



**BLUE MARINE
FOUNDATION**

The Lyme Bay Reserve Ray Project

Focussing on the local mixed fishery in the
Lyme Bay Conservation and Fisheries Reserve

FINAL REPORT

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Catherine Whitley, Blue Marine Foundation



OVERVIEW

This is an initial report on research conducted by Blue Marine Foundation (BLUE) to support sustainable management of the local ray fishery within the Lyme Bay Fisheries and Conservation Reserve (“the Reserve”). The project, developed in partnership with the Marine Conservation Society (MCS), started in May 2018 and covered one ray fishing season.

Aims:

The aims of the project were to gather data on local populations and the local commercial fishery for rays in the area to:

1. Determine the number of commercial fishing vessels targeting rays within the Reserve and the spatial extent of their fishing activities.
2. Investigate the main capture methods employed by the fishermen to evaluate the sustainability of the local fishery.
3. Quantify the catch composition of rays and the number of discards.
4. Identify additional appropriate management measures to further enhance the sustainability of the fishery.

Methods:

The study was comprised of two parts:

- Qualitative interviews with fishers to gather baseline data and anecdotal information about the fishery.
- On-board observer surveys on multiple commercial fishing vessels targeting rays inside the reserve.

Key Results:

This report summarises data collected from interviews with 19 fishermen and on-board surveys conducted on eight individual trips between October 2018 and February 2019. Four local boats targeting ray within the Reserve were used during the study and the results were combined with additional data submitted by two fishermen.

Outcome 1: Qualitative interviews with fishers to gather baseline data and anecdotal information about the fishery.

- All 19 fishers use specific netting gear with mesh sizes ranging between 10.5 and 12.5 inches to target adult rays and reduce the accidental bycatch of other demersal species including juvenile and vulnerable rays. Both mesh sizes are larger than the EU minimum (8.66 inches).
- Fishers usually return smaller, but legal-sized, rays back to sea due to poor market prices.

- Fishers start targeting rays in September and continue through the winter until the beginning of May. This minimises the risk of catching juvenile rays and ensures a high proportion of net-caught rays with a disc width greater than 40cm.
- Some fishers stated fishing patterns are dictated by sediment type, with soft sandy sediments generally avoided due to higher numbers of juveniles.
- Soak times vary between 24 – 72 hours and fishers perceived discarded rays to have a very high survival rate, of which eight fishers stated 90 – 99% of discards survived.
- Most of the fishers delivered a positive response when asked about implementing management measures, and 42% were in favour of including a minimum landing size (MLS) within the Devon and Severn Inshore Fisheries and Conservation Authorities (IFCA) district (mirroring measures currently enforced in Southern IFCA’s district). Additional measures suggested by fishers interviewed included (1) using larger mesh sizes to specifically target adult rays, (2) establishing a maximum soak time of 72 hours, (3) returning pregnant females and (4) abiding by best-handling methods to carefully return undersized or prohibited species.

Outcome 2: On-board observer surveys on multiple commercial fishing vessels targeting rays inside the reserve.

- A total of eight trips were made on four separate vessels between October 2018-February 2019.
- Observer data were combined with two additional fishers providing data, this totalled 393 rays assessed during the study.
- 79% of all rays caught were thornback rays, *Raja clavata*. This was supported by interview results from local fishers. Undulate ray, *Raja unduata*, were the second most common ray species (14%).
- 97% of all caught rays reported to be in a “lively” condition. Condition assessments conducted during surveys showed that all rays hauled from nets were found alive and in good condition.
- 96% of captured rays were sexually mature when nets with a 10.5-inch mesh size were used. This suggests that nets with this mesh size have a high selectivity towards targeting mature adult rays and minimising impact to juvenile bycatch. These data can be used to underpin appropriate mesh size recommendations for the ray fishery inside the Reserve.
- It also suggests the current MLS (40cm), enforced by Southern IFCA on the eastern side of the Reserve, is suitable as this ensures the majority of rays caught are sexually mature. However, most of the on-board surveys were conducted on the western side of the Reserve. This area of the Reserve is managed by the Devon and Severn IFCA which do not enforce a MLS above the EU minimum. This indicates fishers are using precautionary measures to land sexually mature rays in accordance with neighbouring regulations.

