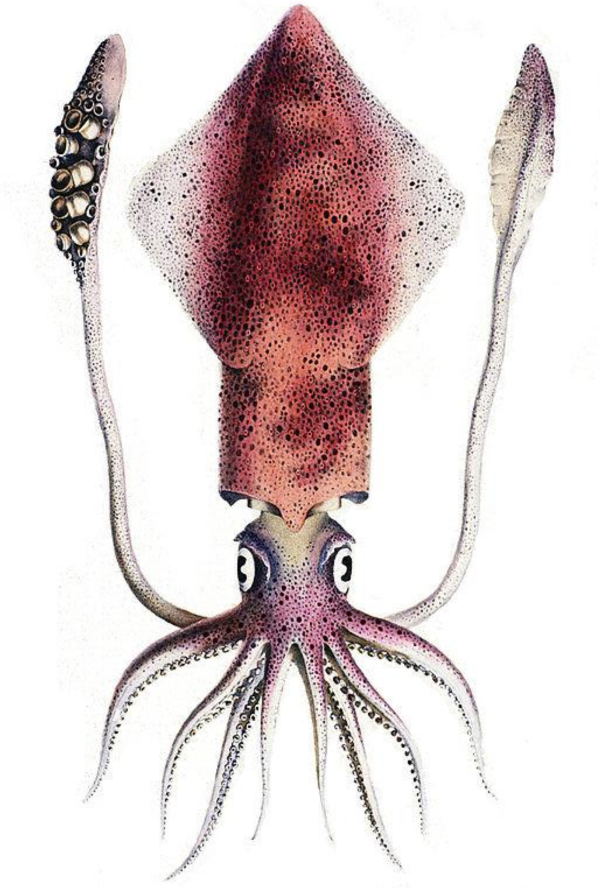
Fisheries Research & Management Plan

Squid in the North of Devon & Severn IFCA's District



Devon & Severn IFCA Inshore Fisheries and Conservation Authority

NORTH DEVON BIOSPHERE

European Union European Structural and Investment Funds

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Cover image *– The European squid (Loligo vulgaris) (Verany, 1835, https://commons.wikimedia.org/wiki/File:Loligo_vulgaris2.jpg [unedited])*

Contents

Introduction

Background

In 2017, the UK fishing fleet added an estimated £1.53 billion to the UK economy and provided employment to 23,000 people in Great Britain. Globally the demand for fish is expected to rise but growth in fish catches has stalled, with some regions experiencing declines of up to 35% between 1930–2010, primarily driven by overfishing. The fishing industry is also an integral part of coastal communities' cultural heritage and fishing has been passed down through generations, making the future of the industry an emotive issue.

The North Devon fishing fleet landed just under 1,000 tonnes of documented catch in 2019, with an estimated value of £1.7 million (MMO, 2020). Much of the commercial fishing effort in the Bristol Channel is potting for shellfish and important trawl fisheries for skates and other demersal species. There are also traditional netting fisheries close to the shore for species such as herring and bass. Although these fisheries are low in financial value they carry immense cultural value to the fishers and their communities, being seen as part of their history and way of life (FRMP Interviews, 2020).

UK Government 25 Year Environment Plan

In 2018 the UK Government published a 25 Year Environment Plan (25YEP) with goals and targets for "*improving the environment within a generation and leaving it in a better state than we found it*". These goals and targets include "*ensuring that all fish stocks are recovered to and maintained at levels that can produce their maximum sustainable yield*."

To inform the development and implementation of the 25YEP the Government set up a series of pioneer projects including a Marine Pioneer in North Devon (see **Figure 1**). The pioneer projects have been created to test innovative ways of managing the environment and using a natural capital approach. The intention is that successful measures can be scaled up and applied at a national level.

As part of the Marine Pioneer, the Devon and Severn Inshore Fisheries and Conservation Authority (D&S IFCA) and the North Devon Biosphere have produced a series of innovative Fisheries Research Management Plans (FRMPs) for commercially important species in the north of D&S IFCA's District (see **Figure 1**).

Fisheries Research & Management Plans

The FRMPs use a localised and ecosystem-based fisheries management (EBFM) approach. EBFM is a holistic way of managing fisheries. It takes into account interactions between species, the overall health of the ecosystem and pressures that can affect this such as aggregate dredging, poor water quality and marine developments.

The FRMPs are different from previous work in this area because they take local and historical knowledge into account and include the cultural and heritage value of the fisheries. The plans also account for ecosystem factors that are sometimes overlooked by traditional fisheries management such as the impacts of local marine developments and the relationships marine species have with one another.

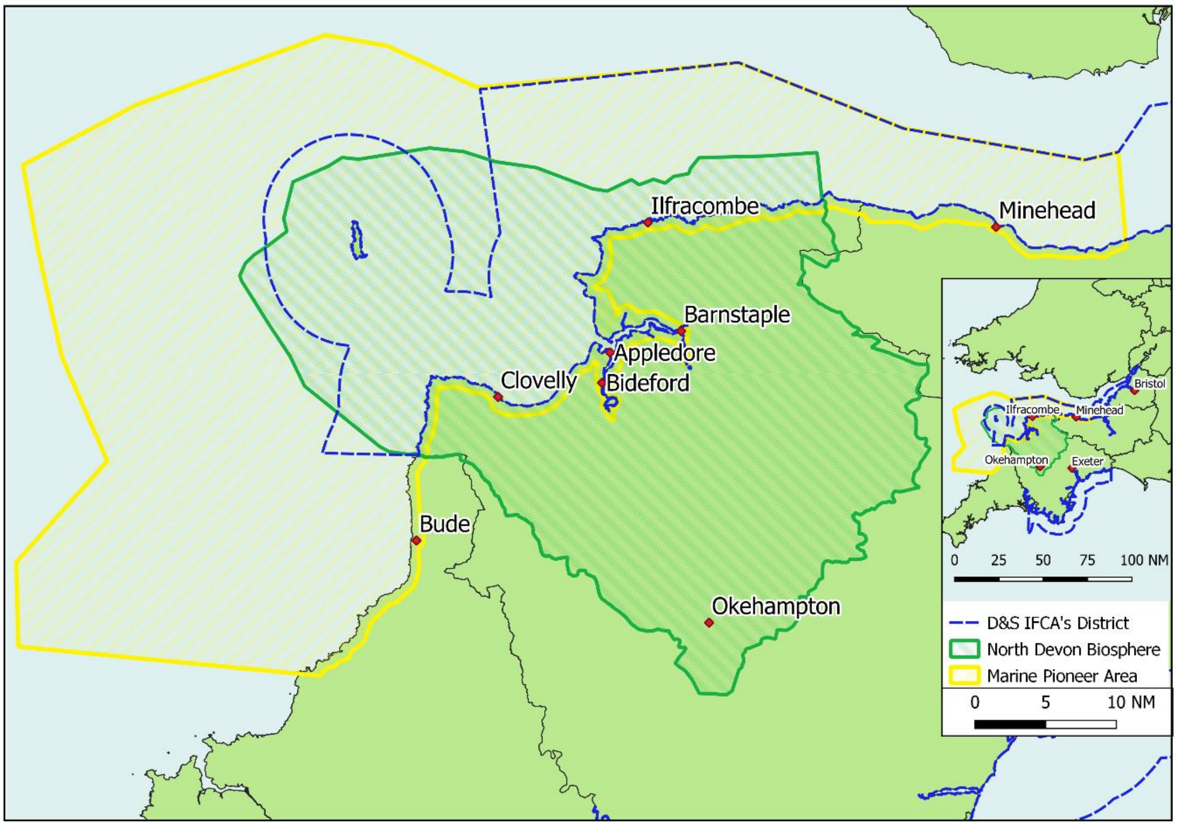

Figure 1 *- The Marine Pioneer area, North Devon Biosphere reserve, and Devon & Severn IFCA District on the North Devon and Somerset coastline.*

Methodology

Each FRMP has been developed using existing data and knowledge combined with information gathered through stakeholder engagement. There was a thorough review of the evidence available in academic journals, grey literature, regulator and industry reports and historical sources. Semi-structured interviews were held with 9 fishers who are or have been active in the north of the D&S IFCA's District, and with individuals who have fished in this area in the past and worked within the inshore fishing industry. This included commercial and recreational fishers, charter boat operators and members of the North Devon Fishermen's Association (NDFA).

Each FRMP includes:

- A full ecosystem-based review of the ecology, fisheries, and management for the focal species, which can be used by a range of stakeholders as a comprehensive source of fish and fisheries knowledge.
- An evidence base that can be used to evaluate the impact of human activity on fisheries, fish and habitats. This can also be used to engage with other organisations in the development of national policy and implementation of Fishery Management Plans under the Fisheries Act (2020).
- Identification of current gaps in evidence so that D&S IFCA and other organisations can take a rational and prioritised approach to future research.

- Recommendations for fisheries management, making the case for local, sustainable, ecosystem-based fisheries management where realistic and appropriate.

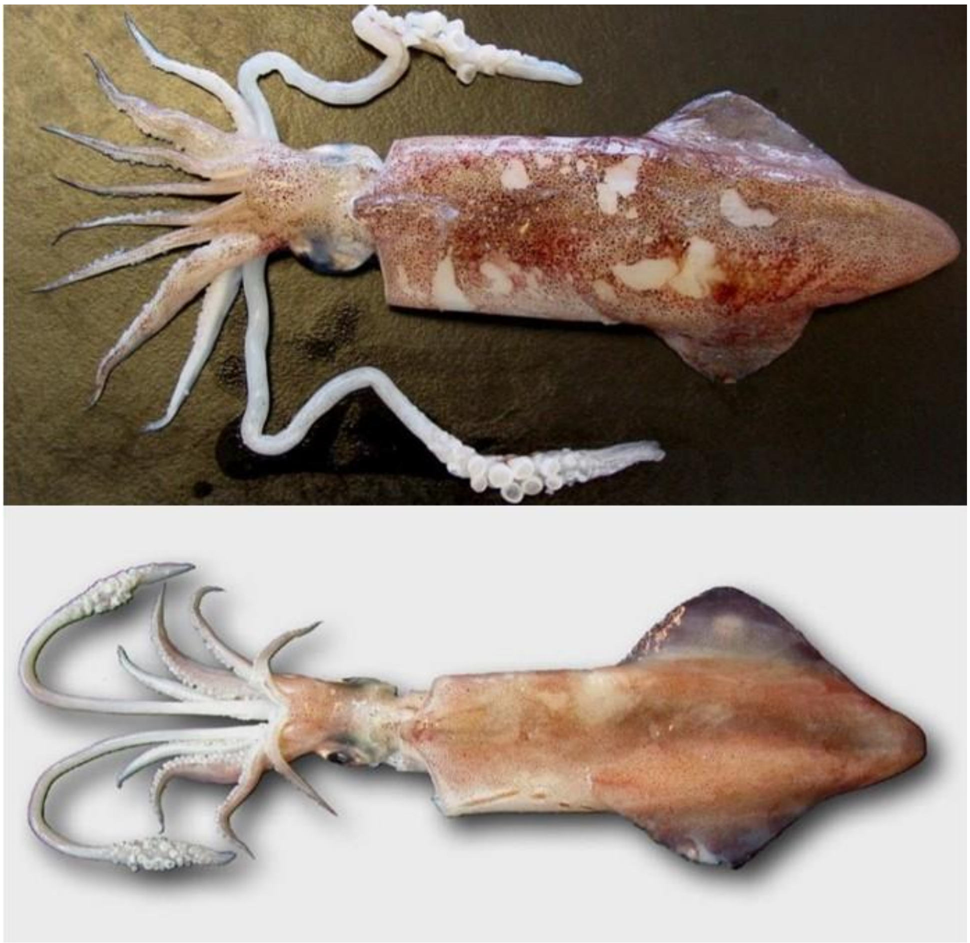

Figure 2 *- (Top) The long finned squid (L. forbesii) and (bottom) the European squid (L. vulgaris) (Jereb et al., 2015,* [*http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR325.pdf*](http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR325.pdf) *[unedited]).*

North Atlantic Squid

There are approximately 290 species of squid and 30 – 40 of these are considered as commercially important (Arkhipkin et al., 2015). They are found all over the world in almost every ocean and sea but the habitats they occupy vary drastically from species to species (Hanlon and Messenger, 2018). Several species of squid are commonly found and fished in UK waters and along the coast of north Devon. The most often caught of these species are the veined or long-finned squid - *Loligo forbesii*; and the European squid - *L. vulgaris* (see **Figure 2**; Hastie et al., 2009). A range of smaller squid species are also be caught by fishermen in lesser amounts. These include: the European common squid (*Alloteuthis subulata*), the midsize or little squid (*Alloteuthis media*), the European flying squid (*Todarodes sagittatus*) and various species of *Ommastrephid* squid classified as "short-finned" squid (Hastie *et al.*, 2009)*.* The smaller squid species are not as important commercially as the larger *Loligo* species but they are often sold as bait to anglers and recreational fishers. This FRMP applies to the different species of squid found and fished within the Bristol Channel.

Summary of Recommendations

Drawing on existing data and knowledge, and information gathered through stakeholder interviews, this plan makes a series of recommendations to facilitate the transition to a localised approach to managing squid fisheries in the north of the D&S IFCA's District. Recommendations have been grouped into 'research' and 'management'. Many of the recommendations are interconnected and would need to be delivered as a whole for them to be effective.

You can find the details of each recommendation in **PART 1** of this plan.

Research

Establish detailed knowledge on squid stocks, ranges, and movements to improve understanding regarding current squid population distributions and inform management.

Establish understanding of relationship between environmental factors and squid distributions to give managers a better understanding of how squid populations react to environmental change.

Investigate current and historical ecosystem roles and interactions of squid to better understand how ecological interactions affect populations and enable an ecosystem approach to management.

Investigate disappearance of squid from the Bristol Channel to determine a cause for the apparent squid declines and establish if this is an isolated event or likely to occur elsewhere.

Involve fishers in the planning of future research to make the most of local expertise and knowledge.

Management

Improve integration between fisheries management and marine planning to make sure the exploitation of the marine environment is responsible and sustainable.

Develop a best practice framework for commercial squid fishing to ensure fisheries expand in the most sustainable way.

Improve landings data collection for squid species to inform management on what species are present locally and to what extent they are caught by commercial and recreational fishers.

Identify potential future squid fisheries and forecast stock health by using ecological and environmental knowledge gathered from research recommendations to predict how squid distributions will change and inform sustainable future management.

Improve communication and engagement with fishers to establish stronger fisheries enforcement presence in the north of D&S IFCA's District and combat illegal fishing and non-compliance in the area.

PART 1. RECOMMENDATIONS FOR MANAGEMENT TO FACILITATE A TRANSITION TO A LOCALISED, ECOSYSTEM BASED APPROACH

This section outlines the research and management changes that are needed to adopt a local, ecosystem-based approach to squid fishery management. The evidence to support the recommendations is outlined in ***PART 2*** *of this plan. The recommendations have been categorised in terms of priority. Many of the high priority recommendations need to be addressed first to make it possible for the others to be carried out in the future. For example, many of the management recommendations can only be actioned once the research gaps have been filled.*

Summary of Current Fishery Status

It is not currently possible to carry out detailed assessments on squid fisheries nor the status of stocks because due to a lack of information regarding the ecology and distributions of squid species in the Northeast Atlantic. Restrictive management of squid is not needed at present as species are not heavily fished but squid fisheries are expected to expand in the future as traditional fish stocks continue to decline.

Squid stocks around the UK are largely unexploited and there are currently only a few targeted fisheries. One such targeted fishery is off North Devon in the Bristol Channel, however in recent years this fishery has declined, with fishers reporting a drastic fall in squid numbers in the area. Fishers say they continue to look for and attempt to catch squid each year, but the fishery has virtually disappeared (FRMP Interviews, 2020).

Research Recommendations

The research recommendations are also available on D&S IFCA's website and will be shared periodically with interested parties to encourage collaborative research between fishers, scientists and managers that is relevant to management and policy.

Establish detailed knowledge on squid stocks, ranges, and movements – *High Priority*

Detailed ecological knowledge of squid is essential to provide a baseline for future management and to predict the future distributions of squid species. There is currently a lack of ecological knowledge regarding stocks on a local and large-scale in the UK. This makes squid particularly difficult to manage as fisheries need to be directed without much understanding about how fishing effort may impact stocks. As squid fisheries are expected to expand in the future, it is essential to fill these knowledge gaps to inform fisheries management and ensure future exploitation is sustainable.

IFCAs and other research bodies should start this investigation on a local or regional scale and then feed the information into larger scale assessments when appropriate. Local research on squid stocks could be undertaken in collaboration with local fishers to look at the quantities, location, and condition of squid bycatch in other commercial fisheries. Information on stock size and spawning events could also be gathered by surveying known spawning grounds and counting the numbers of squid eggs deposited on static fishing gear. This would help to understand how and when local squid populations are breeding.

Next steps:

- Any future monitoring or research should be designed in collaboration with IFCAs and fishers to ensure local knowledge is utilised, and with Cefas and ICES to ensure the data is suitable for input to stock assessments.
- Findings can help inform future squid Fisheries Management Plans (FMPs), and contribute to delivery of the ecosystem and scientific evidence objectives of the Fisheries Act 2020.

Establish understanding of relationship between environmental factors and squid distributions – *High Priority*

Understanding how squid populations react to environmental processes and conditions and how this impacts their distributions is essential for managing them effectively. These knowledge gaps must be filled before the fisheries expand so that managers have the necessary information to sustainably manage squid in a rapidly changing ocean. This information will also allow managers to predict the health of future squid stocks and adapt management accordingly to avoid overexploitation.

Research has shown that squid are extremely sensitive to factors such as temperature and the North Atlantic Oscillation. Further climate change is expected to cause the range of many species' in UK waters to expand and create potential for larger fisheries. Focusing research to understand exactly how squid distributions are likely to change will inform sustainable fisheries management in the future. This information can also be used to help "forecast" the health of squid stocks in the future based on recent climate and environmental factors, allowing for more effective fisheries management.

Next steps:

- There are opportunities for researchers to explore the viability and distribution of future fisheries under scenarios of stock health, climate change and management approaches.
- This research would help inform stock assessments and sustainable fisheries management and FMPs, and contribute to delivery of the scientific evidence, climate change, sustainability and ecosystem objectives of the Fisheries Act 2020.

Involve fishers in the planning of future research – *High Priority*

Local fishing knowledge and fisher engagement should be used to support the planning of future research and fill in gaps in ecological knowledge for management. The local knowledge and expertise of fishers can prove invaluable in directing future research. For example, the decline of the North Devon squid fishery was uncovered through interviews to inform the writing of this FRMP.

Next steps:

- D&S IFCA is well-placed to facilitate fisher/researcher collaboration and will investigate what is needed to make this standard practice (for example, collaborations will require standardised protocols and terms of reference, including for shared use of vessels and research equipment).

Investigate current and historical ecosystem roles and interactions of squid, including with spurdog – *Medium Priority*

Squid are an important prey for many species including harbour porpoise which is a reason for designation of several MPAs (e.g. Bristol Channel Approaches SAC). Effective ecosystem-based management of human activities, in pursuit of Good Environmental Status and improved natural capital assets, will require knowledge of how human activities have and will affect the ecosystem roles of squid. Local fishers have perceived a decline in squid populations in the Bristol Channel area, and have proposed that this is due to predation by spurdog, which the fishers believe are increasing in abundance (FRMP Interviews, 2020).

Next steps:

- There is an opportunity for PhD research in partnership with D&S IFCA and local fishers to investigate squid-spurdog interactions and the impact these have on fisheries.
- The findings from these projects would help inform management and support delivery of the ecosystem and scientific evidence objectives of the Fisheries Act 2020.

Investigate reported disappearance of squid from the Bristol Channel – *Medium Priority*

It is vital to establish the drivers of recently observed declines in squid in the Bristol Channel. Management needs to understand whether this is due to predation, fishing, natural population fluctuations or environmental factors, and whether it is an isolated event.

Next steps:

- There is an opportunity for PhD research in partnership with D&S IFCA and local fishers to investigate the drivers of local-scale squid abundance and distribution and the impact these have on fisheries.
- The findings from these projects would help inform management and support delivery of the ecosystem and scientific evidence objectives of the Fisheries Act 2020.

Management Recommendations

Improve integration between fisheries management and marine planning – *High Priority*

In areas beyond the Bristol Channel there is concern that the effects of human activity on marine organisms and environments is not being appropriately considered by planners. Detailed information about marine species and ecosystems is required to inform environmental impact assessments, Habitats Regulations Assessments, and other licensing and permitting assessments affecting marine developments. There is a strong need to realign and unify aspects of marine spatial planning, licencing, and permitting with fisheries and environmental management so that these are more accurately and reliably considered in the process. This is particularly true in the Bristol Channel and Severn estuary, where there are high levels of interest for aggregate extraction and renewable energy developments.

Next steps:

- Findings from the recommended research in this FRMP should be incorporated into regional Marine Plans through discussions with D&S IFCA and the MMO.
- This would aid delivery of the Government's 25 YEP and Fisheries Act 2020 objectives, including utilising an ecosystem approach and prioritising sustainability.

Develop a best practice framework for commercial squid fishing – *Medium Priority*

Management should use the findings from the recommended research listed above to develop a best practice framework to ensure sustainable commercial squid fishing. Squid fisheries are extremely challenging to manage compared to most finfish species as their short life cycles mean managers have little information about the exploitable adult stock (Arkhipkin *et al.*, 2020). A different management approach to traditional finfish fisheries may be needed to manage squid sustainably and effectively. There is some consensus that future squid management should be based on effort limitation (Caddy, 1983; Hastie *et al.*, 2009). This could include utilising entry dates for fisheries and fleet restrictions combined with bycatch and habitat surveys to assess the impacts of the fishery on local ecosystems. The appropriateness of these possible measures will need to be assessed alongside the results of further research into squid.

Next steps:

- Managers should develop a best practice framework to enable sustainable squid fishing based on the results of the research recommended above.
- A well-evidenced best practice framework would support delivery of the sustainability objective of the Fisheries Act 2020.

Improve landings data collection for squid species – *Medium Priority*

Reliable data on fish mortality is essential for the effective management of fisheries. Some improvements with catch data collection have been made following the introduction of the <10 metre vessel catch app from the MMO, making the recording of all small vessel commercial landings mandatory. However, there is still a lack of basic ecological knowledge on a local scale regarding squid, particularly after the declines reported in the Bristol Channel. The IFCAs are well-placed to undertake research/trials in improving landings data for squid around the country to help further understand squid distributions at a national level.

Next steps:

- The IFCAs are well-placed to facilitate improvements in landings data for squid to increase species-specific understanding of squid distribution and abundance at local to national scales. Additional data requirements should be evaluated in collaboration with those who are best placed to use them for stock/distribution assessments e.g. Cefas/ICES.
- When specific data needs are identified, such as mandatory species-level recording of squid catch, a pilot or trial study should be undertaken in collaboration with local fishers as part of D&S IFCA's Annual Plan.

Improve communication and engagement with fishers to establish stronger fisheries enforcement presence in the north of D&S IFCA's District – *Medium Priority*

There is a strong consensus among fishers in the north of the District that a stronger enforcement presence is needed to help combat non-compliance and illegal fishing in the inshore fishing industry. D&S IFCA has one of the largest districts of any IFCA and is the only IFCA with two separate coastlines to cover and monitor. The limited size of the enforcement team means it is not possible for IFCA officers to maintain a strong presence in every area of the District. Consequently, officers must implement an intelligence-led, risk-based approach to their work that is proportionate to the compliance requirements: officers must prioritise patrols in areas with high numbers of reports of illegal fishing activity, which is typically the south coast of the District.

To enable enforcement officers to focus more of their activities (e.g., patrols) in the north of D&S IFCA's District, there needs to be more comprehensive reporting of illegal activity from those in the area, and improved communication between officers, fishers, and other local stakeholders. Additional external funding to expand research and enforcement capabilities would also improve this situation.

Next steps:

- D&S IFCA to improve collaboration and engagement through activities such as virtual roadshows for ports, sectoral meetings and further FRMP interviews. More information about planned activities is available in the D&S IFCA's Annual Plan and Communications Strategy, accessible via the D&S IFCA website.

Identify potential future squid fisheries and forecast stock health – *Low Priority*

Management should use the findings from the recommended research listed above to identify potential future squid fisheries and then gather detailed ecological information on them. This information is needed to apply the ecosystem approach to managing the fisheries and will highlight how squid are affected by human activities and other species. Future fisheries will most likely be in areas where squid are abundant and may be most welcome as displacement fisheries in areas where there have been recent declines in, or restrictive measures implemented on traditional finfish species.

Next steps:

- Management should use the findings from the recommended research listed above and interaction with local fishers to identify potential future squid fisheries and then gather detailed ecological information.
- It is unlikely that this work will be possible before information is gathered on how squid distributions are influenced by climate, environmental conditions and food web interactions.
- Findings from this work would be crucial for inclusion in squid FMPs and would enable managers to adopt the ecosystem approach when managing fisheries in the future.

PART 2. REVIEW OF EXISTING SCIENTIFIC RESEARCH AND FINDINGS FROM STAKEHOLDER ENGAGEMENT

Species Ecology

Squid are distinctive cephalopods that have elongated bodies with distinct heads, a mantle, and large eyes. Squid possess two long tentacles as well as eight small arms that are used for hunting and feeding (Barnes and Fox, 2004). Like many other cephalopods, squid are mainly soft-bodied, however they have a small internal skeleton composed of chitin. From an ecosystem perspective, squid occupy a similar role to teleost fish as open water predators, playing a vitally important role in the marine food web (Hanlon and Messenger, 2018).

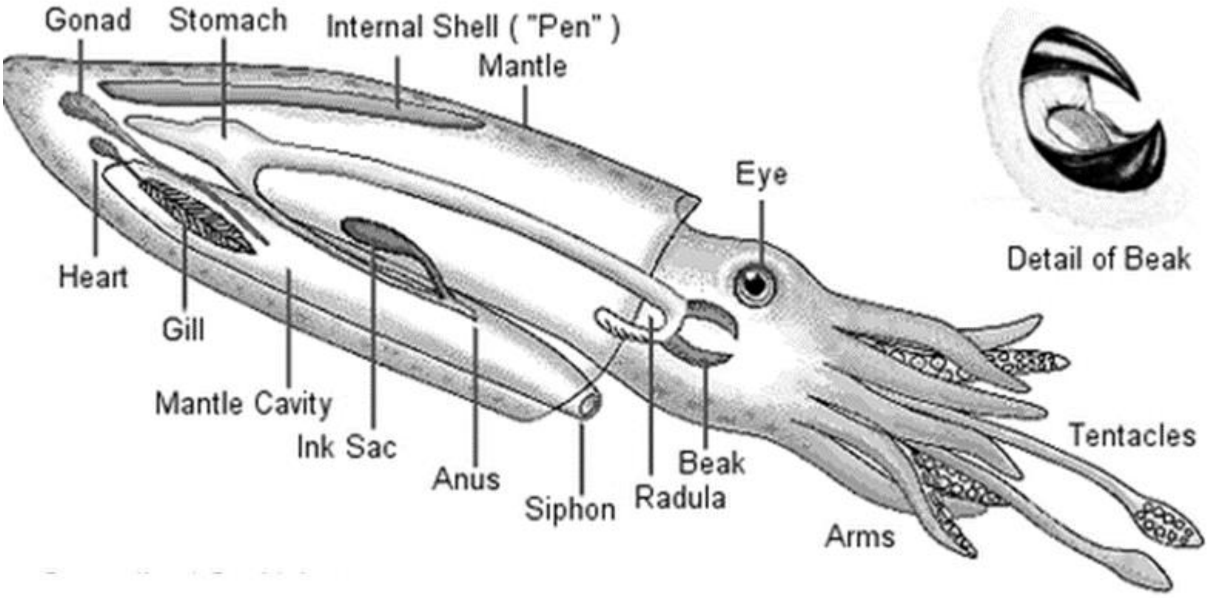

__Figure 3__ - General squid anatomy.

Squid are molluscs that have evolved over millions of years and adapted to an actively predatory lifestyle. They are very rapid swimmers, using their siphon to propel them through the water in a jet propulsion-like manner (Johnson, Soden and Trueman, 1972). Many species of squid can manipulate their skin pigments to change colour. This is controlled by colour-changing cells called chromatophores and is used both as camouflage from predators and to signal to fellow squid (Byrne et al., 2003; Mäthger and Hanlon, 2006). Some squid species are also bioluminescent. Squid are among the most intelligent invertebrates, with groups in the wild displaying co-operative hunting strategies (Hanlon, Vecchione and Allcock, 2018). Many squid possess an ink gland which can eject a stream of blue-black ink into the water, creating a thick cloud, providing the squid with cover to escape from predators. However, scientists in Japan have recorded squid using ink to stun prey before attacking it, making squid ink glands both a defensive and predatory adaption (Wood et al., 2010; Sato et al., 2016).

Geographical Range, Migrations & Habitat

The squid species found in the north of D&S IFCA's District have similar geographic ranges (see **Figure 4**) and can be found throughout the Mediterranean and parts of the Northeast Atlantic (see **Table 1**).

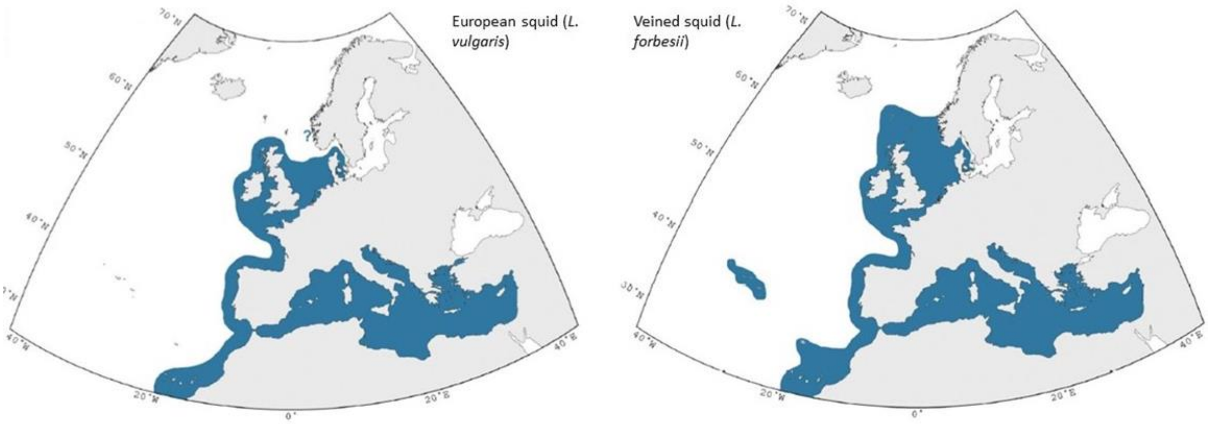

Figure 4 *- The ranges and distributions of the European squid (L. vulgaris, left) and the veined squid (L. forbesii, right) in the northeast Atlantic and Mediterranean oceans (Adapted from Jereb et al., 2015,* [*http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR325.pdf*](http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR325.pdf)*).*

There is some uncertainty regarding the true ranges and distributions of smaller squid species such as *A. subulata* and *A. media*, due to difficulties in correctly identifying the two as separate species in the field (Jereb et al., 2015). Both species can be found throughout the Northeast Atlantic and Mediterranean, however it is believed that *A. subulata* has a more northernly range, being found throughout Scottish, Irish and Norwegian coastal waters and extensively in the North Sea, whereas A. media is only rarely reported in these areas (Grimpe, 1925; Zuev and Nesis, 1971; Lordan, 2001). There are reports of *A. subulata* being commonly found in South West English waters, being one of the more dominant squid species present alongside *Loligo vulgaris* (British Sea Fishing, 2020a). *Ommastrephid* squid are distributed throughout Europe and UK waters, with many artisanal and commercial fisheries in place for various species, particularly in Spanish, Portuguese, and French waters (Hastie et al., 2009).

Table 1 - Geographic distributions, ranges and habitats of UK Loligo squid.

Species	Depth Range	Proximity to Shore	Geographical Range	Substrate Preference	Environmental Conditions	Sources
European squid (*Loligo vulgaris*)	Found down to 500 metres depth, though most common in first 150 metres of water column. In areas where range overlaps with veined squid, European squid tend to favour shallower waters above 70-80 metres.	Within 200 kilometres of the coast.	North Sea, from northern Scotland across to southern Norway and Sweden. Also present in the Baltic Sea. Abundant in the English Channel and sometimes caught in the Celtic Sea. Distribution spreads south along western coasts of France, Spain, and Portugal and into the Bay of Biscay. Widely distributed throughout the Mediterranean, Adriatic, Ionian and Aegean Seas, as well as some coastal regions of North Africa.	Coarse sandy-bottomed habitats and sea grass beds with good access to prey.	12.5 - 20°C, most found at 13 - 15°C. Avoids low salinity waters.	(Bello, 2003; Casali, Piccinetti and Soro, 1998; Hornborg, 2005; Jereb, Vecchione and Roper, 2010; Jereb and Roper, 2010; Jereb et al., 2015; Mangold-Wirz, 1963; Pierce et al., 2010; Worms, 1983)
Veined squid (*Loligo forbesii*)	Found down to 500 metres depth, though most common in first 150 metres of water column. Some populations living and breeding as deep as 700m. In areas where range overlaps with European squid, veined squid tend to favour deeper waters below 70-80 metres.	Within 200 kilometres of the coast.	Near identical range and distribution to the European squid. However, can be found much further north than European squid. Older records of veined squid from Baltic Sea, though presence is considered extremely variable in these regions. Unlike European squid, veined squid have been reported in the Azores. Distribution continues into the Mediterranean, where it is highly abundant. Also found in the Strait of Sicily, northern Ionian, Adriatic and Aegean Seas as well as the Levant Basin.	-	12.5 - 20°C, most found at 13 - 15°C. Avoids low salinity waters.	(Casali, Piccinetti and Soro, 1998; Collins, Burnell and Rodhouse, 1995a; FAO, 1982; Grimpe, 1925; Hornborg, 2005; Hastie et al., 2009; Howard, 1979; Jereb and Roper, 2010; Jereb et al., 2015; Lefkaditou et al., 2003; Martins, 1982; Nordgaard, 1923; Roper, Sweeney and Nauen, 1984; Salman and Laptikhovsky, 2002)

Due to their semi-demersal nature, squid species are usually associated with specific bottom substrates, particularly during the spawning season, likely due to the suitability of these substrates for egg string attachment (Mangold-Wirz, 1963; Worms, 1983). Squid tend to avoid low salinity waters, in which eggs can die very early. They are rarely seen in estuarine or lagoon environments, though *A. media* is occasionally found in brackish waters (Sen, 2004).

Figure 5 *– European common squid (A. subulata) over coarse sand and rocky seabed (BeachStuff, 2020, http://www.beachstuff.uk/cuttlefish_squid_octopus.html [unedited]).*

In general, UK *Loligo* squid have similar migration patterns. Migratory movements are mainly related to sexual maturation and spawning events, with some squid travelling as far as 500km (Tinbergen and Verwey, 1946). However, some populations of smaller squid stay in the same location year-round, particularly populations of *A. subulata* (Rodhouse, Swinfen and Murray, 1988). During spawning events, large, mature, or maturing squid will travel towards shallow and coastal waters to group together and form breeding aggregations before spawning, with males arriving a few days or sometimes weeks sooner than females (Roper, Sweeney and Nauen, 1984). These movements are also sometimes seen in immature animals, but usually sometime later than the mature ones (Worms, 1983). Like many aspects of squid life history, it is likely that temperature plays a key role in this movement (Lefkaditou, 2006). Once hatched, the young squid migrate towards deeper water, away from the coasts (Jereb *et al.*, 2015). Squid also migrate vertically through the water column: they spend the daytime near the seabed and migrate towards the surface to feed at night (Roper, Sweeney and Nauen, 1984; Boyle, 1990). Tagging experiments have also shown that during night-time feeding, squid will also travel over a larger area than when they are nearer the bottom during the day (Cabanellas-Reboredo *et al.*, 2012).

Reproduction & Life History

Squid reproduce sexually and eggs are then deposited by females. The mating process is similar for many squid species, however, the timing of this and other life history traits vary greatly between species, and can even vary within a species depending on environmental factors such as temperature (Pierce *et al.*, 2010). Once the squid have moved inshore and reached their spawning grounds, the males form large aggregations, swimming together in large circles. As the females join the large school, the males use their chromatophores to put on a display of colour changes to attract a female (Collins, Burnell and Rodhouse, 1995b). Males sometimes act extremely aggressively when finding females to mate with during these events (Jereb and Roper, 2010). The squid, still swimming in this large formation, form male-female mating pairs, and copulate (see **Figure 6**). One of the male's eight arms is specialised for transferring sperm to the eggs near the ink sac of the female.

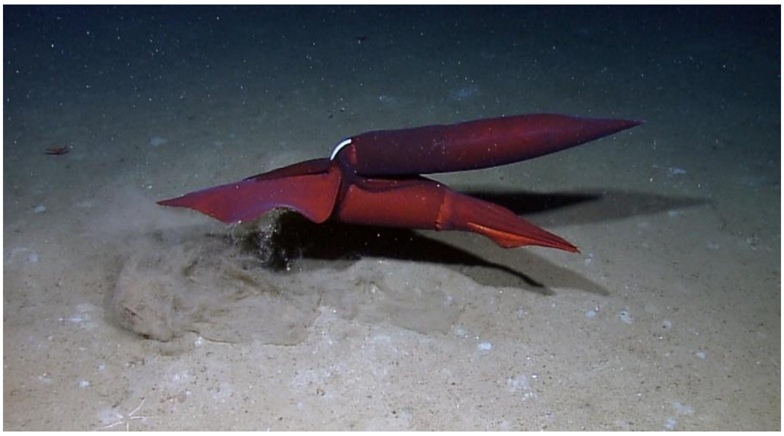

Figure 6 *- Two squid mating (Vecchione, 2012, https://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/apr21/welcome.html [unedited]).*

Upon mating, eggs are deposited in strings on rocky and solid substrates (see **Figure 7**). Females die shortly after laying. The incubation period varies between species and is heavily dependent on temperature (Jereb *et al.*, 2015). Upon hatching, the squid larvae (see **Figure 8**) spend a short time living planktonically before developing the ability to swim and entering a period of rapid growth.

Figure 7 *- Loligo egg masses (Amptman, 2019,* *https://commons.wikimedia.org/wiki/File:Market_Squid_Eggs.jpg* *[unedited]).*

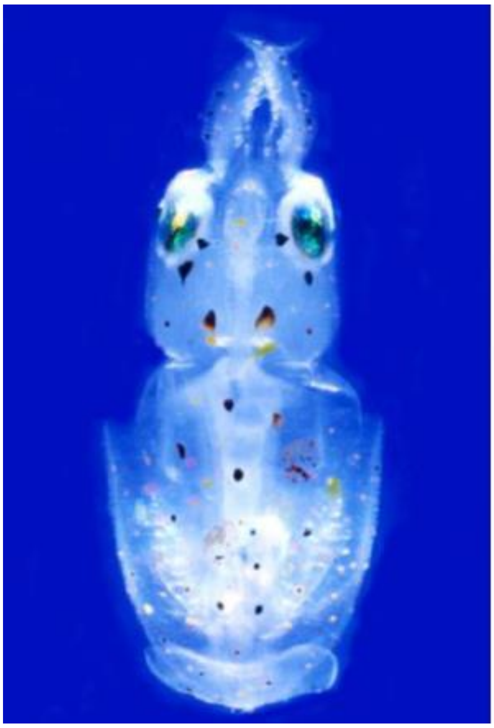

Figure 8 *- European squid (L. vulgaris) larvae (Jereb et al., 2015,* *http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR325.pdf* *[unedited]).*

Many squid species adopt a "live fast, die young" life history, fully completing their life cycle and dying in little over a year and only reproducing once (Hanlon and Messenger, 2018). The life histories of both described *Loligo* squid species are outlined in **Table 2**.

Table 2 - *Life histories of UK Loligo squid.*

Species	Breeding Season	Fecundity	Juvenile Information	Sexual Maturity	Adult Size	Sources
European squid (*L. vulgaris*)	Winter spawner with year-round spawning with seasonal peaks seen in some regions	Between three and six thousand eggs per female, laid on rocky and solid substrates in shallow waters. Average of 90 eggs per string.	Development of embryos influenced by temperature (~30 days at 17°C, longer in colder temperatures). Hatchlings spend two or three months living planktonic lifestyle. Growth rate dependant on temperature.	Males mature sooner than females. Size of maturity can vary from 90mm to 230mm depending on region.	Females - 37cm Males - 55 cm	(Mangold-Wirz, 1963; Boletzky, 1979; Worms, 1983; Coelho *et al.*, 1994; Rocha and Guerra, 1996; Villa *et al.*, 1997; Raya *et al.*, 1999; Sen, 2004; Moreno *et al.*, 2007, 2012; Pierce *et al.*, 2010; Jereb *et al.*, 2015)
Veined squid (*L. forbesii*)	Winter months, December - March in UK waters. Some summer spawners observed.	Up to 100,000 "finger-like" eggs per female laid in strings on rocky substrates in shallow waters. Average of 54 eggs per string.	Development of embryos influenced by temperature (~75 days at 12.5°C, longer in colder temperatures). Hatchlings are 3 - 5mm in length and begin swimming in first few days of life.	Males mature sooner than females. After approximately a year Average of 310 - 320 days.	Females - 35cm, 1.2kg Males - 65cm, 3.7kg	(Boyle, Pierce and Hastie, 1995; Collins, Burnell and Rodhouse, 1995b; Holme, 1974; Jereb et al., 2015; Lordan and Casey, 1999; Pierce et al., 1994; Porteiro and Martins, 1994)

The other smaller and short-finned squid species present in UK fisheries are also rapid-growing and short-lived with life cycles ranging between six months and a year in length, though there may be several spawning seasons per year, each with separate cohorts (Arkhipkin and Nekludova, 1993). For example, there are three separate spawning populations of the European common squid (*A. subulata*) that breed in spring, summer, and autumn within the English Channel (Jereb *et al.*, 2015), with separate spawning events through the year for populations in the Irish and North Seas (Nyegaard, 2001; Hastie *et al.*, 2013). The smaller squid species also migrate inshore to breed and deposit egg capsules, with development and hatch times being highly influenced by temperature (Yau, 1994; Jereb and Roper, 2010). Males usually achieve larger body lengths and sexually mature slightly earlier than females. However, like many other life history characteristics, this can vary geographically (Lordan, 2001).

Food Web & Interspecies Interactions

Squid are highly mobile predators that feed on a variety of organisms. They hunt by quickly darting forward, seizing, and pulling in their prey with their two long tentacles. The prey is then held by the tentacles and shorter arms while being quickly swallowed using the squid's beak (see **Figure 9**). Many species of squid are opportunistic predators that will feed on any organisms they are able to overcome and it is thought that prey availability is a major factor in influencing squid species distribution (Bidder, 1950). With most squid species, juveniles consume planktonic, pelagic organisms of small size, before then moving to benthopelagic prey as they become older and larger. Their juvenile diet is particularly dominated by planktonic crustaceans such as copepods, mysids (shrimp), euphausiids (krill) as well as fish larvae (Jereb, Vecchione and Roper, 2010). This change in diet over the course of an organism's development, known as a dietary ontogenetic shift, occurs in most squid species. Once the squid have grown out of the juvenile stage, their diet becomes much less restricted (Jereb *et al.*, 2015).

***Figure 9** – Upper and lower beaks of a European squid (L. vulgaris) (Lamiot, 2017, https://commons.wikimedia.org/wiki/File:Bec_de_calmar_Loligo_vulgaris_beak_01.jpg [unedited]).*

The specific diets of adult squid vary between species due to differences in size and prey availability. The two *Loligo* species share a very similar diet as they grow to similar large sizes and share much of the same range; fish are the most common form of prey, making up increasing proportions of diet as squid body size increases (Rocha Valdés, 1995). The fish families *Gadidae*, *Clupeidae*, *Ammodytidae*, and *Gobiidae* are those most frequently consumed by the *Loligo* species; it is therefore likely that the *Loligo* species feed upon the local herring stocks in the north of D&S IFCA's District (Collins and Pierce, 1996). In addition to fish species, various crustaceans, cephalopods, polychaetes, and other molluscs are consumed by both *L. forbesii* and *L. vulgaris* (Pierce *et al.*, 2010). Cannibalism has also been observed in both species (mainly larger individuals), but diet studies suggest that other squid species do not constitute a major part of the diets of European or veined squid (Coelho *et al.*, 1994; Rocha Valdés, 1995). Squid diets vary regionally; for example, in Scottish waters, whiting (*Merlangius merlangius*), *Trisopterus* spp., and sandeels (*Ammodytidae)* are the predominant fish prey of *Loligo* squid (Howard, 1979; Hastie *et al.*, 2009), whereas in Irish waters, the dominant prey species include sprat (*Sprattus sprattus*; Collins, Burnell and Rodhouse, 1995a). Seasonal variation in diet composition likely reflects changes in prey availability (Rocha Valdés, 1995). Dietary composition does not appear to differ between males and females (Pierce *et al.*, 2010).

Squid play a vitally important role in the marine food web, acting as a food source for a huge variety of different animals. Species-level identification of squid beaks found in the stomachs of marine organisms can be extremely difficult, though distinguishing *Loligo* beaks from those of *Alloteuthis* spp. is possible (Pierce *et al.*, 2010). The veined and European squids are commonly preyed upon by large pelagic and demersal fish, such as small sharks, skate, cod, and a variety of other fish species (Farias *et al.*, 2006; Magnussen, 2011). During interviews with North Devon and Somerset fishers, increased predation of squid by spurdog over the last decade in the Bristol Channel was mentioned several times (see **Threats to Fishery & Industry**; FRMP Interviews, 2020). They are also a key food source for marine mammals such as seals, dolphins, and porpoise (Pierce et al., 1991; Börjesson, Berggren and Ganning, 2003), including in the Bristol Channel. *Loligo* squid are also predated upon by several species of whales, including killer whales (*Orcinus orca*) and long-finned pilot whales (*Globicephala melas*; Jereb *et al.*, 2015). The great skua (*Catharacta skua*) is the only bird species from Northeast Atlantic waters known to have consumed *Loligo* squid (Furness, 1994). Although a range of different marine organisms predate upon *Loligo* squid, none are considered to be a major cause of mortality overall (Jereb *et al.*, 2015). Squid eggs are also predated upon by a number of organisms, including marine snails (see **Figure 10**).

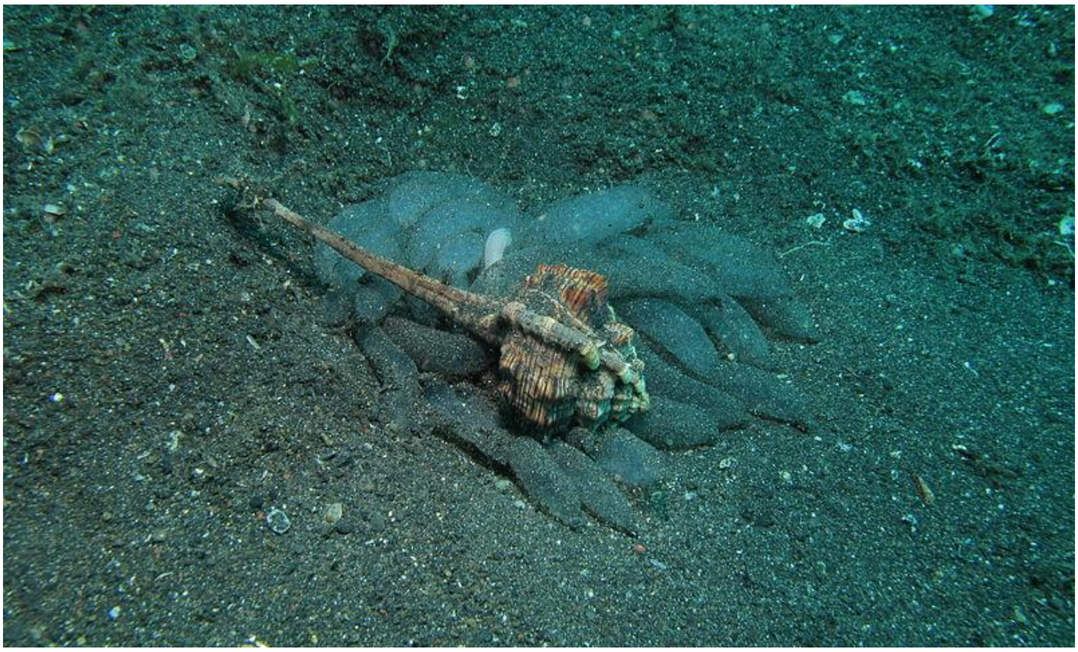

Figure 10 *- Murex Snail (Haustellum haustellum) feeding on squid eggs (Dupont, 2009, https://commons.wikimedia.org/wiki/File:Murex_Snail_(Haustellum_haustellum)_feeding_on_squid_eggs_(8456165705).jpg [unedited]).*

The European common squid (*A. subulata*) is the most common cephalopod species found in the stomach contents of demersal fish in UK waters (Jereb *et al.*, 2015). It is also consumed by marine mammals (particularly dolphins), larger species of cephalopod, and many predatory fish species such as cod, hake, whiting, ling, tuna, sharks, halibut, wolffish, and plaice (Zuev and Nesis, 1971; Hislop et al., 1991; Daly et al., 2001; Velasco, Olaso and Sánchez, 2001). Less is known about the role of the midsize squid in the marine food web, though it has been recorded in the diets of 16 different fish species and is known to be an important food source for blue whiting (*Micromesistius poutassou*) in the Bay of Biscay (Velasco, Olaso and Sánchez, 2001). The midsize squid is also present in a Cefas fish stomach-contents database for UK waters, meaning it is also preyed upon in UK waters. However, as previously mentioned, squid beaks are difficult to identify to a species level when found in stomach contents, so it is only certain that *Alloteuthis* species are preyed upon here, rather than specifically *A. media* (Pierce *et al.*, 2010).

Fishery Information & Structure

Around 30 to 40 different squid species are commercially exploited by humans around the world, and although they do not make up a significant portion of global fisheries landings, their popularity as catch is increasing with over 2.18 million tons of squid and cuttlefish being landed globally (British Sea Fishing, 2020b). Squid are landed commercially by most major European countries both as targeted catch and as bycatch in other fisheries. In Britain there are few vessels that directly target squid as most landings are a result of bycatch in bottom trawl fisheries, however, there are a few small specialised fishing operations for squid in place off the South West coast of England (including the Bristol Channel) and the northwest coast of Scotland (Hastie *et al.*, 2009).

Due to the falling numbers of many commercially important finfish species, many fisheries are looking to expand into new, 'untapped' areas of fishing. Overall, squid are a commercially underexploited species and could represent alternative catch and income for many fishermen. However, a historical lack of interest in squid fisheries means they are largely unregulated and lacking in data (Pierce *et al.*, 1998).

Importance & Value of Fishery

Much of the value and importance of UK squid fisheries lies in their potential, as most species are currently thought to be underexploited and there is a strong need to displace fishing effort from traditional finfish stocks such as cod and bass. Declines in the stocks of many commercially important fish stocks and increasing appetite for squid consumption has driven the development of cephalopod fisheries over the past twenty to thirty years: global squid landings increased from approximately one million tonnes in 1970 to over 4.3 million in 2007 (Jereb and Roper, 2010; Arkhipkin *et al.*, 2015). Squid live in naturally large populations displaying shoaling behaviour and are high-quality protein, making them well-suited for commercial exploitation (Hastie *et al.*, 2009). There is also some evidence that squid populations have increased in a number of areas where traditionally fished finfish stocks have declined due to overfishing (Caddy and Rodhouse, 1998). Overall, very little is known about squid stocks and populations, though estimates suggest that the amount of squid consumed annually by whales and other marine predators exceeds the world commercial catch of all marine species combined (Clarke, 1983; Rodhouse, 2005), suggesting there are vast amounts of commercially exploitable squid stocks in the ocean.

In 2019, over 3,600 tonnes of squid were landed into the UK by the UK fishing fleet with a value of £14.7 million (see **Figure 11**). When landings into overseas ports are included, this increases dramatically to 7,350 tonnes of squid valued at over £25 million (MMO, 2020). The majority of this squid is caught as bycatch in trawl fisheries, meaning although it is still landed and sold for a profit, it was not the intended catch of that fishery. In North Devon, squid landings have fluctuated dramatically from 66 tonnes being landed in 2014 (valued at over £200,000) to less than half a tonne landed in 2019 (MMO, 2020). This may be due to a number of reasons including shifting squid distributions or population declines; however, it is well known that the landings declared by inshore fishing fleets are not always accurate representations of the true catch (ICES, 2018a). It is therefore possible that the true landings of squid is being underestimated. Unfortunately, MMO landings data does not date back far enough to see if or how the 2010 spurdog fishing ban affected squid fisheries in the Bristol Channel in terms of landings.

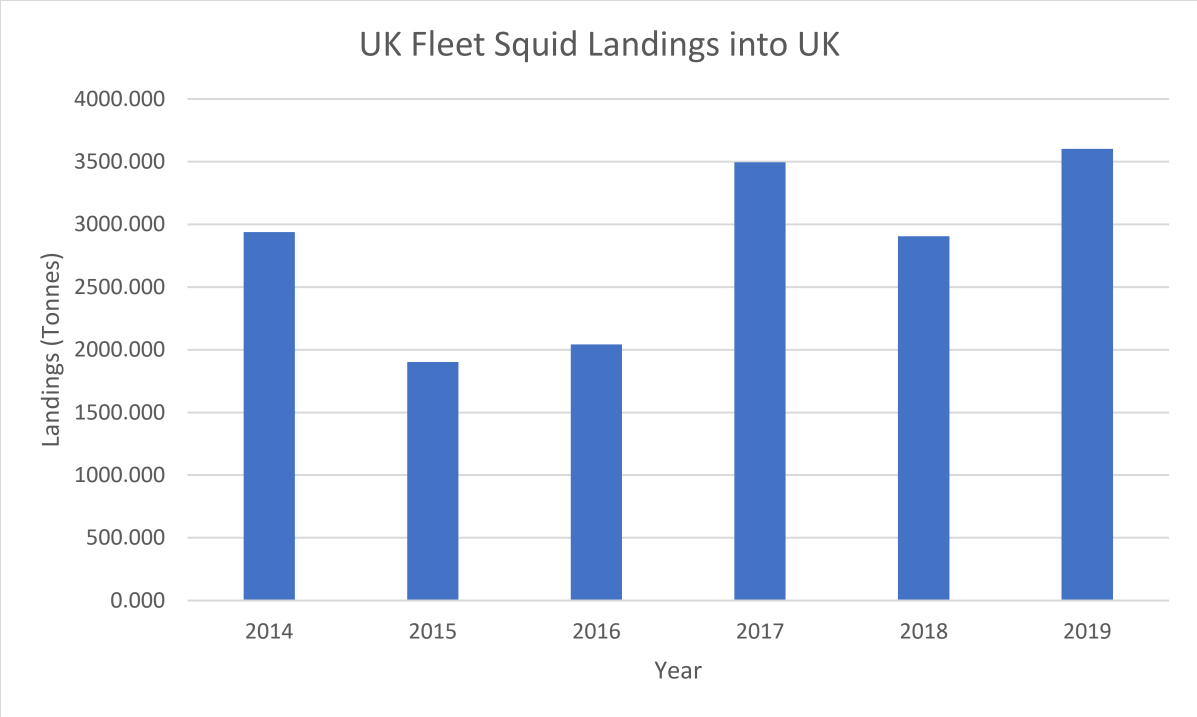

Figure 11 *- UK annual squid landings into UK ports from 2014 to 2019 (MMO, 2020).*

Squid are now also targeted by recreational fishers and anglers. Traditionally, squid were not often sought after by anglers, however in recent years, their popularity as a target species has increased in the south and south west of England as they offer a different experience to catching traditional fish species (British Sea Fishing, 2020a). A collection of surveys conducted during the Sea Angling 2012 project highlighted the range of benefits sea angling provided for people, including important social, physical and wellbeing qualities. It was found that there are over a million sea anglers in Britain and collectively they spend £1.23 billion per year on the sport, supporting over 10,000 jobs (Armstrong *et al.*, 2013). Being a group more regularly targeted by anglers, squid contribute to this value.

Historical Landings & Changes Over Time

Cephalopods and squid are rarely mentioned specifically by name in historical accounts of fishing; however, there are some accounts of targeted squid fisheries from as early as the 15th and 16th centuries. For example, in 1458 the Japanese completed construction on a prototype of modern jigging gear to be used in small inshore fisheries for flying squid (Arkhipkin *et al.*, 2015). Modern literature on squid fisheries began in the early 1800s, however, there is little to no data from this time regarding landings. Modern squid fisheries began to develop in the early part of the 20th century as specific trawling and jigging gear technology and motorised fishing vessels were developed (Hastie *et al.*, 2009). Catches of squid globally remained low until after World War II (see **Figure 12**); with the development of ocean-going vessels cephalopod and squid catch grew into the hundreds of thousands and then millions of tonnes landed each year globally (Hunsicker *et al.*, 2010).

For the most part, squid have remained relatively unexploited in the Northeast Atlantic Ocean compared to other regions of the world (Hunsicker *et al.*, 2010). Landings have increased in recent decades due to declining finfish stocks, as more fishermen are turning to target species at lower trophic levels such as forage fish and shellfish (Caddy and Rodhouse, 1998). In

Northern Europe, expansion of squid and cephalopod fisheries was somewhat restricted by limited local consumption, for example most of the squid now landed in Scotland is exported to southern Europe, though appetites for such sea food are increasing (Rodhouse, 2005). Over 95% of the total Northeast Atlantic squid catch is landed by French, Spanish, Portuguese and UK vessels, though substantial squid fisheries have previously, though briefly, operated in Norway (Arkhipkin *et al.*, 2015). As with other species, squid abundance shows natural variation, which is reflected in fluctuations in landings over the years (see **Figure 12**). Despite these natural fluctuations, landings have steadily been increasing since the 1950s, with 10,000 – 18,000 tonnes of squid per year being landed across the Northeast Atlantic through the 2000s, with 2,000 - 3,000 tonnes of this landed by the Scottish fleet alone (Hastie *et al.*, 2009).

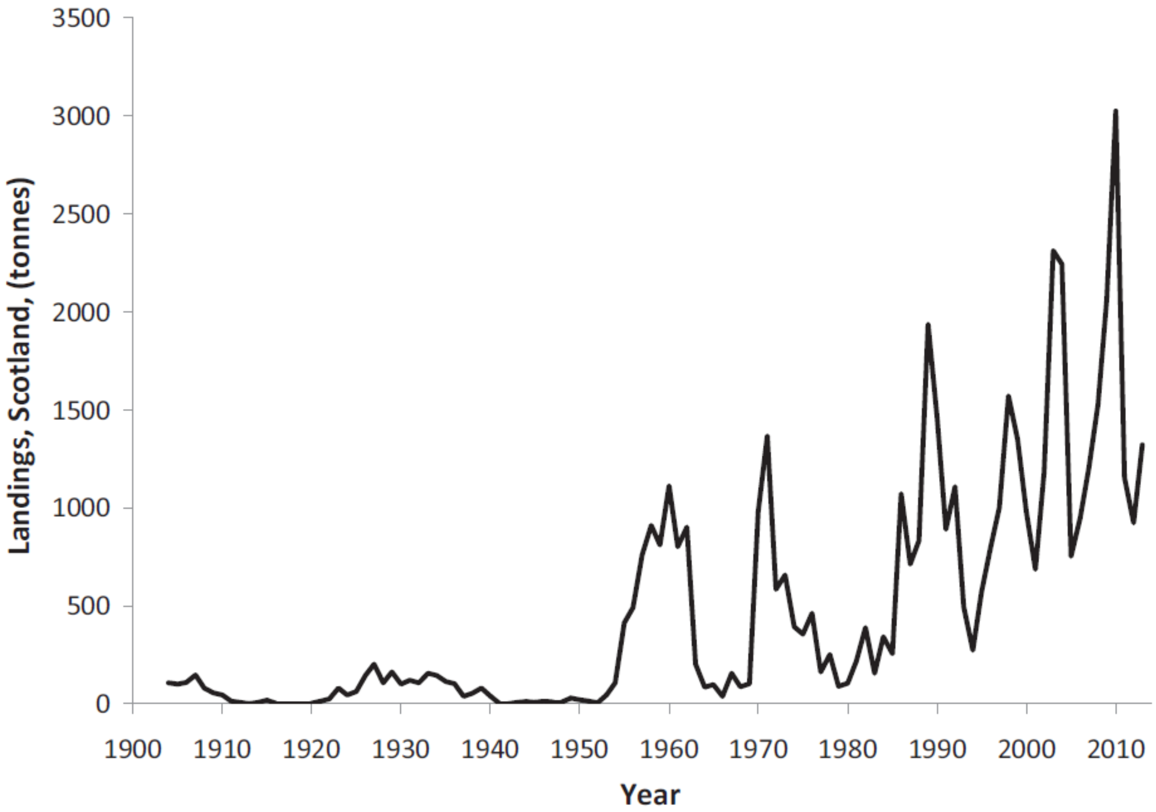

Figure 12 *- Annual landings of squid by Scottish fishing fleet throughout the 20th century (Arkhipkin et al., 2015, https://www.tandfonline.com/doi/pdf/10.1080/23308249.2015.1026226 [unedited]).*

Little is known about squid populations in the Northeast Atlantic, so it is difficult to determine if any major changes in abundance or distributions have occurred as a result of overfishing or other drivers. However, the available evidence points to significant declines in the abundance of *L. forbesii* in the southern areas of its range during the 1990s, leading to increased dominance of *L. vulgaris* in the same regions (Pierce *et al.*, 2010). Squid are often landed into generalised taxonomic categories rather than at species level so changes such as these are difficult to document.

Inshore fishers in the Bristol Channel area have reported that squid populations, that once provided a reliable and productive fishery, have virtually disappeared over the course of the last decade or so (FRMP Interviews, 2020). There is no clear reason as to why this may have happened, and a lack of large-scale assessments for squid populations means it is difficult to determine the scale of this and if it is an isolated incident. However, some fishers believe that it may be related to what they perceive to be large increases in local spurdog populations.

Gear Used

In UK waters, squid are caught using two main fishing methods, jigging and trawling (Hastie *et al.*, 2009). Jigging is one of the oldest known fishing methods, which dates back centuries for a variety of target species (Arkhipkin *et al.*, 2015). Jigging involves the use of multiple hooks along a line, with a lure (designed to resemble small fish) attached to each hook. The lines are usually moved in an up and down fashion to simulate the movement of small fish and attract the target catch (see **Figure 13**). To catch squid, mechanised jigs are used, comprising of lures armed with barbless hooks. Squid jigging usually takes place at night while powerful halide lamps are used to lure squid close to the surface (Seafish, 2020a). Squid jigging is a very specialised type of fishing and as such is only practised by dedicated squid fisheries off the west coast of Scotland and along the South West coast of England (Hastie *et al.*, 2009).

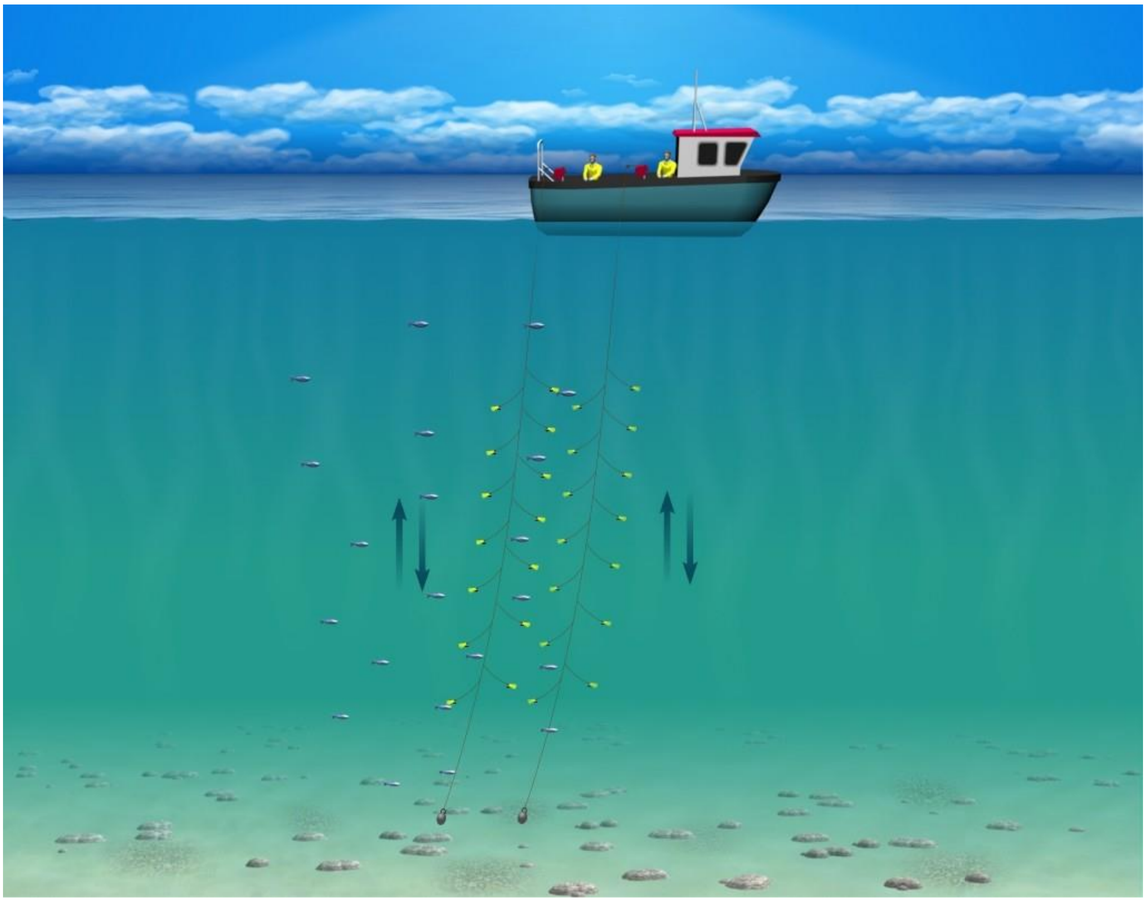

Figure 13 *- Jigging fishing gear (Seafish, 2020, https://seafish.org/gear-database/gear/jigging/ [unedited]).*

Jigging is mostly used to catch short-fin (*Ommastrephid*) squid in the UK though this method often catches some of the smaller long-fin (*Loliginid*) squid additionally (Porteiro and Martins, 1994). Jigging is one of the most environmentally friendly fishing methods, as gear has minimal contact with the seabed (Jereb *et al.*, 2015), is only shot in specific areas where the target species is known to be abundant, and unwanted bycatch can immediately be returned to the sea alive (Seafish, 2020a). Additionally, hook size can be varied to regulate the size and species caught, further decreasing bycatch. Jigging further offshore increases the likelihood of large animal bycatch (e.g. seabirds and marine mammals) though this is less likely when jigging at night.

Trawling is one of the most common methods of fishing overall, catching important commercial species such as cod, sea bass and skates and rays. In the UK, long-finned squid are typically caught by trawlers during the daytime as the squid spend most of their time on or near the seabed (Hunsicker *et al.*, 2010). Trawls are large cone-shaped nets towed behind one or more vessels (see **Figure 14**), either along the seabed (demersal) or through the water column with no seabed contact (pelagic). For squid fishing, a variety of different trawling gears can be used, including demersal otter trawls, pelagic trawls and specialised squid trawls with small mesh cod ends and higher head ropes than those normally used to catch fish (Pierce *et al.*, 1994).

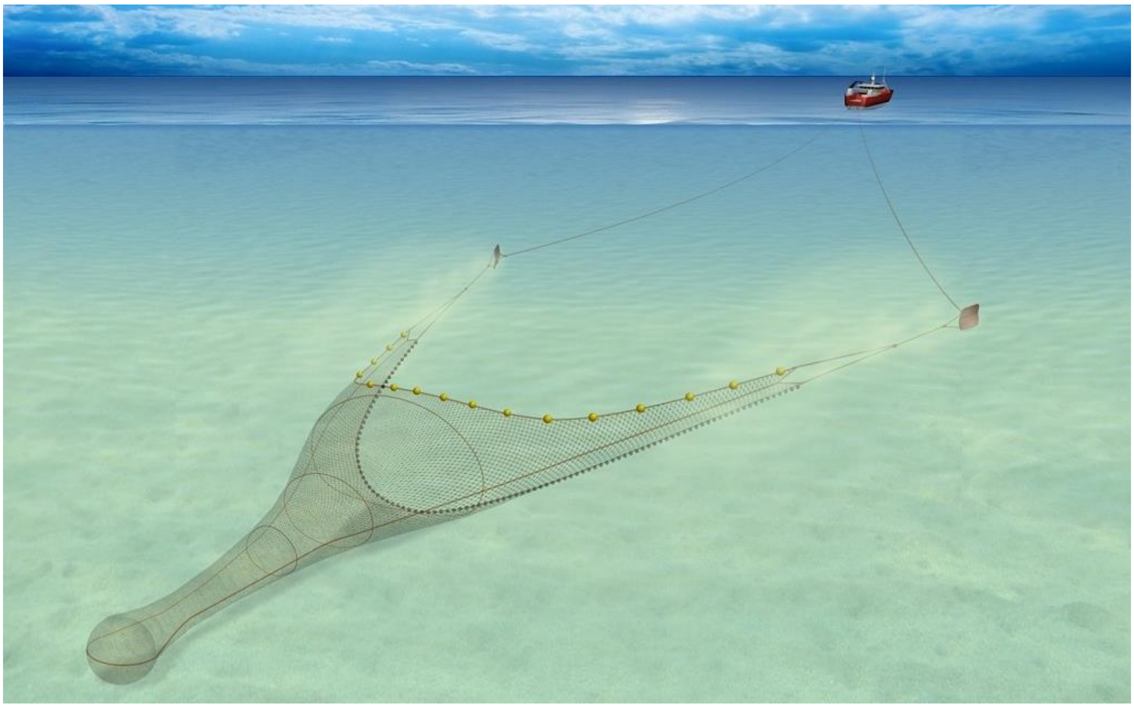

Figure 14 *- Demersal trawl with otter boards holding net mouth open (Seafish, 2020a, https://seafish.org/gear-database/gear/demersal-trawl-general/ [unedited]).*

Trawlers catch a variety of different species at once, meaning they form mixed fisheries; for example, much of the squid landed in the UK is caught as bycatch in demersal trawl fisheries targeting other species (Pierce *et al.*, 2010). Trawling (especially demersal) has received a lot of criticism over the years for its lack of selectivity and the associated damage caused to habitats on the sea floor from the trawl doors (Thrush and Dayton, 2002). The size of the catch can be controlled by altering the cod end mesh size of the trawl or with other selective devices such as escape gaps in the netting. On board equipment such as sonar and echo sounders can be used to distinguish between shoals of target catch and unwanted fish.

Spatial and seasonal restrictions on trawl fisheries are often used by fisheries managers to help protect vulnerable fish stocks and prevent damage to the sea floor. It is important to note that demersal trawling mostly takes place over sand, mud and shingle beds that are already subject to regular disturbance through natural tides and water movement (Seafish, 2020b). However, there is a vast amount of scientific evidence showing regular trawling can be damaging even in these habitats, especially if used for spawning grounds, and that these ecosystems can take years to recover post-disturbance (Hiddink *et al.*, 2017; Sciberras *et al.*, 2018). Pelagic trawls are also used to catch squid with minimal contact or damage to the sea floor, though the funnel-like nature of the netting still results in large numbers of unwanted fish being caught (Thrush and Dayton, 2002). As with other fishing methods, much of the selectivity of this fishing is dictated by skipper knowledge and experience about where the target species is likely to be at that time of year. Species that undergo seasonal movements and migrations, such as sea bass, can be reliably fished by experienced skippers with knowledge about their annual movements.

Recreational squid fishers will use rod and lines or handlines with lures (similar to those used in jigging) to catch squid (British Sea Fishing, 2020a). Recreational angling for squid is currently limited to a few select areas across the UK where squid are abundant in coastal waters and it is unlikely that recreational fisheries are significantly impacting UK squid stocks.

Current Landings & Stock Status

Presently squid populations in the Northeast Atlantic have no routine stock assessment measures in place (for any species); several exploratory stock assessments and research projects have been undertaken, though currently there is very little biological data for management of squid stocks to be based upon (Pierce *et al.*, 2010). The results of early genetic studies on squid populations suggest that, due to their high mobility, it is unlikely that more than one stock exists for each species, with the exception of an isolated population of *L. forbesii* in the Azores, however further research is needed to confirm this (ICES, 2018b). Given that squid fisheries demonstrate natural large fluctuations in landings between years, it will be extremely difficult to predict or detect when stocks are depleting or near collapse without regular and continuous stock assessments (Starr and Thorne, 1998).

Current landings of *Loliginid* squid caught in the European ICES divisions (see **Figure 15**) are currently in the region of 11,000 - 12,000 tonnes annually (ICES, 2018b). The most important area for these catches in recent years has been the English Channel (divisions VIId & e; contributing 44% of the total catch), followed by the North Sea (division IV; 19%), Northwest Scotland plus Ireland and Rockall (divisions VIa & b; 18%) and Cantabria/Bay of Biscay (divisions VIIIa, b & d; 12%). It is also noteworthy that areas with high catches seem to be areas with low reported discards (ICES, 2018b).

Figure 15 *- ICES divisions in Northeast Atlantic (ICES, 2020, http://ices.dk/Pages/default.aspx).*

Squid landings by the UK fleet fluctuate annually but have remained steady and are currently in the region of ~3,500 tonnes per year, though this effectively doubles when landings into overseas ports are included (see **Figure 16**). Some of the largest squid fisheries in the world are located in the South West Atlantic off South America including the Falkland Islands, which imports large amounts of frozen squid to Europe (Arkhipkin *et al.*, 2015).

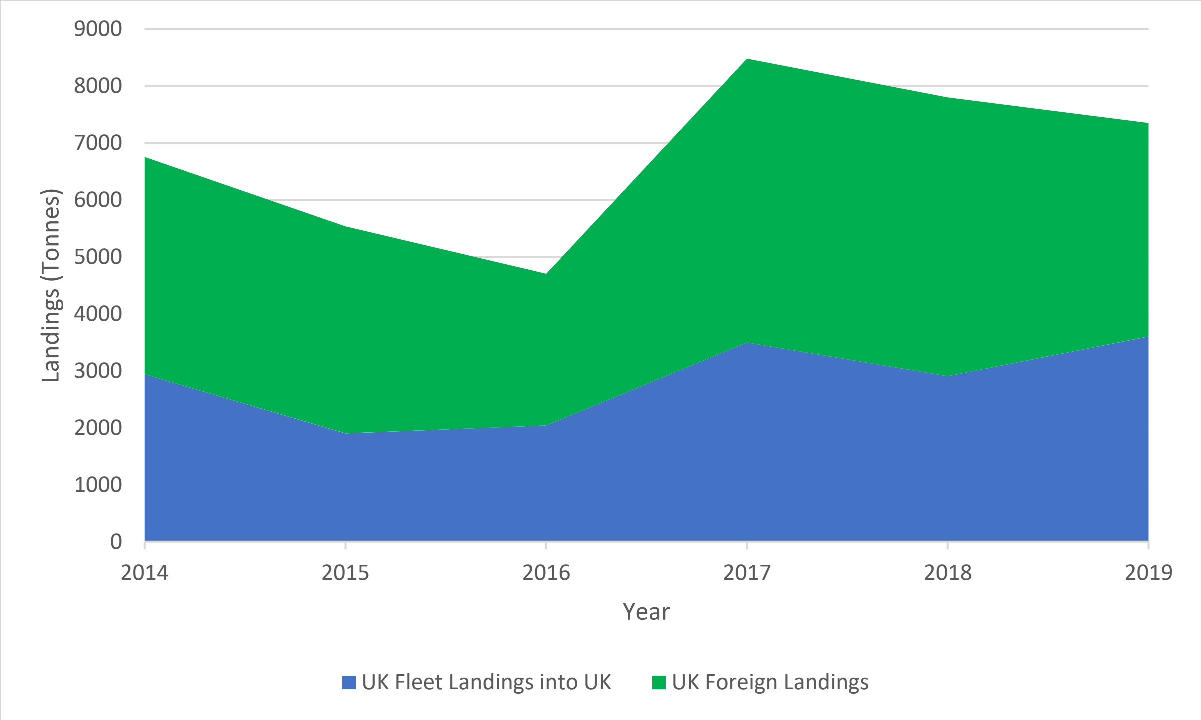

Figure 16 *- Annual domestic and foreign/overseas squid landings by UK fishing fleet (MMO, 2020).*

Squid landings in North Devon have not shown similar patterns of stability, with huge drops in landings seen over the past five years, to just 0.3 tonnes landed in 2019 (see **Figure 17**). Until more is known about the ecology and stock structures of squid, it will not be evident what caused this drop in landings, though fishermen in North Devon have noted that squid have become rarer and rarer in the region and one stated that he "*hadn't seen squid around in nearly ten years*" (Marine Pioneer Interviews, 2020), suggesting that squid populations in the area have dropped, possibly as a result of overfishing or shifting ranges due to climate change. Several commercial fishers operating out of North Devon believe squid populations in the area have dropped due to predation from the perceived increase in spurdog in the Bristol Channel (see **Threats to Fishery & Industry**; FRMP Interviews, 2020). It is possible the declines in landings are due to shifting/declining squid populations in North Devon or as part of the wider natural fluctuations, though this also difficult to determine as little is currently known about UK squid stocks and populations (Jereb *et al.*, 2015).

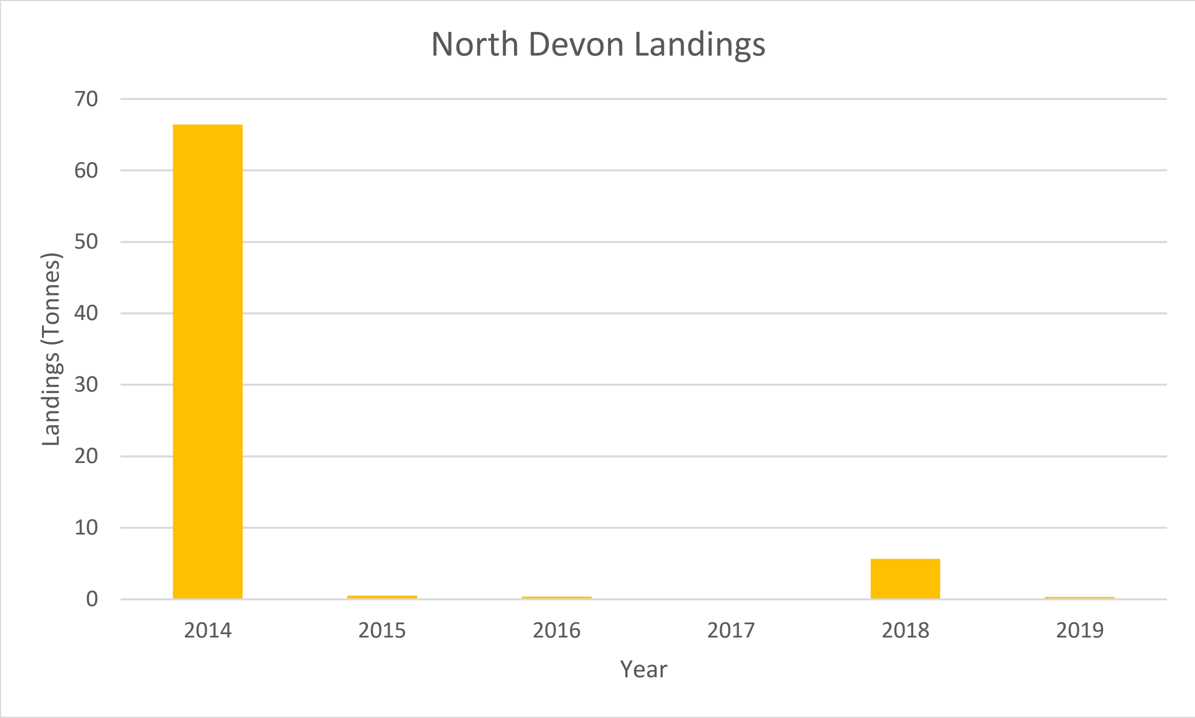

Figure 17 *- Annual squid landings into North Devon ports from 2014 to 2019 (MMO, 2020).*

Current Fishery Management

The management measures laid out in the following section have been summarised for the sake of this management plan. For full details of the most up-to-date management regulations, please seek out the original legislation at either the EU-Lex, Legislation.gov or the D&S IFCA websites.

Squid fisheries in Europe are primarily managed under the European Union's Common Fisheries Policy (CFP). Species managed under the CFP are subject to EU fishing regulations applying to all member states and then additional management measures can be applied at a national or regional level within member countries.

Since the UK's departure from the EU, and the coming into force of the Fisheries Act and related legislation, the British fishing fleet is not subject to EU regulations while operating in British waters, though many of the regulations brought in through the European Commission are still present in UK law (e.g., the landing obligation). The EU-UK Trade and Cooperation Agreement allows the UK to establish its own regulations for fisheries, as provided for by the UK Fisheries Act, and will not be bound to the EU's CFP rules. This ability to deviate from the CFP and establish regulations that can be more responsive and specific to the situation in UK waters has long been an important issue for UK policymakers and the fishing industry.

Marine activities in England are regulated by the Marine Management Organisation (MMO), who are responsible for managing fishing fleets, quotas and fighting illegal, unregulated, and unreported fishing. English inshore and regional fisheries are managed by the Inshore Fisheries and Conservation Authorities (IFCAs); IFCAs are responsible for enforcing national and EU-derived fishing legislation as well as ensuring local fishery exploitation remains sustainable through the implementation of byelaws in their regional districts.

Past Management Measures

Squid fisheries have been subject to very little management in the past, with no minimum sizes or TACs currently in place to restrict fishing effort in Europe or the UK. In 2019, the European Commission brought in a minimum mesh size for towed gear when fishing for squid with the aim to reduce unwanted bycatch of haddock and cod in European waters (see **Table 3**), though apart from this, no other restrictions or management measures have been implemented specifically regarding squid fisheries on an EU level.

***Table 3** - Past management measures for squid in European waters at EU, National and Regional level (as of March 2020).*

Year of Implementation	Management Body	Management Measures	Areas Affected	Reasons for Implementation	Reference
2018	Devon & Severn IFCA	Use of mobile gear is restricted in certain estuaries and MPAs throughout the district	Various locations throughout district, including the Taw and Torridge estuaries in North Devon	Aimed to protect vulnerable fish populations and key habitats	Devon and Severn IFCA's Mobile Fishing Gear Permit Byelaw
2019	Commission of the European Union	Netting mesh size of at least 40mm when fishing for long and short-finned squid with towed gear	Waters of all EU member states	Aimed to reduce unwanted catch of haddock and cod	Regulation (EU) 2019/1241

In addition to any EU and national regulations, fishermen targeting squid within the NDMP Area also must comply with local IFCA regulations. IFCAs each have a set of byelaws in place regulating the fishing effort and gear in their districts. Fishers in the north of D&S IFCA's District who target squid with mobile gear need to comply with regulations set out in the Mobile Fishing Permit Byelaw. Squid may also be caught as bycatch in netting activities, which must be carried out in accordance with the Netting Permit Byelaw. These byelaws were established by D&S IFCA and most recently revised in 2018. These byelaws regulate inshore fishing throughout the District by placing catch, gear, temporal, and spatial restrictions on fishers (outlined in **Table 4**) to effectively and sustainably manage fisheries. As well as these gear-specific byelaws, D&S IFCA has additional byelaws in place that were inherited from Devon Sea Fisheries and the Environment agency, described in the IFCA 'byelaw booklet.'

Available at: https://www.devonandsevernifca.gov.uk/Enforcement-Legislation/D-S-IFCA-Byelaw-Book-and-Minimum-Conservation-Reference-Size-List

Management Measures Currently in Place

The minimum mesh size for towed gear of 40mm still applies to squid fisheries within European waters today, though as previously mentioned this is the only restriction on squid fishing effort in place through European management. The squid fishery in D&S IFCA's District are not subject to squid-specific IFCA byelaws, but is subject to management through the permitting byelaws currently in place, as outlined below (see **Table 4**).

***Table 4**- Fishing restrictions in place affecting squid fisheries as part of D&S IFCA byelaws (as of March 2020).*

Regulation Type	Gear	Restrictions	Byelaws
Gear	Netting	Nets must be marked with floating markers displaying port, vessel and permit details as well as fixed with tags when required by the authority	Netting Permit Byelaw
		Nets with mesh sizes between 71 and 89mm are prohibited	
	Seine netting	When using authorised seine nets, permit holders must remain with the net for the full time of deployment as well as deploy and haul the net in one continuous action	
	Drift netting	When using authorised drift nets, permit holders must remain within 100 metres of the net for the full time of deployment	
	-	The storing of crabs, lobsters, scallops, or bass in containers within the sea or estuaries is prohibited	
Spatial	Netting	In the North Devon estuaries (defined in Annex 2), fishers are not permitted to use any nets other than seine and also providing that they are no longer than 20 metres in length, all species other than sand eel are returned to the water and that the mesh size is no greater than 20mm	Netting Permit Byelaw

	Netting	Only a single net, no longer than 25 metres may be used by category two permit holders in the seaward areas defined in Annex 2	Netting Permit Byelaw
	Netting	In the Annex 3 coastal areas, use of a net is only authorised when the headline of the fixed net is set at least 3 metres below the water's surface, and if the net used is a drift or seine net	
	Netting	In the areas off Lundy Island (defined in Annex 4) no netting of any kind is authorised	
	Netting	The use of fixed nets is prohibited in the Somerset areas (defined in Annex 5) unless in accordance with temporal restrictions in the netting byelaw	
	Demersal mobile gear	In the Lundy SAC and MCZ (defined in Annex 1) the use of demersal fishing gear is prohibited except for the authorised use of demersal trawl gear in the areas outlined in Annex 1a and the authorised use of demersal scallop gear in the areas defined in Annex 1b	Mobile Fishing Permit Byelaw
	Demersal mobile gear	In the Severn Estuary SAC (defined in Annex 6) the use of demersal mobile fishing gear is prohibited	
Temporal	Fixed nets	The use of fixed nets is authorised in the Somerset areas (defined in Annex 5) between 30th September and 1st April	Netting Permit Byelaw

Risks & Threats

Conservation Status

Of the squid species found in UK waters, only the veined squid has been assigned a classification on the IUCN Red List of Threatened Species. This species is listed as Least Concern, while most other species described in this plan are Data Deficient (IUCN, 2019). During its 2015 IUCN assessment, it was determined that the fishing exploitation levels on veined squid was not unsustainable (Allcock (SRLI) and Headlam, 2015), however, this may have changed in recent years. The data deficient status was assigned to European squid (*L. vulgaris*) during the 2015 assessment as there were no statistics available to determine the extent to which this species is being fished (Allcock (SRLI) and Galway), 2015). However, it is noted that fishing occurs throughout the majority of the species range and so pressure may be unsustainable. Better stock and harvesting assessment methodologies are needed to ensure accurate reassessments in the future.

Threats to Current Populations & Ecosystem

Susceptibility to overfishing and challenges for management

Most species of squid are fast-growing, short-lived, and breed only once, early in their lives (Jereb *et al.*, 2015). In some respects, this makes them more resilient to overfishing than other fish species, as many of the squid will have the opportunity to quickly mature and breed before being caught. However, this "short and fast" life history can also lead to rapid population declines when subject to heavy fishing pressure. There is concern that a lack of regulation and overfishing could lead to much of a generation being caught before they have the chance to breed, resulting in a largely reduced population of squid the next year (Hastie *et al.*, 2009). Squid also have highly complex migratory patterns that remain poorly understood in most species. Predictable movements such as these can lead to unsustainable overfishing, particularly if squid are fished when aggregating in inshore waters during the breeding season. The presence of such an abundant and unexploited commercial fishery with existing markets combined with declining finfish stocks means that increases in squid fishing across Europe and the UK is most likely inevitable (Hastie *et al.*, 2009).

The same biological and life history traits that make squid susceptible to overfishing also make them extremely challenging to manage effectively. Compared to many other commercially important fish species, little is known about the ranges and distributions of squid species as they are not regularly surveyed (Jereb *et al.*, 2015). The fact that they are only susceptible to be caught in trawls for short periods of their lives, makes regular surveys investigating squid abundance and distributions extremely difficult. Additionally, the short life cycles of squid mean that, if management was implemented, there would be little opportunity to make any adjustments to fishing effort during one generation (Bravo de Laguna, 1989). Therefore, if fishing mortality was too high one year, little could be done to prevent it affecting recruitment the next year. The fact that most commercial squid rarely live longer than a year means there is almost no "carry over" of squid from one year/generation to the next, regardless of fishing pressure. However, this also means that the size of a population is almost entirely dictated by the success of the breeding and recruitment from the year before, therefore, the consequences of any events affecting recruitment (whether they be anthropogenic or natural) could severely hinder commercial fisheries shortly after. It has also been pointed out however, that, paired with favourable environmental conditions, this style of breeding and life cycle could enable stocks to recover rapidly from a depleted state, making squid fisheries an appealing alternative to depleted traditional stocks (Pierce and Guerra, 1994). It could be argued that shifting effort to exploit a fishery that naturally fluctuates so violently is ill-advised, however, given the state of many traditional finfish stocks, some feel there may be little choice in the matter (Arkhipkin *et al.*, 2015). Due to the small number of targeted fisheries and the sheer abundance of squid in UK waters, it is unlikely that stocks of squid in the UK are in danger of being depleted or overfished under current fishing effort levels.

Demersal Fishing

The majority of squid caught in the Bristol Channel are/were caught in trawl fisheries, which tend to have high levels of discards and low selectivity between species. Demersal trawls can be damaging to some marine environments, particularly when the area is trawled often (Jennings *et al.*, 2002). Contact between the trawls and the seabed can damage benthic habitats, reduce the abundance of target and non-target species (both fish and other organisms that live on or in the sediments; Hiddink *et al.*, 2017; Amoroso *et al.*, 2018) and truncate age and size distributions (Kaiser *et al.*, 2006; Jorgensen *et al.*, 2007). A vast amount of research has shown that trawling can greatly alter the dynamics of ecosystems; for example, by reducing the abundance of large predators, trawling can increase the abundance of small and fast-growing species that can recover quickly from disturbance (Tillin *et al.*, 2006). Trawling can also increase the availability of organic matter (in the form of more dead or injured animals) to scavengers and bottom feeders and decrease the feeding efficiency of filter feeders by resuspending sediment from the sea floor (Bradshaw, Collins and Brand, 2003; Howarth et al., 2018). Management often restricts demersal trawling away from sensitive areas with rich benthic communities to prevent long-term damage to these ecosystems, however, there are still areas such as sand, mud, and shingle beds where trawling regularly takes place. Though these areas may be seen as more resilient to demersal activity as they are subject to regular seabed disturbance through natural water movements, continuous trawling can still be highly damaging to these ecosystems and their communities, especially if the disturbances brought about by fishing outweigh those from natural processes (Diesing, Stephens and Aldridge, 2013).

As described in **Reproduction & Life History**, squid deposit their eggs demersally, often on rocks and other hard substrates. These areas tend to be avoided by trawlers as fishing gear can be easily damaged, however, some squid species have been observed depositing eggs on gravel-bottomed habitats, which can be targeted for demersal fishing and other potentially harmful practices such as aggregate dredging (see **Marine Development & Resource Extraction**), which may lead to significant egg mortality. Once research has been able to identify such areas, protective measures could be considered in order to protect spawning beds, especially if squid fisheries expand as predicted. Squid eggs are also regularly reported to be deposited on static fishing gear such as pots or traps (Jereb and Roper, 2010; Hanlon and Messenger, 2018). Although these eggs will most likely be damaged and removed from the gear when it is collected by fishers, the recording of deposited eggs such as this can be used to better understand local squid distributions and breeding patterns. In these scenarios, the presence of squid eggs on gear may encourage adaptable, inshore fishers to temporarily target squid while their abundance increases in inshore areas during breeding, providing a seasonal alternative catch.

Bycatch & Discards

There are only a few targeted squid fisheries around the UK, where most landed squid result from bycatch in demersal fisheries. The unaccounted fishing mortality of commercially fished species is recognised as a global problem, and can be as high as 50% of the overall catch in some fisheries (Stevens *et al.*, 2000). As with many fisheries, there are potential issues regarding discards when fishing for squid, particularly due to the mixed nature and high bycatch rates of the fishery. Discards are the portion of catch that are not retained on board for landings upon returning to port and are instead returned to the sea. Discards can be made up of the target species as well as bycatch meaning both squid populations and those of other marine species are affected by these fisheries. Fish are discarded when they are unmarketable, below MCRS, or are species which fishermen are not authorised to land. The health and survival of fish discarded back to the sea varies greatly based on what fishing gear was used to catch them, for example, hook and line fisheries can return unwanted fish back to the sea immediately after capture with relatively little injury, which is one of the reasons these fisheries are so sustainable (Rush and Caslake, 2009). Conversely, fish caught in demersal trawls can often be severely injured or killed during the trawl, meaning fish returned to the sea are most often already dead, adding additional mortality to the stock. (Wade *et al.*, 2009).

Marine Development & Resource Extraction

The Severn Estuary and Bristol Channel are the focus of several plans for marine development and resource extraction, each representing a number of pressures on fish populations. Squid live a very benthic existence, spending much of their time near the sea floor with female squid depositing their egg strings on the seabed after breeding, sometimes favouring gravely substrates (see **Reproduction & Life History**). These substrates are amongst those targeted most often for aggregate dredging and extraction, meaning squid habitats may be subject to continuous disturbance in areas with high levels of anthropogenic activities affecting the seabed or coastal development. Currently there are seven aggregate dredging licenses operating within the Severn Estuary, removing ~2.7 million tonnes of marine aggregate each year, with two more applications pending approval (The Crown Estate, 2020). One of the largest sites for aggregate extraction is found near Minehead (see **Figure 18**), near an area that local fishers have claimed multiple species use as nursery grounds (FRMP Interviews, 2020), though further investigation is needed to confirm this. Identifying and mapping important areas for marine species such as spawning sites and nursery grounds is essential in order to effectively protect them as this information can feed into management and spatial planning in marine environments.

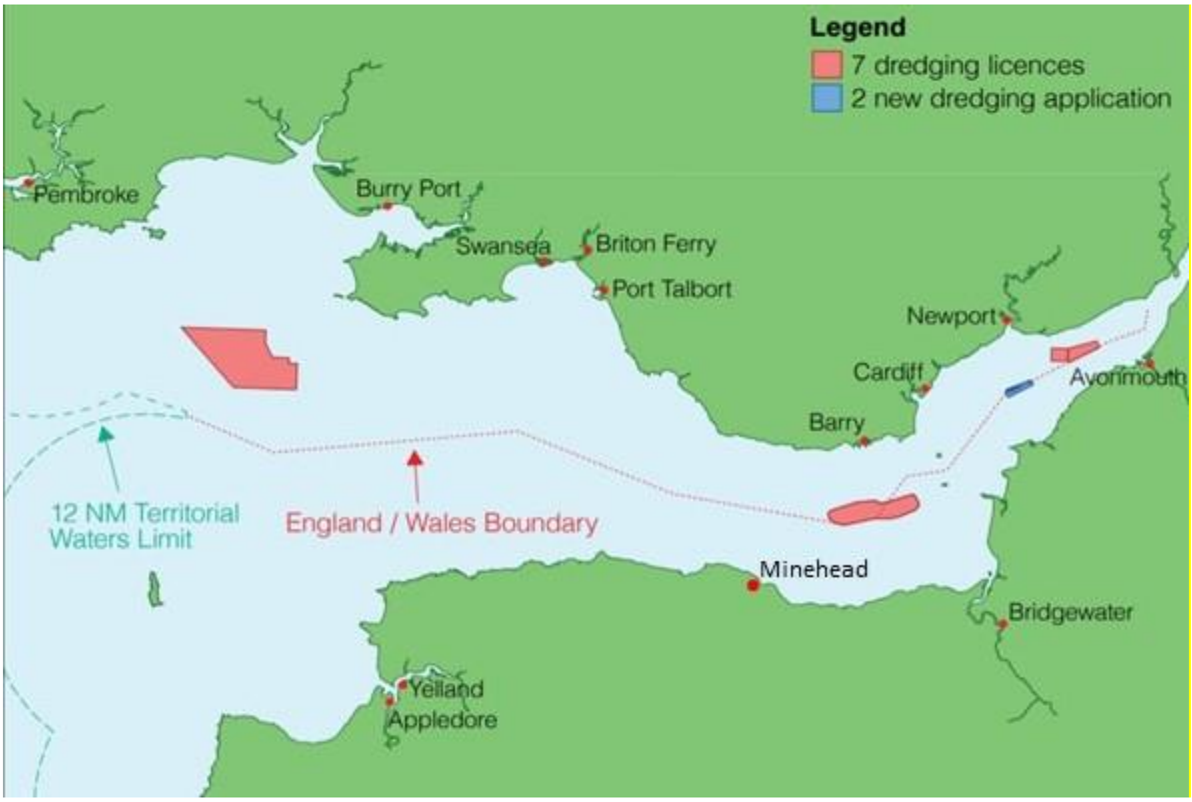

Figure 18 *- Active and potential aggregate extraction sites within the Bristol Channel (The Crown Estate, 2020, https://www.thecrownestate.co.uk/media/3634/2020-capability-portfolio-report.pdf).*

The Severn Estuary is designated as a European Marine Site (EMS). There are currently several existing or planned development projects within the EMS in various stages of development that could potentially negatively impact marine species and ecosystems. The importance of the Bristol Channel for commercially fished species, as well as the possible presence of spawning and nursery grounds off Minehead, has added to these concerns regarding local conservation of marine life, particularly near Hinkley Point Nuclear Power Station. Hinkley Point C (HPC) is an ongoing project to construct a 3,200 MWe nuclear power station next to Hinkley Point A (decommissioned) and Hinkley Point B nuclear power stations in Somerset. This project includes plans to abstract 132 cumecs of water directly from the Severn Estuary (over 11 million cubic metres per day) in order to cool the two reactors at HPC. The extraction of this quantity of water, from intake heads situated on the seabed 3.3 km offshore, has raised significant concerns regarding impacts on the marine environment, including the assemblage of fish species (Devon & Severn IFCA, 2018, 2019, 2020a; Environment Agency, 2020). The various permits and licences necessary for HPC to extract large quantities of cooling water from the Severn Estuary were conditionally granted in 2013 on the understanding that three mitigation measures would be implemented to reduce any impacts on the fish assemblage. The developers have sought to remove the requirement to install Acoustic Fish Deterrents (AFDs), which were the central part of the three mitigation measures. The Environment Agency have estimated that, without the AFD, the cooling water system of HPC would be responsible for significant fish losses from several commercial stocks (Environment Agency, 2020). D&S IFCA are concerned about the effects of these fish kills local populations, some of which are vulnerable to rapid decline and subject to regular fishing pressure.

The fish assemblage, including squid, is protected in the Severn Estuary as part of the Severn Estuary SAC and Ramsar site. It is only on this basis that the effects of HPC and other marine developments on fish can be considered in a regulatory and licencing context. In turn, this highlights the regulatory gaps for fish protection in other locations (e.g., the rest of the Bristol Channel) that do not fall within designated sites, or that fall within designated sites that do not include designations relevant to fish or the fish assemblage.

Due in part to its funnel-like shape, the Severn Estuary has one of the largest tidal ranges in the world, around 14 metres (Xia, Falconer and Lin, 2010). There is increasing interest in harnessing this large tidal range for tidal power projects, especially after the Government's commitment to increase the usage of renewable energy sources. Although there is a strong desire and environmental justification to shift away from the usage of fossil fuels, tidal power developments can be damaging to marine life and greatly alter their habitats. In 2013, plans for a tidal barrage across the mouth of the Severn were rejected by MPs due to several economic and environmental problems (Harvey, 2013). Among these were concerns of fish mortality when passing through turbines, delays or prevention of reproduction/migrations and loss of habitat (House of Commons Energy & Climate Change Committee, 2013). Since then, smaller scale tidal lagoon projects have been proposed in the Severn Estuary, such as the Swansea, Cardiff, and Newport tidal lagoon projects, however, these projects still carry similar threats to marine populations on a more localised scale. Though some tidal energy proposals focus on Welsh waters of the Severn Estuary and Bristol Channel, these waters form part of a large and connected ecosystem. The movement of these waters and the fish within them transcends administrative boundaries; consequently, effects of tidal energy developments have the potential to impact ecosystems within the jurisdiction of D&S IFCA.

In addition to tidal energy generation, interest in offshore wind farms for energy generation has increased greatly in the last two decades, particularly in the Bristol Channel. In 2007, proposals were set out for the development of a 240 turbine offshore windfarm just off the island of Lundy (Quilter, 2013). However, the project met considerable resistance due to environmental concerns and the plans were eventually scrapped due to "technical and financial reasons". The development of offshore wind farms can trigger a variety of potentially damaging effects to marine life (Hiscock, Tyler-Walters and Jones, 2002). Damage to the seabed and benthic communities can be partly mitigated through the use of floating turbines, however, these farms can still negatively impact wildlife, particularly birds and marine mammals (Bailey, Brookes and Thompson, 2014; Bergström et al., 2014). Despite this, the development of offshore wind farms is expected to increase with some experts stating that the development of a wind farm within the Bristol Channel is most likely inevitable, e.g. project Erebus off south Wales (Cooper, 2019; BBC, 2020).

Climate Change

After overfishing, one of the most pressing threats to marine life and the fishing industry is climate change (Stewart and Wentworth, 2019). Climate change is predicted to affect the oceans in many ways, including warming waters, changes in oscillations and currents, increases in dissolved carbon dioxide concentrations and rising sea levels (Petitgas *et al.*, 2013; Stewart and Wentworth, 2019). Changes in water temperature are expected to dramatically affect many fish species, especially those whose development, behaviour, and physiological processes are influenced by temperature, including squid (Gervais and Johnson, 2020). The effects of climate change on squid are likely to be extremely complex, for example, research is showing that increased water temperatures, consistent with those expected due to climate change, can reduce the size of newly hatched squid (Pecl and Jackson, 2008). This in turn may have a critical influence on the size these squid achieve as adults, and means that climate change will likely result in some squid populations being composed of squid that hatch out of eggs earlier and at smaller sizes, growing faster and maturing quicker over shorter life spans (Boletzky, 1994; Vidal *et al.*, 2002). These squid will require more food and oxygen due to faster metabolisms and will likely be less able to cope in periods of short food supply (Pecl and Jackson, 2008). In addition to this, fast growth rates and rapid turnovers at population level mean squid are able to respond to environmental changes rapidly compared to many other marine organisms, and fill "vacuums" in ecosystems when predators or competitors are removed (Pecl and Jackson, 2008). With characteristics such as these, it is logical to think that climate change may end up benefitting many populations of squid, however it is likely that squid reactions to climate change will be extremely complex and vary greatly between species and populations (Pecl and Jackson, 2008; Moustahfid *et al.*, 2020).

In addition to warming waters, the increasing frequency of hypoxic (very low oxygen) ocean "dead zones" have been attributed to climate change and the runoff of fertilisers into rivers (Diaz and Rosenberg, 2008). Dead zones have significant consequences for the functioning of marine ecosystems and the services they provide to society, including fisheries production, water filtration, and nutrient cycling (Altieri and Gedan, 2015). Fertiliser used on farmland will often run off into rivers and be transported downstream to estuaries. The increase in nutrients such as phosphorus and nitrogen in these environments (known as eutrophication) can cause blooms of marine algae (Joyce, 2000). As the algae dies, it sinks to the bottom, where oxygen in the water is consumed by microbes as part of the decomposition process, lowering the oxygen concentrations in the water. Stratification, or layering, of the water column prevents mixing between these low-oxygen waters and surface waters. Stratification is linked to temperature and salinity concentration gradients in the water and is projected to increase due to warming waters, particularly in more northerly latitudes (Keeling, Körtzinger and Gruber, 2010). This process continues until the area has been transformed into an oxygen-deficient or oxygen-free zone, devastating marine life in the area, particularly within benthic communities (Diaz and Rosenberg, 2008). The frequency at which these "dead zones" are occurring is increasing, and they are common across much of the range of commercial squid species (see **Figure 19**). Changes in EU legislation regarding fertiliser usage has led to improvements in oxygen conditions in the North Sea, though hypoxic zones are still present throughout areas of Europe (Townhill *et al.*, 2017).

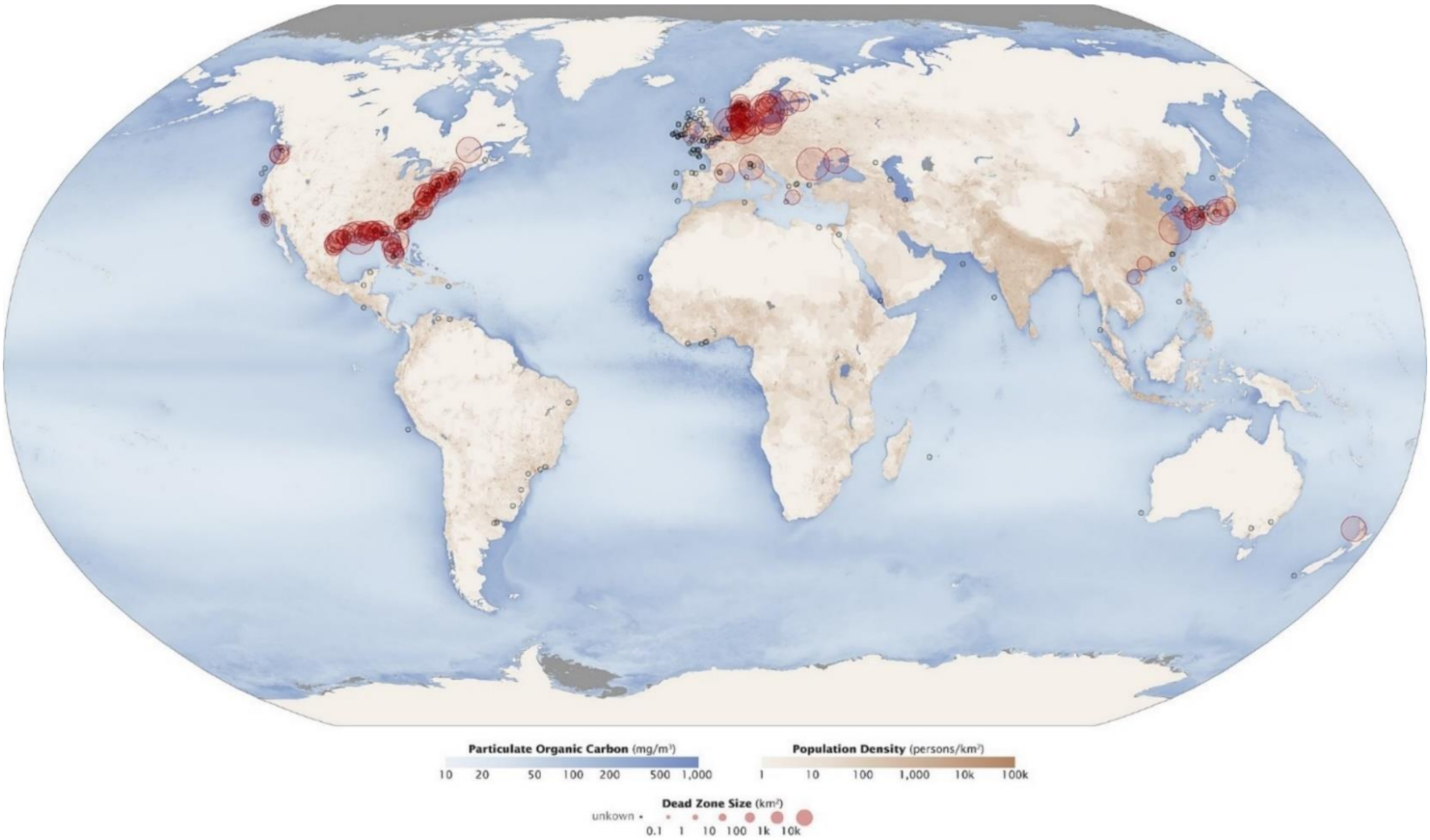

Figure 19 *- Locations of hypoxic and anoxic dead zones. Red circles on this map show the location and size of many of our planet's dead zones. Black dots show where dead zones have been observed, but their size is unknown (Allen, 2010,* [*https://commons.wikimedia.org/wiki/File:Aquatic_Dead_Zones.jpg*](https://commons.wikimedia.org/wiki/File:Aquatic_Dead_Zones.jpg) *[unedited]).*

Although hypoxic dead zones can pose a threat to all nearby inshore marine life, they are potentially devastating for fish species that use inshore and estuarine habitats as nursery or spawning areas as these are the areas where dead zones are most likely to occur (Altieri and Gedan, 2015). Although squid are rarely found in such environments, they may come in close proximity to active dead zones when migrating inshore to spawn. Increases in the frequency of dead zones in or near areas where squid deposit their eggs could lower the reproductive output of populations and hinder any recovery of lowered stocks.

Climate Change: Coastal Squeeze & Flooding

With sea levels across the world rising due to climate change, a phenomenon known as coastal squeeze is an increasing concern to conservationists. As sea level slowly rises, the sea encroaches upon coastal areas causing terrestrial erosion and loss of habitat. In the marine environment, organisms and ecosystems "migrate" towards the shore to maintain their positions relative to the water level (Torio and Chmura, 2013). However, to combat rising seas, humans have installed flood defence systems such as sea walls and groynes to protect coastal areas from the rising water. Barrier defences such as sea walls prevent coastal marine life from migrating to maintain their position in preferred habitats, and thus reduce the availability of coastal habitat (Pontee, 2013). This is a very slow process but poses a significant threat to coastal ecosystems, particularly for benthic organisms.

Figure 20 *- Flood defence sea wall on Chesil Cove Beach, Dorset (BennH, 2014,* *https://commons.wikimedia.org/wiki/File:Chesil_Cove_flood_defences.png* *[unedited]).*

As weather patterns get more extreme and less predictable due to the effects of climate change, the potential for flooding within the Bristol Channel increases. There are many major cities and built-up areas surrounding the Severn that are at risk of flooding, with flood defences installed in such areas. The effects of coastal squeeze will be most severe in these developed and defended areas compared to the more rural coastal zones of the estuary, as the lack of flood defences and developments allow marine communities to retreat inland as the sea rises. In addition to causing coastal squeeze, there is concern that the construction of new flood defence installations could be damaging to fish populations within the Severn Estuary. For example, the planned construction of the new Bridgwater flood defence barrier on the river Parrett (which feeds into the Severn Estuary) will involve extensive construction work on and around the river, and local authorities have raised concerns that the potential impacts of such projects on local fish populations, particularly juveniles, are not being properly addressed and mitigated during planning (Devon & Severn IFCA, 2020b).

Threats to Fishery & Industry

The decline of the squid fishery within the Bristol Channel over the past 10 to 15 years was a common theme brought up during interviews with fishers (FRMP Interviews, 2020; Marine Pioneer Interviews, 2020). Many fishers attribute the disappearance of squid to rising populations of spurdog (*Squalus acanthias*) within the Bristol Channel following an EU fishing ban on this species in 2010 (Council of the European Union, 2010). During these interviews, fishers described how spurdog (see **Figure 21**) were now abundant in the Bristol Channel and that the feeding habits of these increased populations were causing declines in other species, with one fisher describing spurdog as "*pests,*" that "*eat up everything they can*" (FRMP Interviews, 2020).

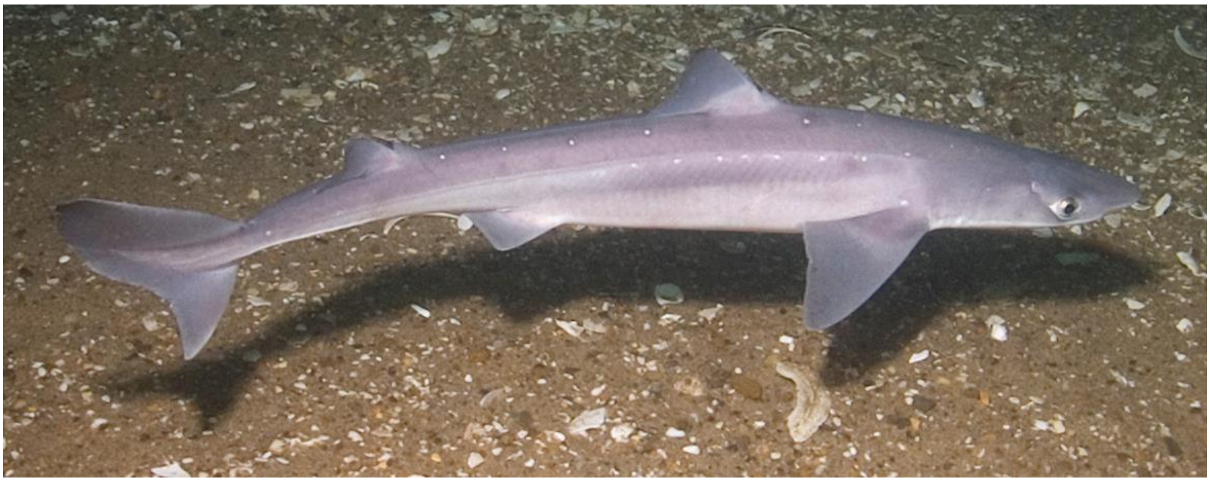

Figure 21 - *Spurdog (Squalus acanthias) (NOAA, 2013, https://commons.wikimedia.org/wiki/File:Squalus_acanthias_stellwagen.jpg [unedited]).*

This has resulted in Bristol Channel commercial fishermen feeling that they are losing viable fisheries and are unable to then fish the rising spurdog population as the fishing ban is still in place. Because of this, there is a strong desire amongst North Devon fishermen to open up a longline fishery for spurdog, even if only on a trial basis, to make up for lost income while relieving predation pressure on squid (FRMP Interviews, 2020; Marine Pioneer Interviews, 2020). The decline of squid in the Bristol Channel warrants further investigation as, if the squid declines are due to spurdog feeding, similar declines may occur in squid populations across the North Atlantic Ocean. However, it is also possible that the decline seen in Bristol Channel squid is part of a particularly large natural fluctuation often seen in squid species. Fish and squid populations have also been seen to be dramatically affected by factors related to climate, such as changes in the North Atlantic Oscillation (Dawe *et al.*, 2000; Sims *et al.*, 2001; Zuur and Pierce, 2004).

The issue with spurdog in the Bristol Channel highlights another major issue often raised by inshore fishers. Many commercial fishermen in the Bristol Channel feel fisheries and fish stocks are not assessed or considered at the correct scale when new management measures are written (FRMP Interviews, 2020). Some fishers described how large-scale fishing restrictions are often implemented (at a national or European level) without considering the economic importance of species and fisheries to the fishing industry, leading to local fisheries potentially becoming unviable. For example, in 2017 the European Commission proposed a zero tonnes TAC for small-eyed rays in the Bristol Channel, which would have been devastating to local fisheries as many trawlers rely on this species to make their businesses viable. Following an appeal put together by the NDFA and Defra, the ban was lifted and a TAC on small-eyed ray in Divisions VIIf and g implemented. Due to a lack of current management restrictions, this is unlikely to be a major problem for squid fisheries in the near future, however, most commercial fishermen target many species throughout the year, and as traditional commercial stocks decline or become more restricted, fishing effort is redirected towards other fisheries, particularly non-quota species such as squid.

An issue seen in many inshore fishing areas is that of illegal, unreported, and unregulated fishing. This issue was raised by almost all fishermen during interviews as part of this project, with one fisherman commenting “there is a lot of fishing going on up here you don’t know about…” when discussing illegal fishing in the north of D&S IFCA’s District (FRMP Interviews, 2020). This problem is thought to be most common within sea bass fisheries, though many species and ecosystems will be affected by such activity. Some fishermen were worried that this wasteful, illegal activity is undermining the sustainable nature of their fishing efforts and that a stronger enforcement presence was needed from D&S IFCA to discourage illegal fishing and ensure fishing regulations are followed by both commercial and recreational fishers (FRMP Interviews, 2020). The large size of D&S IFCA's District, and a small enforcement team made up of only four officers, means patrols are limited to areas with higher numbers of reports of illegal fishing, which is primarily the south coast. Engagement with fishers from the north of the District has highlighted a sense of mistrust towards the IFCA from the inshore fishing industry and shown some fishers have no confidence in the IFCA, which may contribute to illegal fishing activity remaining unreported (FRMP Interviews, 2020). It is important to work to rebuild this trust and engage with fishers as much as possible, including to encourage the reporting of illegal activity.

D&S IFCA is seeking to rectify this, including the improvement of collaboration and engagement through activities such as virtual roadshows for ports, sectoral meetings and future FRMP interviews. More information about planned engagement activities is available in the D&S IFCA's Annual Plan and Communications Strategy, accessible via the D&S IFCA website. It is hoped that this will improve stakeholder engagement with D&S IFCA's intelligence-led, risk-based approach to enforcement and compliance work, which is prioritised to areas with high numbers of reports of illegal fishing activity.

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