Alternative Gear Desktop Review:
A review of alternative gears for the commercial sector of the Northern Territory Barramundi Fishery

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Introduction

The NT Barramundi Fishery

Barramundi (*Lates calcarifer*) is one of Australia's most iconic and sought-after fish species, targeted by commercial, recreational, and Indigenous fishers across northern Australia. It is valued for its high-quality flesh, making it a staple in both wild-caught and aquaculture markets. They are euryhaline, found in coastal rivers, estuaries, and nearshore marine environments, with productivity closely linked to rainfall variability (Staunton-Smith et al., 2004; Robins et al., 2005; Halliday et al., 2010; Leahy and Robins, 2021; Crook et al., 2022; Roberts et al., 2024).

Barramundi are the primary target of the Northern Territory Barramundi Fishery (NT BF). The NT BF is a multi-sector fishery comprising commercial, recreational, Fishing Tour Operator (FTO), and Aboriginal Traditional sectors. In 2024, Barramundi made up 65% of the catch composition, followed by 33% King Threadfin (*Polydactylus macrochir*), and <2% all other finfish. While historically impacted by high commercial fishing pressure in the late 1970s and early 1980s, stocks have recovered, exceeding 60% of virgin biomass for the last two decades and reaching 88% in 2019 (Roberts et al., 2024). Commercial catch has declined sharply in recent years, from 736 tonnes in 2012 to a historic low of 101 tonnes in 2024, driven by declining profitability and loss of access to fishing grounds, yet the fishery remains sustainable (Roberts et al., 2024). Aboriginal fishers continue to harvest barramundi for cultural, health, and economic purposes, while recreational anglers prize the species for its sporting qualities.

This review of alternative fishing gears focuses solely on the commercial sector of the NT BF, which currently uses monofilament gillnets to target Barramundi and King Threadfin. The commercial sector currently has 14 licenses and operates from 1 February to 30 September each year. Each license allows up to 1000 meters of net with a maximum mesh size of 180mm (7 inches). This mesh size captures mid-sized (85-100cm) Barramundi, aged between 3 and 8 years old (DAF, 2024). Fishing is permitted from the high-water mark to 3 nautical miles offshore, with fishers predominantly setting nets over tidal mudflats (Figure 1), although there are a number of restrictions on where fishing can occur. Certain areas, including waters between the Little Finnis River and the Wildman River, are closed to commercial fishing. Access to intertidal waters over Aboriginal land requires Section 19 Land Use Agreements. Additional closures aim to protect threatened species, with Coopers Creek and the East Alligator River closed to reduce impacts on river sharks and sawfish. Fishing and anchoring are also prohibited in the Dugong Protection Area in the southwestern Gulf of Carpentaria. In 2024, temporary effort limits were also in put in place in Anson Bay, Moyle River, and Roper River.

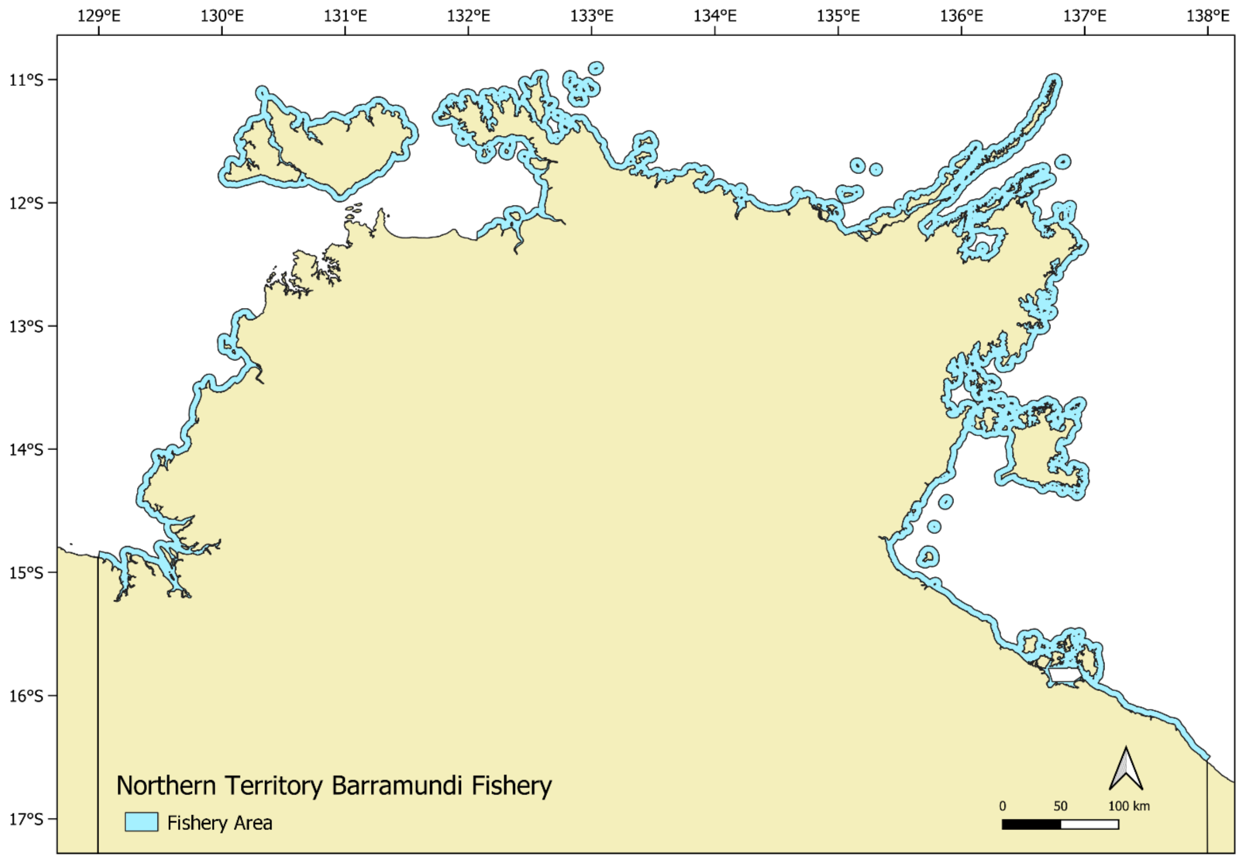

Figure 1. Map showing the Northern Territory Barramundi Fishery area.

Threatened, Endangered and Protected species (TEPS) inhabit areas where commercial fishing in the NT BF occurs, resulting in the interactions with these species and leading to fishery-related impacts. TEPS interactions occur across all sectors of the NT BF, but are highest in gillnets used in the commercial sector. TEPS this fishery interacts with include dolphins, Dugong, marine turtles, estuarine crocodiles and sharks and rays. Sawfish are the most numerous bycaught TEPS in this fishery, due largely to their higher susceptibility to entanglement from their long, toothed rostrum and their preference for intertidal mudflats where fishing occurs.

TEPS have a high ecological value, playing important roles in ecosystem functioning. They also have high social and cultural value, being important for tourism, education and research, and often feature in lore, ceremony and song for Aboriginal and Torres Strait Islander people. While the NT Government developed the NT Barramundi Fishery Threatened, Endangered, and Protected Species (TEPS) Strategy (2024–2029) to address these interactions, mitigating TEPS bycatch remains a major management challenge for the fishery.

Alternative Gear Desktop Review

The objective of this review is to provide the commercial Barramundi fishing industry with information on alternative fishing gear options to gillnets to enhance sustainability and bolster resilience and adaptability within the sector. The Review is focused on the commercial sector of the NT Barramundi Fishery, but the outcomes are applicable across all northern Australian gillnet fisheries. This review represents a compilation of evidence on alternative fishing gears, considering their potential to reduce threatened species interactions while maintaining target species catches, and key environmental, social, economic, and operational factors associated with each gear type.

This review does not attempt to make recommendations for gears suited to the NT BF fishing context. Future work will need to assess the technical feasibility of the reviewed gears through consultation with industry, fisheries managers, gear technologists, and researchers to inform gear selection within the context of the NT BF (e.g., spatial footprint, target and bycatch species, legislative context). The testing of alternative gears is out of scope for this project, but if suitable alternative gear is identified, the focus of future work will need to be on comprehensively testing these gears under normal fishing operations.

Desktop Review Approach

The desktop review canvassed available literature and key fisheries research and management resources to develop an overview of alternative gear options. For each gear type identified, the following information is included:

- Description of the gear, its design, and operation.
- Relevant fisheries currently using the gear commercially in similar regions, environments, and/or for similar target species.
- Comparisons to commercial gillnets, if available.
- Environmental considerations, including environmental impacts, such as interactions with TEPS, and current mitigation actions.
- Economic considerations, including catch quality and catch per unit effort information, setup and maintenance costs, and gear and crew requirements.
- Social considerations, including public perceptions and potential conflict with other sectors.

Brief Gear Summaries are provided in Appendix A for each gear type reviewed.

Alternative gears considered in this review was restricted to those currently used in commercial marine and coastal wild capture fisheries targeting finfish. Innovative gears, less established techniques, and gears used only in limited or specialised contexts were not considered. This ensures the review offers industry viable gear options that are:

- Readily available: Gears that are already accessible in the market allow for quicker adoption and lower barriers to entry.
- Adaptable to specific fishing contexts: Well-known gears have demonstrated their ability to be customised to meet the needs of different fisheries.
- Known interaction rates with threatened species: These gears have established interaction profiles with threatened species, including well-researched and tested bycatch mitigation strategies.
- Known environmental, social, and economic impacts: The effects of these gears are documented, providing a clearer understanding of their benefits and drawbacks.

By focusing on proven gears, the review seeks to provide practical, implementable options for industry.

Alternative gears were first identified using the International Standard Statistical Classification of Fishing Gear (ISSCFG) (FAO, 2016) and further definitions provided in He et al. (2021) (see Appendix B for full list of gears). This list contains 45 gears that are not gillnets (termed set gillnets in the classification) and 12 categories for gears not included in other gear categories (termed not elsewhere included (NEI)). The NEI categories were excluded from the review as they are unlikely to encompass known and tested gears that could feasibly be integrated into current NT BF fishing operations. Further, an initial screening of the listed fishing gears was conducted to eliminate any gears deemed clearly unsuitable as alternative options for gillnet fisheries (e.g., gears used only to target shellfish). To streamline the review, gears considered sufficiently similar were reviewed together. The gears reviewed in this Desktop Review, and their links to the ISSCFG, are provided in Table 1.

Table 1. Fishing gears included in the Desktop Review, including the gear category and specific gears reviewed, as well as links to gears defined in the International Standard Statistical Classification of Fishing Gear (ISSCFG) (FAO, 2016)

Gear Category	Gear	ISSCFG Gears included in category
Net-based Gears	Surrounding nets	• Purse seines • Surrounding nets without purse lines
	Beach seines	• Beach seines
	Boat seines	• Boat seines
	Trawls	• Beam trawls • Single boat otter trawls • Twin bottom otter trawls • Multiple bottom otter trawls • Bottom pair trawls • Single boat midwater otter trawls • Midwater pair trawls • Semipelagic trawls
Trap Gears	Pound nets	• Stationary uncovered pound nets • Barriers, fences, weirs, etc.
	Tunnel nets	• N/A
	Fish pots	• Pots
Hook and Line Gears	Simple hook and line	• Handlines and hand-operated pole-and-lines • Mechanised lines and pole-and-lines
	Multi-hook lines	• Set longlines • Drifting longlines • Vertical lines • Trolling lines

Alternative Gear Reviews

Net-Based Gears

Surrounding nets (purse seines and lampara nets)

General Description

Surrounding nets are active gears that use a long panel of netting to surround schools of target fish. Here, the surrounding net category includes (i) purse seines and (ii) lampara nets (surrounding nets without purse lines). Boat seines and beach seines can also be considered surrounding nets, but these are explored as separate gears in the following sections. Purse seines use a purse line attached to the footrope that closes the bottom of the net prevent fish from escaping through the bottom of the net (Figure 2), whilst surrounding nets without purse lines, also known as lampara nets, have a footrope that is shorter than the headrope and tension when hauling moves the footrope ahead of the headrope to prevent the downward escape of fishes (Figure 2). Both gears may include a 'bunt' of smaller mesh in the centre where catch is aggregated during hauling. Both gears are scalable from artisanal to industrial fisheries, but lampara nets are typically used at smaller scales while purse seines are well suited to large-scale operations. Both are typically used to target schooling pelagic species but can be adapted to shallow coastal environments.

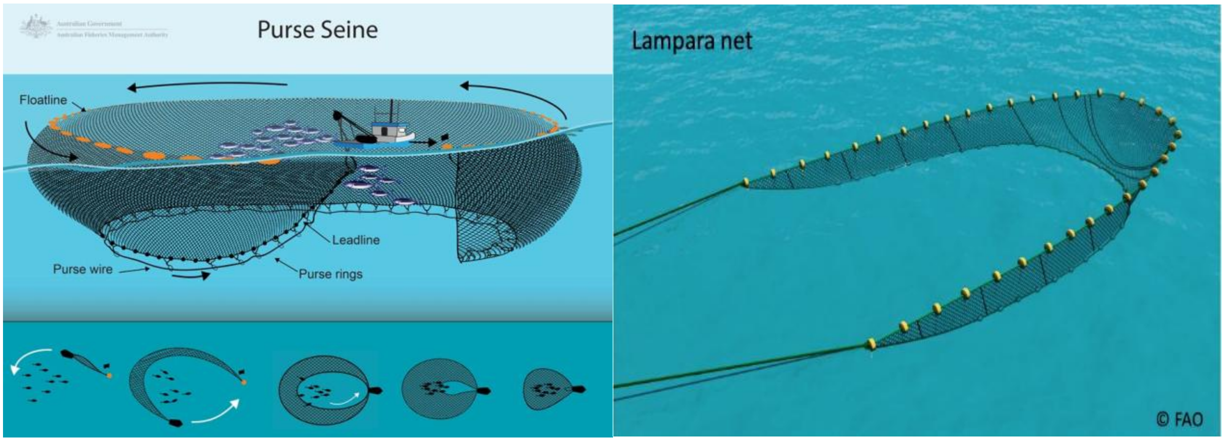

Figure 2. Left: Illustration of a purse seine (Source: AFMA. https://www.afma.gov.au/species/australian-sardine). Right: Illustration of a lampara net. (Source: FAO, 2021).

Surrounding nets offer several advantages, including high catch efficiency and selectivity when schools of target species can be located. There are also a range of bycatch mitigation methods available, and the gears are scalable. However, there are also some notable disadvantages. These include potentially high discards and interactions with threatened, endangered, and protected species (TEPS). At larger scales, the associated vessel requirements can lead to high costs, and there is a risk of gear loss. Additionally, the effectiveness of surrounding nets may be limited in shallow waters or low-visibility environments.

Relevant Fisheries

In Australia, purse seines are widely used to target pelagic species such as southern Bluefin Tuna (*Thunnus maccoyii*), Australian Sardines (*Sardinops sagax*), Blue Mackerel (*Scomber australasicus*), and Jack Mackerel (*Trachurus declivis*) (AFMA, 2023b). Globally, tuna is the primary target for purse seine fisheries, particularly in international waters (He et al., 2021).

Lampara nets are widely used in smaller-scale coastal and inland fisheries globally, including regions like the Mediterranean, North America, and South America (He et al., 2021). They primarily target herrings, anchovies, mackerels, tunas, and flying fishes, and are frequently used to catch baitfish for hook-and-line fisheries. In Australia, lampara nets are restricted to multi-gear commercial fisheries in New South Wales (NSW) and South Australia (SA), where they are used to target Australian Halfbeak (*Hyporhamphus australis*) and Southern Garfish (*H. melanochir*), respectively.

Comparisons to Gillnets

Although purse seines are traditionally used in open waters, a modified version for sampling fish in estuarine environments was tested in Tampa Bay, Florida, where it proved effective at depths between 1.0 and 3.3 meters (Wessel & Winner, 2003). The modified purse seine was a scaled-down version of commercial purse seines used in the Florida baitfish industry at the time. The study showed that while gillnets tended to select larger fish compared to the modified purse seine, the latter offered a viable alternative in estuaries; however, the modified purse seines performed poorly in areas with strong tidal currents, wind, or seafloor obstructions, limiting their deployment in such conditions. It should be noted that the trials were for multi-species sampling, and species selectivity was not explored. No such comparative studies were found for lampara nets and gillnets for this review.

Operational Considerations

Surrounding nets, including purse seines and lampara nets, encircle entire schools of pelagic species near the surface. Both types consist of a headrope with floats and a weighted footrope, creating a vertical net that traps fish within the enclosed area. The nets are scalable, making them suitable for small artisanal fisheries as well as large-scale industrial operations. The effectiveness and selectivity of surrounding nets depend on various factors, including the type of net used, the target species, and operational modifications. When used in shallow waters, there is an increased risk of gear entanglement and damage from contact with the seafloor, limiting applications in inshore or estuarine environments.

Purse seines are generally considered one of the most efficient tools for catching both small and large pelagic species. While purse seines are not species-specific post-deployment, the catch efficiency can be enhanced through technologies like bird radar, spotter planes, and high-speed boats, which help locate and herd fish toward the net (He et al., 2021). Fish Aggregating Devices (FADs) can boost catches but are banned in some regions, including Australia, due to bycatch concerns (AFMA, 2023b).

On the other hand, lampara nets lack a purse line, which means they are not fully closed at the bottom and typically target smaller pelagic species like anchovies and mackerels. These nets can be deployed in coastal areas, including to catch baitfish for other fisheries. Although considered more selective than purse seines, lampara nets can still catch undersized individuals, but their selectivity can be improved by adjusting mesh sizes (Stewart et al., 2004). While lampara nets are simpler and often easier to operate manually, their deployment and retrieval can be labour-intensive, though the use of machinery like capstans can aid the process (He et al., 2021).

Both purse seines and lampara nets can be adapted for different environments. Purse seines are typically used in open waters, where schools of fish can be identified through surface observation or sonar. However, small-scale versions of both purse seines and lampara nets can also be used in shallower coastal environments, sometimes targeting demersal species by fishing the entire water column. In such cases, increasing mesh size improves size selectivity and reduces bycatch, which is especially useful for fisheries aiming to minimize the capture of non-target species (Gonçalves et al., 2008).

Overall, surrounding nets offer versatility and efficiency in targeting schools of fish, but the choice between purse seines and lampara nets depends on the specific fishing context, target species, operational considerations, and financial resources available. By incorporating selective techniques such as mesh size adjustments and bycatch mitigation methods, both gears can be optimized to balance catch efficiency with environmental sustainability.

Environmental Considerations

There are several environmental considerations for the use of surrounding nets. The most prevalent of these issues is bycatch of megafauna, including threatened species, which is most common in large-scale commercial purse-seine fisheries (Duffy et al., 2019). Bycatch in these fisheries is largely comprised of sharks and rays, dolphins, sea turtles and non-target teleost fishes (Duffy et al., 2019; Amandè et al., 2010; Gillman 2011; Romanov, 2002). There is evidence to suggest that some marine animals (e.g. dolphins and whale sharks) are more susceptible to capture in purse-seine nets due to associations with target species (e.g. Tuna) (Romanov, 2002; Scott et al., 2012).

Despite potentially high megafauna interaction rates, there has been considerable investigation of a range of bycatch mitigation technologies and procedures. The most widely accepted of these are Medina Panels and the backdown procedure, which are commonly used to reduce the bycatch of marine mammals by providing an escape route for non-target animals whilst still in the water (Ballance et al., 2021; Barham et al., 1977). Acoustic deterrents, such as pingers, have been used with some success to deter marine mammals, but there is evidence that they may also attract some species or even cause injury if sound outputs are too high (FAO, 2021), and so trailing of such devices within specific fishery contexts is necessary to evaluate their effectiveness. Several other methods have been shown to reduce processing and release times for sharks and rays post capture, including sorting grids and release ramps (Murua et al., 2022). Spatial and temporal closures have also proven to be effective measures to reduce bycatch of turtles, elasmobranchs, and marine mammals (BMIS, 2024; Dunn et al., 2011).

Lampara net fisheries are suggested to have minimal bycatch (McBride and Styer,2002). Fish species captured within these fisheries are often smaller bodied, and exhibit schooling behaviour at or near the surface. There is however a high incidence of depredation by dolphins in some fisheries (Bruno et al., 2021). This can be effectively mitigated through the attachment of sonar devices, which has been shown to reduce depredation significantly (> 80%; Bruno et al., 2021). Lampara nets are suggested to be highly selective when used in combination with sonar devices owing to the ability to release TEPS with minimal damage (Commonwealth of Australia, 2023).

Purse-seines are suggested to have high quantities of discards (1.0 million tons), but moderate discard rates, averaging 5–10% of total catch (Amandè et al., 2010; Pérez Roda et al., 2019). These discard rates are considerably lower than several other common gear types (Pérez Roda et al., 2019). The large volume of fish discarded is suggested to be inflated by the overall catch of purse seines (Pérez Roda et al., 2019). Fish aggregating devices have been shown to increase bycatch rates (Amandè et al., 2010; He et al., 2021). There is also the potential for high mortality and mutilation of catch during the hauling process, especially when fishers use a technique known as “slipping” where catch can become highly crowded during the final stages of capture prior to being released (Breen et al., 2024). This is due to the higher amounts of stress, physical pressure, and oxygen depletion that occurs throughout the hauling process (Breen et al., 2024).

Surrounding nets used in deeper marine environments to target pelagic species pose little, to no threat on benthic environments. However, when used in shallow coastal and estuarine environments (most commonly with Lampara nets), there is the potential for nets to contact substrata, disturb benthic environments, and catch on rough materials. This is especially the case in areas where water levels are volatile due to tidal movement, and where visibility prevents precise net deployments (He et al., 2021; Wessel and Winner, 2003).

Economic Considerations

Surrounding nets are scalable. Purse-seine fisheries are considered the most important fisheries globally by volume landed, and lampara net fisheries often form an important part of smaller multi-gear fisheries (He et al., 2021). The overall capture efficiency of surrounding nets is high, when schools of fish are targeted prior to deployment (Hilborn et al., 2023).

The equipment required to safely operate a surrounding net depends on the scale of the fishery and the specific net to be used. Small scale fisheries often deploy and haul nets manually, or with the assistance of small winches from one or two vessels (He et al., 2021). In contrast, larger operations targeting large, valuable fishes use hydraulic drums, spotter planes, two to three vessels, and other sensing devices to locate, and target schools of fish. Surrounding nets are the most fuel-efficient major fishing gear in terms of litres of fuel used per megaton of catch landed (average 252L/MT) (Parker and Tyedmers, 2015). Thus, equipment maintenance is likely to be the greatest operational cost for purse-seine and surrounding nets more generally.

Whilst gear loss is not uncommon in these fisheries, it is unlikely that there will be severe damage to nets during shots because of the low risk of bottom contact when used in pelagic environments. This coupled with the use of durable materials like nylon or polyester increases the lifespan of fishing materials and reduces the operating costs of surrounding nets.

The quality of catch depends on the method used, and how the animals are processed. Large scale operations and poor hauling practices can lead to a decreased overall quality of catch through mutilation and stress. In smaller fisheries, catch that is not fit to sell is often converted to chum rather than being discarded (McBride and Styer, 2002).

Social Considerations

The social perception of surrounding nets is dependent on the specific gear type. Typically, larger fisheries are viewed as less sustainable and are likely to experience greater public scrutiny. Another consideration that may influence the public perception of a fishery is its carbon footprint. Despite being an active fishing method, purse-seines have the lowest carbon footprint of all major fishing gears (Hilborn et al., 2023; Parker et al., 2015). There is historical evidence of conflict between commercial fishers about congestion, gear conflicts and allocations, and between recreational fishers in some instances (Spratt, 1992).

Beach seines

General Description

Beach seines are an active fishing gear that is operated from the shore. Deployment typically involves visually identifying a school of fish, encircling it with one end of the net using a small boat, and hauling both ends of the net back to shore, where fish can be processed (Figure 3; He et al., 2021, Tietze et al., 2011). The net structure is characterised by large wings, a headline and lead line, and a codend made of finer mesh (Figure 3). A sufficiently heavy lead line is essential to maintain contact with the bottom and prevent the escape of any fishes. This gear type is used globally in shallow inland, estuarine, and coastal areas to target demersal and pelagic species of fish (Tietze et al., 2011). It is especially prevalent in small-scale artisanal fisheries.

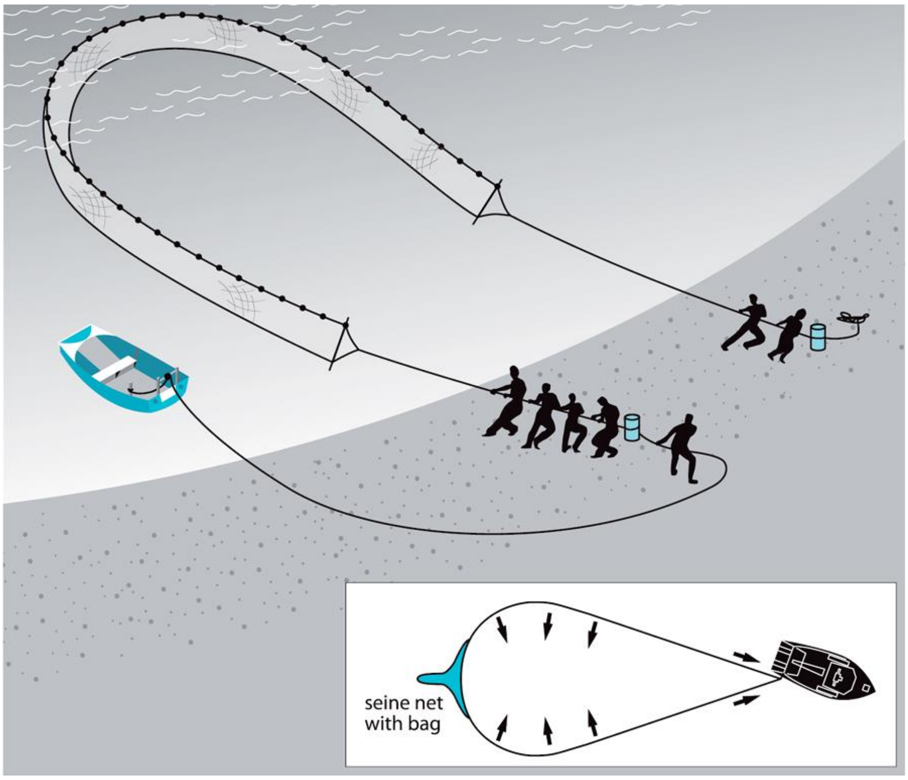

Figure 3. Illustration of beach seine deployment and hauling (Source: Status of key Northern Territory Fish Stocks Report, 2017).

This gear has several advantages owing to its active nature and the simplicity of operation. When schools of fish are visually targeted, this gear type has the potential to be very selective. The gear can have high discard rates and result in interactions with several bycatch species, including TEPS; however, post-catch survival of non-target species is often high. As this gear type operates on smaller scales, there has been limited investigation into potential bycatch mitigation solutions, although there are operational guidelines to improve survival outcomes for TEPS.

Relevant Fisheries

In Australia, beach seines are used in small-scale fisheries in NSW, Queensland (QLD), Western Australia (WA), SA and the Northern Territory (NT), and is mostly used in shallow, coastal and estuarine environments. It often forms part of larger multi-gear fisheries and is commonly used to target small to medium sized teleost fishes and cephalopods. Commonly targeted species include Australian Salmon (*Arripis trutta*), School Mackerel (*Scomberomorus queenslandicus*), Blue Threadfin, Queenfish, Garfish, Whiting, Australian Sardine, and Sea Mullet (*Mugil cephalus*). In the NT, beach seine nets are used in the NT Coastal Net Fishery to target Mullet and Blue Threadfin.

Comparisons to Gillnets

One comparative study of post-capture mortality between beach seine and gillnets suggested that beach seines have lower post-capture mortality compared to gillnets (Bass et al., 2018); however, Broadhurst et al., (2008) showed an inverse trend with the mortality observed in both gear types being higher for smaller fish, highlighting the importance of careful selectivity for beach seines (Broadhurst et al., 2008). With regard to target species, Russell (1988) noted low catch rates for Barramundi and Threadfin Salmon and suggested that beach seines are not a suitable replacement for gillnets for these species. However, the cause of the lower catch per unit effort was not discussed.

Operational Considerations

There are several operational considerations for beach seines. This includes whether to visually locate a school of fish before fishing and how nets are deployed and hauled. In many parts of the world, beach seines are deployed using an unpowered boat (e.g., a canoe) and are hauled to shore by hand, though use of powered vessels and winches are also commonplace (Teitze et al, 2011). Deployment is limited to soft sediment habitats, as seafloor structures present a risk of snagging or environmental damage from the net requiring constant contact with the seafloor to operate effectively.

Hauling is generally quite quick (<30 minutes) and due to the small scale of this fishing method, survival of bycatch is generally high. There is also some evidence to suggest that short haul distances (< 50m) may reduce fish escape during hauls (Lombardi et al., 2014). Examples of best practise from Queensland fisheries include the use of finer mesh size to reduce risks of gilling non-target species, and spatio-temporal closures ensure that the interactions with TEPS are minimised (Jacobsen et al., 2019). Processing catches whilst nets are partially submerged is another method that fishers can use to reduce stress, especially where TEPS have been caught (Jacobsen et al., 2019).

Environmental Considerations

Bycatch is common in beach seine fisheries, with non-target teleost species, elasmobranchs, and sea turtles frequently caught, which may include threatened species. Discard rates can also be high, which has been linked to impacts to local biomass (Viera et al., 2020), so careful consideration of local effort is necessary for this gear type. Data from the Botany Bay beach seine fishery (NSW) show that up to 44% of the total individuals caught were discarded as undersized or not commercially valuable (Gray et al., 2001). Similar discard rates were observed within the NSW Ocean Haul fishery (Gray and Kennelly, 2003), including a high capture rate of juvenile commercially and recreationally important species (Gray and Kennelly, 2003; Tietze et al., 2011), which may impact recruitment and long-term sustainability. While most bycatch is released, post capture mortality remains unknown for most species. Post-capture mortality reported by Broadhurst et al., (2008) suggests that beach seine discards of undersized individuals may have negative economic, ecological, and social consequences for commercial and recreational fisheries. The operation of beach seines involves constant contact with the seafloor, which may present a risk of damage to sensitive habitats.

Economic Considerations

Beach seines are an important fishing gear that is commonly used in small commercial and artisanal fisheries globally due to the comparatively low cost of operation. In Australian waters, beach seines are often used in multi-gear fisheries. The rapid hauling and processing times for beach seines can reduce incidences of catch damage seen in larger scale surrounding net operations, resulting in higher quality catch. However, the high proportion of juveniles caught in beach seines is an economic consideration that has received little attention in the literature despite it being ubiquitous across all fisheries (Gray et al., 2001; Tietze et al., 2011). Use of the gear my require a number of personnel for hauling, but this can be alleviated through the use of winches.

Social Considerations

Beach seine fisheries often operate close to densely populated areas, leading to high public exposure to fishing activity and potential negative social perceptions (Gray and Kennelly, 2003; Lamberth et al., 1995, 1994; Signa et al., 2008). The bycatch of commercially and recreationally important species may also result in conflict between the recreational and commercial fishing sectors (Gray et al., 2001; Gray and Kennelly, 2003). Similar issues have arisen around the globe in small scale artisanal fisheries, where there is spatial overlap between different gear types, including beach seine (Tietze et al., 2011).

Boat seines

General Description

Boat seines are a conical shaped net, with two large mesh wings that lead to a codend used to fish along the seafloor. Long hauling lines are attached to either end of the net and are used to encircle a school of fish (Figure 4 ;He et al., 2021). These nets are very similar to trawl nets structurally but differ in how they are deployed, which usually involves one or two boats (i.e., pair-seining). Single boat operations most commonly use either the Danish seining or Scottish seining technique. Danish seines involve hauling the net up to an anchored boat and while Scottish seines use the boat to tow and close the net as it is hauled (He et al., 2021). This gear is used globally to target demersal species of fish including cod, and benthic species like flounder. Typically, it is operated in coastal and offshore environments ranging from 50 – 500 metres in depth.

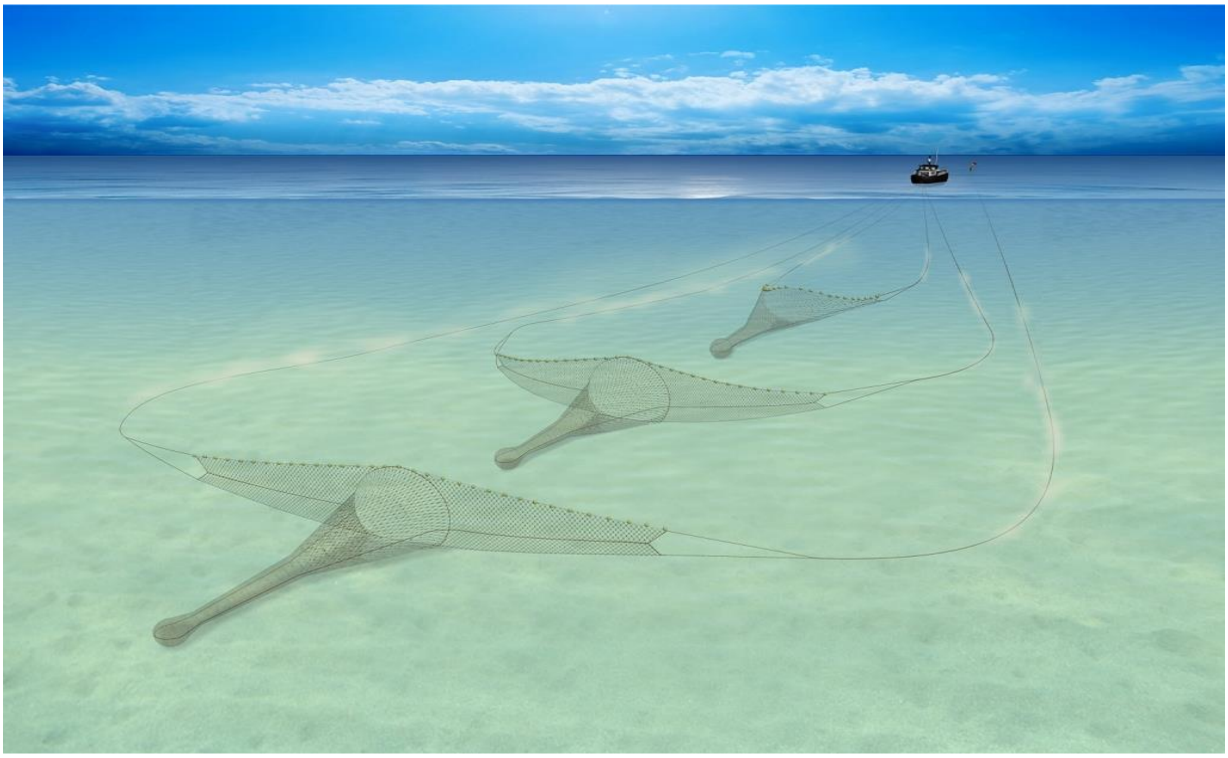

Figure 4. Illustration of boat seine deployment on seabed (Source: Seafish https://www.seafish.org/responsible-sourcing/fishing-gear-database/gear/ssc-scottish-seine/).

Relevant Fisheries

In Australian, boat seines are often used in multi-gear fisheries alongside trawls. These fisheries commonly target demersal species such as Tiger Flathead (*Neoplatycephalus richardsoni*), Bluespotted Whiting (*Haletta semifasciata*), Stout Whiting (*Sillago robusta*), and Eastern School Whiting (*S. flindersi*) (AFMA, 2023a). Overseas fisheries target demersal species such as Red Mullet, Squid, Whiting, Atlantic cod (*Gadus morhua*), Hake (*Merluccius* spp.), Seabass, Flounder, and Halibut.

Comparisons to Gillnets

To our knowledge, there are no empirical comparisons between boat seines and gillnets in efficiency or specificity.

Operational Considerations

Vessel and equipment requirements for boat seines vary with scale but often requires sufficient deck space for storing nets and handling catch, and mechanised equipment for deploying and retrieving the nets. Operation also typically requires skilled crew to handle the process.

The use of boat seines (especially Danish Seines) is largely restricted to flat substrata (He et al., 2021). Although, Scottish seines are typically made of more robust materials with thicker ropes and therefore can be used on coarser substrate (Noack et al., 2017). However, this durability comes at the expense of benthic habitats and fishing efficiency associated with heavier bottom contact as there are likely higher vessel power and fuel requirements and maintenance needs (Eigaard et al., 2016; Noack et al., 2017). Although, these expenses are less than for comparable bottom trawls (Eigaard et al., 2016).

Selectivity is a major concern for this gear type. Some modifications to boat seine deployment have been suggested to improve selectivity, including mesh shape, hauling speeds, and the angle of coded to take advantage of species-specific escape behaviour (Herrmann et al., 2016; Noack et al., 2017). Further potential modifications include the use of "topless" seine nets to allow longer escape times, use of square mesh panels or codends to reduce catch of undersized animals, sorting grids, separator panels, and modifications to footropes (Walsh and Winger, 2011).

Environmental Considerations

Boat seining is generally considered to have lower environmental impact than other large-scale bottom fishing gears used commercially, however direct assessment of the impacts of boat seines are generally lacking (Walsh and Winger, 2011). High discard rates have been recorded for boat seining (~25%; Pérez Roda et al., 2019). Modifications to codends and fishing operations can help improve size and species specificity (e.g., NSW Ocean Trawl Fishery; Koopman et al., 2010; Broadhurst and Millar, 2024). Bycatch of megafauna, including threatened species, also occurs (Sporcic et al., 2021).

As a bottom gear, boat seine operations can cause damage to sensitive benthic environments, and associated species. In general, the impact on these environments is low when the seafloor is flat and comprised of soft sediments (Bell et al., 2016; Sporcic et al., 2021). Although invertebrates like sponges may be disproportionately affected by localised fishing pressures (Bell et al., 2016). There is currently insufficient evidence to characterise the impacts of boat seining on benthic environments.

Gear loss has been reported in the Australian SESSF for entire or partial nets (Sporcic et al., 2021), which may lead to impacts from ghost fishing. Further, Danish seine ropes in Norway have been estimated to contribute between 77 – 97 tons of microplastic to marine systems annually (Syversen et al., 2022). This is associated with the friction applied to seine ropes that drag along the seafloor during net deployment. A total of 311 tons per year of microplastics are estimated to be produced globally by boat seine fisheries through this mechanism alone (Syversen et al., 2022).

Economic Considerations

Boat seining is one of the most economical methods of active benthic fishing in terms of fuel consumption and gear maintenance (Walsh and Winger, 2011). This can be attributed to the lower engine power required to tow nets in comparison to other larger and heavier gears, like bottom trawls (Noack et al., 2017a; Walsh and Winger, 2011). However, modern boat seines are now considered to be as technically demanding as trawls in terms of equipment and staff.

Catch quality is generally high from boat-seine operations. The shorter haul time compared to trawls, and the late entry of fishes into the codend reduce the likelihood of catch to be mutilated during hauling (Noack, 2017; Walsh and Winger, 2011). Although, the quality of caught fish does vary based on operational characteristics such as onboard processing, storage capacity, and the mesh size used (Walsh and Winger, 2011).

Social Considerations

Boat seining may lead to social conflict between commercial and recreational fishers. For example, in Tasmania, there are strict zonal closures to minimise both the ecological and social impact of this boat seining, including weekend closures to reduce interactions between commercial and recreational anglers (Tasmanian Government, 2023). Concerns about resource sharing have been raised within the Ocean Trawl Fishery (NSW) between Danish seiners and other commercial sub-fisheries for the same resources.

This gear may have a negative public perception due to its similarity to trawling. Many commercial fishers question the sustainability of Danish seine fishing, with some now believing this gear to be as damaging as bottom trawling due to gear modifications and technical advancements, although these claims remain unsubstantiated (Hale, 2012).

Trawls

General Description

Trawls are an active fishing gear consisting of large nets with a wide opening, and narrow codend where fish are collected, that is towed behind a vessel at a speed that exceeds that of the target catch. Trawls are versatile, able to be used at a range of depths, with a range of mesh sizes and in many configurations (e.g., single net with multiple codends, multiple trawls towed in parallel) to target various species. They account for almost a quarter of global fish landings (Amoroso et al., 2018). There are two general types of trawls, demersal (bottom) and pelagic (midwater) (Figure 5). Demersal trawls are used to target benthic or demersal species and use heavy groundgear to maintain contact with the seabed during operation (He et al., 2021). In contrast, pelagic trawls tend to be much larger and are used target schooling fish in the water column, in particular clupeids (herrings and sprats) and scombrids (mackerel, tuna, and bonito), with very high catch rates for effort (He et al., 2021).

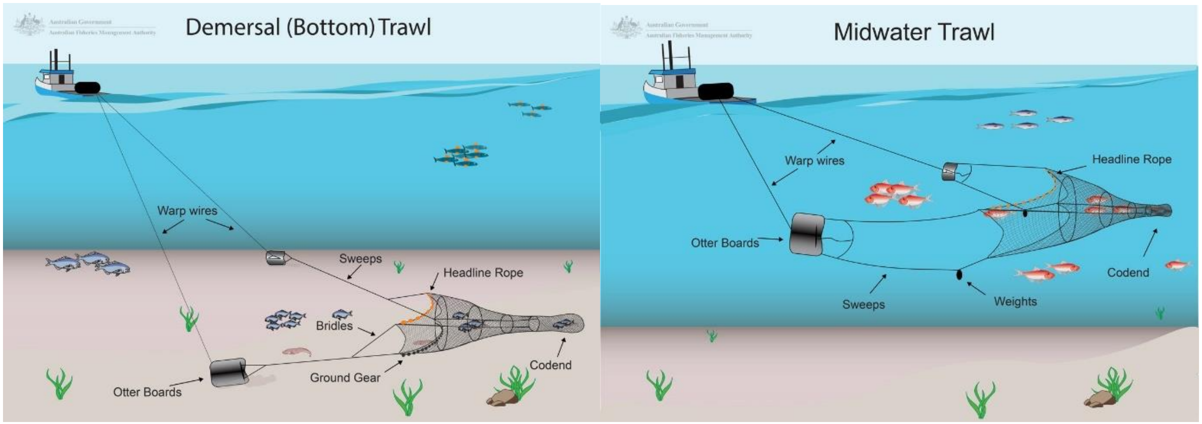

Figure 5. Illustration of a demersal (bottom trawl) (left) and midwater trawl (right) (Source: AFMA https://www.afma.gov.au/methods-and-gear/trawling).

Relevant Fisheries

Australia has a relatively low footprint of trawl-based fisheries (<10% of seabed area is trawled, mostly sandy or muddy substrate), with the highest trawling activity in the north-east and south-east continental shelf (Amoroso et al., 2018). Australian trawl fisheries that target finfish include NSW Ocean Trawl Fishery (Whiting, Flathead, Silver Trevally, sharks and rays), QLD Fin Fish Trawl Fishery (Whiting, Yellowtail scad, Goatfish), Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (Flathead, Blue Mackerel, Pink Ling, and Blue Grenadier), and the Commonwealth-managed Small Pelagic Fishery (Mackerel, Redbait, Sardine).

In the Northern Territory, there is one commercial fishery currently using trawls (Northern Territory Demersal Fishery). The fishery is a multi-gear fishery, permitted to use fish traps, hand lines, droplines, and demersal trawls. The demersal trawls are used to target Saddletail Snapper (*Lutjanus malabaricus*) and Crimson Snapper (*L. campechanus*) (Northern Territory Government, 2019). This fishery interacts with TEPS, and Bycatch Reduction Devices (BRDs) are mandatory on all trawl vessels to reduce interactions (Northern Territory Government, 2019). Licensees also voluntarily use square mesh cod-ends to reduce the retention of non-target species (Northern Territory Government, 2019).

Comparisons to Gillnets

Comparisons between gillnets and trawls have shown that gillnets tend to capture larger fish (Boje, 1991; He, 2006; Huse et al. 1999; Huse et al. 2000; Nedreaas, et al., 1996), even where the same mesh size is used (Lowry et al., 1994). Small trawls have also been trialled as an alternative gear to finfish gillnets in the Gulf of California, with results showing the high catch efficiencies and low bycatch rates, but further research was recommended by the authors (Herrera et al., 2017).

Operational Considerations

There are many types of trawls, with the type and operational considerations being dependent on scale and target species (Table 2; FAO, 2024). The various types of trawls and specific considerations are summarised in Table 2. Generally, trawl fishing gear is designed as cone-shaped nets towed behind vessels to capture fish. Trawler vessels range from small undecked boats operating in inshore environments to factory trawlers operating offshore (FAO, 2024). Trawl gear often requires vessels equipped with winches, net drums, and hydraulic lifting systems for handling large nets and catches (FAO, 2024). For coastal, demersal fish species, the most appropriate type of trawl would likely be a type of pair trawl or semi-pelagic trawl due to ability to operate in shallow estuarine environments, and ability to target demersal species with minimal impact on seabed habitats.

Trawls can be configured in many ways to target different species individually, or concurrently (He et al., 2021). Demersal trawls use heavy groundgears like ropes, chains, and weights to maintain contact with the seabed (He et al., 2021). Pelagic trawls often use echosounders or scanning sonar to detect fish schools in the water column (He et al., 2021).

Selectivity of trawls can be influenced by modifying the codend. Modifications include adjusting mesh size and shape, knot orientation, hanging ratio, twine thickness, codend diameter, towing speed, towing depth, and hauling practices (Pérez Roda et al., 2019). Selectivity in trawl gear is further enhanced through modifications like escape panels and BRDs (Figure 3). Turtle Excluder Devices (TEDs) are usually mandatory BRDs in Australian trawl fisheries to support the escape of larger species, such as turtles, rays, and sharks.

Table 2. Summary of common trawl types. BRDs = Bycatch Reduction Devices, TEDs = Turtle Excluder Devices

Gear	Target species	Area environment	Operation	Impacts
Pair trawls				
Demersal pair trawl	Demersal fish, mainly flatfish. Lesser extent prawns	Very shallow (5-800m) to deep (<800m)	Operated by two vessels, with one handling the catch and the other only for towing. Vessels can be open boats with an outboard engine, or any vessel up to 60m	• Lower physical impact than ploughing trawls (e.g., beam trawls); can be rigged to sit a few metres above seafloor • High discard rates but regulated through min. mesh size, square mesh, and selection grids
Pelagic pair trawl	Pelagic and demersal species	Coastal to offshore, and lakes		• No impact on bottom. • Bycatch rates generally low. • Bycatch of marine mammals may occur.
Otter trawls				
Multiple demersal otter trawls	Demersal and benthic fish and invertebrates	Typically shallow coastal waters	More than two trawl nets are towed over the seabed by one boat that is generally large and powerful, with haul ramps, winches, and net drums	• Bycatch and discard rates often substantial due to small mesh size of prawns. • Sea turtle bycatch common in tropical waters, but TEDs help to reduce bycatch.

				• High impact on seabed and benthic ecosystems.
Single boat demersal otter trawls	Demersal and benthic fish and invertebrates	Rivers and estuaries (<2m depth) to depths of more than 1000m	Generally large and powerful vessels used, but small vessels can also be used to tow a small trawl in shallow water. Designed to have bottom contact and heavy ground gear.	• Bycatch and discard rates substantial • Sea turtle bycatch common in tropical waters, but TEDs help to reduce bycatch. • High impact on seabed and benthic ecosystems.
Twin demersal otter trawls	Demersal and benthic fish and invertebrates	Typically shallow coastal waters		• Bycatch and discards often high, but somewhat mitigated with BRDs including Nordmore grates and TEDs • High physical impact to seabed
Single boat pelagic otter trawls	Pelagic schooling species, such as clupeids and scombrids	Deeper waters - continental shelf and lakes	Usually large vessel and with sophisticated machinery and equipment. Sounders required to detect schools of fish. Catches usually very large to powerful winches required.	• No impact on seabed • Bycatch rates low is targeting single species • Incidental catch of marine mammals may occur.
Semipelagic trawl				
Semipelagic trawls	Demersal fish, such as haddock or pollock.	Shallow to deep marine waters	Generally large and powerful vessels used, but small vessels can also be used to tow a small trawl in shallow water. Trawl net or otter boards touch the seabed.	• Some contact with seabed can lead to physical impacts. • Some bycatch is possible for mixed target species fisheries
Beam trawl				
Beam trawl	Flatfish and prawns	Shallow coastal < 100m depth	Towed by specialized medium size vessels, equipped with powerful engines arranged with large outriggers. Towed in close contact to seabed with tickler chains to disturb fish from seabed.	• High physical seedbed impact • High discard of undersized and non-target species, sometimes mitigated with square mesh panels

Environmental Considerations

The environmental impact of trawl fishing gear, particularly demersal trawls, is considered significant due to poor selectivity, high discards, seabed disturbance, and carbon footprint (He et al., 2021; Hilborn et al., 2023; Pérez Roda, et al. 2019). Demersal trawl fisheries account for 46% of commercial global fishery discards, whilst pelagic trawls contribute 16%, which is similar to gillnets (Pérez Roda, et al. 2019). Despite the gear adjustments implemented in commercial fisheries, capture of TEPS, particularly sharks, rays, turtles, and seabirds, remains a significant concern in many trawl fisheries (Hilborn et al., 2023).

BRDs and TEDs have been shown to reduce bycatch, specifically for larger species like turtles, sharks, rays and pinnipeds, and there has been considerable investment in bycatch mitigation research and development for trawl fisheries, particularly in Australia. In the QLD Northern Prawn Trawl fishery, there was a large decrease in bycatch of turtles, sharks, and rays, as well as a small decrease in commercially important prawns with the inclusion of BRDs and TEDs (Brewer et al., 2006). Whilst these devices have been shown to decrease bycatch, there remains an issue of sawfish entanglement forward of the TEDs due to the higher entanglement risk for these animals (Brewer et al., 2006). Several modifications have been proposed to remedy this issue (see Brewer et al., 2006), but sawfish bycatch remains a management challenge.

Mortality rates for discarded finfish from trawlers are often high, but the types and severity of injuries to fish that impact mortality are highly specific to gear, operations, environmental conditions, species and size, and handling and release practices (Pérez Roda et al., 2019). Generally, smaller fish are more impacted by stressors associated with capture, including exhaustion from enduring swimming, suffocation from high densities, and physical injury from collision with the net or other animals or from escaping through the mesh or BRDs (Pérez Roda et al., 2019).

The environmental impact of demersal trawls extends beyond discards to include seabed disturbance and habitat degradation (Amoroso et al., 2018; Hiddink et al., 2017); but impacts are likely to be gear-, species- and/or area-specific (Hiddink et al., 2017). Although the type of substrata trawled influences the extent of damage caused by trawls, estimates indicate that the recovery of some bottom trawled habitats can take over six years (Hiddink et al., 2017), highlighting that long-term impacts from these fishing practices are possible.

Economic Considerations

The costs associated with starting a trawl fishery vary considerably depending on the gear type and operation chosen, including the cost of gear, fuel, crew, ongoing repairs, and cost of implementation fishery management controls. Bottom trawl fisheries are considered one of the least fuel-efficient fishing gear types (mean fuel use intensity = 1,363 L t^{-1}), while pelagic trawls are more fuel-efficient (691 L t^{-1}), and at a similar rank to gillnet fishing (742 L t^{-1}) (Parker & Tyedmers, 2015).

The quality of catch can also be impacted by stressors experienced by caught fish, including exhaustion from enduring swimming, suffocation from high densities, and physical injury from collision with the net (Pérez Roda et al., 2019). Gear modifications can improve the catch quality, but often slightly reduces catch quantity (Brewer et al., 2006).

Social Considerations

There are strong public perceptions associated with trawl fishing, due to environmental impacts, overfishing, and carbon footprint; however, others recognise the economic importance of this fishing method, particularly for high valued seafood, and advances in gear and bycatch reduction technologies are improving sustainability within trawl fisheries.

Historically, demersal trawl fisheries have a high level of conflict with bottom-set passive fishing gears (e.g., bottom longlines, gillnets, and pots), often requiring the implementation of spatial and temporal arrangements between sectors (Hilborn et al., 2023) or banning of trawling in areas important for artisanal or small-scale fisheries (McConnaughey et al., 2020). There is also competition over space between demersal trawls and other ocean uses, such as oil and gas pipelines, and communication cables, windfarms, tidal power, and seabed mining, which require use of the seafloor and present hazards to demersal trawling (Hilborn et al., 2023).

Trap Gears

Pound nets or arrowhead traps

General Description

Pound nets, or arrowhead traps, are a type of passive and stationary fishing gear that consists of a long 'leader' that intercepts migrating schools of fish and leads them into a holding chamber(s) or 'pound', where they can then be selected for processing or release (Figure 6). Pound nets are often fixed, but can be semi-permanent or portable. Traps are one of the oldest commercial fishing gears in the world (He & Inoue, 2010) and have been used by indigenous communities for thousands of years (Rowland & Ulm, 2011).

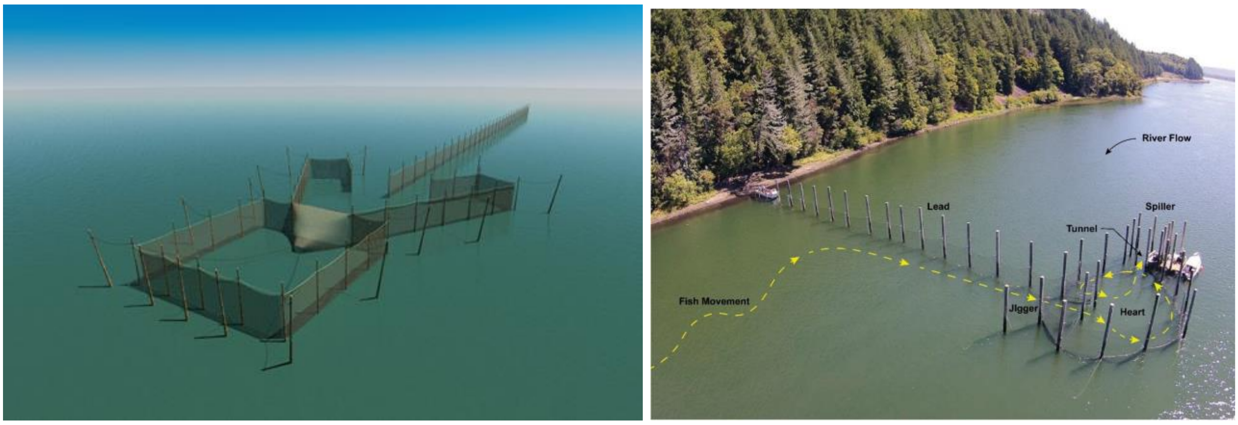

Figure 6. Left: Illustration of an arrowhead trap, a type of pound net (Source: He et al. (2021)). Right: An example of a prototype commercial fish trap (pound net) in the Lower Columbia River, Washington State, USA (Source: Gayeski et al. (2020)).

Relevant Fisheries

Pound nets have historically been used in QLD waters, including within the Great Barrier Reef Marine Park (GBRMP) (Chin et al., 2022). Throughout the 1900's, there were close to 300 arrowhead traps used around the GBR alone which were typically set on mud flats with large tidal runs (S. Williams, QLD DAF, pers comm.). These traps were used to target Barramundi, Blue Threadfin, King Threadfin, School Mackerel, Mullet, and Trevally, with catch composition varying by region and seasonally (S. Williams, QLD DAF, pers comm.). The use of arrowhead traps in the region was substituted with gillnets owing to the increased 'efficiency' of gillnets and lower maintenance requirements. The concept of fish traps have been used by Aboriginal communities in Australia for thousands of years, with some still in use today.

Globally, they are used in North America, United States, Japan, and the Baltic Sea. In North America pound nets are used to target Atlantic cod (*Gadus morhua*), Atlantic mackerel (*S. scombrus*), Atlantic herring (*Clupea harengus*), and capelin (*Mallotus villosus*) (He & Inoue, 2010). Pound nets are regaining popularity owing to their more selective nature compared with other gears. An example of this is The Fish Trap Project by Wild Fish Conservancy in the Columbia River, which is trialling the use of pound nets for selectively harvesting hatchery-origin salmon whilst improving survival of threatened wild-origin salmon (Wild Fish Conservancy, 2024). In Japan, this method is used to target large pelagic species like Tuna and Salmon, or demersal species like Sea Bream (He & Inoue, 2010). The most caught species is Chum salmon (*Oncorhychus keta*), with 95% of coastal salmon landings coming from this gear type (He & Inoue, 2010).

Comparisons to Gillnets

Arrowhead traps are considered a strong candidate for replacing gillnets (Chin et al., 2022). In some regions they have been progressively phased out for 'more efficient' gillnets; however, there has been recent shifts back to pound nets in some cases due to higher selectivity and high post-release survival for non-target fish (e.g., The Fish Trap Project by Wild Fish Conservancy).

Pound nets used for harvesting of hatchery-reared salmon have been shown to have a 100% post-release survival of bycaught threatened salmon stock (Tuohy et al., 2023; Tuohy et al., 2020), whilst conventional gillnets were shown to have survival rates as low as 40% (Gayeski et al., 2020).

Operational Considerations

Pound nets consist of net walls attached to stakes and are set in shallow coastal environments with walls reaching from the bottom to above the high tide height. One or more leaders (linear walls of netting) are used to intercept migrating schools of fish and lead them into one or a series of holding chambers or 'pounds' (He et al., 2021). The pounds may have netting across the bottom, and the catch is retrieved by hauling the entire pound onboard small open boats, either by hand or mechanically (FAO, 2024; He et al., 2021), or scoop nets are used to bring small amounts of fish up at a time for sorting. These traps are typically set in place for extended periods (i.e., entire seasons to year-round) and visited daily to sort and collect the catch (FAO, 2024). When not in use, escape doors in the pound can be opened or netting can be lifted to allow trapped fish to escape or move through the gear without being captured.

Traps are typically set in shallow coastal waters, estuaries and rivers, and run perpendicular to the coastline, often making use of natural features such as headlands or rock bars (FAO, 2024). As fish typically seek deeper water when encountering an obstruction, leaders are run from shallow to deep with the trap set in the deeper water (FAO, 2024). The more visible the leader is (i.e., the higher the contrast against the surrounding water), the more effective it is in guiding fish into the pound (He & Inoue, 2010).

Traps are considered to have good size and species selectivity as they are designed to target single schooling species with specific movement behaviours that can be leveraged. Selectivity can be managed via changes in mesh size and modifications to the leader, such as using a sunken or raised leader net, deflector panels, or panels of netting with differing mesh sizes at the top or bottom of the leader (He & Inoue, 2010). For instance, on the Canadian east coast, implementing a sunken leader reduced Atlantic salmon (*Salmo salar*) bycatch in cod fish traps by 88% (Brothers, 1996).

Given traps are passive gears that work by exploiting the natural movement and migratory behaviour of target fishes, a good understanding of fish behaviour and local ecology is critical for successful trap fishing. Poor placement or design can result in catch failure for the season. He and Inoue (2010) summarise a range of behavioural and design considerations for traps.

Environmental Considerations

Pound nets are highly efficient gears. In some places, they have been phased out due to being too effective, leading to overfishing and local depletions (e.g., salmonids in U.S Pacific Northwest; Gayeski et al., 2020). Hence, pound nets need to be carefully managed.

Pound nets allow fish to swim freely within the pound and be harvested alive. This method of live harvest allows for more humane practices and a higher quality product, as the fish can be bled and placed in slush ice immediately upon capture (Tuohy & Jorgenson., 2022). This also allows bycatch species to be released alive and increasing chances of post-release survival (He & Inoue, 2010). For example, pound nets used for selective harvesting of hatchery-reared salmon stock were shown to achieve 100% post-release survival of threatened salmon stock (Tuohy et al., 2023; Tuohy et al., 2020), whilst conventional gillnets were shown to have survival rates as low as 40% in the region (Gayeski et al., 2020). There is a risk of injury or mortality from contact with the mesh or entanglement, or through increased stress when there is a large catch in the pound (He & Inoue, 2010). Therefore, traps need to be attended frequently.

Interactions with marine megafauna, such as mammals, sharks, turtles, and birds can occur for pound net gears. This risk can be reduced through gear modifications. For example, using a hanging leader can allow turtles to pass over the leader of the net at the surface rather than being led to the trap (Silva et al., 2011). Similarly, a raised leader may allow benthic species to pass by. Exclusion grids are also often used at the entrance of the pound to prevent larger animals from entering the gear all together. However, where this gear is used to target prey of megafauna species, interactions may increase due to these animals potentially taking advantage of the trapped fish for foraging (He & Inoue, 2010). As a stationary gear, animals may also learn associations with foraging over time. This may carry additional financial or operational implications, as the presence of predators around the trap may deter target fish from the area or predators may cause damage to the near (He & Inoue, 2010). Gear reinforcement or bycatch deterrent technologies like pingers or exclusions grid may help to combat this (Lehtonen and Suuronen, 2004; Gayeski et al. 2020).

In tropical environments, care must be taken to reduce thermal and oxygen stress on trapped fish (Chin et al., 2022). This can be mitigated by checking traps with each tidal cycle to reduce exposure of trapped fish to high temperatures with lowering water levels. As a stationary gear, physical disturbance is limited but some localised intertidal disturbance can occur following initial set up, but these impacts don't usually persist as the inshore environments they are set in themselves are typically highly mobile (Seafish, 2024). Use of semi-permanent or portable gears may help mitigate this.

Economic Considerations

The greatest cost associated with pound nets is the installation, maintenance, and deconstruction of the physical structures. The cost of a fish trap is likely to be initially high. In the lower Columbia River, a salmon fish trap has been costed at ~AU$150k to AU$230k, depending on location, materials, and design, while annual non-labour costs (permits/licencing, maintenance, fuel, etc) for a 20-day season were estimated at ~AU$10000 (Tuohy & Jorgenson., 2022). Importantly though, Tuohy and Jorgenson (2022) found that revenue for the target salmon exceeded annual cost estimates. In addition, when compared to other fishing gears, pound nets have low fuel consumption due to their passive nature meaning that vessels are only required for catch retrieval and processing. In Australia, it has been suggested that semi-permanent pound nets may be suited to the tropics, with traps installed over winter (removed prior to the cyclone season) for relatively low cost and by just 1 or 2 fishers, if designed well (Chin et al., 2022).

Given the traps are passive and rely on the movements and migrations of target species which can vary with environmental conditions, catches can be unstable (He & Inoue, 2010). Good understanding of target fish behaviour and ecology are critical for effective trap design and location. This is often informed by generations of local fishing knowledge (He & Inoue, 2010) and ongoing refinement, necessitating investment in research and development in collaboration with local fishers and gear technologists.

The live capture process of pound nets distinguishes it from some other gear types, with the catch suffering minimal physical damage and stress thus increasing its quality. This is often reflected in the price of trapped fish compared to alternative methods in some regions (e.g., gillnets; Tuohy & Jorgenson, 2022). However, pound nets still face challenges from marine megafauna, such as marine mammals, sharks, turtles, and seabirds, which can damage gear (He & Inoue, 2010) and potentially damage fish through depredation or scaring target fish away, reducing catch quality and quantity (He & Inoue, 2010).

Social Considerations

Pound nets are regarded as a low-impact and highly selective fishing method, which aligns with consumer demand for environmentally safe and responsibly sourced seafood (Wild Fish Conservancy, 2024). However, public amenity or perception may be impacted through installation of these potentially large, permanent structures in coastal environments. This issue may be alleviated using semi-permanent or seasonal deployments or the use of portable nets. Conflict between other ocean users may post a risk, however, particularly with the recreational sector that favour coastal inshore areas for fishing and with indigenous fishing interests.

As a fixed gear, pound nets can simplify compliance and management, as the gear is fixed in place and can be checked at any time. Remote monitoring equipment like cameras and sensors can be fixed to the gear (Chin et al., 2022). The gear can also be used as a research or education platform (e.g., The Fish Trap Project).

Tunnel nets

General Description

Tunnel nets are large, portable net structures that are used to exploit the natural movements of fish along tidal flows. Tunnel nets have large, curled wings that guide fish into the "tunnel" of the net as water recedes with the tide (Figure 7). Each deployment is done over a single tidal cycle. This gear is used in shallow coastal and estuarine environments, with its placement being directly influenced by the low, and high-water marks.

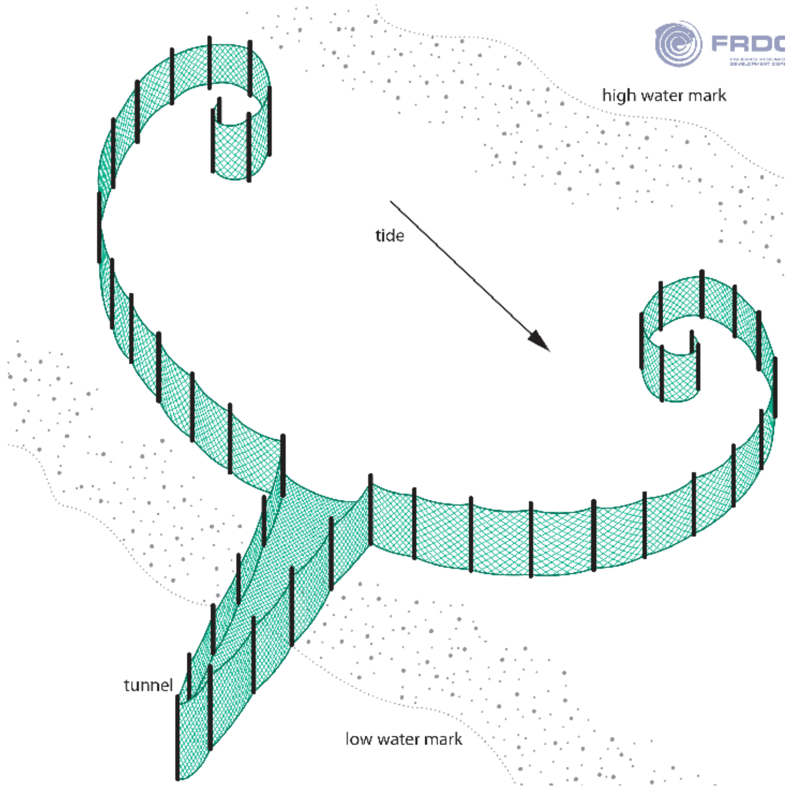

Figure 7. Illustration of a tunnel net (Source: FRDC).

Relevant Fisheries

Tunnel nets have been used in estuaries as part of the Moreton Bay Tunnel Net Fishery (MBTNF) for decades. Target species include Mullet, Bream, Garfish, Flathead, Whiting and Trevally. The fishery has a Code of Best Practice guiding tunnel net fishers on best practices with regard to reducing environmental impacts and securing the future of the fishery (MBSIA, 2012).

Comparisons to Gillnets

Tunnel nets have been explored as an alternative for gillnets within the East Coast Inshore Fin Fish fishery (ECIFFF). It was deemed technically feasible, although potentially unsuitable for targeting species of interest like Barramundi, King Threadfin Salmon, and Blue Threadfin Salmon (Chin et al., 2022). However, the authors suggest some modifications may improve catch efficiency for this species, such as reinforced nets and changes to exclusion grids.

Operational Considerations

Tunnels nets can cover extensive areas (> 1 km long). The net materials are made of thick cord, with small mesh and the trap walls have a floatline and leadline and span the water column. This gear is set at high tide, with the trap portion set below the low-water mark to hold captured fish. Sand anchors and stakes are attached to the wings in specific intervals to secure the gear in place. Exclusion grids placed at the mouth of the tunnel are mandatory in Australian tunnel nets to prevent entry of TEPS into the tunnel (He et al., 2021; Chin et al., 2022). With the outgoing tide, the wings of the nets are retrieved, leaving only the trap in place for processing fish. TEPS and other non-target animals can be released during this process before they encounter the exclusion grid or trap section. TEPS can also be released upon sighting by simply lifting the net walls.

Setting locations need to be over sandy substrate with a sufficiently steep slope such that the trap and tunnel are set deeper than the wings and remain submerged at low tides. Low turbidity assists fishers to see gear, fishes and other trapped animals. Shelter from wind and swell also help to reduce gear damage. Fishing requires a moderate tidal run, typically over neap tides, and a good understanding of how the tide runs off the intertidal zone (He et al., 2021). The gear is often deployed by wading, although it can be done entirely from a small powered or unpowered vessel. Tunnel nets are not structurally robust, and so they can be easily damaged when used improperly or in poor weather or in strong currents. Fouling can also be an issue in warmer waters (Chin et al., 2022).

Trials of tunnel nets in northern QLD have shown that this gear is technically feasible, but further testing is required to understand their effectiveness and commercial viability (Chin et al., 2022). Importantly, during these trials, target size Barramundi and King Threadfin were likely excluded from the net through the use of an exclusion grid with too small spacing to allow larger individuals through. In addition, larger individuals escaped from the net by breaking through the net walls. Research and development will help improve the effectiveness of this gear for targeting these species (Chin et al., 2022).

Environmental Considerations

Bycatch is a major concern for tunnel nets, which includes TEPS such as turtles, sharks, and rays. Nets are designed to have high catch efficiency, and low selectivity until processing. They fish relatively indiscriminately as tide drops, but captured fish are held alive and free-swimming, and can be quickly released in good condition and with low post-capture mortality. For TEPS and other megafauna, tunnel nets are reported to have few negative interactions, as mesh size prevents entanglement and exclusion grids prevent entry to the trap, allowing animals to swim away freely once gear is removed. Large animals are also usually able to push through wings, and as the gear is constantly manned, fishers can release large animals opportunistically by lifting the net walls.

In tropical regions of Australia, interactions with crocodiles and stingers are a concern for this gear type; however, this risk can be lowered by limiting fishing to winter months (i.e., the dry season) (Chin et al., 2022) and setting the traps entirely from small vessels. Similarly, during the dry season, water clarity is typically better, thus improving the observational capacity of fishers when monitoring fishing gear and interactions. Water temperatures are also lower at this time, which can reduce oxidative stress on captured fish, improving post-release survival for bycatch and quality of retained fishes (Chin et al., 2022).

As nets are portable, and used only over a single tidal cycle, localised seabed impacts are minimal, but care is needed in use over sensitive habitats (e.g., seagrass). Due to the environmental constraints of using tunnel net gear (i.e., tide range, tide timing, weather) and timing required for areas to replenish between shots, sites are typically only fished once a month, resulting in negligible localised impacts (MBSIA, 2012).

Economic Considerations

Tunnel nets provide a high catch quality due relatively low physical and physiological stress placed on fish during the capture process. On harvest, retained fish are sorted in a matter of seconds and immediately placed into an ice slurry, resulting in a high quality product (MBSIA, 2012). Tunnel nets can also provide fishers flexibility to 'fish to order', allowing them to choose which species to retain based on market value.

Initial costs of gear can be high due to the size, and research and development may be needed to maximise fishing efficiency (Chin et al., 2022). Vessel, fuel and crew requirements are also generally low, typically requiring one larger vessel as a base, 2 small powered or unpowered vessels for net operation and sorting catch, and can be crewed by 3 to 4 people. Although, fishing is labour intensive. The semi-permanent nature of this gear means it does not withstand poor weather conditions (Chin et al., 2022), resulting in missed fishing opportunity and catch quantity, but the gear is able to be quickly packed with the onset of adverse whether to avoid gear damage.

Due to the reliance on particular tidal requirements and appropriate weather conditions, fishing sites are typically only fished once a month, and fishers therefore require access to several suitable sites to allow for a fishery to be commercially viable (Chin et al., 2022). This may increase costs associated with movement between fishing grounds or limit the commercial viability if there are few suitable fishing sites or competition between license holders.

Social Considerations

Given the temporary and portable nature of tunnel nets, this gear may have better public perception compared to more permanent trap-style gears set in the same coastal areas, such as pound nets. However, the gear can span large areas and be very visible when set up, which may impact visual amenity or public perception. Overlap with other uses is likely to occur, which may result in conflict over space or resources (e.g., recreational fishing, boating).

The Moreton Bay Tunnel Net Fishery is considered the ‘gold standard’ in fish capture in Moreton Bay, which sees many other fishing gears used (MBSIA, 2012). This is supported by the comprehensive Code of Best Practice for the fishery, which could be adapted for other tunnel net fisheries to guide sustainable practice and support good public image of this fishing method.

Fish traps or pots

General Description

A pot (also known as a trap or creel) is a small trap or enclosure that uses bait or other attractants to attract fish through one or more one-way entrances (Figure 8; AFMA, 2023c; He et al., 2021). They are a passive fishing gear, and usually set on the seafloor, either individually or in a connected series, with a surface marker (He et al., 2021). Pots are predominantly used for crustaceans but are also used to catch reef and estuarine fishes (fish traps/pots). This gear type is typically bottom set, but some technological advances allow for setting off the bottom for pelagic fish.

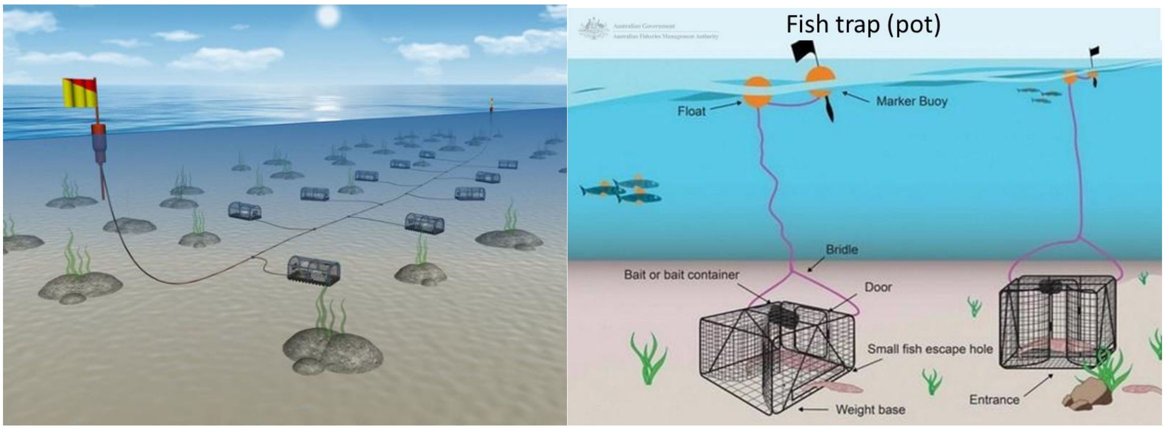

Figure 8. Left: Illustration of a series of lobster pots (Source: Seafish (2024)). Right: Illustration of fish pots (Source: AFMA (2023)).