Recommendations:

It is important this research is continued to further evidence the sustainability of the Reserve static gear ray fishery. Due to limitations on data collection and the variability in ray fishing efforts over the winter 2018/2019, more on-board surveys are required to build on the current dataset. Assessments of the spatial distribution of fishing effort across the whole reserve is also needed. Further evidence will help provide a greater understanding of the conservation status of thornback rays within this area and inform sustainability ratings and further conservation measures.

It is recommended that BLUE:

- Collate landings data from individual fishermen operating within the Lyme Bay Reserve and from the Marine Management Organisation (MMO) to understand catch per unit effort (CPUE).
- Carry out further on-board observer studies on a greater number of vessels that target ray to better understand the local fishery, fishing practices and landings.
- Use the data to inform improved management of the local ray fishery through the introduction of additional measures to the Reserve's voluntary Code of Conduct:
 - MLS of 45cm (disc width) for thornback ray
 - Minimum mesh size for ray nets of 10.5 inch or more
 - Soak times not to exceed 72 hours when targeting rays
 - All pregnant females to be returned
- Further research should then be undertaken to assess and evaluate the effectiveness of any conservation measures and how these measures affect the local ray stocks.
- Submit the data to the Marine Conservation Society (MCS) to inform a specific rating in their Good Fish Guide for ray species caught within the Reserve.
- Work with The Shark Trust to introduce and promote a Best Practice guide for handling and discarding skates and rays for commercial and recreational fishermen.

INTRODUCTION

Blue Marine Foundation's (BLUE) pioneering work in the Lyme Bay Fisheries and Conservation Reserve ("the Reserve") (Fig 1) has been hailed as a 'world first' because of the way it engages fishermen to take the lead in the conservation of their fishery and therefore, provide long-term benefits to the abundant marine life, fishermen and local community. Since 2008, the Reserve has been closed to bottom towed fishing, through a Statutory Instrument¹ but still supports a local low-impact, static fishery who target a variety of fish and shellfish throughout the year.

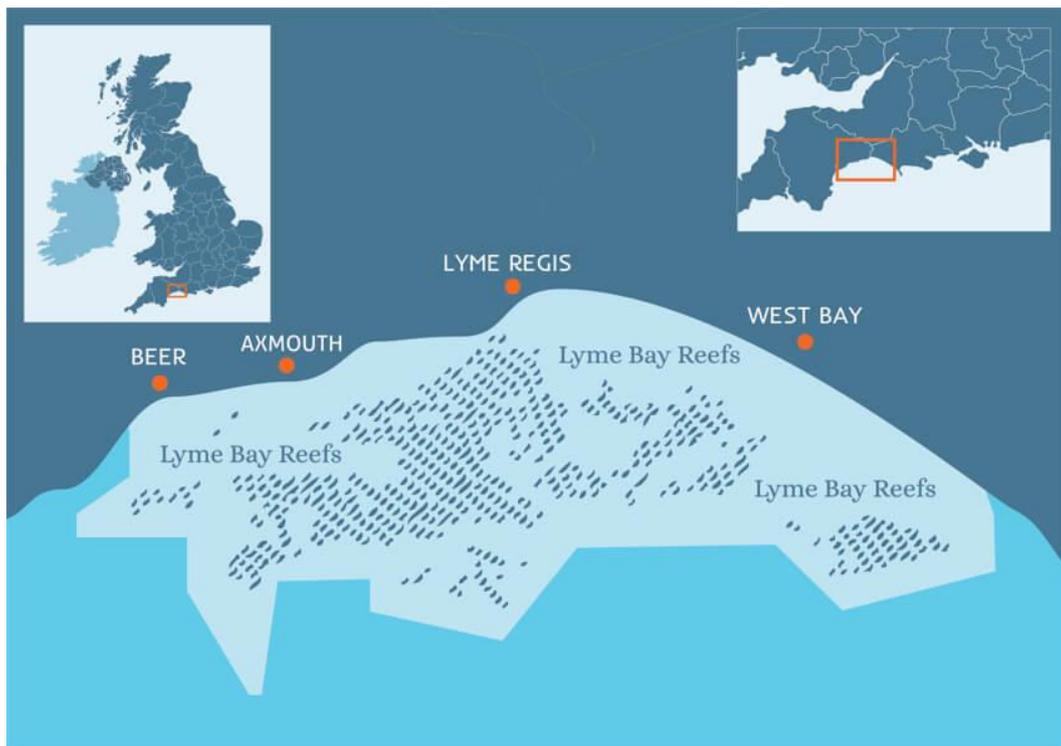


Figure 1. Map of the Lyme Bay Reserve

In 2018, 32 boats were signed up to the Reserve's voluntary Code of Conduct² which stipulates a number of limits on fishing effort, such as pot limits, and requires all vessels to carry on-board monitoring, through the use of a mobile app, enabling traceability of catch. These conservation measures were designed and implemented by the fishermen with help from BLUE, scientists and regulators through the Lyme Bay Fisheries and Conservation Consultative Committee.

In recognition of the fishermen's dedication to fishing responsibly and adhering to sustainable conservation measures, BLUE created the Reserve Seafood³ brand in 2014. The brand markets catch from fishermen who operate within the Reserve and abide by the voluntary Code of Conduct. At present, no MCS red listed seafood can be sold through Reserve Seafood.

¹ http://www.legislation.gov.uk/uksi/2008/1584/pdfs/uksi_20081584_en.pdf

² https://www.lymebayreserve.co.uk/download-centre/files/Lyme_Bay_Fisheries_and_Conservation_Reserve_Voluntary+Code_of_Conduct.pdf

³ <http://www.lymebayreserve.co.uk/reserve-seafood/>

Over the last few years, local fishermen from the commercial and recreational fishing sector have observed higher catch rates of rays, particularly thornback ray, *Raja clavata*, within the Reserve. These observations are encouraging as thornback ray is currently classified as “near threatened” by the IUCN⁴ and rated level 5 - “fish to avoid”- on the MCS Good Fish Guide⁵ for the Western English Channel. These ratings are based on scientific trawl surveys (Burt et al., 2013; Ellis et al., 2016) and mainly focus on target fisheries using demersal otter and beam trawls to catch various ray species. This stock area, officially classified as ICES Western English Channel Division 7e, includes the Reserve, but covers an extensive area between Poole in East Dorset to the Lizard in Cornwall. There is therefore a lack of localised information on thornback ray targeted by low impact capture methods within the Reserve.

BLUE and the Reserve fishermen initiated a ray project to understand the current fishing gear used, handling methods, and to quantify the current ray fishery (size cohorts, species, and abundance) occurring in the Reserve. The results from this study will help inform additional conservation measures for rays in the Reserve’s voluntary code of conduct and may help inform an improved MCS Good Fish Guide rating for thornback ray in the local area. This will further demonstrate the benefits of collaboration between local fishermen, researchers and conservationists to support well-managed fisheries using sustainable fishing methods.

SKATES AND RAYS (RAJIDAE) IN THE RESERVE

1. Population

Lyme Bay has been considered one of the main areas of abundance for thornback ray in the western English Channel (Silva et al., 2014). Although ICES state the stock structure of thornback ray in Division 7e as unknown until there is further information on stock abundance and exploitation levels, for the past three years a precautionary approach has been applied (ICES, 2018). Using this data-limited approach, ICES advise landings should be no more than 212 tonnes in each of the years 2019 and 2020. Nevertheless, current landings of thornback ray have increased within this stock area (ICES, 2018) and recent trawl survey data indicates the relative abundance of this species is stable or increasing in Lyme Bay (Burt et al., 2013). More surveys are required to provide information on the current conservation status of thornback ray and to identify more accurate stock indicators for the future.

2. Ecology and habitat

The biological characteristics of skates and rays, such as low fecundity, slow growth rates and late maturity, makes them vulnerable to overfishing (Hueter et al., 2002; Chevolut et al., 2006; McCully et al., 2012). This, coupled with their generally large size, morphology and aggregating behaviour makes them susceptible to capture in demersal fisheries. Furthermore, their fidelity to certain locations may also increase their risk of local depletion (Ellis and Walker, 2000; Ellis et al., 2010).

⁴ <https://www.iucnredlist.org/species/39399/103111648>

⁵ <https://www.mcsuk.org/goodfishguide/search>

Rays are also known to express habitat preferences for different sediment types. Local fishermen in Lyme Bay have observed this characteristic and are therefore able to target specific areas where they know they will catch certain species (pers. comms, anonymous, fisher from West Bay). This is supported by ecological studies detailing the difference in substrate preference for various species such as spotted ray, *Raja montagui*, which prefers sandy substrates whereas thornback ray tend to reside on gravel and pebble banks with mid- to strong current speeds (Ellis et al., 2005; Martin et al., 2012).

Furthermore, different life stages of rays aggregate in varying depths. For example, juvenile thornback rays remain close to shore in shallow waters (10-30 m) on soft, sandy sediment for several years until maturation (Walker et al., 1997). As they mature, they then migrate further offshore to deeper depths (close to 200m) to feed. The adult rays then return to spawn during the spring/summer period annually (Ellis et al., 2005). This was shown in a tagging study which reported rays expressed philopatric behaviour as individual rays and were found in the same site during spring/summer every year (Hunter et al., 2005). This “home range” shows rays exhibit high site fidelity, potentially resulting in localised impacts to discrete populations if overfishing occurs (Chevolot et al., 2006).

The combined results of recent trawl survey data and ecological studies highlight Lyme Bay as an important site for different life stages of ray species throughout the year.

FISHERIES FOR RAYS (RAJIDAE) IN THE RESERVE

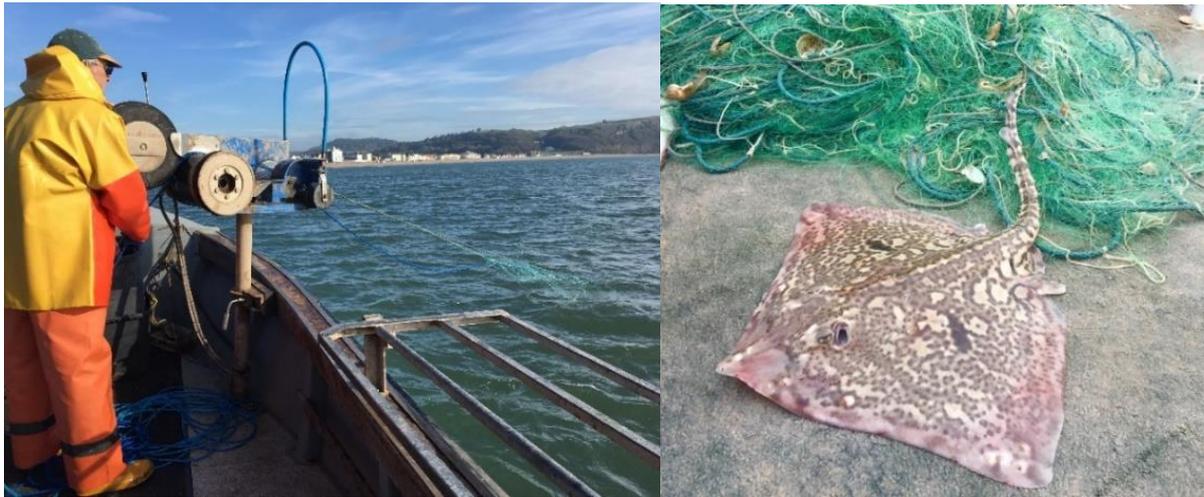
1. Commercial Fishery

Thornback ray is a commercially important species to demersal fisheries operating in European waters (Ellis et al., 2018). Along the UK coastline, rays are targeted in small-scale fisheries using longline and gillnets but are mainly landed as bycatch in demersal mixed fisheries (Chevolot et al., 2006). In 2017, 13% and 64% of thornback rays caught in ICES Division 7e were landed using beam trawls and bottom trawls, respectively. The remaining 18% were caught using static nets (ICES, 2018).

Within the Reserve, thornback ray are among a number of commercially important species targeted by the local mixed fishery using set nets. During certain times of year, skates and rays can comprise the majority of catch and therefore provide a valuable source of income. Concerns over the sustainability rating for thornback ray has sparked industry interest, from both local fishermen and market buyers, to conduct research into the conservation status of local ray stocks to ensure they are being sustainably managed.

Within the Reserve, out of the 32 boats signed up to the code of conduct, there are 19 boats which target skate and rays using set gillnets (see Fig. 2). This fishery will typically begin in September and continues throughout the winter months until April when the spawning adult rays return to the area (Chevolot et al., 2006). These gillnets are specifically designed in accordance with EU regulations which stipulate catches of skate and ray must be taken with a minimum mesh size of 220mm (8.7 inch) if over 70% of the catch is comprised of rays (EU

Regulation 850/98). Smaller mesh sizes are allowed if the catch is <30% skates and rays. Within the local fishing fleet, fishermen will deploy nets with larger mesh sizes, ranging between 10.5 and 12.5 inches to selectively target adult rays and reduce the bycatch of juveniles. The larger mesh sizes also allow other smaller bycaught individuals of other species to escape (pers. comms, anonymous, fisher from Lyme Regis)). Fishermen will stagger their nets horizontally to the incoming tide. It is believed the nets work better during spring tides due to the increase in sediment turbulence (pers. Comms, anonymous, fisher from Beer). Soak times (exposure of nets when set in the water) vary between 24-72 hours and the nets are hauled and flaked on board to immediately put marketable rays onto ice.



Left: Lyme Bay Reserve fisherman Gavin Ziemann hauling in ray nets off Seaton Beach. Right: A thornback ray, *Raja clavata*.

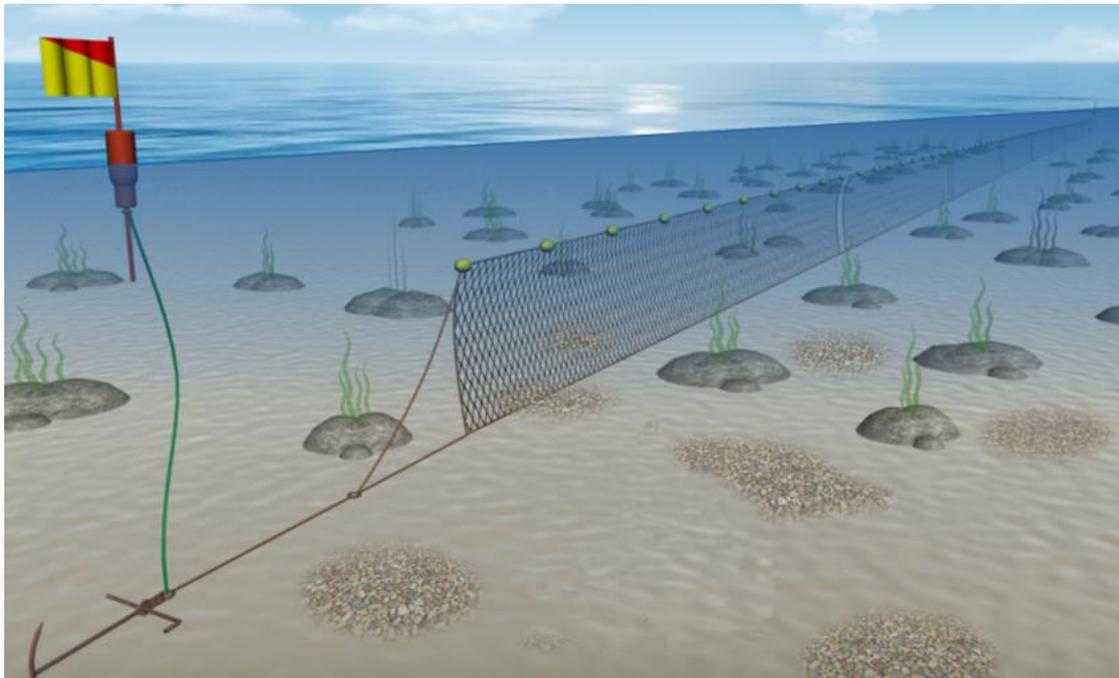


Figure 2. A deployed gillnet. Each end is anchored with a flag to mark its location. (Source: Seafish)

To further support the study and demonstrate the increase in landings from the Reserve, the number of skates and rays landed into Axmouth Harbour over the last three years was acquired from the MMO. All fishermen landing skates and rays into this port are signed up to the voluntary code of conduct. Due to data restrictions on accessing individual fishermen's landings, these port landings provide a reliable insight into the changes in ray landings for part of the fishery. Figure 3 demonstrates the significant, yet variable, increases in ray landings observed in 2016 and 2017, when compared to 2015.

The annual landings data were then compared to the allocated quota for the area in order to assess if landings have increased because of increased quota or other factors. These data are shown in Table 1 and show the increase in landed weight and value since 2015. The data also highlights the increase in the volume of landed rays between 2015 and 2016, from 0.1t to 1.35t (an increase of 93%), when quota remained the same (345.9t).

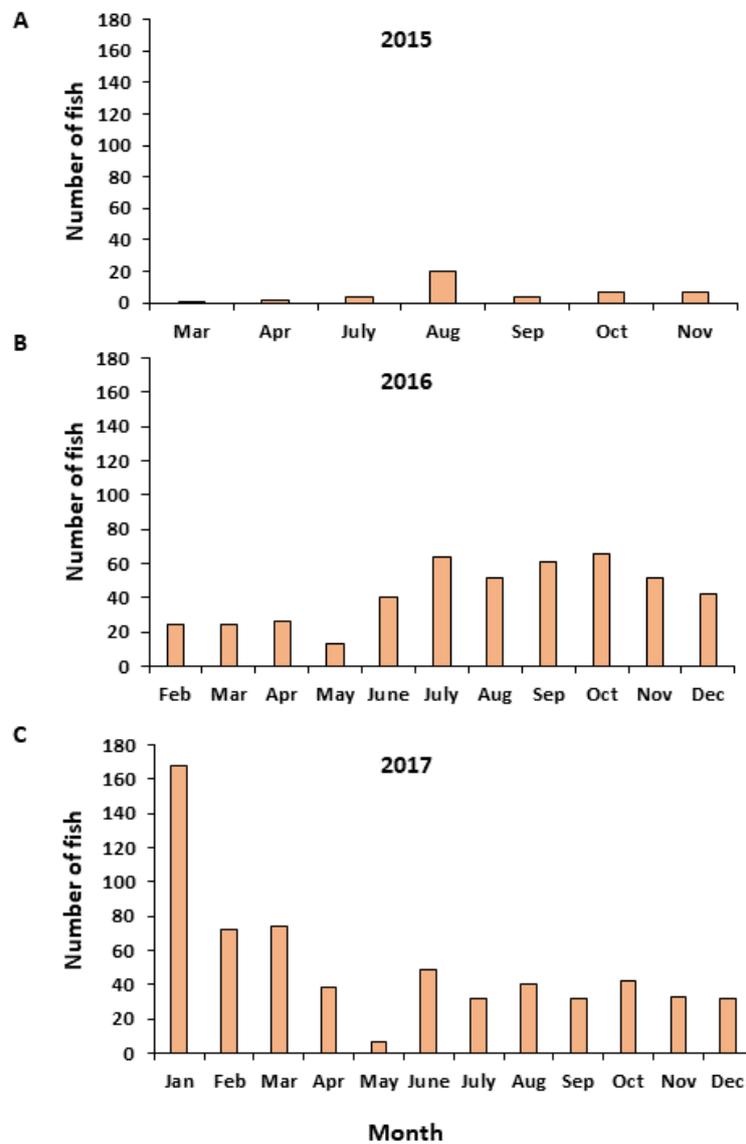


Figure 3. Monthly landings of the numbers of skates and rays into Axmouth harbour during, A, 2015, B, 2016 and C, 2017.

Table 1. Quota allocations for under 10m vessels in ICES Divisions 6, 7a-c, e-k and 7d alongside the landed weight and value of rays into Axmouth Harbour. Data sourced from the MMO.

Year	Area 6, 7a-c, e-k	Area 7d	Landed weight (tonnes)	Value (£000s)
2015	345.9	76.9	0.1	0.34
2016	345.9	92.9	1.35	3.23
2017	363.2	102.5	1.73	4.63
2018	417.8	123	-	-

2. Recreational Fishery

Over the past few years, the recreational fishing sector has grown, and anglers are recording an increase in the number of rays caught per trip (pers. comms, anonymous, recreational angler). Anecdotal information also conveys an encouraging picture of increasing population trends for endangered species such as small-eyed and undulate rays (pers. comms, anonymous, recreational angler). These species are typically caught from shore by anglers, whereas thornback rays are caught from boats further offshore inside the Reserve.

Rays are not a target species for anglers and are therefore mainly caught as bycatch. However, the number and diversity of species caught are growing and on average, an angler will catch between 2-3 rays per trip (pers. comms, anonymous, recreational angler). One angler stated, “a few years ago, it would be rare to catch as many in a month!”. Anglers will fish the entire shore length of the Reserve and have also observed different species preference for different grounds stating undulate and small-eyed rays are commonplace on hard, coarse sediment and thornback ray are more abundant on muddy and shingle seabed sediments.

In the UK, there is no management for skates and rays within the recreational sector. However, anglers fishing in the Lyme Bay area are encouraged to follow a voluntary Code of Conduct⁶ implemented through the Reserve project which includes precautionary measures such as always returning undersized individuals. Most anglers are members of sea angling clubs who record catch data and host regular competitions. During these events, every fish caught is returned as part of their “catch and release” policy. Interestingly, the membership of one of the local clubs has doubled in the last year indicating the Reserve’s popularity to recreational anglers. Utilising data from the recreational angling sector will be very useful going forward with the project.

To facilitate this, BLUE designed and encouraged recreational fishers to download a mobile app called Epicollect5⁷ to record ray catches. The app will ask a series of questions including GPS location, gear type, ray species, size, date and time, which will feed into this ongoing study. It is important to note, since the beginning of this project, we have had five entry points.

⁶ https://www.lymebayreserve.co.uk/download-centre/files/Lyme_Bay_Code_of_Conduct.pdf

⁷ https://five.epicollect.net/project/blue-marine-foundation/data?fbclid=IwAR3hO77D-Gc_osc4A8R0MRyontmhCcuOBxT9-KSOzo2WgFzeH_GGWTF2U2s

3. Management within the Reserve

Across the UK, fisheries management for skates and rays is minimal due to their lower economic value compared to other demersal species (Dulvery et al., 2000). Currently, skates and rays are managed under a total allowable catch (TAC) which is applied to a group of species rather than individual stocks. These include blonde, spotted, cuckoo and thornback rays. The combined skate and ray TAC in ICES Divisions 6, 7a-c, e-k has steadily increased and earlier this year, an increase of 5% on the 2018 quota was welcomed by the fishing industry as a reflection of stable catch rates experienced by fishermen (MMO, 2019).

For those species allowed to be landed, there is no national minimum landing size (MLS). However, the following IFCA's mandate a MLS of 40-45cm disc width for all skates and rays: Kent and Essex, North Western and Southern. Half of the Reserve sits within the Southern IFCA district, whereas the other half is managed by Devon and Severn IFCA who do not enforce a district specific MLS. This will have implications on the size of landed rays and therefore, introducing a MLS for the whole Reserve could ensure holistic management across the area.

Other management measures include the prohibition of landing certain species such as small-eyed ray, *Raja microocellata*, which must be returned; however, some endangered species are under restrictive management due to local abundances. A bycatch allowance of 100kg live weight is currently in place for undulate ray in ICES Areas VIId and VIle (MMO, 2019), yet elsewhere in the UK landings are strictly prohibited (pers. comm., MMO). From 1st March 2019 onwards, the bycatch allowance is set to decrease to 70kg and will apply across both ICES divisions to ensure the UK stays within its 58 tonne TAC⁸. Additionally, restrictions on minimum and maximum landing size and a closed period during May through to August will remain in place for ICES Areas VIId and VIle (MMO, 2019).

As a result, a high proportion of rays are discarded in this fishery. