engaged with scientists and described two-way transfers of knowledge, others felt that exchanges were unidirectional, and some had very few personal or professional interactions with scientists altogether.

> Fisher 32: *They [fisheries scientists] don't ask us much. They might normally just tell us a lot.*

The level of fisher-scientist knowledge exchange seemed to differ across fisheries. Interviewed fishers from high Gross Value Product (GVP) fisheries, such as the WRL fishery, often described high levels of knowledge sharing with the scientific community. WRL fishers, for example, were often engaged for their knowledge, and scientists regularly updated these fishers about research outputs relating to the fishery. Some WRL fishers also collaborated with researchers on science projects, where mutual learning took place. Accordingly, WRL fishers described that scientists were familiar with fishers' unique perspectives, and vice-versa.

> Fisher 26: *I was on the Rock Lobster Advisory Committee which was an advisory group made up of a couple of fishermen from each zone I think, if I remember, and a couple of processors and the government guys. It worked really well in the early days when we did all the effort reductions and season shortening and pot reductions, and we worked with all the early scientists.*

In contrast, interviewed fishers operating in smaller GVP fisheries such as demersal wetline and sardine, described that they were rarely approached by scientists about their specialised fishery knowledge. Some were disgruntled by this and expressed that a fishery can only be managed effectively if scientists have both practical and theoretical knowledge about said fishery (Table 2).

Table 2. Example quotes from interviews of WA professional fishers from small scale fisheries on their level of interaction with scientists and managers.

| Fisher ID | Region/fishery | Example |
|---|---|---|
| 32 | North, wetline | *They [fisheries scientists] don't ask us much. They might normally just tell us a lot.* |
| 10 | Midwest, wetline | *I've never known a snapper [researcher].. anybody, a research officer, to go out on a wetline boat out of here. The whole time I've been here. And the only* |

| | | |
|---|---|---|
| | | *guys that have been out, that I know of, is the odd one that's gone out to the Abrolhos Islands, you know. They don't even come out on boats to even know what we're doing.* |
| 13 | Albany, herring and sardine | *So the old days, the researchers would come to the beaches, they'd see you operating, they'd come in the season, because it's all seasonal, talk to you about it, look at the fish, come to the factory, get the samples, cut em' up, do the aging and stuff and everything was fine for 40, 50 years.* |
| 15 | Albany, sardine | *The only researchers we have on our boats now is for purse seine fishing, for protected species.* |
| 17 | Albany, estuary | *The researchers actually running the project we don't see very much of.* |
| 12 | SW capes, sardine, herring, salmon and whitebait | *So I left school when I was 16 and I'm 54 now and I've had one research bloke come out on the boat. And I haven't seen a research person on the beach. So it's a bit sad that you don't get the opportunity because I'm sure that there's things we see and do..[trails off].* |

The lack of engagement of fishers in low-value fisheries with scientists may be by chance among interviewees, but also reflects trends in the allocation of management resources, with more allocated to high GVP fisheries than lower GVP fisheries. Unfortunately, this likely means there are fewer opportunities for fishers' knowledge to be translated into science and management, potentially to the detriment of the fishery.

> Fisher 2: *The gap between what the scientists are saying and the [Western Rock Lobster] fisherman think is probably really close. With the wetline stuff, we are way ahead of the science.*

Whilst resource allocation may be lacking in low-value fisheries to engage with fishers' knowledge, conversely fishers' knowledge may present an opportunity to expand the knowledge base of these fisheries at low cost. Interviewing and listening to the observations of fishers in a systematic way may be a cost-effective way to inform the management of these fisheries in the absence of budgets for comprehensive monitoring.

The integration of knowledge systems (scientific, local and Indigenous) to inform management is an important area of research with many challenges. In some instances, fishers' expressed frustration that their knowledge was not listened to or acted upon by scientists.

> Fisher 26: *We were telling them that the breeding stock was down in the 90s... What I should have done was written a paper on it. Then they can't walk away from it. Because if you just tell them at meetings, no notice is taken of these verbal reports, or any investigation carried out. I only realised this much later, and any matter I brought up later written up in a formal way was given attention.*

Such barriers between knowledge systems are relatively common (Johannes, Freeman and Hamilton, 2008). However, other barriers between knowledge systems often found in Local Ecological Knowledge research were not present for WA professional fishers. In particular, previous research has identified unwillingness in some cases amongst local knowledge holders to have their knowledge "tested" using scientific approaches as doing so might re-enforce extractive science principles and undermine the validity of non-scientific knowledge systems (Hart, Leather and Sharma, 2021). Contrary to these cases, professional fishers in WA were encouraging of scientists making increased use of their knowledge and testing their observations using scientific approaches. Some fishers advocated for greater involvement or consultation for science projects, especially when research projects were related to their fishery. Further, those who had collaborated with scientists on research projects often felt empowered.

> Fisher 7: *I contributed to the biology of the king crab from Deakin University. I've got a good friend there. And he set up a logbook. And also an observer came out and was tagging the king crab. At the time king crab was a virgin stock, and it was really useful work.*

This highlights the potential for collaborative projects between WA professional fishers and scientists to be rewarding to both researchers and fishers.

## 5. 2 Breadth and depth of professional fishers' knowledge

The interviews revealed that professional fishers in WA held knowledge on a diverse range of topics. Fishers discussed approximately 32 different topics, falling broadly into 9 categories summarised in Figure 3. This included target species ecology, oceanography, bycatch, observations of non-target species, temporal variations in catch, ocean conditions affecting fish behaviour, the state of the fishery, habitat and grounds, and technology creep. Interestingly, many fishers shared knowledge on topics beyond their target species, highlighting the broad basis of their knowledge, and the potential to engage with fishers' knowledge on a wide range of scientific and management questions.

