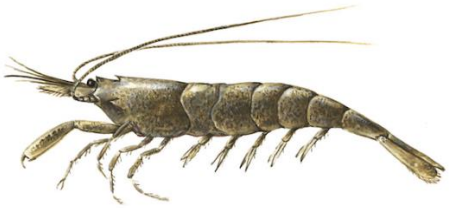
Status of the brown shrimp (*Crangon crangon*) fishery

North Western Inshore Fisheries and Conservation



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Executive Summary

The rationale for this work stems from growing concerns raised regarding a decline in the both the landings and size of shrimp. The purpose of this report is to review work that has previously been carried out in the district, gather information on the current state of the brown shrimp fishery and to investigate potential avenues for further research.

From 1966 there has been a gradual decrease in the landings of brown shrimps within the NWIFCA district. A sharp decline was observed in the late 80's and landings have not recovered since.

- Data from tractor landings is limited however a decrease in shrimp abundance is apparent from both vessel landing data, and stakeholder testimonies.
- Vessel landings from 2012-2022 are significantly lower than landings between 1975-1992.
- Historical vessel landings data showed that previously landings have exceeded 600 tonnes per year yet current landings do not exceed 12 tonnes per year.

A reduction in effort is evident with less stakeholders exploiting the fishery compared to historical records and many current stakeholders exploiting the fishery for a lesser amount of time annually than past activities. Shifts in effort to other species has occurred due to low abundances of brown shrimp.

Potential avenues for further research include:

- Changes in temperature, nutrient concentration and chemicals within the water
- Changes to predator abundance
- Investigating the geography and population dynamics of brown shrimp in the NWIFCA district

Potential management avenues include:

- Improved monitoring of data poor sectors of the fishery, such as the tractor shrimpers
- Establishing a shrimp working group with stakeholders to identify opportunities for data gathering

The study reveals knowledge gaps in understanding the decline in shrimp in the North West. The NWIFCA plans to collaborate with academic institutions on research projects, develop an internal research plan and improve monitoring of shrimp stocks.

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1. Introduction

The brown shrimp (*Crangon crangon*) fisheries in the North West are artisanal fisheries with a long history and community connection. Shrimp have long been an important income source for many areas of the district and the popularity of “Morecambe Bay Potted Shrimp” has created a high demand. However, over the last several years, industry have had growing concerns regarding a decline in both the landings and size of shrimp and the impact this is having on their livelihoods.

NWIFCA’s current understanding of the shrimp population in the district is limited; with the majority of the research surrounding the districts fisheries having been undertaken pre-millennia. Since then, there has been continued changes in the fisheries, and there is the need for an up-to-date review of the current state of the fishery, and investigation into the potential reasons for its continued decline.

Aims:

The objective of this study was to gain a greater understanding of the current state of shrimp fisheries and their decline in the North West. To identify the main stakeholders and their views on the matter, and identify the key knowledge gaps where further research could be focussed.

To achieve this aim, the project was broken down into 3 stages:

1. Collate the most recent information regarding the biology and life history of *Crangon crangon,* and any relevant research on its declines via a literature review,
2. Investigate the past and current state of the shrimp fisheries, including evidence of historical declines from statistical reports and stakeholder feedback via a questionnaire; and
3. Identify the potential avenues for further studies to assist our understanding and management.

2. Methods

A literature review of previous papers exploring the brown shrimp fisheries in the North West was conducted. Various papers from authors including but not limited to: Jane Lancaster, Abbot and Perkins, Paul Driver and Stephen Sankey were reviewed. Information from these was used to build up a picture of the history of the local shrimp fisheries. Other research regarding the biology and life history of shrimp was also reviewed to understand the factors affecting brown shrimp populations.

To assess the current state of the fishery, two questionnaires were compiled and sent out to stakeholders. The questionnaires were active on the NWIFCA website for 1 month from mid-November to mid-December 2024. Stakeholders were alerted to the publication through the website news page, phone, text or email. The aim of the questionnaires were to gather information from local fishers

(including recreational, commercial, tractor, vessel and push netters), to gather current perspectives on historical declines, and potential causes for the decline. The first questionnaire was aimed at fishers, and the second on processors of the industry which included those who boiled, picked, potted and sold brown shrimp commercially.

The processors questionnaire only receives 2 respondents so this was not analysed further. Responses from the fishers questionnaire were extracted and analysed to show quantitative and semi quantitative data.

Understanding gained from the literature reviews and the questionnaires were used collate up-to date information, to identify knowledge gaps and identify potential areas of further research regarding the shrimp fisheries in the NWIFCA district.

3. Ecology and Life History of the Brown Shrimp

Life history

The common brown shrimp (*Crangon crangon*) is a decapod crustacean species characterised by their brown mottled colour, short rostrum and antenna that are the length of the body. They can grow up to a length of 85mm however male shrimps are often smaller than their female counterparts (Lloyd & Yonge, 1947). The life span of brown shrimp used to be up to 5 years (Lloyd & Younge, 1947; Tiews, 1970); more recently the life expectancy has been estimated at around 3 years with most individuals being in their first year of life due to the high rate of mortality in shrimp populations (Oh et al., 1999; Schumacher & Tiews, 1979). It is unclear whether this change in expected life span is due to a declining life expectancy or due to different scientific methods. Shrimp are R-strategists with high mortality rates, so population density is closely linked to recruitment (Martínez-Alarcón et al., 2019). This means intermittently due to favourable conditions, the population experiences periods of rapid population growth, free from competition. But these growth periods are interspersed with periods of unavoidable mortality and population decline due to unfavourable conditions.

Distribution

Although brown shrimp are mainly distributed in the Irish Sea, English Channel and North Sea, *C. crangon* can be found from the Baltic Sea down to the Mediterranean Sea (figure 1). They live within sandy or muddy estuarine environments and prefer sediment grain sizes between 125µm to 710µm (Pinn & Ansel, 1993). Shrimps can be found up to 150m deep, but they are generally only found in waters from the intertidal up to 50m deep (Fischer et al., 1981). There are 6 populations of brown shrimp

in the UK, thought to be related to distinct plankton assemblages which are isolated by water masses that do not completely mix (Henderson et al. 1990).

Behaviours

Shrimps are often berried and migrate to the surface of the seabed daily, mainly for feeding. Daily vertical migrations are thought to be modulated by a variety of factors including light, tide and turbidity. Emerging behaviour is increased during high tide, during hours of dark and when there is higher turbidity to enable the shrimp to more effectively evade predation whilst feeding on the seabed (Adhub-Al & Naylor, 1975). Shrimp in the intertidal area will closely follow the tidal rhythm with smaller shrimps following this more closely whilst larger shrimps stay in deeper waters. On a flood tide shrimp will move inland and on an ebb tide the shrimp will retreat (Hartsuyker, 1966).

Figure 1: Distribution of the Common Shrimp (*Crangon crangon*) ©FAO. (Source accessed 23/05/24). Species Distribution Map Viewer (fao.org)

Environmental stressors and reproduction

Shrimp have a high tolerance to environmental stressors such as temperature and salinity (Reiser et al., 2013; Saborowski & Hünerlage, 2022) however these factors can still impact migrations and recruitment. Females are thought to have a better tolerance to low salinity compared to males of the same age and juveniles are thought to have better tolerance than adults (Abbot & Perkins, 1977a; Henderson & Holmes, 1987).

The sea water temperature can affect the population of the following year (Reiser et al., 2013). Colder winters can delay and reduce the recruitment to the fisheries during spring due to berried females migrating further offshore resulting in larvae having further to migrate back inshore after hatching (Beukema, 1992). The time of hatching may also be related to the timing of phytoplankton blooms which can be varied due to climatic conditions. There is a high level of mortality within the larval stage and as shrimp larvae feed on phytoplankton they are often released offshore in areas of low turbidity and high phytoplankton abundance to maximise survival (Bamber & Henderson 1994; Hünerlage et al., 2019).

The production of eggs and therefore the abundance of berried females occurs all year round however this is highly variable between years, can be influenced by environmental factors and is often reduced in late Autumn months (Hünerlage et al., 2019; Urzúa et al., 2011). Berried females will carry their eggs up until hatching which ranges from 4-13 weeks (Boddeke, 1989). Within their lifetime females can carry up to 35000 eggs; the number of eggs that they can carry increases each year (Tiews, 1970).

Juvenile shrimp

Following hatching the planktonic larval stage will go through 5-7 moults before benthic settlement of the post larval stage at a size of approximately 5mm (Criales & Anger, 1986; Kuipers & Dapper, 1984). The mean growth rate of larvae has been recorded to be up to 0.57mm per day with greater growth rates being observed at warmer temperatures (Dalley, 1980; Hufnagl & Temming, 2011).

Following settlement shrimp will grow and metamorphose into juveniles and subsequently grow to the adult stage, the growth between moults is generally 1-3mm (Lloyd & Yonge, 1947). Growth rates between individuals vary; females have a greater growth rate compared to males (Lloyd & Yonge, 1947). Smaller more juvenile shrimps will grow faster than older, larger shrimps (Hufnagl & Temming, 2011).

Female shrimps are thought to reach maturity at a total length of approximately 45-50mm and a carapace length around 12-13mm however some studies suggest that this figure may be as low as 8mm (Abbot & Perkins, 1977b; Henderson & Holmes 1987; Oh & Hartnoll, 2004).

Ecosystem function

Shrimp play a key role in ecosystem functioning due to their interactions with a variety of marine species at various trophic levels throughout their life cycle, both as predator, and prey (Siegenthaler et al., 2022). Shrimp larvae are pelagic and will feed on microzooplankton or phytoplankton in the water column (Saborowski & Hünerlage, 2022). Juvenile and adult shrimps are opportunistic feeders and whilst they are omnivores much of their diet consists of plankton (Lancaster, 1999). Juvenile or smaller shrimp will often feed on copepods, ostracods, nematodes and foraminifera. Larger shrimps often feed on amphipods, polychaetes, gastropods, bivalves and young fish such as plaice (Gibson et al.,1995; Oh et al., 2001; van der Veer & Bergman, 1987). Shrimp must come to the surface of the seabed to feed therefore they often feed at night or at times of low visibility such as when eutrophication or turbidity is high so that they can evade predation (Isaksson et al., 1994).

There is a high mortality rate within shrimp populations and this is largely due to predation. Shrimp are often predated by fish species including cod, whiting and plaice; birds and even ctenophores and jellyfish (Abbot and Perkins, 1977a; Berghahn, 1996; Hünerlage et al., 2019; Walter & Becker, 1997). The abundance of predator species could be a key influencing factor in the population and recruitment of shrimp to a fishery each year. As the spatial distribution of juvenile fish and shrimps often overlap, there is opportunity for predation. This predator prey interaction is size dependent and therefore in the example of plaice and shrimp they can both predate on each other; larger shrimps will predate on smaller plaice and larger plaice will predate on smaller shrimps (Gibson et al., 1995).

The discard of small shrimp following riddling has shown a low percentage of mortality (< 25% mortality) however the shrimp that are discarded injured have a higher change of becoming food for seabirds and benthic scavengers (Lancaster & Frid, 2002).

4. History of the North West brown shrimp fishery

Artisanal shrimp fisheries in the North West district have been active for hundreds of years. Originally the use of small sail boats and horses powered the shrimp industry until the use of tractors, motor boats and rigs began to emerge in the early 1900's.

Traditionally shrimps are boiled alive until they turn pink and must be cooked soon after being caught to prevent spoiling. Boiling can either be done whilst still out on the sands if a boiler is brought to the fishing grounds (figure 2) or on a vessel. Alternatively, shrimp are boiled as soon as they have returned from fishing. Once boiled, shrimp are often picked. Picking is the removal and discarding of the hard exoskeletons (shells) and appendages so that only the edible meat is left.

Pickers are typically relatives or members of the local community. The availability of pickers was often a limiting factor to the amount of shrimp that can be landed (Sankey, 1987). However recently the number of shrimp being landed will also limit the amount of pickers able to work.

Figure 2: Fishers boiling shrimps with equipment towed onto the fishing grounds

The tradition of shrimping was a skill often passed down the generations within families and children would join their relatives from a young age. However due to low catches of shrimp in more recent years, many fishers are reporting that they are unwilling or unable to hand down the techniques as younger generations are fishing for more lucrative species or joining different sectors of work.

Previous shrimp research in the North West

Various relevant research papers have been written regarding brown shrimp within the NWIFCA district however due to the historical boundaries of different sea fisheries committees none of these encompass the whole of the current district in their research.

A report by Abbot and Perkins, 1977a, studying brown shrimp in the Solway Firth suggested that the highest abundance of shrimps to be from August onwards due to the recruitment of small shrimp to the fishery between July and September (figure 3). Lowest abundance of shrimp was observed between March and July. The study also postulated that an offshore migration of shrimp does occur.

Jane Lancaster (1999), studied the Solway Firth fishery from 1995 to 1997 finding it to be the second largest shrimp fishery in the UK after The Wash. Most landings occurred between May and October in the Inner and Mid Solway whilst an offshore winter fishery in the Outer Solway was present from November. This offshore fishery was only accessible to the larger vessels targeting the fishery. In 1995, 19 vessels were exploiting the fishery; two years later in 1997 this had dropped to 9 with many of the larger boats no longer exploiting the fishery due to declines in the market price for rough shrimp.

In the historic North West and North Wales Sea Fisheries Committee district most landings occurred in April and between September to December with Flookburgh, Lytham and Hoylake having the largest value of landings (Sankey, 1978).

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Abbot and Perkins, 1977												
Lancaster, 1999												
Sankey, 1978												

Figure 3: Months with highest landings as reported by the respective papers, green indicated months where there were highest landings and red represents months where there were lowest landings.

Historical data on shrimp in the North West

Data on vessel landings in the district is available from the 1960's onwards, however, this is likely to be incomplete. The data from 2012 onwards has been sourced from the UK government website from data provided by the MMO and older data has been sourced from MAFF fish stats. No landings data is available from tractors/rigs as there is no obligation for these fishers to report their landings. A large proportion of shrimp fishing in the NWIFCA district does not occur on vessels, therefore without any data from these alternative methods of shrimping a full analysis cannot be completed.

Personal records supplied to NWIFCA by an active shrimp fisher showed a catch of 320kg "shell on" shrimp (cooked but not picked) which were caught August 2015 in the Kent Channel by three fishers using ATVs/Tractors (figure 4). This catch was similar to the rest of their landings everyday throughout the season in 2015. Compared to recent anecdotes, where often a maximum of one box is filled, this would be considered a good catch.

Figure 4: a) Total catch from the Kent Estuary, August 2015. b) Unpicked, cooked brown shrimp ("Shell on").

From the available vessel landings data statistical analysis was completed and graphs were created. The data shows that there are frequently large fluctuations between years in the amount of shrimp caught. However, there has been an overall downward trend observed from around 1966; a steep decline in landings is evident from the late 1980's with no apparent recovery since. Landings between 2012 – 2022 are significantly lower than in the 1900's ($p < 0.005$) (figures 5 & 6). Previously vessel landings have exceeded 600 tonnes per year but recent landings do not exceed 12 tonnes per year.

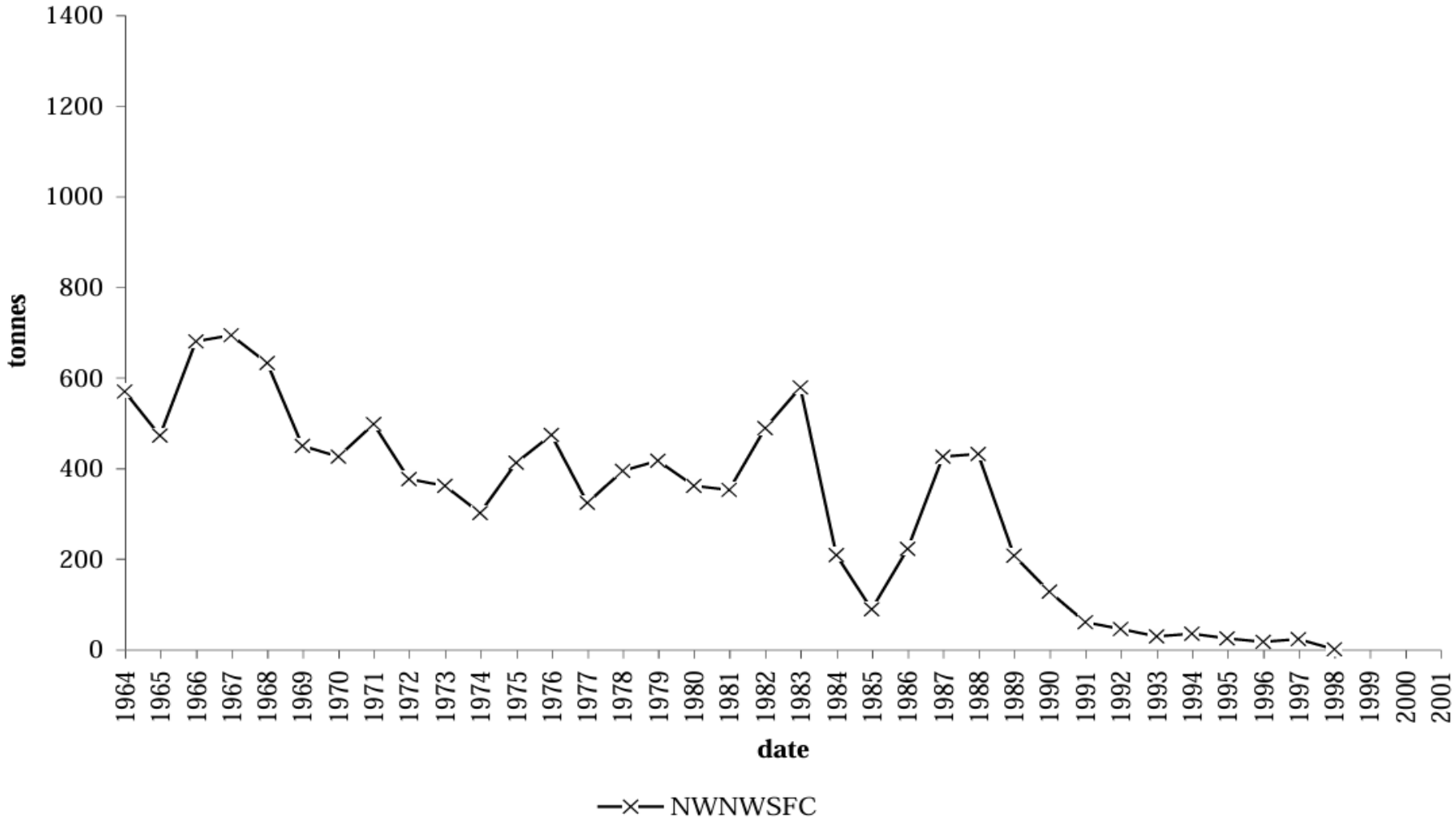


Figure 5: Graph modified from a 2001 report by NWNWSFC on the population of shrimp in 1964-2001 (MAFF Data); the data includes landings recorded in Wales that are no longer a part of the NWIFCA district and excludes the Cumbrian part of the district (Davies, 2002).

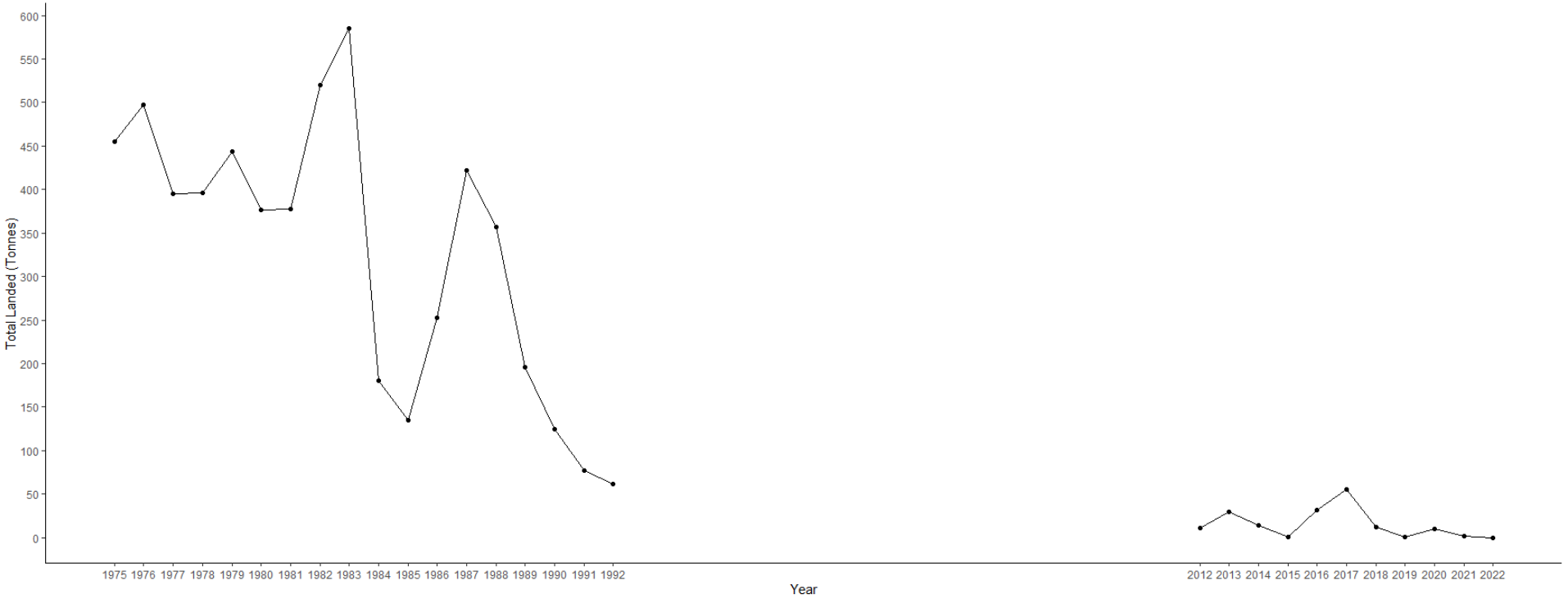


Figure 6: Shrimp landings in the NWIFCA District from 1975 - 1992 (MAFF Fish Stats) and 2012 - 2022 (MMO Data). This graph includes data from ports within the NWIFCA district.

Shrimp landings also fluctuate throughout the year (figure 7), however, these fluctuations can mainly be attributed to their migration patterns described above. The amplitude of these fluctuations however varies year by year; some years two discrete peaks can be observed whilst other years there may be only 1 or up to 3 peaks. The reasons for these changes in fluctuations may be due to variation within the shrimp population or due to other factors such as differences in fishing effort between years.

A reduced effort could be the reason for the long-term change in the shrimp landings, however, there is anecdotal evidence that changes in the shrimp fishery led to a reduction in fishing effort as the practice was no longer able to support the livelihoods of fishers. Newspaper articles from the 60's and 70's describe how consecutive years of poor shrimp catches forced many fishers to sell their equipment and

change their jobs to either different fishing methods or even industries unrelated to fishing to support themselves. This decline in the size of the shrimp industry has been escalated due to other large fisheries in the district such as cockles and mussels becoming much more lucrative.

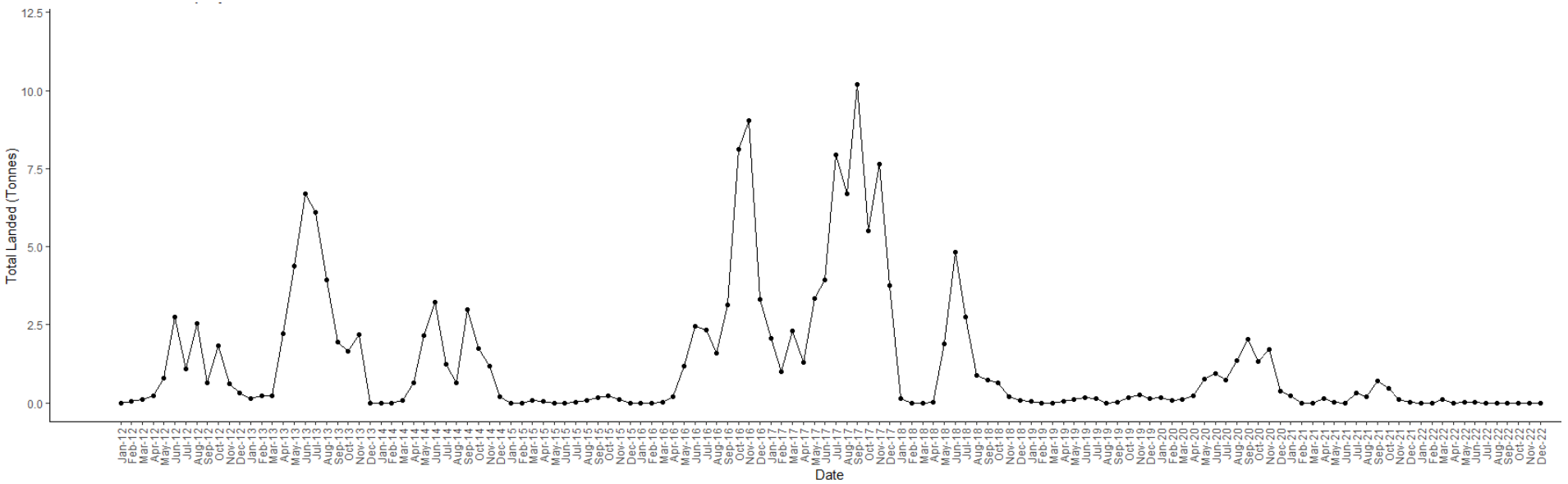


Figure 7: Shrimp landings in the NWIFCA district by month 2012-2022 (MMO Data). This graph includes data from ports within the NWIFCA district.

5. Byelaws and regulations related to the shrimp fishery

Bycatch within the shrimp fishing industry has received a lot of research. The main species often caught as bycatch are plaice, sole, dab and flounder; of which some are commercially important. Juveniles in the 0-age group are often caught as bycatch in the intertidal areas where shrimp are targeted, especially by tractors, as these are the nursery areas for these species (Sankey, 1987). As shrimp are caught through bottom trawls, demersal species are the most at risk of being caught as bycatch. Sorting grids or veils within nets can reduce the amount of bycatch that enter the cod-end and riddles are used after hauling to separate the catch and remove undersize shrimp and bycatch. In the NWIFCA district it is a requirement to riddle any catch, however the use of sorting grids/veils are not a requirement.

Several byelaws managed by the NWIFCA are related to shrimp fishing and the associated gear used. Due to the merge of the North Western Sea Fisheries Committee (NWSFC) and the Cumbria Sea Fisheries Committee (CSFC) some byelaws are only in force in certain areas of the district (figure 8). There are also higher-level council regulations set out by the government that apply to the whole of the UK. The relevant byelaws and regulations are outlined below (table 1).

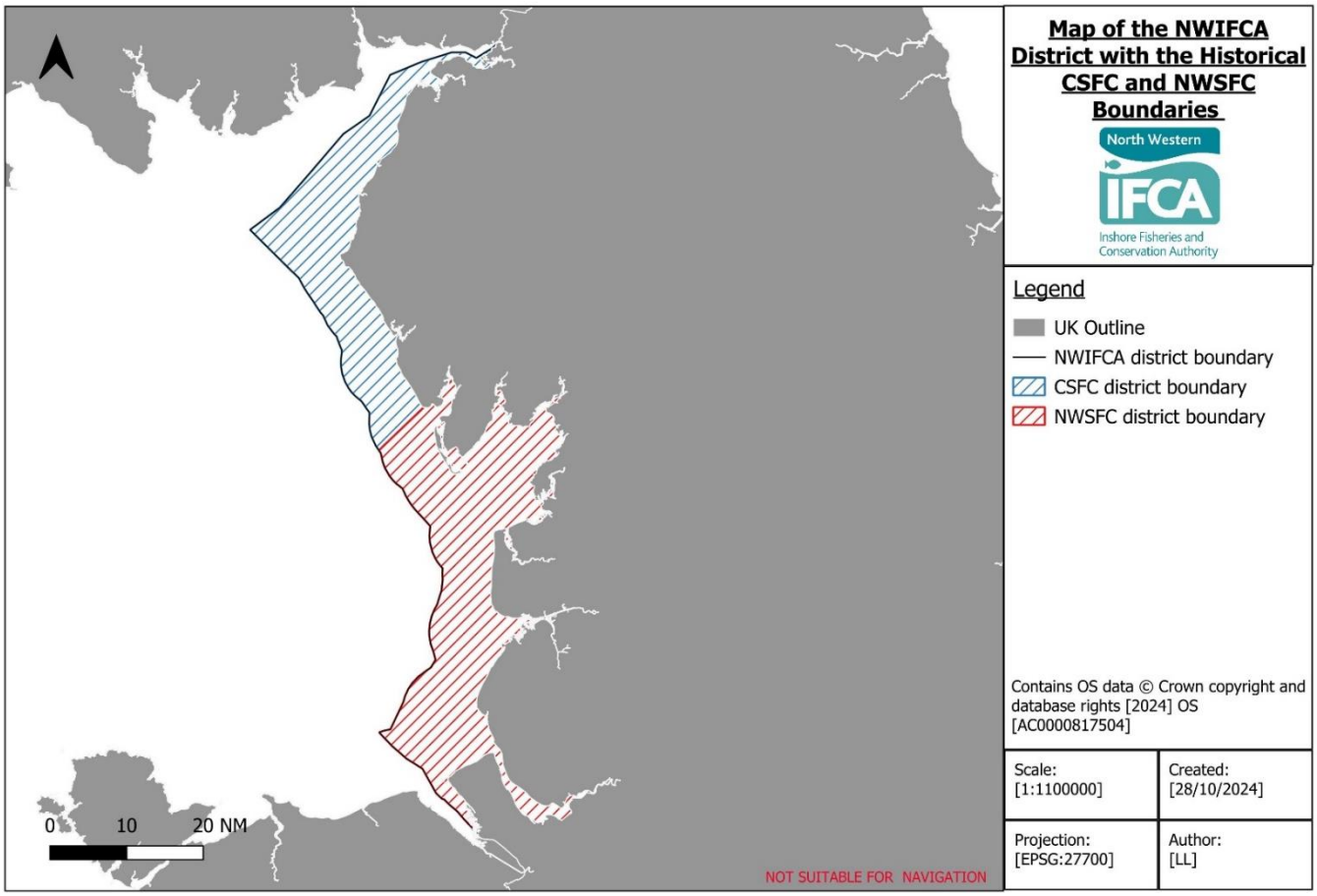


Figure 8: Map of the NWIFCA district with the two historical boundaries of Cumbria Sea Fisheries Committee (CSFC) and North Western Sea Fisheries Committee (NWSFC).

Byelaw	Restrictions
NWIFCA Byelaw 6	Bottom trawling is prohibited in areas protected by this byelaw.
NWSFC Byelaw 2	Prohibits any device being used to dimmish the mesh size of any net.
NWSFC Byelaw 6	Limits the length of any beam (inc. extremities) to 10m. Requires nets and riddles to be of a determined size. Immature fish that pass through the riddle must be returned to the sea unless the landing obligation requires them to be landed.
NWSFC Byelaw 9	Limits the maximum vessel length .
CSFC Byelaw 3	Limits the maximum vessel length.
CSFC Byelaw 13	Prohibits multi-rigged trawling gear except for when using beam trawls.
CSFC Byelaw 14	Limits the aggregate beam or headline length to 9m. Catch must be riddled and immature fish that pass through the riddle must be returned to the sea unless the landing obligation requires them to be landed.
CSFC Byelaw 15	Limits the engine power of vessels.
CSFC Byelaw 20:	Prohibits the use of a towed net between June and October.
Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019	Minimum mesh size must be at least 16mm. Vessel engine size and beam length are limited.

Table 1: Byelaws currently managed within the NWIFCA district related to shrimp fishing activities. North West Sea Fisheries Committee (NWSFC) byelaws are enforced in the old NWSFC district only; Cumbria Sea Fisheries Committee (CSFC) byelaws are enforced in the old CSFC district only.

6. Current State of the fishery

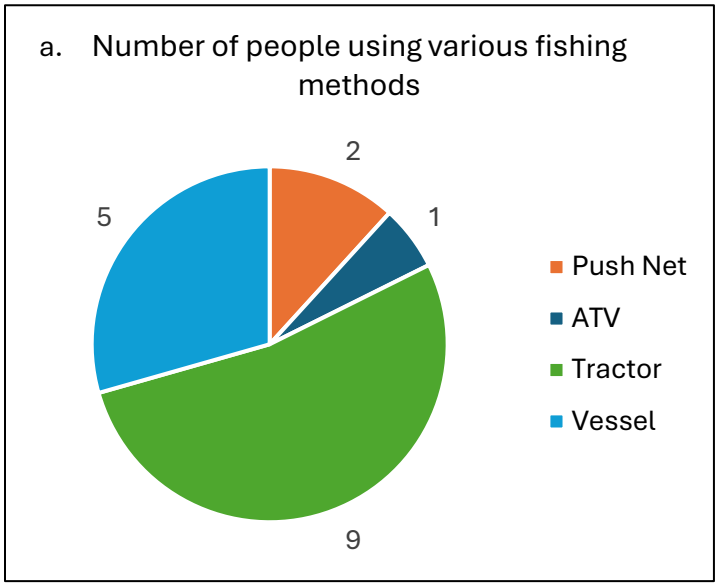
The processors questionnaires only received two respondents, most likely due to the fact that many fishers process their own catch. However there were 15 respondents to the fishers questionnaire; 13 of these are currently fishing for brown shrimp. Through this questionnaire, conversations with stakeholders and officer knowledge it is estimated that there are approximately 20 active shrimp fishers in the district.

Questionnaire results:

Current Fishing Gear

There is a range of methods and trawl and net types used within the district with some fishers using multiple gear types at different times. Tractors are the most common access method used and beam trawls the most common gear type (figure 9). Push nets are the smallest gear type being used with widths of 1.2m and 1.8m. Beams and shanks range from approximately 3m to 8m with most of the fishers using 2 to 3 beams or shanks at one time. Nets used are courlene shrimp nets or old salmon cage netting with diameters of 20-22mm. Hand riddles are the most common type of riddle used however mechanical riddles are also used by 6 fishers.

Changes to the gear used include a transition to bobbins from tickler chains and otter trawls rather than beams trawls; more minor changes such as an increase in the length or amount of nets have also occurred. Many of these changes were to experiment with different gear to maximise the landings.



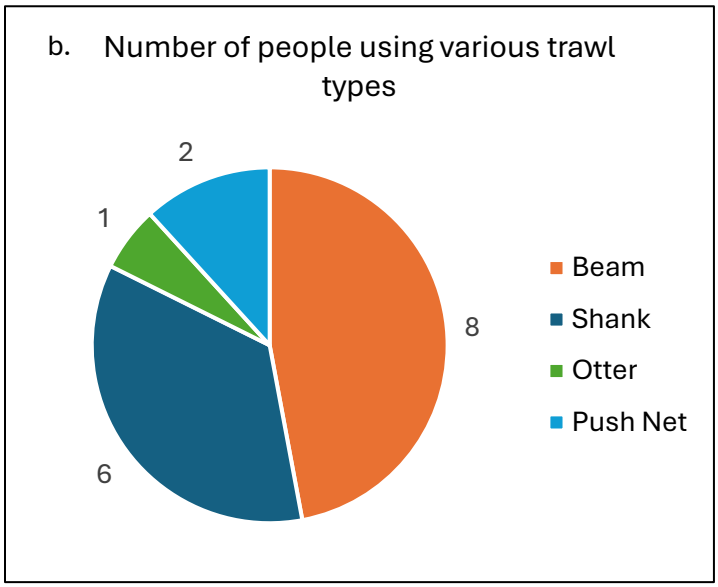


Figure 9: Methods and gear used by fishers in the NWIFCA district. a) Fishing method. b) Trawl or net type. Note: All recreational and commercial fishers have been included in these results.

The majority of fishers (93%), stated that they do part or all of the processing themselves. Those with vessels have boilers on board, some tow tractors onto the fishery to enable them to boil shrimp as they go and others will boil shrimps upon returning from the fishery. Around 75% of fishers reported that they also pick the shrimp and ~15% of these pot shrimp. Picking tends to be done by the individuals, their families or a small group of employed pickers. The number of employed pickers was reported to have reduced due to the decline in the frequency of fishing activity and the number of shrimp landed.

Location of current fishing activity

Shrimp fishing occurs throughout the NWIFCA district with the majority of the activity in the central and southern part (figure 10). Tractors work throughout Morecambe Bay and along the coast near Southport, the Ribble estuary and Lytham. Vessels work in and around the Ribble estuary, the Solway Firth the Dee estuary and the Liverpool Bay area. There is officer knowledge that vessels are also active in the Morecambe Bay area (pers. Comms) however no representatives were able to be contacted. There are recreational push netters who are active around the Fylde coast and Morecambe Bay.

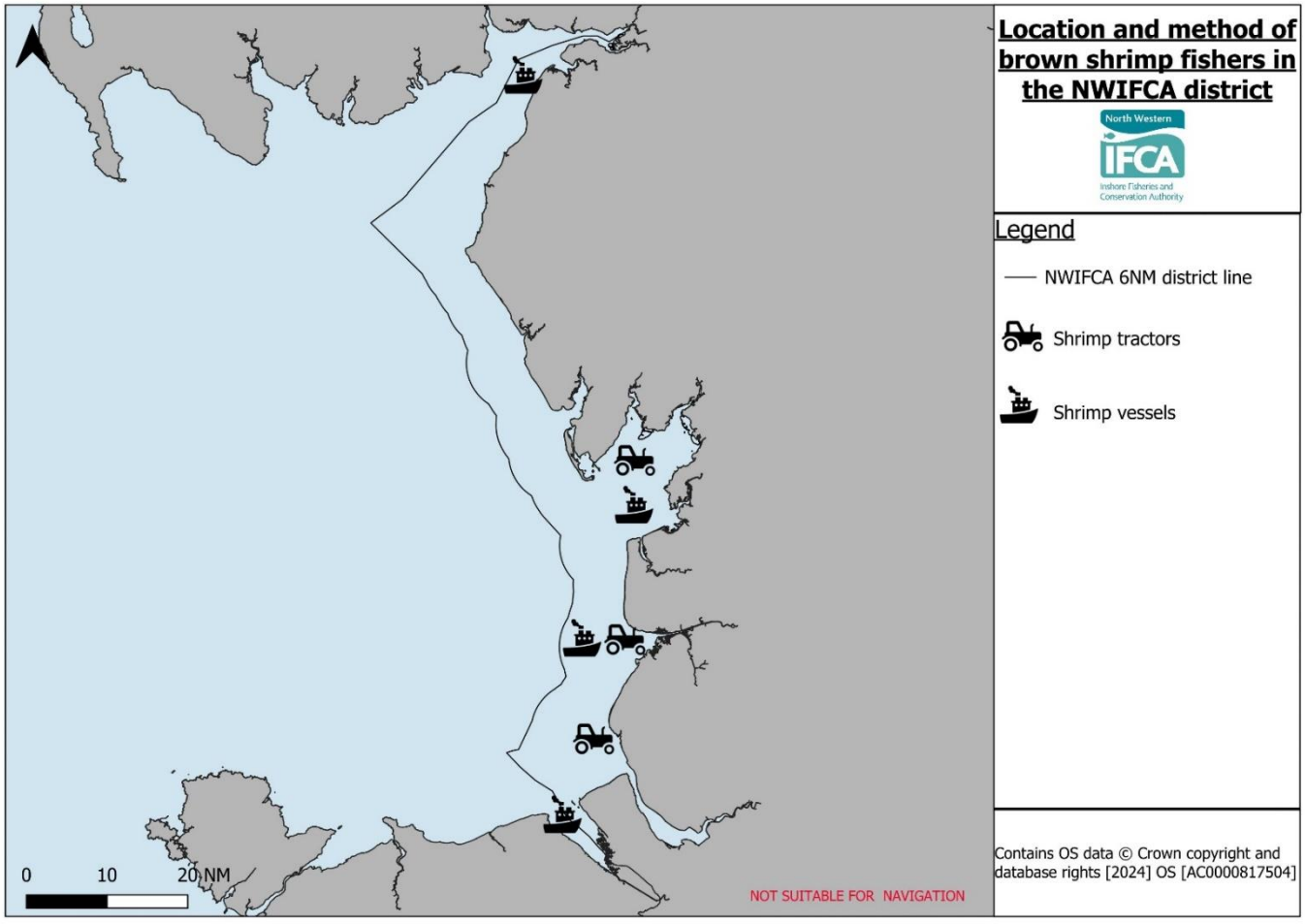


Figure 10: Infographic of the locations targeted by shrimp vessels and shrimp tractors in the NWIFCA district.

Current fishing activity

The general fishing season has been described as between the end of March and December however many fishers will not be active during the summer months due to the recruitment of small shrimp over this time period. Many fishers mentioned that the season used to run until early November whilst more recently they have been able to catch shrimp up until mid-December albeit smaller shrimp.

Tractor, ATV and push net fishers will fish over low tide often until an hour after low whilst the vessel fishers are able to fish over both low and high tide, often favouring high tide. Generally fishers will complete 2-3 trawls per trip, each of these trawls take approximately 20-30 minutes and cover 1-2 miles. The lengths and duration of trawls can be influenced by the amount of shrimp being caught; large catches or high volumes of muck will force the nets to be emptied earlier. Fishers mentioned that the area that they trawl is dependent on the quality of the catch and they will cover larger distances when necessary to improve their catch.

When asked about weather influences 87% of stakeholders mentioned that weather conditions can influence their activity. In some cases adverse weather; mainly high winds; may prevent fishers from being able to access the fisheries or force them to fish in areas that are more sheltered. It was also reported that high winds from certain directions (often Easterlies were quoted) reduce the number of shrimp that are caught. High winds resulting in clearer waters were also mentioned as an occurrence that reduces the number caught, as shrimp are more abundant in more turbid waters where they are able to evade predations more effectively. Conversely to this, a lack of wind resulting in very calm conditions was also reported to reduce the amount of shrimp landed with claims that moving water is favoured by shrimp.

Changes in the fishery

The rationale behind this report was that a change in the shrimp fisheries in the NWIFCA district were being reported. Changes in the fishery have been highlighted and have begun to be explored in the past however there is limited information on the state of the fishery in the last 20 years.

All of those who answered the questionnaire or had conversations with officers reported that they have seen an decline in the number of shrimp caught. Some mentioned that the decline has been within the last 5-7 years whilst others suggested a more long term decline of about 20-30 years has occurred.

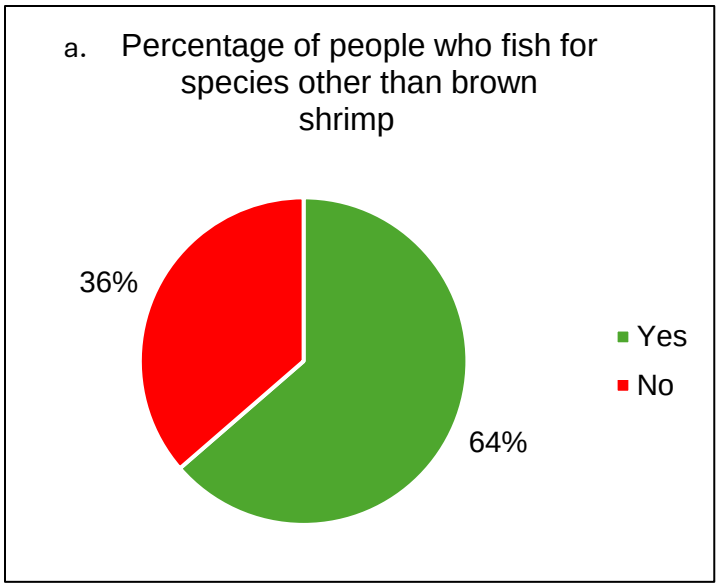
Many stakeholders reported that when they began fishing for shrimp they were able to land 60kg – 130kg per day of fishing; currently their landings are around 1.5kg to 40kg per day of fishing which is

up to a 40 fold decrease (figure 11). Fishing frequency used to reach 200+ days a year per person, now this figure more often ranges from 20-100 days a year per person which is up to an 18 fold decrease. Although there has been a decline in fishing activity of both tractor and vessel fishers, tractor fishing has had a larger decline in fishing frequency. Despite this decline in landings and fishing activity there is still a demand for brown shrimps, however many stakeholders agreed that there was not a great enough supply to meet this demand.

Figure 11: The rough boiled catch of one fisher on the 23rd October 2024. The fisher had used a tractor to access the fishery. The amount of shrimp landed here was described to be much lower than what they used to be able to land at a similar time of the year under similar conditions.

Other species such as mussels, cockles and teleost fish are more reliable and lucrative than brown shrimps, encouraging many stakeholders to begin to focus more of their effort on these species. Results from the questionnaire showed that 64% of current commercial shrimp fishers target other species and that 57% of these began to target other species due to changes in the shrimp fisheries (figure 12).

Although shrimp fishing at some point has been a mainstay for 81% of current commercial fishers, this is no longer the case. Many no longer consider shrimping their main catch (figure 13) and are unable to financially rely upon it. These pie charts demonstrate that shrimp are not the primary catch for many fishers; the reason for this is that there has been a decline in the availability of shrimp. Many of those who used to fish solely for shrimp were forced to begin to fish for other species and many of those who already fished for other species began to shift their focus more towards other more lucrative and stable species.



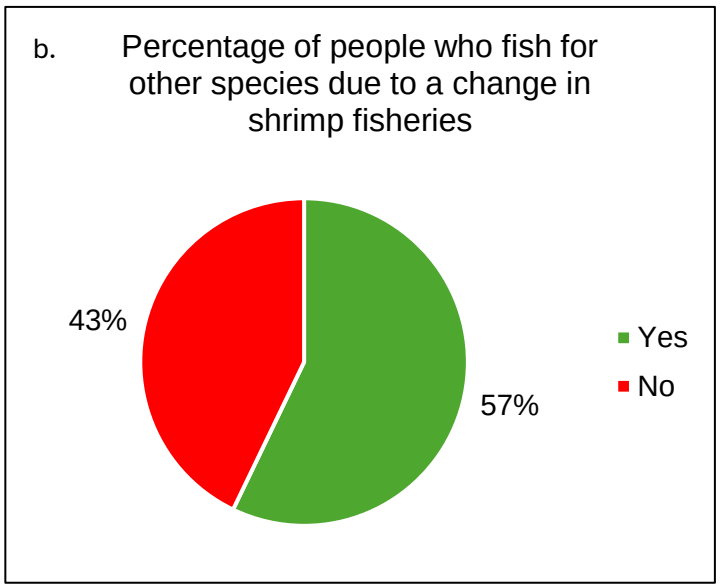


Figure 12: Questionnaire results of current commercial fishers: a) Do you fish for other species? b) Did you begin to fish for these other species due to a change in the shrimp fisheries? Note: Only current commercial fishers are included in these results due to the nature of commercial and financial interest being a potential factor for a change in target species.

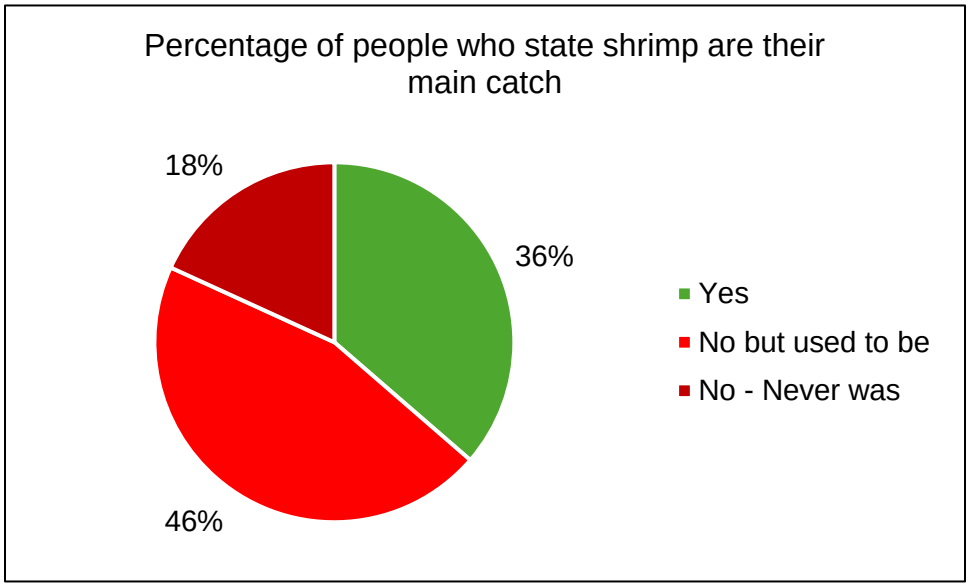


Figure 13: Questionnaire results of current commercial fishers: Do you consider shrimp to be your main catch? Note: Only current commercial fishers are included in these results due to the nature of commercial and financial interest being a potential factor for a change of fishing effort.

A change in the size of shrimp was reported by 60% of the questionnaire respondents (figure 14), all of whom stated that there had been a decline in the number of large shrimps seen within catches and that landings now consisted of more small shrimp. Although throughout the season there has always been differences in the size of shrimps caught coinciding with the migration on young shrimp to the fishing

grounds; now there are reports that smaller shrimps do not seem to be growing and reaching the size that they formally did.

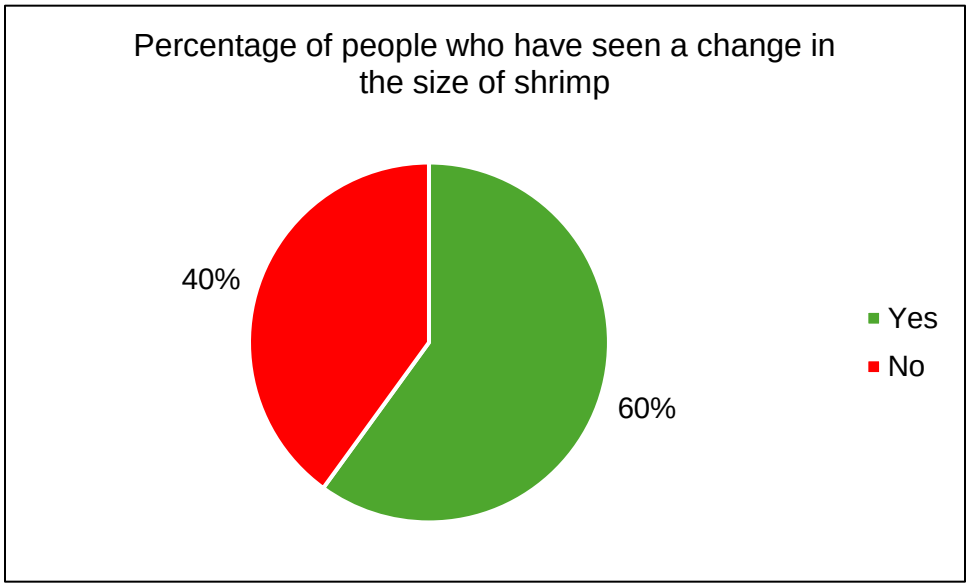


Figure 14: Questionnaire results: Have you seen a change in the size of shrimp? Note: All recreational and commercial fishers have been included in these results.

Suggested reasons for changes observed

A variety of reasons for the declines seen in the NW district shrimp fisheries have been suggested (figure 15). Some of the more popular answers are explained in more detail below.

- Increased chemicals, detergents or drugs in the water:
    - There are concerns about the use of chemicals, detergents and drugs which eventually enter the environment and could have detrimental impacts on marine life including brown shrimps. There have been reports of the water smelling “like bleach” as well as reports of the behaviour of the shrimp being different. Some have mentioned that shrimp used to ‘jump’ in the buckets once caught however they now seem more docile.

- Warmer sea temperatures and predation
    - It has been postulated that warmer sea temperatures have resulted in a northern shift in the geographic range potential predator species. It has been suggested that an increased number of potential predator species such as smooth-hounds, bass, dogfish and Dover sole has contributed to the decline of brown shrimp.

- Geographical changes to habitats
    - ‘Silting up’, a process of siltation and sedimentation, is thought to be resulting in changes to water masses and channels; causing them to move or disappear. Many shrimp fishing areas are within channels so changes to channels may disrupt the habitat of the shrimps and therefore the landings.

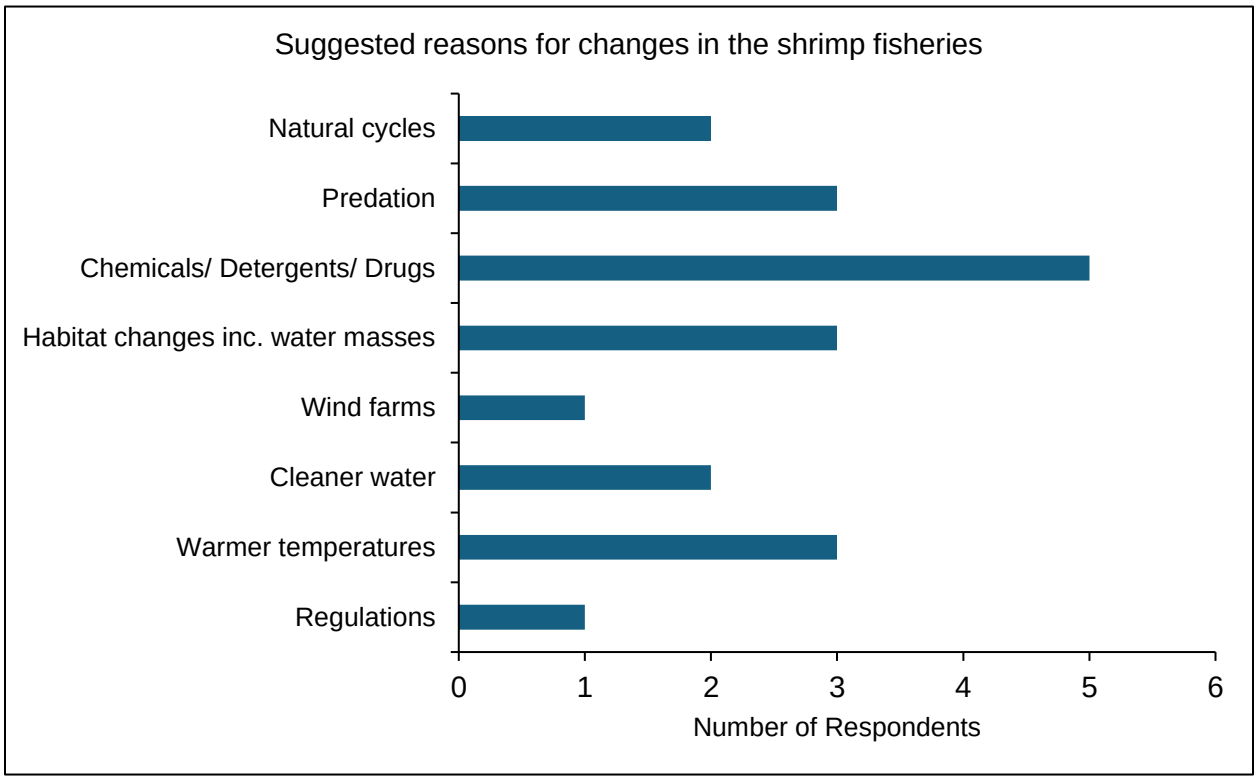


Figure 15: Suggested reasons for changes seen in the North West shrimp fisheries quantified by the number of people who suggested them. Note: all commercial and recreational fishers are included in these results.

7. Further Research

Key Points

- Temperature, nutrients and predators have been identified in literature as factors that could affect the population of shrimp.
- There are knowledge gaps surrounding other factors such as changes to habitats, chemical pollution and wind farms.
- There is limited up to date information on the geography of early life stages and offshore brown shrimp in the NWIFCA district.
- There is limited up to date information on the age, size and sex ratio of shrimp in the NWIFCA district.

- The development of research projects internally and with academics is required to further investigate the decline in landings observed.
- Due to the nature of the fishery in the NW being predominantly tractor fishing, a significant amount of data is unaccounted for - monitoring of this fishery needs to be improved in order to identify patterns of decline.

Suggested topics for further research

There has been a range of suggested factors that may affect the shrimps fisheries in the NWIFCA district raised by both stakeholders and research for this report. Selected factors have already got literature relating to them whilst others have highlighted knowledge gaps. Some areas outside of the NWIFCA district that have been studied long term have reported a stable or increasing adult shrimp abundance contradictory to what has been reported in the NWIFCA district (Campos et al., 2010; Henderson et al., 2006; Siegel et al., 2005). These studies spanned at least 25 years and investigated the abundance of shrimp throughout the year, highlighting inter-annual variation related to physical and biotic factors.

Temperature

There are many papers investigating the impact of temperature on brown shrimps (i.e. Beukema, 1992; Henderson et al., 2006; Reiser et al., 2013; Saborowski & Hünerlage, 2022; Urzúa et al., 2011); studies show that temperatures can influence the egg production, larval development, recruitment and survival of shrimps. Many authors agree that winter temperatures are the most vital to understand the influences on brown shrimp however all seasons should be taken into account to ensure that all life stages are studied. It is well agreed upon that warmer winter temperatures can increase the rate of egg and larval development, causing the recruitment of shrimp the following year to be earlier and more prolonged. A recent long-term study concluded that warming sea temperatures, especially over winter, can increase shrimp mortality due to a mis-match in the timing of hatching and phytoplankton blooms which are a main source of food for larval plankton (Saborowski & Hünerlage, 2022). Long term temperature and biological data will be required to complete an analysis on the effects of temperature change on the shrimp fisheries in the NWIFCA district.

Cleaner Waters

Cleaner waters related to reductions in the concentrations of nutrients in some coastal areas has been identified as waste management and fertiliser use is now more regulated (AIC, 2024; CEFAS, 2018; DEFRA, 2002). The nitrogen to phosphorous ratio (N:P) within the oceans is important for the

productivity of phytoplankton (Redfield, 1934). A disruption in this ratio can decrease the rate of productivity as nutrients will become a limiting factor. A reduction in phosphorous was seen along the Dutch West coast and was suggested to have reduced plankton productivity and therefore the available food for brown shrimp (Boddeke, 1996). Alternately, as shrimp have been shown to prefer areas with high levels of eutrophication for predator avoidance (Isaksson et al., 1994), reductions in nutrient concentrations could impact the survivability of shrimp. The impact of other key nutrient concentrations on brown shrimp have not been investigated. Currently the NWIFCA have no data on nutrient concentrations and temporal changes in the district.

Predators

A high abundance of predators has been correlated with a lower abundance of shrimp in autumn and the following year (Hünerlage et al., 2019; Seigel et al., 2005). The predators identified in these studies were mainly fish species that would feed on shrimp post benthic settlement so the impact of predation on the larval stage of shrimp is unknown. Seigel et al., 2005, hypothesised that colder winters may negatively impact predators development and survival, enabling brown shrimp to develop with less competition therefore reducing mortality, however no evidence is available to support this. The combined impact of warmer sea waters and predator abundance was raised as a concern by stakeholders however there is no relevant research on this area.

Other areas of research

There is little or no research into the impacts of chemicals, windfarms, natural cycles of abundance or changes in sedimentation and water masses which could influence habitats. Therefore these have been identified as knowledge gaps.

Literature surrounding the role of salinity (controlled by rainfall and run-off) on the control of shrimp population does not have a clear conclusion. Some studies suggested high rainfall and run-off leading to low salinities positively correlate with shrimp stocks the following years (Driver, 1976), however some studies found no correlation (Gelin et al., 2001). Due to the euryhaline nature of shrimp (an ability to survive in a wide range of salinities) and as it is not a factor that is widely suggested to be impacting shrimp it is not proposed to focus research on this area.

Limited up to date information is available on the geography of brown shrimp in the NWIFCA district. Although the location of the fishing grounds have generally stayed the same, the location of nursery grounds and offshore winter grounds are unknown. Increased understanding of the geography of brown shrimp could aid in the identification of potential factors influencing recruitment and migration, both of

which are critical activities. The NWIFCA has limited up to date information on the age, size, and sex ratio of shrimps in the district. An understanding of these may enable us to highlight factors potentially affecting different life stages and key processes such as reproduction. The study by Jane Lancaster in the 1990's researched these in the Solway Firth however studies encompassing the whole district and including more recent data are not available.

Next Steps

This study has identified clear knowledge gaps in our understanding of the decline in shrimp in the North West. To continue to investigate the decline in shrimp landings there are range of actions that NWIFCA will look to undertake (table 2). Researchers at academic institutions will be contacted to discuss potential research project collaborations regarding some of the issues such as temperature, nutrient concentrations and chemical changes. Internally the NWIFCA plan to develop a research plan to mimic the study by Jane Lancaster in the 1990's looking at variables such as age, size and sex ratio within the shrimp population with hopes this data can be used in conjunction with academic work. The NWIFCA will explore potential funding streams to support these projects. The creation of a working group involving stakeholders can support continued input to the direction of research and updates to the progress of these.

Monitoring of the shrimp fisheries in the NWIFCA district is limited with more than 50% of commercial landings coming from tractors that are not required to submit landings. This has resulted in large data gaps; working with stakeholders to create a returns system would aim to reduce this data gap in future years and enable the NWIFCA to identify patterns of decline.

It may be necessary to involve other authorities to discuss management; within their remit; needed to tackle the decline in landings.

Research questions	Who can assist	Management
What is the effect of sea temperature on shrimps?	Academics/researchers/stakeholders	Monitoring of landings - NWIFCA
What are the effects of nutrient concentrations on shrimps?	Academics/researchers/stakeholders and relevant authorities	Other authorities
What is the effect of chemical pollution on shrimps?	Academics/researchers/stakeholders and relevant authorities	Other authorities
How do sediment changes effect shrimp populations?	Academics/researchers/stakeholders	Other authorities
How are predator populations impacting shrimp?	Academics/researchers/stakeholders	Monitoring of landings - NWIFCA
Where are the main offshore, fishing and nursery grounds of shrimp in the district?	Industry stakeholders	Monitoring of landings - NWIFCA
What are the population dynamics of shrimps in the district?	NWIFCA and industry stakeholders	Monitoring of landings - NWIFCA

Table 2: Avenues for further research, the institutes that can assist the NWIFCA with this and the potential management that is required.

8. Conclusions

This is the first study of the brown shrimp fishery in the NW in the last 20 years. It has had successful participation and interest from the stakeholders involved enabling the NWIFCA to gain an understanding of the history and current state of the shrimp fishery. This report confirms a decline of already severely reduced landings is evident, with a decreasing size of landed shrimp also observed. These declines have already reduced the amount of people exploiting the fishery and are putting it at risk of further decline as new generations of fishers are discouraged to enter the industry due to its poor performance. A change in the effort of those still exploiting the fishery has also been seen as many have chosen to target other species which are more commercially viable. Factors that are potentially impacting the shrimp fisheries have been identified from stakeholders and through literature. Areas of possible further research relating to the NWIFCA district have been identified. Next steps include discussions with researchers to identify potential projects, the development of an internal project to study population dynamics and discussions relating to potential monitoring techniques such as a voluntary returns system.

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