Relevant Fisheries

In Australian waters, pots (called 'fish traps'), are used to target demersal finfish species in very shallow (2m) to very deep waters (100's of meters) (AFMA, 2023c; FRDC, 2024). Fish traps are used in both small-scale fisheries and commonwealth managed fisheries to target species like Emperor, Snapper, Bream, Trevally, and Morwong. Fish traps are currently used commercially in the NSW Ocean Trap and Line Fishery, WA South and North Coast Scalefish Fisheries, and the NT Demersal Fishery, amongst others.

Comparisons to Gillnets

A study comparing catch efficiency of Atlantic Cod between conventional gillnets and collapsible fish pots suggests that while gillnets had greater catch volume, traps caught cod more consistently across seasons (Nguyen & Morris, 2022). Almost 100% of Cod caught in fish pots were captured alive, compared with only 45% for gillnets, resulting in higher quality fish from the fish pots. Bycatch was higher in the pots compared to the gillnets but could be released alive. Fish traps have also been trialled as an alternative gear to gillnets in the Gulf of California, with results suggesting lower bycatch, modest catch rates and overall strong viability as a replacement for gillnets, but the cost of bait and fuel was a limiting factor and research and development into the most effective gear design for specific target species is necessary (Herrera et al., 2017).

In a comprehensive review of pots as alternative and sustainable fishing gears in the Mediterranean Sea, Petetta et al. (2021) highlight several advantages of pots over other gears. In comparison to gillnets specifically, pots were considered to be more robust, less labour intensive, require lower fuel consumption, have lower discards and support higher survivability for discarded fish, have lower risks of depredation, and result in higher quality fish due to live harvesting. Some disadvantages included gear loss leading to ghost fishing, generally lower catch efficiencies, and higher costs of the gear. Although, pots are generally more robust than nets and require less ongoing maintenance.

Operational Considerations

Fish pots are typically set on the bottom, individually or in a connected series, and are hauled either manually or by machinery. Some pots are designed to sit above the seafloor to target pelagic fishes. Fish pots are versatile and can be made from different materials (metal, mesh, wood), in different colours, and various shapes and sizes. Careful design and trialling are required to maximise efficiency in targeting specific species and environments. The size of vessels needed depends on the scale and type of pot and can range from small boats and hand hauling in inshore fisheries, to large vessels capable of setting hundreds of pots (FAO, 2024). When deploying pots in series, they are baited (either with fish or artificial baits) and released from the vessel as it moves slowly forward (Seafish, 2024).

Escape panels/vents are mandated in Australian waters to prevent the retention of small fishes (AFMA, 2023c). Given the high potential for gear loss, sacrificial anodes are also attached to traps in Australia to open the trap after a period to enable trapped fishes to escape (AFMA, 2023c). There are several other gear design options for ease of operation and bycatch mitigation including funnel design, mesh size, trap shape, bottom or pelagic setting, weighted ropes, BRDs, and attractant/deterrent lights.

Environmental Considerations

Float ropes from pots present an entanglement risk to marine mammals in particular, which become entangled and drown (Hamilton et al., 2019). Some mitigation measures have included the use of weighted ropes, weaker ropes to allow animals to break free, changes to rope colour to improve visibility, the use of ropeless pots, and acoustic deterrents, with various levels of success (Hamilton et al., 2019). There are bycatch issues for critically endangered Speartooth Sharks (*Glyphis glyphis*) in mud crab pots in northern Australian rivers, with high rates of mortality (Pillans et al., 2022).

The primary environmental impact of this gear type is the effects of gear loss and subsequent ghost fishing (FAO, 2024; He et al., 2021; Seafish, 2024). Lost pots, particularly those without escape panels/vents, effectively continue to self-bait for extended periods, creating a feedback loop of ongoing fish capture and death (He et al., 2021). This has in part been remedied though the use of biodegradable materials or sacrificial anodes (FAO, 2024; He et al., 2021; Seafish, 2024). Improved technology also allows for monitoring gear placement using GPS, allowing gear to be accurately positioned and reducing the risk of gear loss (Seafish, 2024).

When compared to other commercial fishing gears, pots have moderate discard rates (~17%) (Hilborn et al., 2023); however, fish are captured alive and free swimming in traps, thus bycatch species are often quickly and easily released post capture (Seafish, 2024). The selectivity of these pots can be managed through variations in trap configuration and materials, soak times, positioning in the water column, weighted ropes, and BRDs like exclusion grids (FAO, 2024; Seafish, 2024).

Economic Considerations

The economic requirements are dependent on the scale of the fishery. Most costs for pot fisheries are attributed to purchase of traps themselves, and ongoing fuel and bait requirements (Virgili et al., 2024). As the scale of the fishery increases, the number of pots, crew members, hauling and sorting equipment, and fuel increases. Use of fresh bait attracts additional costs and crew time in rebaiting, but this can be reduced through use of artificial baits (Petetta et al., 2021). Although, fish pots are considered to be less labour intensive than other gears (Petetta et al., 2021). The loss of gear may also impose a considerable cost to commercial operators (Richardson et al., 2019), but this may be reduced with technology (e.g., GPS locators).

Social Considerations

There is evidence of conflict between both commercial sectors and recreational fishing, namely boat seines, bottom trawls, and other pot fishers (Virgili et al., 2024). This conflict may be exacerbated by the impacts of gear loss, and ghost fishing in frequently used fishing grounds. Fisheries with high risks of ghost fishing can also lead to negative public perception.

Hook and Line Gears

Simple hook and line (handlines, pole-and-line, and trolling)

General Description

Simple hook and line gear refers to gears consisting of single lines with a small number of hooks. The main types are handlines, pole-and-line, and trolling methods (Figure 9), and is charactered by individual or sets of lines being attended by a fisher for quick retrieval when fish are caught (He et al., 2021). This gear is adjusted for target species by varying line weight, length/depth, and towing speed, and can include outriggers to increase the number of lines. Fishing with this gear may be accompanied by methods used to attract fish, including chumming and spraying water onto the sea surface (He et al., 2021; AFMA; 2023). These gears are used all over the world (FAO, 2024), and are generally used to target pelagic (e.g., Tuna, Mackerel), and demersal and reef-associated (e.g., Snappers, Emperors).

Figure 9. Left: Illustration of Pole and Line Fishing method (hand operated) (source: MSC (2024)). Right: Illustration of Trolling fishing method (source: AFMA).

Relevant Fisheries

Simple hook and lines are used in both Commonwealth and State managed commercial fisheries. These include, the Eastern and Western Tuna and Billfish Fisheries, Ocean Trap and Line Fishery, NT Spanish Mackerel Fishery, WA Gascoyne Demersal Fishery, WA South Coast Demersal and Scalefish Fishery, Qld Reef Line Fishery, Qld East Coast Spanish Mackerel Fishery, NSW Ocean Trap and Line Fishery, Tas Southern Calamari Fishery, and SA Marine Scalefish Fishery. A broad range of species are targeted, ranging large-bodied pelagic fishes (e.g. Mackerel, Swordfish, and Tuna), reef-associated species (e.g., Trout and Emperor), and cephalopods (e.g., squid). Some commercial fishers in Qld use rod and reel fishing to target Barramundi, but operations are very small-scale (e.g., Chris Bolton Fishing, 2024).

Comparisons to Gillnets

In the Western Central Atlantic Cobia fishery, simple hook and lines have been shown to have a lower impact compared with bottom-set gillnets, with respect to lower discard rates, higher selectivity, and lower megafauna interactions (Peebles et al., 2014). In the Newfoundland and Labrador Cod Fishery, handlines are considered a good candidate for gear switching from bottom-set gillnets based on lower bycatch and TEPS interactions, lower capital investment in gear, and higher quality of catch, but uptake has been slow (Blackmore et al., 2023).

Operational Considerations

Simple hook and line gears are simple gears, requiring hooks or lures, lines and fishing poles and reels. The specifics of the operation and required rigging equipment will depend on the scale, target species, and environment. Hook type and size can also impact selectivity (e.g., Nguyen et al., 2021), and bait or lure requirements are a key consideration depending on target species. There are differences in catch selectivity and effectiveness between stationary fishing and trolling (e.g., Eighani et al., 2019), but this will also vary depending on the species being targeted.

Environmental Considerations

The rate of bycatch in simple hook and line fisheries is highly variable depending on the scale of the fishery, gears used, and the target species (Miller et al., 2017); however, they are thought to have some of the lowest discard rates among commercial fishing gears (Pham et al., 2021). Post-release survival of bycatch species is considered to be generally high owing to fast retrieval and processing (Miller et al., 2017).

There are some risks to seabirds and marine mammals, but evidence suggests these interactions are infrequent and caught animals can be quickly retrieved and released (Bell et al., 2016). Research in East Africa has shown that handlines had the lowest impact on vulnerable megafauna, such as turtles and sharks and rays, and low post catch mortality for these species (Kiszka 2012). Mitigation can include spatial and temporal closures, use of bird scarers, faster sinking hook set ups, changes to line and bait visibility, and choice of hook type like circle hooks (Løkkeborg, 2011). There is some evidence of depredation in simple hook and line fishing, particularly with trolling, although it is less common compared to other gear types like longline fishing (Zollett & Atkins, 2006).

Economic Considerations

Initial investment in simple hook and line gears varies depending on method, scale, and target species, with mechanised methods incurring greater costs than manual methods. Use of bait can increase costs significantly, depending on scale and type, while lures are a cheaper and reusable option, but do require replacement from damage over time. Implementing bycatch mitigation measures and other regulatory requirements (e.g., circle hooks, bird deterrents) can result in additional expenses. In general though, it is a relatively cost effective method, with annual costs considered to be significantly lower than for longlining (Thunberg, 2015).

Labour costs can be high for manual gears, that require fishers to tend to one or more lines, while mechanised methods require less crew (He et al., 2021). Use of mechanised systems typically require skilled workers to operate them properly and safely and will require more specialised equipment and potentially larger vessels, which will increase the cost of fishing operations.

Catch rates can be quite low compared with other gear, but this is offset by superior catch quality from fish typically be retrieved quickly upon hooking. Although, catch rates do differ between the types of fishing conducted. For instance, catch rates are generally higher for mechanised systems and trolling compared with handline gears due to greater fishing effort, which can lead to greater profitability. Depredation does occur and can lead to economic loss (Zollett & Atkins, 2006).

Social Considerations

There is minimal evidence of negative social consequences of this gear type. It appears to be perceived as highly selective and sustainable by the public. There may be conflict between sectors, particularly the recreational sector who use hook and line to target the same species.

Multi-hook lines

General Description

Multi-hook lines can take several forms depending on the target species and habitat. Common configurations are pelagic or demersal longlines (set or drifting) and droplines (also known as vertical lines) (Figure 10). Both longlines and droplines consist of a mainline and branch-lines with baited hooks or lures attached, and are set either drifting, anchored, or attached to a boat (He et al., 2021; FAO, 2024). Longlines sit horizontally in the water column or along the seafloor, while droplines sit vertically. The gear can be deployed by hand or with assistance from powered drums or reels (He et al., 2021). Similarly, the baiting of hooks can either be done by hand or machine. Pelagic longlines are used to target large pelagic species like tuna, billfish, or sharks, demersal longlines target shark and demersal finfish species, and droplines target finfish.

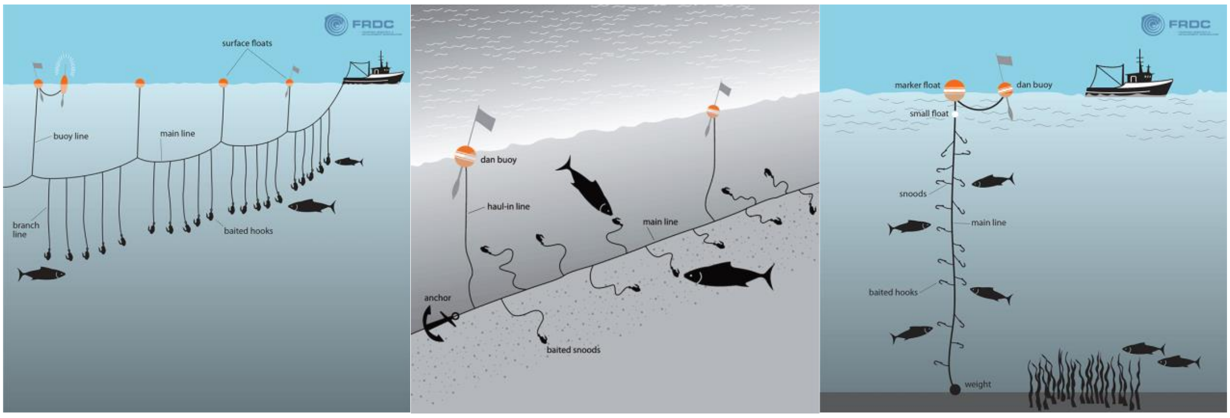

Figure 10. Illustrations of pelagic longline, demersal longline, and dropline (source: FRDC).

Relevant Fisheries

Pelagic and demersal longlines are used in a range of commercial fisheries in Australia, including Commonwealth-managed Tuna, Scalefish, Toothfish, Billfish, and Shark fisheries, and various state-managed fisheries targeting species like Snapper and Shark. Droplines are less common, but are used in the NT Coastal Line Fishery, NT Timor Reef Fishery, and WA South Coast Demersal Scalefish Fishery, targeting demersal and reef-associated fish.

Comparison to Gillnets

Longlines have been trialled as an alternative gear to gillnets in the Gulf of California, with results suggesting they are more selective than conventional gillnets (Herrera et al., 2017). A study in the European Hake Fishery also revealed that fishing yields were significantly higher in longlines when compared with gillnets (Santos et al., 2002). Switching from gillnets to bottom longlines has also been shown to be a practical approach in Argentina, in terms of similar catch composition and catch size, reduced bycatch of threatened dolphins and undersized fish, reduced effort, and economic viability (Berninsone et al., 2020).

Operational Considerations

Multi-hook lines can take several forms depending on the target species and habitat. Longlines are typically pelagic (drifting) or demersal (set), while droplines sit vertically in the water column. All generally consist of a mainline and branch-lines (or snoods) coming off the mainline with baited hooks or lures attached, and are set either drifting, anchored, or attached to a boat (He et al., 2021; FAO, 2024). Lines can be tens of kilometres long, carrying hundreds to thousands of individual hooks. These lines can be deployed by hand or with assistance from powered drums or reels (He et al., 2021). Similarly, the baiting of hooks can either be done by hand or machine. They can also be set with radio or satellite buoys to aid in relocating the gear for retrieval and minimise gear loss. The operational requirements therefore depend on the type of lines used, scale, target species, and environment being fished. Crew requirements will also depend on scale; but as an example, the typical crew for a tuna longliner using pelagic or drifting longlines would be around 4 to 8 people, including the skipper (Beverly, 1996).

Once set, longlines are usually left to fish for 6 to 8 hours, but this varies with line types and target species, as well as fishery management controls which often restrict soak time to reduce bycatch. Longer soak times may increase catch rates but can also increase the risk of depredation and TEPS interactions.

There is a large body of work supporting the use of real baits in favour of artificial ones to improve catch of target species (Løkkeborg et al., 2014, Kumar et al., 2016, Jonsson et al., 1997). Although, there have been experiments showing that artificial baits can help reduce bycatch (Lokkeborg, 2011), and some trials have shown that artificial baits can improve selectivity (Bach et al., 2012).

Environmental Considerations

Bycatch of TEPS and other species, including marine mammals, sharks, sea turtles, and seabirds, is a major conservation issue for multi-hook line fisheries (Gilman et al., 2023). There are an estimated 300,000 seabird deaths associated with longline gear types annually (Anderson et al., 2011), and approximately 40,000 sea turtles (Fitzgerlad et al., 2013). Some work suggests that seabirds and sea turtles have better post-capture survival rates than other groups (e.g., elasmobranchs) (Kiszka, 2012, Fitzgerlad et al., 2013). Mitigation measures depend on the bycatch species of interest, but can include seasonal and spatial closures, restrictions on soak duration, setting depth and time (e.g., at night), the type of baits, hook types (e.g., circle hooks), leader material and length, weighted lines, bird-scaring lines, hook shielding devices, and deterrents such as acoustic pingers or electric deterrents (Løkkeborg, 2011, Avery et al., 2017, Clarke et al., 2014, Werner at al., 2015, Dawson et al., 2013, Doherty et al. 2022).

Longlining fisheries have a moderate discard rate of 12.3% and account for around 4% of discards globally (Perez Roda et al., 2019). Demersal longlines typically have lower selectivity than pelagic longlines, resulting in higher discards for this type of gear, while droplines generally have small rates of discards.

Depredation is a global issue for multi-hook fisheries (Kumar et al., 2016; Gilman et al., 2023). Depredation results from lines remining in the water for extended periods with hooked fish which act as baits for larger fish and other predators. Depredation can occur by a range of megafauna, including TEPS, such as seals and sea lion, dolphins, and sharks and rays (Gilman et al. 2023; Hamer et al., 2012; Mandelman et al., 2008). Depredation imposes an environmental cost, as well as an economic cost, as both gear and catch can be damaged, and the risk of entanglement and death increases (Kimar et al., 2016).

Economic Considerations

In the USA, an estimated average cost of repair and maintenance incurred by a longline vessel is $35,760 USD, with $30,965 USD in additional vessel fees (NOAA, 2015). In larger scale operations, the use of longlines is more economically demanding, requiring greater catch efficiency compared to other gears. Hooks and lines, specifically pelagic longlines, have also been shown to have high fuel use requirements averaging 1612L t^{-1} (Parker & Tyedmers, 2014).

Depredation imposes a cost on longline fisheries due to both catch damage and loss and damage to gear (Kumar et al., 2016, Peterson et al., 2014). Depredation results in the need for greater fishing effort and lower profitability.

Social Considerations

Interactions with charismatic species like dolphins and turtles, as well as other TEPS lead to poor public perception of multi-hook and line fisheries (Gilman et al., 2023). As a result, these fisheries are often viewed as unsustainable, and there are perceived issues with local depletion, especially for large scale operations (Ovetz, 2006). In addition, conflict between sectors is common. Longlines also have a history of conflict with artisanal fishers, with large operations outcompeting local fishers for resources (Ovetz, 2006). Bottom longlining can conflict with other gear types that lie on the bottom like bottom trawls, gillnets, and pots (Hilborn et al., 2023). There may also be issues with gear equity with the recreational sector, as recreational anglers are typically restricted in their line configurations.

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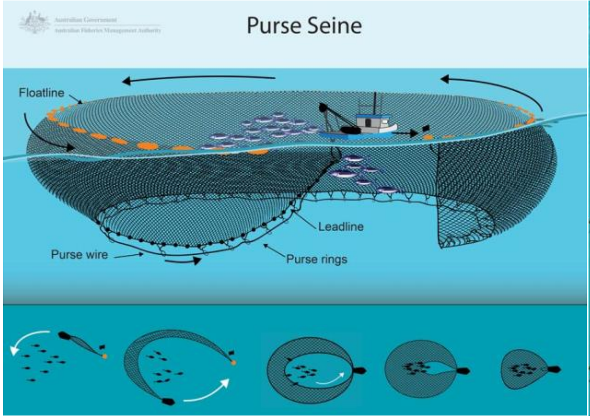
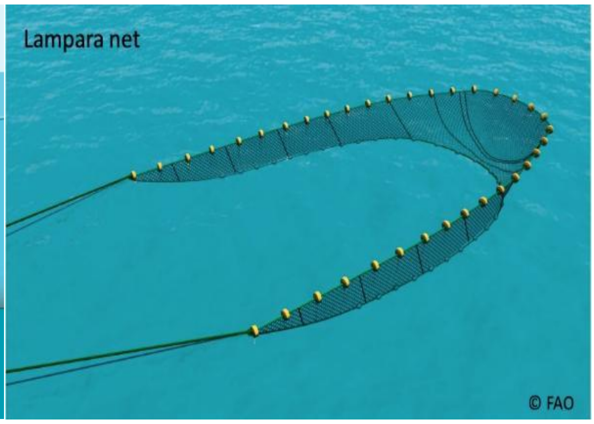
Appendix A – Gear Summaries

Prepared by Dr Joni Pini-Fitzsimmons and Sam Amini

Net based gears – Surrounding nets (purse seines and lampara nets)





General description

Surrounding nets are active gears that use a long panel of netting to surround schools of target fish. There are two types: (i) purse seines and (ii) lampara nets (surrounding nets without purse lines). Purse seines use a purse line attached to the footrope that closes the bottom of the net prevent fish from escaping through the bottom of the net, whilst surrounding nets without purse lines, also known as lampara nets, have a footrope that is shorter than the headrope and tension when hauling moves the footrope ahead of the headrope to prevent the downward escape of fishes. Both nets may have a 'bunt' of smaller mesh in the centre where catch is aggregated. Both gears are scalable from artisanal to industrial fisheries, but lampara nets are typically used at smaller scales while purse seines are well suited to large-scale operations. Both are typically used to target schooling pelagic species but can be adapted to shallow coastal environments.

Key advantages include catch efficiency and selectivity when schools of target species are identified, low operating costs with small scale operations, and tested bycatch mitigation methods.
Key disadvantages can include high discards, TEPS interactions, potentially high costs associated with vessel and fuel requirements of larger operations, gear loss, and potential limited use in shallow or low visibility environments.

Relevant fisheries

Fishery	Net type	Target Species
Skipjack Tuna fishery (Cth)	Purse seine	Indian Ocean Skipjack tuna, Western and central Pacific Oceanic Skipjack tuna
Small Pelagic fishery (Cth)	Purse seine	Australian sardine, Blue mackerel, Jack mackerel, Redbait
Southern and Eastern Shark and Scalefish fishery (Cth)	Purse seine	Blue grenadier, Tiger flathead, Silver warehou, Gummy shark, Pink ling, Eastern School whiting
Southern Bluefin tuna fishery (Cth)	Purse seine	Southern Bluefin tuna
Estuary General Fishery (NSW)	Lampara net	Eastern Sea Garfish
Southern Garfish Fishery (SA)	Lampara net	Southern Garfish

Lampara nets also have widespread use in the Mediterranean, United States of America, South America and Asia to target species like sardines, anchovies, mackerel, and flying fish.

Comparisons to gillnets

- Modified (scaled down) purse seines may offer a viable alternative to gillnets in estuarine environments but have been shown to perform poorly in areas with strong tidal currents, wind, or seafloor obstructions.
- No comparative studies of lampara nets and gillnets were found.

Operational considerations

- Efficiency and scalability: Gear is highly effective for pelagic species when schools of fish are easily identifiable from the surface or using sounders/radar/spotters (e.g., drones). The gears are scalable from artisanal to large scale commercial fisheries, although the amount of technology and machinery required will increase with scale.
- Selectivity: While not inherently species-specific, selectivity can be improved by use of technology to locate schools of fish, adjustments to mesh size, and use of Fish Aggregating Devices (FADs). NB: Use of FADs is banned for purse seines in Australia.
- Operational complexity: Purse seines are usually larger scale and require more advanced technologies (e.g., sonar, spotter planes) for efficiency, while lampara nets are simpler but can be labour-intensive.
- Environmental constraints: Can be modified for use in coastal and estuarine environments (smaller-scale gears), but high tidal flow, wind and/or seafloor obstructions can hinder use.

Environmental considerations

- TEPS interactions: Bycatch is common in surrounding net fisheries, particularly purse seines, including mammals, sharks, rays, turtles, and non-target fish species. Bycatch mitigation technologies and procedures do exist, including Medina Panels and the backdown procedure for marine mammals, best practice handling techniques, sorting grids and release ramps, as well as bycatch deterrent devices such as pingers for dolphins.
- Depredation: Megafauna may associate captured fish with hunting, leading to depredation of catch and potential unintended capture of predators.
- Selectivity and discards: Purse seines have relatively low discard rates (5 – 10%). Selectivity can be improved through spatial and temporal closures, bycatch reduction devices, and operational changes (e.g., Backdown procedure). Selectivity can also be increased through use of technology to locate schools of fish prior to deployment.
- Seafloor interactions and gear loss: Gear loss is possible in shallow environments due to snagging, which can lead to ghost fishing.

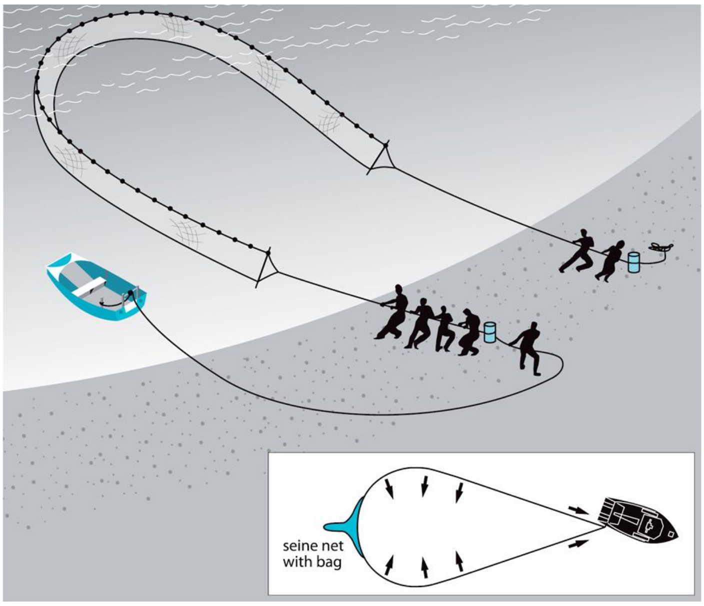
Economic considerations

- Productivity and efficiency: Surrounding nets are scalable, with operational costs being relative to the scale of the operation. Lampara nets are generally cheaper as they are better suited to smaller-scale fishery operations.
- Vessel, equipment, and workforce requirements: Vessel and technological requirements vary based on the scale of the fishing operation. Large operations may require skilled personnel, multiple vessels, spotter planes, fish attractants, or sonar in addition to nets and hauling devices. Smaller operations will have fewer requirements and may be hauled by hand.
- Fuel efficiency: Surrounding nets are reported to be the most efficient major fishing gear globally in terms of litres of fuel used per megaton of catch landed, averaging 252 L/MT.
- Catch quality: Product quality will be determined by the volume of fish caught and handling practices. High amounts of pressure, anoxia, and stress from capture can negatively impact the quality of catch.

Social considerations

- Public perception and conflict: At larger scales, surrounding net fisheries may be viewed as less sustainable and use in inshore environments may lead to conflict with other sectors (e.g., recreational or artisanal fishers).
- Environmental responsibility: Although an active fishing method, the carbon footprint of surrounding nets is small compared to similar gear types (e.g., trawls).

Net based gears – Beach seines



General description

Beach seines are an active fishing gear that is operated from the shore. Deployment typically involves visually identifying a school of fish, encircling it with one end of the net using a small boat, and hauling both ends of the net back to shore, where fish can be processed. The net itself is characterised by large wings, a headline and lead line, and a codend made of finer mesh. A sufficiently heavy lead line is essential to maintain contact with the bottom and prevent the escape of any fishes. This gear type is used globally in shallow inland, estuarine, and coastal areas to target demersal and pelagic species of fish. It is especially prevalent in small-scale artisanal fisheries.

Key advantages include the low-tech nature of the gear, short soak times, and ease of bycatch release.
Key disadvantages include low selectivity, high catch rates of undersized individuals, and potential conflict over resources or fishing areas with other sectors.

Relevant fisheries

Fishery	Target Species
Ocean Hauling fishery (NSW)	Australian Sardine, Sea Mullet, Australian Salmon, Blue Mackerel
Ocean Beach Net fishery (QLD)	Taylor, Yellowfin Bream, whiting, School Mackerel, Golden Trevally, Australian Sardine, Barramundi, King Threadfin
Gulf of Carpentaria inshore fishery (QLD)	Garfish, mullet
Coastal Net Fishery (NT)	Mullet, whiting, Blue Threadfin, shark, trevally, Queenfish, and snappers

Comparisons to gillnets

- Post-capture mortality may be higher compared to gillnets, although this varies based on catch size and processing time. Generally, mortality risk has been shown to be higher for smaller fish.
- Catch rates for some commercially important species, like Barramundi and Threadfin Salmon have been shown to be lower in beach seines in comparison to gillnets.

Operational considerations

- Gear requirements and process: Gear requirements differ based on scale of fishery. Hauling can be performed by hand, vehicle, or winch. The collection of catch involves retrieving and sorting fishes at the water's edge.

- Catch efficiency: Catch efficiency is highest when schools of target fish can be located prior to deployment. Selectivity can be improved with implementation of spatial and temporal closures and altering mesh sizes and shapes.
- Bycatch management: Small scale of operations and short soaking times allow bycatch to be released quickly. Other bycatch mitigation technologies have received little attention.
- Environmental limitations: Gear is best used over soft substrate as snagging and environmental damage can occur in more complex environments.

Environmental considerations

- Bycatch and selectivity: Bycatch is common, with high discard rates of undersized or commercially unimportant species. Megafauna, including threatened species, may also be caught. However, the small-scale and speed of operations allows fishers to release larger animals quickly.
- Post-capture mortality: Post capture mortality remains unknown although quick operational processes and the sorting of catch in shallow water reduces the stress imposed on bycaught animals.
- Seafloor interactions and gear loss: Beach seines are most effective over soft substrate, but localised habitat degradation may occur over time. Contact of fishing gears with sensitive habitats (e.g., seagrass, coral reefs) may also cause habitat degradation and gear damage/loss. Ghost fishing may occur when the net becomes snagged, damaged or lost.

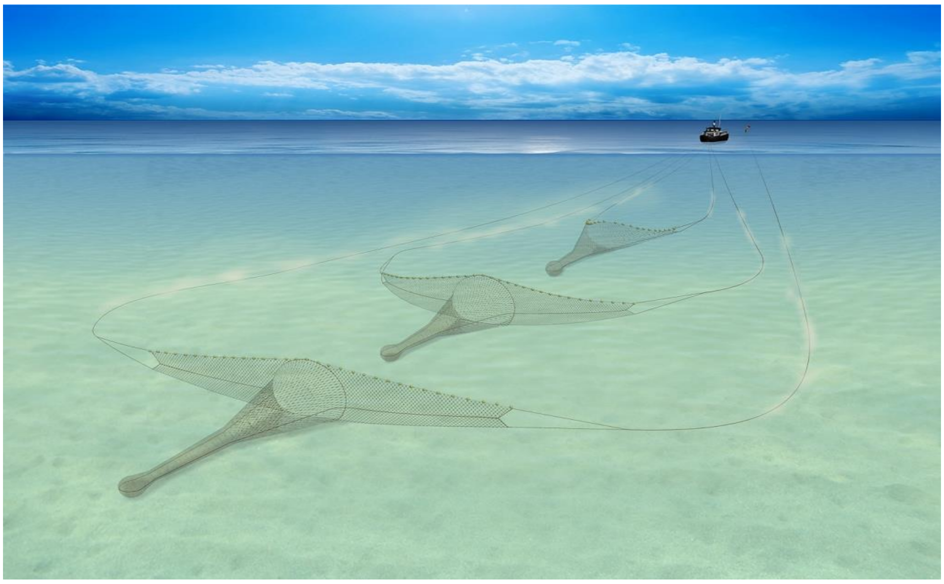
Economic considerations

- Operational Costs: The operational cost of this gear is generally low, but costs will increase with use of motorised vessels and winches as scale increases. A number of personnel may be required for hauling, but this can be alleviated with use of mechanical winches.
- Product quality and market value: The gear can be selective when schools or target and marketable fish are located prior to deployment; however, catch of undersized of unmarketable fish is common. Damage to catch is low due to the small scale of operation, but larger catches may lead to crowding and stress in caught fish during the sorting process.

Social considerations

- Public perception: Gear is typically used in populated areas where public exposure may lead to negative social perceptions.
- Sector conflict: Conflict may occur between sectors due to overlap of target species and fishing areas.

Net based gears – Boat seines



General description

Boat seines are a conical shaped net, with two large mesh wings that lead to a codend used to fish along the seafloor. Long hauling lines are attached to either end of the net and are used to encircle a school of fish. These nets are very similar to trawl nets structurally but differ in how they are deployed, which usually involves one or two boats. Single boat operations most commonly use either the Danish seining or Scottish seining technique. Danish seines involve hauling the net up to an anchored boat and while Scottish seines use the boat to tow and close the net as it is hauled. This gear is used globally to target demersal species of fish including cod, and benthic species like flounder. Typically, it is operated in coastal and offshore environments ranging from 50 – 500 metres in depth.

Key advantages include efficiency in deployment and higher catch rates with lower cost compared with other bottom fishing gears (e.g., bottom trawls).
Key disadvantages include generally low selectivity and high discards including interactions with TEPS, disturbance of benthic habitats, and conflict with other sectors.

Relevant fisheries

Fishery	Target Species
Southern and Eastern Scalefish and Shark Fishery (Cth)	Tiger flathead, Eastern School Whiting
Scalefish Danish Seine Sub-Fishery (TAS)	Tiger flathead, Eastern School Whiting
Danish Seine fishery (NSW)	Eastern School Whiting, Stout Whiting, Bluespotted Flathead
Fin Fish (Stout Whiting) Trawl fishery (QLD)	Stout Whiting

Comparisons to gillnets

- No empirical comparisons identified.

Operational considerations

- Vessel and equipment requirements: Varies with scale, but sufficient deck space required for nets and catch handling, mechanised equipment for deployment and retrieval, and skilled crews required.

- Environmental limitations: Generally restricted to soft substrata, although Scottish seines may be more suitable for use over rough benthic environments due to higher durability. This durability comes at the expense of fishing efficiency, large vessel and fuel requirements, and maintenance needs.
- Selectivity: Mesh size and shape, towing speed, and gear shape and orientation can be used to manage selectivity .

Environmental considerations

- Bycatch and selectivity: Discard rates are relatively high (approx. 25%), but gear modifications can help improve selectivity. Interactions with megafauna, including TEPS, occur (e.g., seals and sea lions, sharks and rays, sea turtles).
- Seafloor contact: Bottom fishing method used for this gear can result in destruction of benthic habitats.
- Marine debris and pollution: Boat seines have been shown to contribute large amounts of microplastics though bottom contact alone. Gear loss and damage can also contribute to ghost fishing.

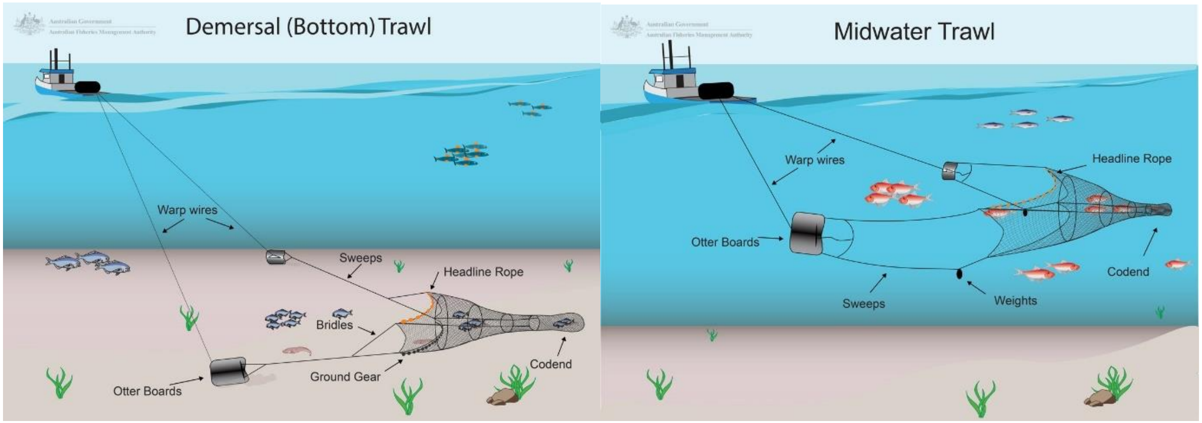
Economic considerations

- Operational costs: Operational costs vary depending on the size of the fishing operation. Modern boat seines are now considered to be as technically demanding as trawls in terms of equipment and workforce requirements.
- Fuel consumption and efficiency: Compared with other active bottom fishing gears, boat seines are considered most economical with respect to fuel consumption and gear maintenance, particularly for Danish seines and when used over soft substrate.
- Product quality and market value: Catch quality varies based on vessel specific characteristics such as onboard processing, storage capacity, and the mesh size used, but quality is typically higher than for trawls.

Social considerations

- Conflict between sectors: Conflict between recreational and commercial sectors have led to zonal and temporal closures in areas like Tasmania. There has been historical sector conflict and resource sharing concerns in NSW.
- Public perception: Some consider boat seining to be as damaging to the environment as bottom trawling due to gear modifications and technical advancements, resulting in negative public perceptions.

Net based gears – Trawls



General description

Trawls are an active fishing gear consisting of large nets with a wide opening, and narrow codend where fish are collected at the end of a shot, that is towed behind a vessel at a speed that exceeds that of the target catch. Trawls are versatile, able to be used at a range of depths, with a range of mesh sizes and in many configurations (e.g., single net with multiple codends, multiple trawls towed in parallel) to target various species. They account for almost a quarter of global fish landings. There are two general types of trawls, demersal (bottom) and pelagic (midwater). Demersal trawls are used to target benthic or demersal species and use heavy groundgear to maintain contact with the seabed during operation. In contrast, pelagic trawls tend to be much larger and are used target schooling fish in the water column.

Key advantages include gear versatility, high catch rates, and well-tested bycatch reduction technologies.
Key disadvantages include high discards and TEPS interactions, high costs associated with vessel and fuel requirements, potentially high impact to benthic environments, and conflict with other users.

Relevant fisheries

Trawls are used widely in Australia, but have a relatively small footprint, with most activity in the north- and south-east continental shelf targeting prawns with demersal trawls. They are also used to target finfish, such as the NT Demersal Fishery targeting snapper.

Comparisons to gillnets

- Small trawls have been trialled as an alternative gear to finfish gillnets in the Gulf of California, with results showing the high catch efficiencies and low bycatch rates, but further research is recommended.
- Trawls have been shown to capture smaller fish compared with gillnets, even when the same mesh size is used.

Operational considerations

- Gear specifications: The specifications and operation of trawl gear depends on the scale, type of trawl and target species. Configurations include single trawls, single trawls with multiple codends, and twin trawls with 2 parallel nets towed simultaneously. Demersal trawls require use of heavy ground gear to maintain seabed contact, while pelagic trawls use often use sounders or sonar to detect fish schools in the water column.
- Vessel requirements: Trawl vessels range from small inshore boats to large factory trawlers, often equipped with winches, net drums, and hydraulic systems for handling large nets.
- Bycatch Reduction Technology: BRDs, including exclusion grids and escape panels are usually mandatory for reducing bycatch of megafauna, including TEPS.

Environmental considerations

- Selectivity and discards: Trawls are generally considered to be less selective than other similar fishing methods. Trawls have significant discards; with demersal trawls accounting for almost half of global fishery discards by weight. Modified fishing operations, gear adjustments, and use of bycatch reduction devices help to mitigate these issues, but challenges still exist.
- Threatened species interactions: Capture of TEPS including sharks, rays, turtles, seabirds, and marine mammals is a significant concern for trawl fisheries. BRDs and TEDs have shown significant reductions catch rates. There are still specific issues for sawfish, which become entangles in trawl nets ahead of BRDs and/or TEDs.
- Post-release survival: Mortality rates for discarded finfish are high, but the types and severity of injuries to fish that impact mortality are highly specific to gear, operations, environmental conditions, species and size, and handling and release practices. Smaller fish are more susceptible to injury and mortality, and post-release survival of these bycaught fish is low.
- Seabed disturbance: Bottom trawls can have significant impacts on the seabed due to the need for constant contact to fish effectively. However, where used over muddy and sandy seabeds that are not as ecologically complex and are already heavily influenced by tides and currents, gear disturbance is unlikely to be long lasting.

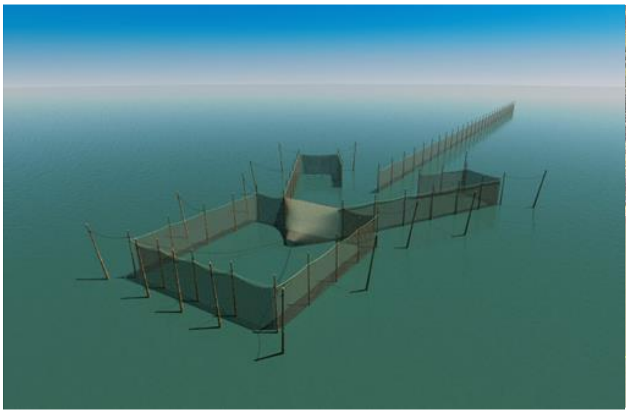
Economic considerations

- Operational costs: Costs associated with starting a trawl fishery vary considerably depending on the gear type and operation chosen, including the cost of gear, fuel, crew, ongoing repairs, and cost of implementation fishery management controls. Regarding fuel, demersal trawls are one of the least fuel efficient across all fishing gear types, while pelagic trawls are similar to pelagic gillnetting operations.
- Vessel and equipment requirements: The type of vessel and equipment required depends on the type of trawl used.
- Skilled workforce: Trawling requires skilled skippers with a high level of familiarity with the gear types, fishing operations, fishing area, and target species to maximise catches while minimising discards and habitat damage.
- Catch quality: Fish can suffer from exhaustion, suffocation, and physical injuries from capture, but use of BRDs and TEDs can reduce damage and improve catch quality.

Social considerations

- Mixed public perception: The environmental impact of trawl fisheries has led to negative public perceptions, however efforts to improve sustainability (e.g., BRDs, strict regulations) are helping to shift these perceptions. Negative perceptions may be exacerbated in near-shore operations where there is greater public exposure to fishing operations.
- Conflict with other users: Potential conflict over space with other fisheries (gillnets, fish pots) and other ocean users (oil and gas pipelines, and communication cables, windfarms, tidal power, and seabed mining), although this is mainly with large-scale demersal trawl fisheries.

Traps – Pound nets or arrowhead traps



General description

Pound nets, or arrowhead traps, are a type of passive and stationary fishing gear that consists of a long 'leader' that intercepts the path of migrating schools of fish and leads them into a holding chamber(s) or 'pound', where they can then be selected for processing or release. Pound nets can be temporary, semi-permanent, or fixed. Traps are one of the oldest commercial fishing gears in the world and have been used by indigenous communities for thousands of years.

Key advantages include live fish capture and release, good species and size selectivity with proper technical and ecological knowledge, low seabed impacts, and low vessel and crew requirements.
Key disadvantages include bycatch issues and learned associations with stationary gears, cost of construction and maintenance, impacts to visual amenity, and interactions with other coastal water users.

Relevant fisheries

- Historically used in QLD, including the Great Barrier Reef (GBR) Marine Park. Traps were phased out in late 1980's, and all arrowhead fishers were issued licenses for 'more efficient' gillnets.
- North America: In Washington State, the Fish Trap Project by Wild Fish Conservancy in the Columbia River, is trialling the use of pound nets for selectively harvesting hatchery-origin salmon whilst releasing threatened wild-origin salmonids.

Comparisons to gillnets

- Post-release survival of threatened salmon stock from pound nets have shown 100% survival, compared to 40% survival from conventional gillnets.
- Research in QLD suggest pound nets are a strong candidate for replacing gillnets in tropical regions for targeting Barramundi and King Threadfin.

Operational considerations

- Trap construction: Can be temporary, semi-permanent, or fixed. Nets are made from thick twine and small mesh. The pound can be reinforced to hold large catches and prevent damage from predators, and can be constructed to be hauled entirely or for harvest by scoop nets. Selectivity and bycatch can be managed through modifications in design and mesh size.
- Habitat selection: Pound nets are designed for targeting species migrating along shorelines with tides or seasonally. Typically set in shallow coastal and rivers, usually in the intertidal zone, with the pound set bellow the low water mark .
- Local ecological knowledge: As passive gears that exploit the natural movements of target fishes, a good understanding of fish behaviour is critical for successful trap fishing.

- Maintenance: Debris accumulation can occur, particularly across leader. This can be mitigated through use of semi-permanent gears or removable nets. Foraging by predators can damage nets, but nets can be reinforced. Deterrent technologies may assist.
- Monitoring: Traps must be checked with each low tide. As fixed structures, cameras and sensors can be affixed to monitor catch and gear operation remotely and in real-time.

Environmental considerations

- Efficiency and overfishing: Pound nets are highly effective when designed well but have historically led to overfishing; management controls are required to ensure sustainable fishing.
- Selectivity and harvest: Allow for highly selective harvesting and quick release of live bycatch. Post-release survival of bycatch can be as high as 100% (see the Fish Trap Project).
- Physical injury and stress: Low risk of mortality but can occur through injury from gilling or impact with netting in high currents, or large catches. Thermal stress is an issue in the tropics when depth of water in pound is insufficient.
- Bycatch mitigation: Megafauna bycatch rates are low with the use of exclusion grids at the pound entrance or height of leader. Captive fish may attract predators, and fixed locations may lead to learned foraging associations for megafauna. Use of deterrent technologies may help reduce these risks.

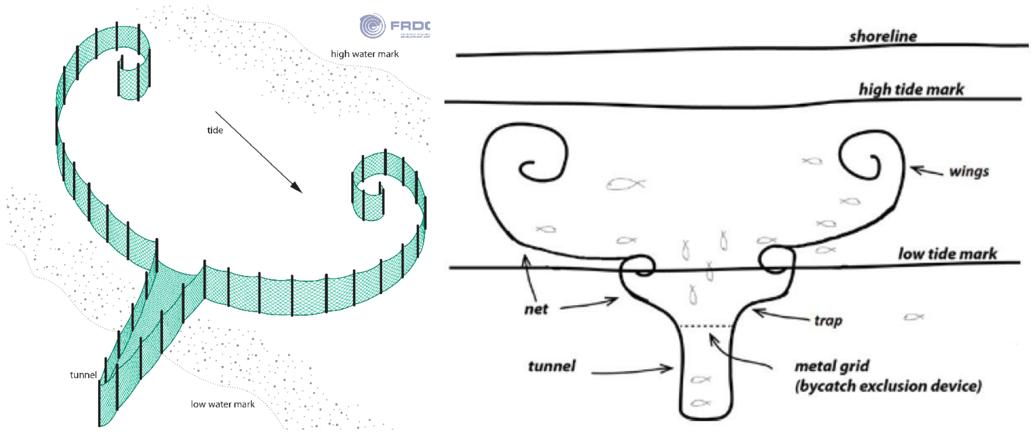
Economic considerations

- Operational costs: Initial set-up cost can be high, and permanent structures require ongoing maintenance, while seasonal or portable designs require additional resourcing for transport, installation, and deconstruction. Vessel and crew requirements are minimal, but traps do need to be checked regularly (daily). Traps can be fished by 1 to 3 people, and one vessel.
- Product quality and market value: The live capture process results in little to no physical and physiological impairment to fish, enhancing product quality and possibly higher market value.
- Catch stability and research investment: Catches can be unstable as the gear is passive and stationary, relying on animal movements which are influenced by environmental conditions. Effective trap design and location require good understanding of fish behaviour and ecology, necessitating investment in research and development with fishers, researchers, and gear technologists.

Social considerations

- Considered sustainable: Pound nets are regarded as a low-impact and highly selective fishing method, which aligns with consumer demand for environmentally safe and responsibly sourced seafood.
- Public amenity and perception: Installation permanent structures may impact public amenity and perception, which may be alleviated through use of semi-permanent, portable or seasonal deployments. Conflict may occur with other sectors, particularly recreational fishers.
- Compliance and monitoring: Fixed gears simplify compliance and management, as they can be easily checked. Use of equipment like cameras and sensors can be used for monitoring.
- Tourism and education potential: Pound nets can provide opportunities for tourism, education, and research, which may enhance social license and community acceptance.

Traps – Tunnel nets



General description

Tunnel nets are large, portable net structures that are used to exploit the natural movements of fish along tidal flows. Tunnel nets have large, curled wings that guide fish into the "tunnel" of the net as water recedes with the tide. Each deployment is done over a single tidal cycle. This gear is used in shallow coastal and estuarine environments, with its placement being directly influenced by the low, and high-water marks.

Key advantages include near-zero negative interactions with TEPS, live fish capture and ease of release, low seabed impacts, fully portable, and low vessel and crew requirements.
Key disadvantages include environmental constraints on site selection and susceptibility to adverse weather, low catch selectivity, impacts to visual amenity, and interactions with other coastal users.

Relevant fisheries

Tunnel nets have been used in estuaries as part of the Moreton Bay Tunnel Net Fishery (MBTNF) for decades. Target species include Mullet, Bream, Garfish, Flathead, Whiting and Trevally. The fishery has a Code of Best Practice guiding tunnel net fishers on best practices with regard to reducing environmental impacts and securing the future of the fishery.

Comparisons to gillnets

Tunnel nets have been trialled as alternatives to conventional gillnets in the East Coast Inshore Finfish Fishery (ECIFF). They were deemed technically feasible, but not fully suitable for targets of Barramundi and King Threadfin, without additional modifications such as reinforcement and alternate exclusion grids.

Operational considerations

- Size and structure: Tunnel nets are large gears, spanning ~1km, and consisting of walls of thick cord net with small meshes to guide fishes trapped with lowering tide. They require significant amounts of netting, plus sand anchors and stakes for holding the structure in place. Exclusion grids are used to prevent megafauna (incl. TEPS) and non-target species from entering the tunnel.
- Operation: Gear is set at hightide, ensuring the tunnel is below the low tide mark. As tide recedes, fish seek deeper water towards the tunnel, the wings are retrieved, leaving the tunnel for harvesting. Operation is done by wading or from small powered or unpowered vessels. The gear is manned for the entire fishing set, which allows fishers to release TEPS as needed by lifting the wings.
- Site selection: The gear must be set over soft substrate, with a relatively steep slope, low turbidity for seeing catch and any TEPS, shelter from weather conditions, and a moderate tidal run (neap tides, 1.5-2.5m). Fishing grounds need to be rotated to mitigate localised depletions and disturbance.

- Target species: Gear designed to trap species that move within the intertidal zone with tidal movements. Trials in northern QLD showed that with some gear modifications, they could be used to capture Barramundi and King Threadfin.

Environmental considerations

- Bycatch and selectivity: Tunnel nets have low capture selectivity as they fish indiscriminately as tide drops, but captured fish are held live and free-swimming and can be quickly released in excellent condition as required.
- TEPS Interactions: Tunnel nets have high interactions with TEPS but are reported to have near-zero negative interactions, as mesh size prevents entanglement and exclusion grids prevent entry to the tunnel, allowing animals to swim away freely by fishers lifting net walls or once gear is removed without the need for any handling.
- Environmental conditions: Tunnel nets can only be used very specific environmental constraints, and fishing grounds need to be rotated to mitigate localised depletion and disturbance.
- Tropical environments: Interactions with crocodiles and stingers are a risk in tropical environments, but this can be somewhat mitigated by limiting fishing to the dry season and setting traps using vessels. In warm waters, thermal and oxygen stress may be a risk to captured animals. Turbidity is also often high in the tropics, reducing ability to fish effectively.

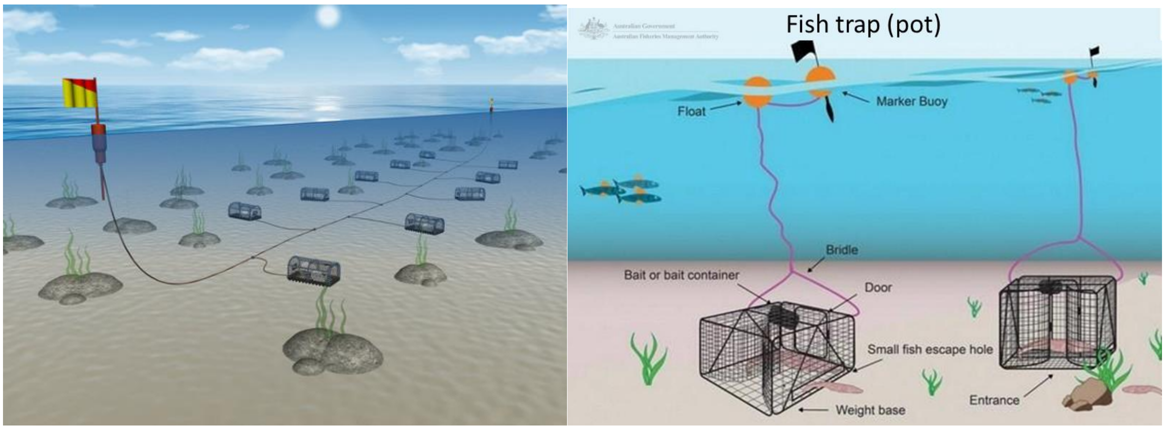
Economic considerations

- Product quality and market value: Live capture process results high-quality product. Gear can provide fishers flexibility to 'fish to order', retaining most marketable fish.
- Operational costs: Initial cost of gear may be high, depending on location, materials, and design. Vessel and crew requirements are low, but operations are labour intensive. Research and development are needed to guide gear design to maximise efficiency for specific species.
- Commercial viability: Due to specific environmental conditions required (soft substrate, moderate tides, steep intertidal areas) and the need rotate fishing sites to limit localised impacts, fishers require access to several suitable sites to be commercially viable. Fishing can be greatly affected by weather, which can result in missed fishing opportunity.

Social considerations

- Public perception: Use of this gear in intertidal zone results in high visibility and may impact visual amenity or public perception. There is also likely to be overlap with other uses, that may result in conflict over space or resources (e.g., recreational fishing, boating).
- Environmental responsibility: The Code of Best Practice developed for the MBTNF has boosted the public profile of the fishery and could be used as a framework for development of new tunnel net fisheries.

Traps – Fish pots



General description

A pot is a small trap or enclosure that uses bait or other attractants to attract fish through one or more one-way entrances that prevent escape. They are a passive fishing gear, and usually set on the seafloor, either individually or in a connected series, with a surface marker. Pots are predominantly used for crustaceans but are also used to catch reef and estuarine fishes (fish traps/pots). This gear type is typically bottom set and targets demersal fishes, but some technological advances allow for setting off the bottom for pelagic fish.

Advantages include live fish capture and release, species and size selectivity with careful design, low risks of depredation.
Disadvantages include gear loss and ghost fish, TEPS interactions with marine mammals and sharks, cost and effort of baiting, and competition or conflict with other water users.

Relevant fisheries

In Australian waters, pots (called 'fish traps'), are used to target demersal finfish species in very shallow (2m) to very deep waters (100's of meters). Fish traps are used in both small-scale fisheries and commonwealth managed fisheries to target species like Emperor, Snapper, Bream, Trevally, and Morwong. Fish traps are currently used commercially in the NSW Ocean Trap and Line Fishery, WA South and North Coast Scalefish Fisheries, and the NT Demersal and Coastal Line Fisheries, amongst others.

Comparisons to gillnets

- Comparisons between gillnets and fish pots for Atlantic cod showed more consistent catch rates and higher quality product in fish traps.
- Fish traps have been trialled as an alternative gear to gillnets in the Gulf of California, with results suggesting strong viability.
- A comprehensive review of pots as alternative fishing gears suggests they are more robust, less labour intensive, require lower fuel consumption, have lower discards, have lower risks of depredation, and result in higher quality fish compared to gillnets.

Operational considerations

- Pot configurations and setting: Can be set individually or in series, on the bottom or mid-water, and made from various materials and in many configurations. The scale of the operation will determine operational requirements. Escape panels/vents are mandated in Australian waters to prevent the retention of small fishes, and sacrificial anodes or biodegradable materials are used to prevent ghost fishing of lost gear. Pots typically use fish as bait, but artificial baits are becoming increasingly popular.

- Vessel, equipment and crew requirements: Depends on scale and type of pots, ranging from small vessels and hand hauling to large vessels capable of setting hundreds of pots with machinery.
- Bycatch mitigation: There are several other gear design options for ease of operation and bycatch mitigation including funnels, mesh size, trap shape, bottom or pelagic setting, weighted ropes, ropeless pots, and BRDs.

Environmental considerations

- TEPS interactions: Float lines can pose an entanglement risk for marine mammals, but use of weighted ropes or ropeless technologies can help mitigate this risk. Bycatch and mortality of Critically Endangered River Sharks in mud crab pots documented in Australian rivers.
- Bycatch and selectivity: Bycatch rates are low due to mesh sizes that allow small fish to escape and prevent access by large animals. Escape panels are also mandatory in some jurisdictions. Fish are captured live allowing quick live release of non-target animals.
- Seabed impacts: Pots have limited impacts to the sea floor, as they are placed for a short period of time with little movement. Seabed impacts can be mitigated through avoiding use in sensitive benthic habitats, rotating fishing areas, or using mid-water traps.
- Ghost fishing: This is the most significant risk for pots. It can be mitigated by using biodegradable materials and technology like sacrificial anodes, which ensure traps disable themselves over time. GPS technology can also be used to locating gear and reducing loss.

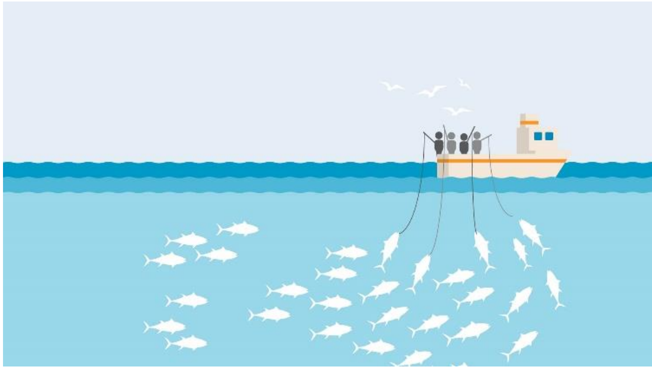
Economic considerations

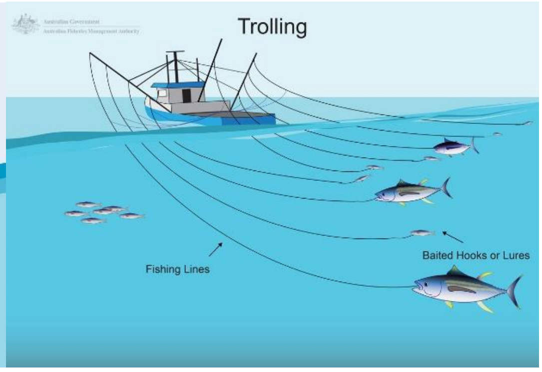
- Operational requirements: The type and scale of operations will dictate vessel and crew requirements. Collapsible pots also allow for a larger number of pots to be stored on a vessel.
- Baits: Use of fresh bait attract additional costs and crew time in rebaiting, but this can be reduced through artificial baits.
- Gear loss: Gear loss can result in significant costs and loss of revenue. Implementing GPS technology can help reduce this risk.

Social considerations

- Sector conflict: Pots can lead to conflict or competition with other sectors, such as bottom trawl fisheries or the recreational fishing sector.
- Perception of ghost fishing: The risk of ghost fishing can result in poor public perception of trap-based fishing.

Hooks and lines – Simple hook and line (handlines, pole-and-line, and trolling)





General description

Simple hook and line gear refers to gears consisting of single lines with a small number of hooks. The main types are handlines, pole-and-line, and trolling methods, and is charactered by individual or sets of lines being attended by a fisher for quick retrieval when fish are caught . This gear is adjusted for target species by varying line weight, length/depth, and towing speed, and can include outriggers to increase the number of lines. Fishing with this gear may be accompanied by methods used to attract fish, including chumming and spraying water onto the sea surface. These gears are used all over the world, and are generally used to target pelagic (e.g., Tuna, Mackerel), and demersal and reef-associated (e.g., Snappers, Emperors).

Advantages include live fish capture and release, minimal bycatch, high post-release survival.
Disadvantages include crew requirements for hand-operated gears, fuel requirements of trolling, cost of baits and lures, depredation, conflict with other sectors with overlap of gears and fishing grounds.

Relevant fisheries

Fishery	Gear Type	Target Species
Eastern Tuna and Billfish Fishery (Cth)	Trolling, Rod and Reel	Tuna, Swordfish, Marlin
Western Tuna and Billfish Fishery (Cth)	Handline, Trolling, Rod and Reel	Tuna, Swordfish, Marlin
Ocean Trap and Line Fishery (Cth)	Handline, Trolling	Kingfish, Mackerel, Tuna, Mulloway, Bonito
Spanish Mackerel Fishery (NT)	Trolling, Handline, Rod and Reel	Spanish Mackerel
Gascoyne Demersal Fishery (WA)	Mechanized Hand Lines	Snapper, Emperor
South Coast Demersal Scalefish Fishery (WA)	Handlines	Redfish, Hapuku, Snapper
Reef line fishery (QLD)	Lines	Coral trout, Red Throat Emperor
East Coast Spanish mackerel fishery (QLD)	Trolling Lines	Mackerel

Comparisons to gillnets

- Hook and line gears are shown to be less efficient in terms of volume of fish caught compared to gillnets but have greater selectivity and produce a superior catch quality.

Operational considerations

- **Operational requirements:** Hook and line gears are relatively simple gears, with the rigging and equipment required depending on the scale, target species, and environment fished. This may require larger crews for

hand-operated gears or specialised equipment for semi-automated fishing. Vessel requirements will depend on type of fishing conducted, with higher fuel requirements for trolling.
- Bait and lure requirements: This will depend on the type of gear and target species. Fishing with baits carry greater costs and effort in re-baiting hooks. Fishing can also be supplemented with chumming, water spraying, or other aids (e.g., lights) to attract target species.

Environmental considerations

- Bycatch and Selectivity: Considered to have low bycatch rates, but varies with the scale, gear used, and target species. Prompt line retrieval upon capture facilitates high post-release survival for bycatch, including TEPS. Size and species selectivity can be managed through careful bait and hook type and size selection.
- TEPS interactions: Seabird, turtle and elasmobranch bycatch occurs, but at relatively low rates. Bycatch can be mitigated through spatial and temporal closures, use of bird scarers, faster sinking hook set ups, changes to line and bait visibility, and choice of hook type. Depredation can occur, but rates are low compared with longlining.

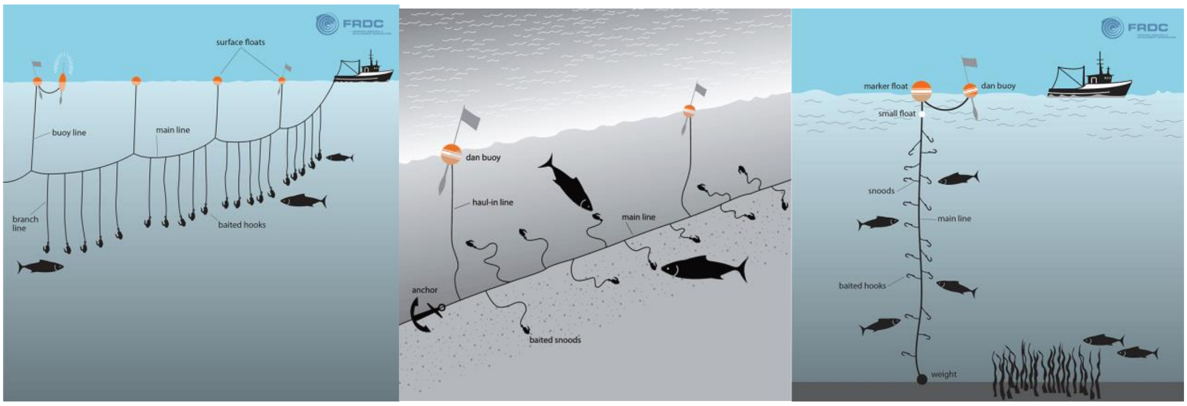
Economic considerations

- Operational costs: Initial investment varies depending on method, scale, and target species, with mechanised methods incurring greater costs than manual methods. Use of bait can incur significant costs depending on scale and type, while lures are cheaper and reusable, but do require replacement from damage. Implementing bycatch mitigation measures and other regulatory requirements (e.g., circle hooks, bird deterrents) can incur additional expenses.
- Labour costs: Labour costs are higher for manual gears, that require fishers to tend to one or more lines, while mechanised methods require less crew. Use of mechanised system typically require skilled workers to operate them properly and safely.
- Catch rates and quality: Catch rates are generally higher for mechanised systems and trolling compared with handline gears, leading to greater profitability. However, fish caught using handlines and pole-and-line are typically in better condition, leading to higher market prices despite lower catch volumes. Depredation can occur and lead to economic loss.

Social considerations

- Public perception: Simple hook and line gears are generally considered to be highly selective and sustainable.
- Conflict between sectors: Potential for conflict or competition with other sectors, particularly the recreational sector who use hook and line to target the same species.

Hooks and lines – Multi-hook lines



General description

Multi-hook lines can take several forms depending on the target species and habitat. Common configurations are pelagic or demersal longlines (set or drifting) and droplines (also known as vertical lines). Both longlines and droplines consist of a mainline and branch-lines with baited hooks or lures attached, and are set either drifting, anchored, or attached to a boat. Longlines sit horizontally in the water column or along the seafloor, while droplines sit vertically. Pelagic longlines are used to target large pelagic species like tuna and billfish, demersal longlines target shark and demersal finfish species, and droplines target finfish.

Advantages include low crew, vessel and fuel requirements (scale-dependent), can be configured and scaled to meet fishery needs, high quality product.
Disadvantages include high TEPS interactions and bycatch, discard rates, and depredation rates, cost of baits and lures and associated labour, and conflict with other sectors.

Relevant fisheries

Pelagic and demersal longlines are used in a range of commercial fisheries in Australia, including Commonwealth-managed Tuna, Scalefish, Toothfish, Billfish, and Shark fisheries, and various state-managed fisheries targeting species like Snapper and Shark. In the NT, longlines are used in the NT Offshore Net and Line Fishery. Droplines are used in the NT Coastal Line Fishery and NT Timor Reef Fishery, as well as the WA South Coast Demersal Scalefish Fishery, targeting demersal and reef-associated fish.

Comparisons to gillnets

- Longlines have been trialled as an alternative gear to gillnets in the Gulf of California, with results suggesting they are highly selective.
- Switching from gillnets to bottom longlines has been shown to be a practical approach in Argentina, in terms of catch composition and catch size, reduced bycatch of undersized fish and threatened dolphin bycatch, reduced effort, and economic acceptability.
- A study in the European Hake Fishery also revealed that fishing yields were significantly higher in longlines when compared with gillnets.

Operational considerations

- Lines, equipment and operation: Operational requirements depend on the type of lines used, scale, target species, and environment being fished. Regardless of type, setting is done from a vessel, and gears typically consist of a mainline and branch-lines (snoods) with hooks attached, and can be several kilometres (up to 100 km) long, and contain hundreds of hooks. Deployment and baiting can be manual or automated. Scale of operation will also dictate crew requirements.

- Fishing depth: Multi-hook lines can be used to fish the sea floor, midwater, surface, or vertically in the water column, to target a wide range of species. Target species will need to be responsive to bait or lures for efficient fishing.
- Soak time: Lines are typically soaked for 6-8 hours, but this needs to be carefully managed to mitigate bycatch and depredation.
- Baits and lures: Many multi-hook line fisheries use real baits, but artificial baits are becoming more widely used, with modifications in materials, shapes, colours, and chemical attractants make lures more versatile. Real baits are considered to result in higher catch rates, but artificial baits may improve selectivity or reduce bycatch in some cases.
- Selectivity and bycatch mitigation: There are several operational modifications that can be used to increase selectivity and reduce bycatch, including changes to fishing activity, spatial or temporal closures, and use of attractants, deterrents, or BRDs.

Environmental considerations

- TEPS Interactions & bycatch: Bycatch of TEPS and other species, including marine mammals, sharks, sea turtles, and seabirds, is a major conservation issue for multi-hook line fisheries. Mitigation measures include seasonal and spatial closures, soak duration, setting depth and time (e.g., at night), the type of baits, hook types (e.g., circle hooks), leader material and length, weighted lines, bird-scaring lines, hook shielding devices, and deterrents such as acoustic pingers or electric deterrents (SharkGuards).
- Discards: Multi-hook line fisheries have a moderate discard rate but only account for ~4% of global fishery discards by weight. Demersal longlines have higher discard rates than pelagic longlines. Droplines have very small rates of discards.
- Depredation: As lines remain in the water for some time with fish hooked, depredation from sharks, sea lions, dolphins, and whales can occur. Depredation can result in entanglements and hooking of TEPS.

Economic considerations

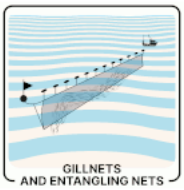
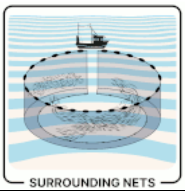
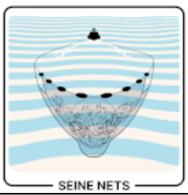
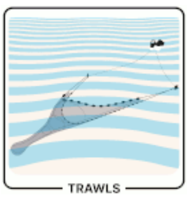
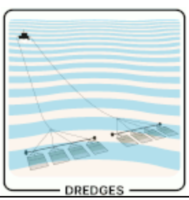
- Operating costs: Costs will depend on the fishing scale, location fished, and gear type used. Baits can be expensive consumables, and the baiting of hooks can be labour intensive unless automated, which requires additional equipment. Crew requirements are relatively low but also depend on the gear used and scale of the fishery. Gear damage and loss can occur when longlines become snagged on the seafloor.
- Bycatch mitigation: Requirements for bycatch mitigation (e.g., hook shielding devices, deterrents) can be costly.
- Product Quality: Fish quality can be high if fish are retrieved in a timely manner; however, depredation can decrease product quality and fishing efficiency.

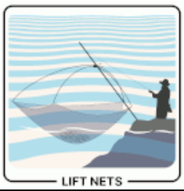
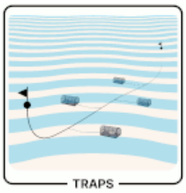
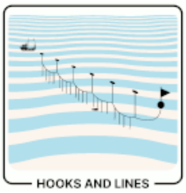
Social considerations

- Public perception: High rates of bycatch can lead to poor public perception, particularly where charismatic megafauna are concerns (e.g., dolphins, sharks, threatened species).
- Conflict between sectors: Large longlining fleets have historically outcompeted local fishers for resources. There may also be issues with gear equity, as recreational anglers are restricted in their line configurations.

Appendix B – ISSCFG Fishing Gears

Sourced from the Revised International Standard Classification of Fishing Gears (ISSCFG), Rev.1 (2016), contained within He et al. (2021).

Gear category	Gear	Included in this review?
Gillnets And Entangling Nets	Set gillnets (anchored)	No – gear currently used in fishery
	Drift gillnets	No – Entangling gear out of scope
	Encircling gillnets	No – Entangling gear out of scope
	Fixed gillnets (on stakes)	No – Entangling gear out of scope
	Trammel nets	No – Entangling gear out of scope
	Combined gillnets-trammel nets	No – Entangling gear out of scope
	Gillnets and entangling nets *not elsewhere included*	No – NEI
Surrounding Nets	Purse seines	Yes – Surrounding nets (Purse seine)
	Surrounding nets without purse lines	Yes – Surrounding nets (Lampara)
	Surrounding nets *not elsewhere included*	No – NEI
Seine Nets	Beach seines	Yes – Beach seines
	Boat seines	Yes – Boat seines
	Seine nets *not elsewhere included*	No – NEI
Trawls	Beam trawls	Yes – Trawls
	Single boat bottom otter trawls	Yes – Trawls
	Twin bottom otter trawls	Yes – Trawls
	Multiple bottom otter trawls	Yes – Trawls
	Bottom pair trawls	Yes – Trawls
	Bottom trawls *not elsewhere included*	No – NEI
	Single boat midwater otter trawls	Yes – Trawls
	Midwater pair trawls	Yes – Trawls
	Midwater trawls *not elsewhere included*	No – NEI
	Semipelagic trawls	Yes – Trawls
	Trawls *not elsewhere included*	No – NEI
Dredges	Towed dredges	No – target shellfish only
	Hand dredges	No – target shellfish only
	Mechanized dredges	No – target shellfish only
	Dredges *not elsewhere included*	No – NEI

Lift Nets	Portable lift nets	No – Target species unsuitable
	Boat-operated lift nets	No – Target species unsuitable
	Shore-operated stationary lift nets	No – Target species unsuitable
	Lift nets *not elsewhere included*	No – NEI
Falling Gear	Cast nets	No – scale too small
	Cover pots/Lantern nets	No – scale too small
	Falling gear *not elsewhere included*	No – NEI
Traps	Stationary uncovered pound nets	Yes – Pound nets
	Pots	Yes – Fish traps
	Fyke nets	No – Similar to pound nets
	Stow nets	No – Similar to pound nets
	Barriers, fences, weirs, etc.	Yes – Pound nets
	Aerial traps	No – Target species unsuitable
	Traps *not elsewhere included*	No – NEI
Hooks And Lines	Handlines and hand-operated pole-and-lines	Yes – Simple hooks and lines
	Mechanized lines and pole-and-lines	Yes – Simple hooks and lines
	Set longlines	Yes – Multi hook lines
	Drifting longlines	Yes – Multi hook lines
	Longlines *not elsewhere included*	No – NEI
	Vertical lines	Yes – Multi hook lines
	Trolling lines	Yes – Simple hooks and lines
	Hooks and lines *not elsewhere included*	No – NEI
Miscellaneous Gear	Harpoons	No – Scale too small
	Hand implements (Wrenching gear, Clamps, Tongs, Rakes, Spears)	No – Mostly target macroalgae.
	Pumps	No – target shellfish only
	Electric fishing	No – Innovative gear, poorly studied
	Pushnets	No – Scale too small
	Scoopnets	No – Scale too small
	Drive-in nets	No – Scale too small
	Diving	No – Target shellfish only
	Gear *not elsewhere included*	No – NEI