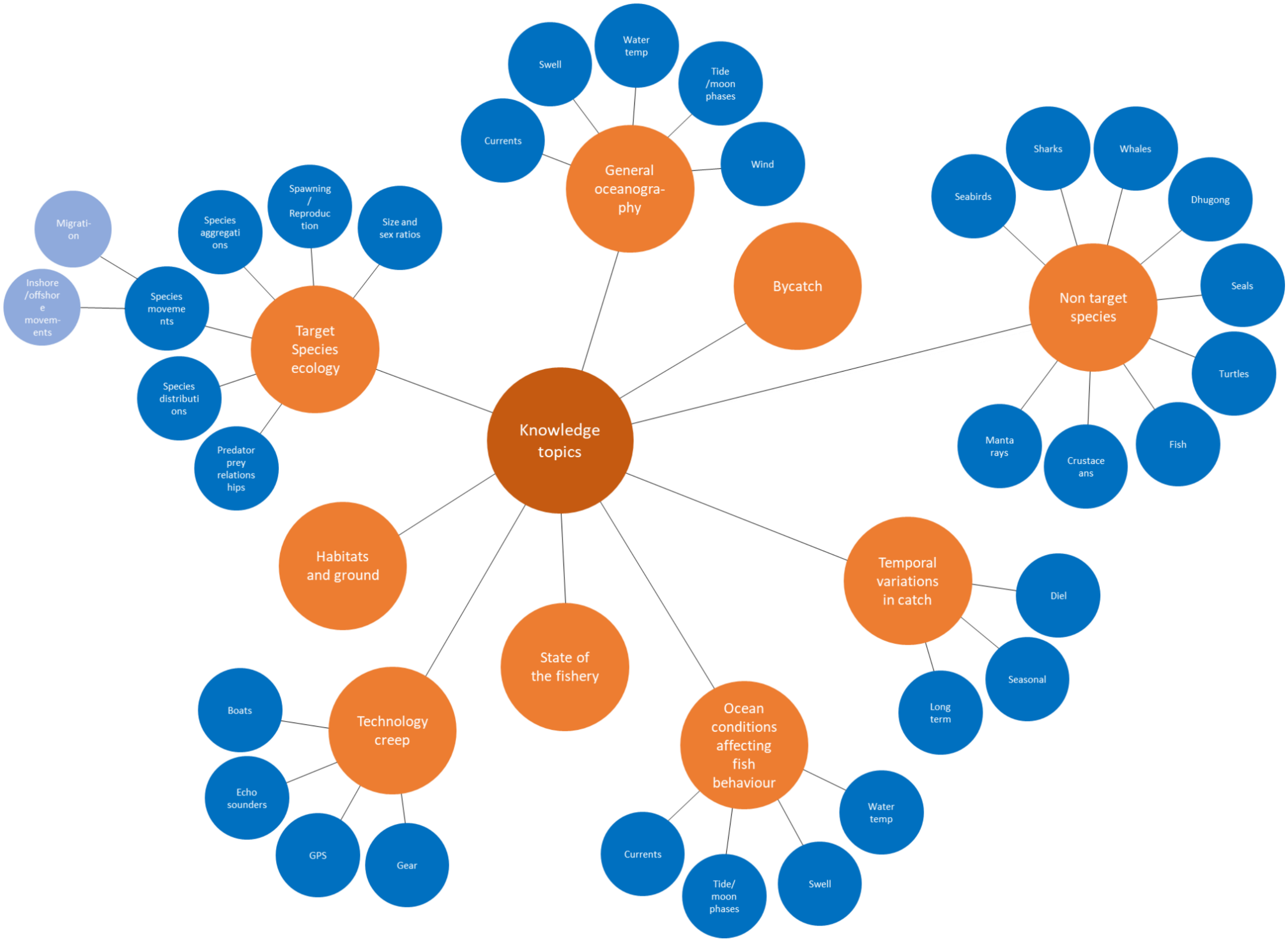


Figure 3. Summary of ecological/environmental knowledge topics that emerged from interviews with Western Australian professional fishers.

The topics fishers were knowledgeable on were strongly guided by the nature of the fishers' interactions with the ocean. Fishers targeting deeper water species shared insights about offshore ocean currents and upwelling zones, while nearshore fishers shared insights about species responses to different swell conditions. Similarly, fishers' knowledge of oceanographic and biological processes was due to the interaction of their fishing gears with the biophysical environment. For example, WRL fishers' understanding of seafloor dynamics reflected observations that their pots would fill with sediment and get washed around despite being heavily anchored to the seabed.

> Fisher 4: *Surprising how the hell they [lobster] survive with, you know when you consider what comes up in the pot sometimes after a good ground swell, you know... a huge ground swell come in, and every pot was snagged out there or just buried. We pulled up and there's big round frilly rocks. Pots are full of them."*

> Fisher 8: *Because your pots will blow off, they'll be full of rocks. Like I mean full. Yeah you wouldn't believe how much movement actually goes on.*

The close relationship between the nature of a fishers' activities and the topics/processes they are knowledgeable on is important for future fishers' knowledge research. Whilst it may seem obvious, fishers are more likely to be knowledgeable on, and therefore more engaged on topics that are closely related to their fishing practices.

Fishers also highlighted that target species abundance and competition between operators influenced their knowledge. The WRL fishery represents an interesting case study. In 2010, the WRL fishery transitioned to a transferable quota system based on maximum economic yield which increased biomass and catch rates and alleviated the previous "race to fish" with fishers now able to catch their quota year-round. According to interview participants who fished for WRL both before and after this regime shift, the stock increase in the years that followed made catching WRL easier for those who remained in the industry. As such, the level of highly specialised knowledge sought and retained by fishers to generate competitive advantage prior to management changes was no longer required under the new management conditions. One fisher described how spatial knowledge of productive fishing grounds became less of a necessity following this change.

> Fisher 3: *We call them secondary or third spots where you never used to catch a cray[2]. But now you can go to those spots and catch pretty good crays. So in other words, the good spots are still good, they only hold, you know, you'll get a pot with 20 or 30 in it. And you still get that 20 or 30. But if you go over there you used to get one or two, but now you get 15, 20 in that too. You know what I mean? They just fill up other... they go to – we call them secondary or third spots – they'll go to those spots and they're becoming good spots now.*

An ex-cray fishermen supported the notion that specialised fishers' knowledge could be lost in high abundance / low competition fisheries by inferring that modern crayfishing was becoming monotonous;

[2] "Crays" refers to the Western rock lobster.

Fisher 33: *Now it's quota and instead of catching, what was it.. 17 million kilos a year we were catching. And (now) they're only catching 6. So there's plenty of crays there. And to some extent, they've become bus drivers. Which is good, it's good for the industry.*

While long-term fishers clearly retained their specialised knowledge that they accumulated prior to the major management changes, some suggested that this knowledge would not be passed down into succeeding generations of fishers.

Overall, the research revealed a strong theme that professional fishers' knowledge in WA is shaped by context. This includes the gear fishers use and the nature of their operations (e.g., location), but also broader contextual factors of the fishery such as the management setting and consequences for the competitiveness of the fishery. This finding again reflects that much of the knowledge fishers have acquired reflects practical and practice-based knowledge; it is knowledge gained through fishing. As such, for scientists and managers to effectively engage with and incorporate fishers' knowledge into management they must have a deep understanding of the nature of fishers' day to day operations and interactions with the ocean.

## 5.3 Key Knowledge Topics

Throughout the interviews fishers shared knowledge on a range of topics. In this section, and with the permission of the interviewed fishers, we present some of the topics that arose in interviews.

### 5.3.1 Marine heatwave impacts on South West ecosystems

In 2011 a marine heatwave event occurred across the WA coast with significant impacts on the coastal ecosystems of the Mid-west and North-west of WA. Some of the well documented impacts included major losses of seagrass in the Shark Bay Gulfs (Fraser *et al.*, 2014), a contraction of kelp forests in the Mid-west (Wernberg, 2021), coral bleaching in Ningaloo Reef (Foster *et al.*, 2014), and pole-ward shifts in key target fish species (Cure *et al.*, 2018; Caputi *et al.*, 2019; Smith, Dowling and Brown, 2019). Many scientists have highlighted that marine heatwave events are becoming more common due to global climate change (Oliver *et al.*, 2018), and that the 2011 marine heatwave begins to give us an understanding of how WA marine ecosystems may respond (Cure *et al.*, 2018; Smith, Dowling and Brown, 2019; Wernberg, 2021).

Whilst the 2011 marine heatwave has been extensively studied by scientists, some fishermen have noted impacts to ecosystems beyond those documented. In particular, line fishers from the South West region of WA described decreases in catch of Nannygai (*Centroberyx gerrardi*) in subsequent years off the SouthWest (Figure 6). One fisherman hypothesised that the decrease in Nannygai may be linked to the loss of sponges which attract small invertebrates such as shrimp, which make up a large part of the Nannygai diet.

Fisher 6: *There's a lot of little sponges and stuff out there, and the nanny's used to eat these little tiny prawns. And they'd spew like mouthfuls of them up. Haven't seen those. Obviously, they must live on the sponge. So yeah, sort of haven't seen those since [the heatwave] really.*

Fisher 36: *All the inshore Nannygai just off Gracies (Gracetown) are just gone.*

The affected area intersects substantially with the South-west Corner Marine Park and suggests that marine heatwaves may be a major pressure on the sponge garden ecosystems of this region, with flow on effects for fishery resources including Nannygai.

A line fisherman also described that the 2011-2012 heatwaves caused WA Dhufish (*Glaucosoma hebraicum*) to concentrate into a small pocket of ocean that was protected from the extreme water temperatures. According to one interviewed fisher, this local abundance of fish quickly became known to the fishing community, causing elevated fishing pressure for a prolonged period during Dhufish spawning in 2012 (Figure 4). The interviewed wetline fisher expressed a belief that this concentration of fishing effort may have hampered the recovery of Dhufish stocks in the South West capes region.

> Fisher 36: *11[2011] it started [referring to the marine heatwave], and 12 [2012] was just nearly as bad. What happened, we noticed between probably Inji [Injidup] and Cape Naturaliste, all the fish piled into there because.. I think the water was cooler in there. Because I didn't have a thermometer, but from what I gathered it was 26 outside and about 23/24 inside, so all the fish piled in. So what happened was, every amateur under the sun was just going out there and dropping over and getting two Dhuies every drop.*

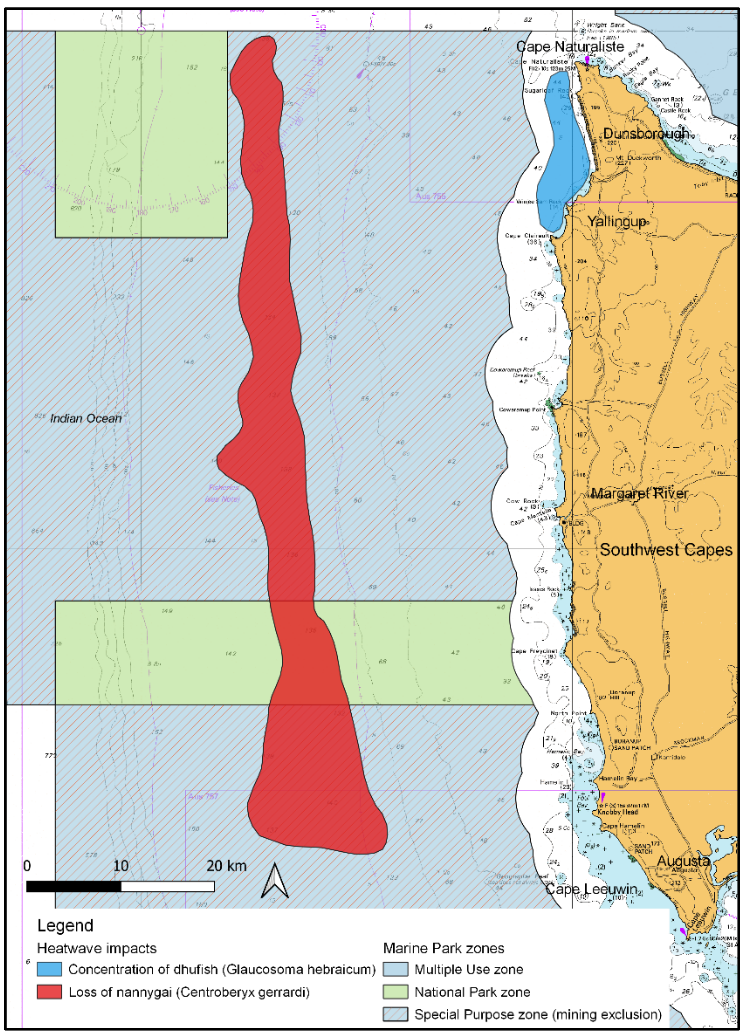


Figure 4. Approximate extent of heatwave effects described by interviewed South West Demersal wetline fishers.

The observations of fishers of marine heatwave impacts in the Australian Marine Parks provides potentially valuable insights into the pressures and processes operating in these parks and the importance of ecological features like sponge gardens for sustaining fish populations. As far as we are aware, marine heatwave impacts on South West demersal fish populations haven't been documented by scientists. These observations also highlight a strength of fishers' knowledge in providing a holistic perspective of marine heatwave impacts that include changes in benthos, associated fish assemblages, fishery catches and fisher behaviour. These linkages, and the holistic picture of marine heatwave impacts are often lost in scientific investigations which are often narrowly focussed on one species or community (e.g., Perkins *et al.*, 2022).

### 5.3.2 Dynamics surrounding sardine fishery following major fish kills

Two major fish kill events occurred in the Sardine (*Sardinops sagax*) population of the South Coast of WA in the late 1990s thought to be the result of a herpesvirus (Jones *et al.*, 1997; Ward *et al.*, 2001). Stock assessments suggest that recruitment to the fishery has since recovered (Blazeski *et al.*, 2021). However, interviewed fishers from Albany and Esperance described lingering effects of these fish kill events.

All interviewed south coast sardine fishers (4 Albany, 2 Esperance) noted that the size ratios of the south coast sardine populations have changed. Interviewed sardine fishers in Albany described that sardine schools holding large size classes used to be caught year-round, but since the virus, schools of large fish are only found over three months of the year between March and May. Interviewed sardine fishers from Esperance described a more general trend reflecting smaller sizes year-round.

Fishers also discussed possible knock-on effects of the sardine fish kill death events in the 1990's. Some claimed that the primary diet of salmon changed from sardines to herring and garfish following the major fish kills. A fisher reported that they don't see as many garfish as they used to, and he attributes this to predation by salmon.

> *Fisher 14: Now the salmon, probably after the virus, maybe you know from around 2000 when there was no sardines, they probably changed their diet to herring and ate a lot of the herring, also eating garfish and whiting, because those fisheries have declined a lot.*

Some fishers also link major observed changes in the salmon migration to these fish kill events. Fishers described that the salmon are now migrating further offshore, and that fewer frequent inshore waters during the migration period. Some hypothesised that this change in distribution was linked with changes in the salmon diet.

> *Fisher 18: And then they seemed to go offshore [the salmon]… And I just feel as though, the food.. either they're going.. traveling through quicker, further offshore, or the food is further offshore, and they're not coming ashore like they used to. There's nowhere near the sightings onshore as ever there was for 60 years. It's just incredible, the drop. Last year, the total sightings on the coast were probably the worst ever seen.*

Fishers' knowledge around the effects of the South Coast sardine fishery likely represents valuable information in a relatively data poor fishery. Stock assessments of the South Coast sardine fish stock are conducted using a risk assessment framework, and are largely limited to analysis of total catch and effort (Blazeski *et al.*, 2021). These relatively coarse data mask changes in size distribution. Additionally, and as is acknowledged in the stock assessments, recovery in catch rates may reflect improvements in fishing efficiency. This case study highlights how fishers' knowledge can be used to complement and in some ways make up for data deficiencies in data poor stocks that are characteristic of many WA professional fisheries.

### 5.3.3 Target species stock health and historic trends

Many fishers interviewed had detailed views on the status of their target fish stock, and how stock health had changed over time. Recent stock assessments for key demersal species like the WA Dhufish (*Glaucosoma hebraicum*) and snapper (*Chrysophrys auratus*) have suggested that the fishery is experiencing overfishing and has likely been overfished for some time (Faircloug et al. 2021).

Fishers' observations in this fishery largely match these findings.

> Fisher 6: *it was pretty common to catch 20 fish on a lump. In, like in a session. Whereas now,  if you catch five or six on a lump it's, yeah it's really good.*

> Fisher 6: *you do (see some aggregations), but not.. definitely not, you know, compared to even 15 years ago. yeah, nah, it's nothing like it was.*

> Fisher 36: *Yeah. School, yeah. Yeah, we used to target them. Oh we still do target them. But yeah I can't remember the last time someone hit a school of dhuies.*

Some fishers with intergenerational connections also provided insights about how the fishery has changed over multi-decadal time-scales, often preceding systematic scientific data collection.

> Fisher 6: Y*ou know, you talk to the old, some of the old pros, and they'd pull like 100 to 200 dhuies off a patch. So that's, that's what they need to have that data for. You know how can they compare data now to then, when they haven't got that data?*

> Fisher 36: *last few years we've only been getting 2s and 3000 kilos a year, where, when it was really bad there for a while. But I remember fishing years ago, in my little boat when I first had it, that must have been.. that would have been 26 years ago, like we got 10,000 kilos of dhuie in a trailer boat.*

> Fisher 10: *Well, like the old.. we all talk the old days, but that was 40, 35-40 years, they were virgin patches. And they always used to be beautiful big snapper. We haven't caught snapper like that for 30 years, really.*

Some fishers described how changes in abundance appeared to reflect range shifts in species, with a general movement of fish species to the South. For fishers in the North this has been observed as loss of historic grounds for species like snapper and dhufish.

> Fisher 10: *But areas off here, Cuvier, and even up to the Bluff, used to be big spawning areas, used to catch lots of snapper. And then it's.. everything sort of crept south. So now there's Cuvier.. Cuvier north, hardly produce any snapper at all.*

> Fisher 2: *hardly any Dhufish now has been caught north of.. virtually Port Gregory north. So a line out through there, they get no dhufish. Where they used to get a few, not heaps,*

*but now there's none. So is it climate change, the water's getting warmer and they've just, they're not pushing up as far as they did?*

Fishers on the South Coast have observed opposite trends with increased abundance of snapper and dhufish ranges indicating a range expansion.

> Fisher 17: *[add fisher number] Oh, I've seen the snapper catches rise and fall again. I never thought I'd see it, but I did see the snapper come back for a few years. Like, more than.. oh, well back like the stories I heard about I suppose, not quite like that, but never thought it was going to happen.*

> Fisher 17*: We've seen dhufish increase in the last three, four years. It's probably steadying off or on a decline now, but depend.. There just must have been stronger currents I'd say. It's just spawn from the west coast, just about basically controls all our fishing on the south coast I think.*

> Fisher 18: *Until the last few years, there's been an increase in dhufish numbers. Albeit they're smaller, generally. I don't know whether that's to do with the warmer currents we've had. I think it's probably got something to do with it.*

Fishers also described ecological shifts that may have occurred due to the decline in some species.

> Fisher 36: *This is learnt from making mistakes, where you have overfished spots, and they haven't come back. And they've.. and then you've got other species of fish that have moved in there, like your crimsons, and your fucking catfish and shit like that.*

The above examples provide some indication of the changes fishers have observed across their careers. These observations correlate strongly with scientific observations, but add depth to the interpretation (e.g., the interplay of range shifts, shifting fisher behaviour and changes in ecological communities). The observations also often pre-date collection of scientific data and as such, provide arguably the most promising source of understanding the baselines in what Western Australia’s fish stocks were like in a relatively un-disturbed state.

### 5.3.4 Mackerel aggregations

Mackerel fishers interviewed in this research shared information about aggregating behaviour of Spanish mackerel in the Midwest of WA. Spanish mackerel (*Scomberomorus commerson*) are known to aggregate around high concentrations of prey around barrier reefs and pinnacles, and aggregations for spawning have been identified in the Great Barrier Reef between Gladstone and Cooktown (Thurstan, Buckley and Pandolfi, 2016). However, little is known about the aggregating behaviour of WA populations of Spanish mackerel.

The two mackerel fishers interviewed as part of this project identified a number of key Spanish mackerel annual aggregation sites in the Midwest of WA. Both fishers described that one of these sites lies within the boundary of the recently established Abrolhos Marine Park National Park Zone (swabrnpz06) which includes a feature known as shallow bank. The two mackerel fishers sketched a mackerel aggregation site on the NW side of a particular pinnacle within the national park zone (Figure 5), and described that mackerel were prolific in that area at certain times of year.

> Fisher 9: *The mackerel are right here where the four is [pointing to depth reading on chart], and along this edge along here.*
> *This area here [circled in figure…] used to be where all the mackerel were. Not this side [pointing to south side of the pinnacle].*
>
> Fisher 10: *That little zone there [circled in figure…] was, when the conditions were right, it was worth me fishing in this zone.*

Fisher 9 described how his catches have changed since losing access to the described aggregation site.

> Fisher 9: *I could pick up, you know, 50s and 60s, 70s [describing number of fish caught in a fishing session at the marked site shown in figure….]. The best I've got there was 79, in there. You know, they're good numbers. Since they've brought this ban in here [national park zone], I might have got 14 or 15. And I might have gone there 50 times [fishing the periphery of the park zone].*

Fisher 9 specified that they would aggregate there early in the year;

> *So I could go over this time of year [March], sometimes later, and catch a load of mackerel around here.*

Fisher 9 broadly agreed on the timing and described that this timing was different to their occurrence inshore at similar latitudes.

> *They come early here [pointing to the shallow bank zone], and then they come later along the cliffs here [pointing to Kalbarri cliffs].*

Aside from supporting an abundance of prey, neither fisher knew why mackerel were particularly prolific at that site at that time of year. Fisher 8 did suggest, however, that the behaviour causing them to return to the same site year after year was likely passed down intergenerationally, implying genetic memory;

> Fisher 9: *I believe the mackerel are somehow attracted… obviously to the school of fish [referring to baitfish], but I'm not too unsure that they aren't handed down where to go to [genetically].*
> *They've got designated areas, you know, they do look for a pinnacle, and they do look for uprisings.*

Fishers' knowledge has emerged as an important approach for understanding targeted fish movement patterns and aggregation behaviours around the world (Johannes, Freeman and Hamilton, 2008; Silvano and Valbo-Jørgensen, 2008; Hamilton, de Mitcheson and Aguilar-Perera, 2012; Bezerra, Hostim-Silva and Teixeira, 2021). This reflects that fishers are often extremely knowledgeable about where and when fish species aggregate. However, fishers' knowledge is rarely used to identify or understand fish movement or aggregation behaviours in Australia. The identification of Spanish mackerel aggregations by interviewed mackerel fishers in WA, along with the international experience, suggests that incorporating fishers' knowledge of behaviour and aggregations into management of targeted fish species may be fruitful.

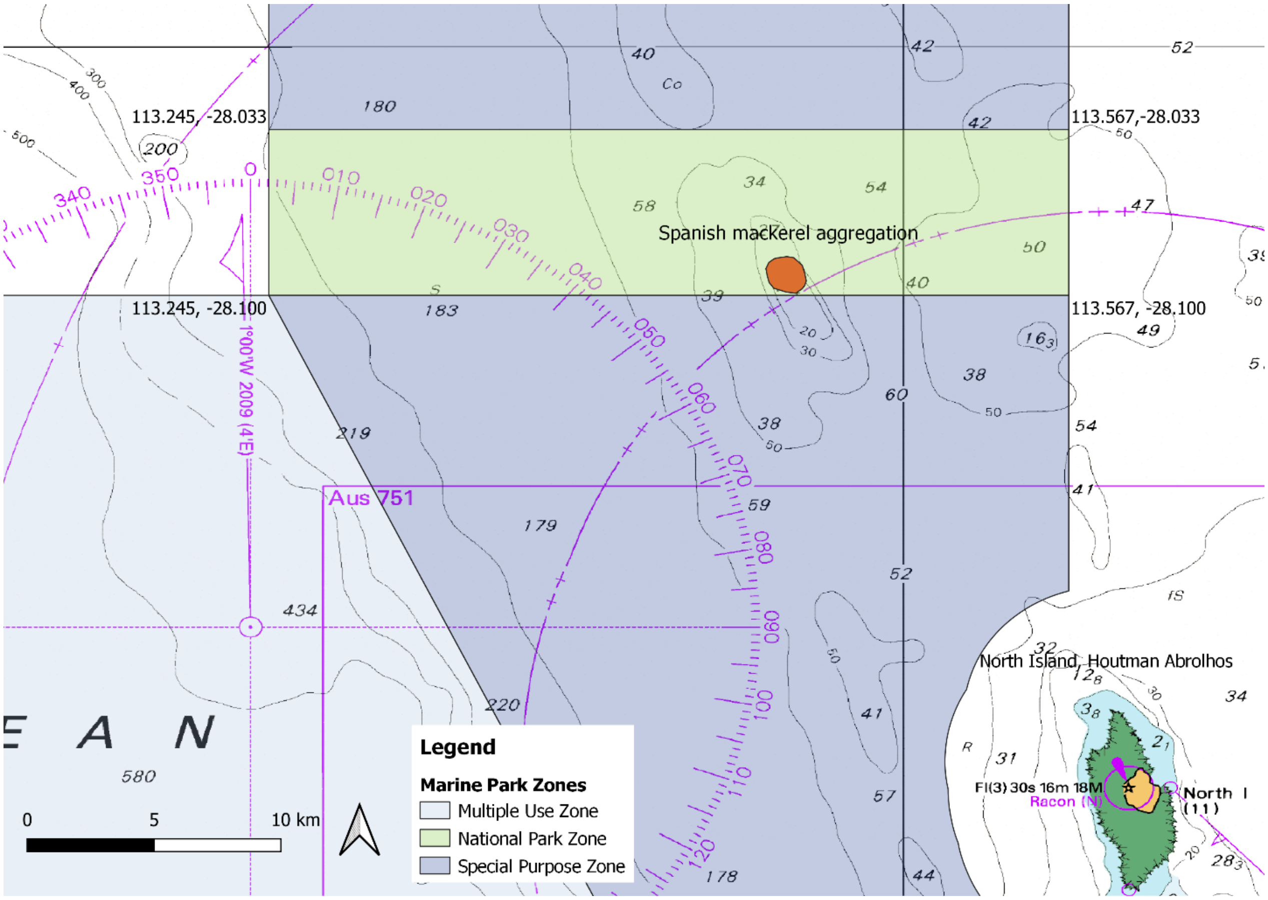


Figure 5. Approximate location of mackerel aggregation site inside a National Park Zone of the Abrolhos Marine Park.

### 5.3.5 Grey nurse shark life history and aggregation

Little is known about the grey nurse shark (*Carcharias taurus*) population along the West Coast of Australia. In particular, unlike for the East Coast population of grey nurse shark with many identified aggregations, only one aggregation site has been identified to date on the West Coast (Hoschke and Whisson, 2016). Whilst the species has been protected since 1999, commercial gillnet, wetline and abalone fishers occasionally interact with grey nurse sharks. Due to the lack of commercial data on this species, fishers' observations represent a key source of information for understanding this species.

Fishers in interviews were often reluctant to share knowledge on grey nurse shark aggregation sites, likely due to fears of losing access to productive fishing grounds. However, in some cases, particularly where sites were already under protection (e.g., those in Australian Marine Parks), fishers were willing to report potential grey nurse shark aggregation sites. For example, several fishers reported a site inside a National Park Zone in the South-west Corner Marine Park (swswcnpz05) (Figure 6). Additionally, many fishers were willing to share information about broad trends relating to the migration patterns of this species which could potentially help address some of the biggest mysteries about the WA population of grey nurse shark including those related to migration timing and key pupping areas.

> Fisher 34: *They'll migrate, but to a lesser extent. They like to hang around reef structures. So basically, I would expect that a grey nurse, during its life cycle wouldn't move much more than about 500 nautical mile.*

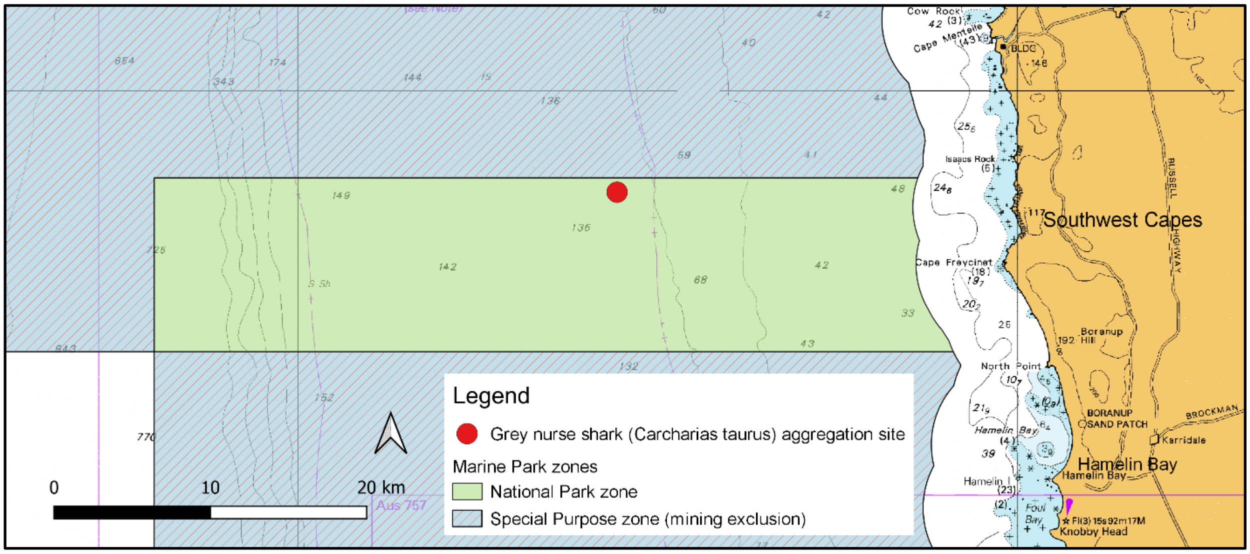


Figure 6. Approximate location of grey nurse shark aggregation site in a National Park Zone of the South-west Corner Marine Park. Note, while the location outline is only approximate, two fishers had coordinates for the above aggregation site.

## 5.4 Principles for engaging with fishers and their knowledge in WA

The above documented knowledge topics highlight the significant potential for fishers' knowledge to help inform the management of our oceans. Fishers expressed a willingness to engage with scientists and managers in knowledge exchange and co-production (Section 5.1.2.2). To help facilitate this process we have synthesised five principles for engaging with professional fishers' knowledge. These principles are based on the interviews with WA professional fishers and reflect some of their key concerns as well as insights about the nature of fishers' knowledge.

**Principle 1 Respect fishers' knowledge**

Scientists and managers engaging with fishers' knowledge should ensure they frame their research in a way that respects the knowledge fishers hold. The knowledge built up within the fishing community, often through personal observation through many days at sea, or across generations (Section 5.1), occurs within a knowledge system that interacts with and can complement western science knowledge approaches. Approaches to engaging with fishers that de-value their knowledge and asserts scientific approaches as the only way of "knowing things" does a disservice to fishers' knowledge.

Where fishers' knowledge contradicts some established scientific observation, healthy conversation should be facilitated to understand how context both in terms of fishers' knowledge and the scientific observations might explain the contradiction. This resulting insight informed by both scientific and fishers' knowledge systems is likely to promote a more nuanced and deeper understanding of marine systems.

**Principle 2 Contextualise fishers' knowledge**

A significant throughline in this project is the importance of context for understanding and engaging with fishers' knowledge. The nature of fishers' knowledge (e.g., the geographical extent, fishery gear and relationship with others) affected the things fishers were knowledgeable about. Similarly, context was important for potentially explaining dissimilarities between fishers (e.g., those from different geographic regions) and between fishers and scientific research (with possible broader geographic reach, but less spatially and temporally detailed observations). For fishers' knowledge to be of the most practical use in informing ocean management, it is important that it is contextualised.

**Principle 3 Avoid negative or perceived negative outcomes for fishers**

Fishers' knowledge is a professional asset that has been hard earned, and sharing this knowledge in some cases may generate negative outcomes for fishers. For example, sharing information on aggregations of rare and threatened species may provide impetus for exclusion from these areas. Similarly, information on aggregations of targeted species may erode competitive advantage of fishers over their peers or recreational fishers. Fishers interviewed in this project were extremely salient of the potential for knowledge sharing to lead to adverse impacts on their livelihoods.

Researchers need to be cognisant of these concerns and do what they can to avoid negative outcomes for fishers. Within this project an approach of informed consent combined with re-checking of interpretation helped avoid negative outcomes for fishers. Informed consent means ensuring that fishers were aware of what information was being collected, why and for what purpose before engaging on interviews. Whilst this is an important step, our experiences within the project suggest that informed consent was not sufficient. Even after being informed that information in our interview might be made public through documents (e.g., this report) some fishers shared information that upon checking they did not want to have appear in a public report. This highlights the importance of providing fishers with final say over what is included in the research outputs. Ultimately it should be up to the knowledge holders (the fishers themselves) to decide what knowledge is shared, where it is shared and in what format.

**Principle 4 Build long-term collaborative partnerships**

Whilst this project occurred on a relatively short time scale, interviews with several fishers highlighted the importance of long-term relationships between fishers, researchers and managers. Some fishers described previous such relationships in which good relationships existed and trust was built. Others described one-off projects that they received little from, and ultimately built distrust.

Implementing systematic ways to build these long-term collaborative partnerships was viewed favourably by fishers. For example, within the WRL fishery, the WRL Council help identify and ensure delivery on research priorities for the industry. Similarly, regular meetings between fishers' and managers along the WRL fishery help maintain connection and communication. Whilst these systems aren't perfect, they are viewed positively by most fishers as facilitating knowledge exchange. In smaller fisheries such engagement was largely absent and fishers felt very little of their knowledge was being shared or incorporated into management. Finding long-term working models for facilitating knowledge exchange with the many small fisheries in WA represents a major opportunity for facilitating knowledge exchange with professional fishers in WA.

**Principle 5 Ensure two-way knowledge exchange**

Several fishers in this project described circumstances where knowledge exchange involved scientists telling them scientific outcomes, but very little opportunity for fishers to share their knowledge and insights. This type of knowledge exchange is one-way: from scientists to fishers. Even if such communication efforts are followed up with discussion on the findings, this set up is not conducive to putting fishers' knowledge on an equal footing with the scientific approaches and genuine interrogation of the findings in-light of fishers' insights. More appropriate two-way approaches to knowledge exchange and incorporating fishers' knowledge might involve co-investigating problems with the assistance of fishers.

Fishers' practical knowledge and expertise makes them high value candidates for collaborations on research projects and doing so would likely add to the robustness of the findings and build trust amongst fishers in the research outputs.

# 6 CONCLUSION

This project has demonstrated the potential for facilitating knowledge exchange between professional fishers of WA and managers of marine ecosystems, including Parks Australia. The knowledge accumulated within the professional fishing industry of WA is substantial, wide-ranging and highly valuable for managemenet. We argue that it is also highly valuable to marine management in WA.

We also show that fishers are willing and ready to engage with scientists and managers. Unlike in other contexts, fishers were willing to work with scientists, share their knowledge and even have their knowledge tested using scientific approaches. Fishers also expressed some frustration with the current lack of engagement with their knowledge in science and management. Efforts to expand upon this work and engage with fishers in knowledge sharing and co-production would likely be a positive step for scientists, managers and fishers.

To help facilitate this process we have identified five principles for engaging with professional fishers in WA. These principles reflect upon concerns and opportunities identified by fishers, as well as the nature of fishers' knowledge. They are designed to help ensure knowledge exchange and co-production is mutually beneficial, and robust. The principles are summarised as:

- Principle 1 Respect fishers' knowledge
- Principle 2 Contextualise fishers' knowledge
- Principle 3 Avoid negative outcomes for fishers
- Principle 4 Build long-term collaborative partnerships
- Principle 5 Ensure two-way knowledge exchange

In light of this research and principle 4 (build long-term collaborative partnerships) the research team behind Fishing For Knowledge are continuing to explore knowledge exchange with professional fishers in WA.

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# APPENDIX 1

**Fishing For Knowledge: Interview protocol**

**Introductory Questions**
*Note: produce map at beginning*

1. How did you first get into the fishing industry?
2. How long have you been fishing?

    Prompt what fishery they are in/have been in, what role they are in, whether their role has changed.

3. Where do you fish? (request to draw broad fishing extent on map)

    Prompt: Does this change seasonally?

4. Do your fishing grounds overlap with other fishers?

**Knowledge Creation (and use)**

5. How did you learn to fish (Note: likely covered above)

    Prompt: were there things you had to learn for yourself, or were you told or shown how to do most things?

6. Is most of your knowledge about the ocean related to your target species, or are you interested in other aspects?

    Prompt: other species, processes, major changes that you have observed

7. How do you decide where and when to fish?
8. Have you made any major changes to your fishing practices over the years? Why?

**Knowledge Transfer**

9. Who do you see around and interact with during your fishing day?

    Prompt: other fishers, researchers, fisheries officers

10. Do you know many other fishing operators in the area?
11. Do you talk to these other fishers often?

    Prompt: what sort of things do you talk about, do you share insights about fishing?

12. Do you talk about fishing with fishers from different sectors (e.g. recreational fishers)?
13. Are you a part of any fishing groups?
14. Do you attend any industry meetings?
15. Do you read any fishing related material?

e.g. fisheries reports, WAFIC material, WRL council material documents, material about the stocks you fish for, social media posts, etc.

Do you ever apply knowledge learnt from these sources to your fishing practices?

**Knowledge Storage**

16. How do you remember things you learn about fishing?

17. Do you keep a log of things (besides your compulsory logbook)?

    Prompt: What kind of information do you record in your log book?

    Do you often refer back to logbooks when deciding how to fish?

**Knowledge Validation**

18. Do you know things about the ocean that you think scientists at fisheries may not know?
19. Do you trust what you hear from the Department of Fisheries?
20. Do you trust what you hear from other fishers?
21. How do you decide if something is trustworthy?
22. Are there people you think are particularly good sources of information?
23. Are there other sources of information which you find useful and accurate?

**Knowledge topics**

24. Some of this has come up already but we really want to hone in on topics that you are particularly knowledgeable about in this area - can you think of anything that you know a lot about from your fishing experiences?

    Prompt: these could be spatial features such as spawning aggregations, species migrations, upwelling zones or endangered species distributions, or non-spatial topics such as species interactions

25. We'd like to come back and chat to you more, but focusing on these specific topics. Are there some things that you would be particularly keen to talk to us more about?

**Final Comments**

26. Feedback findings to fishers
27. Thank fisher for their time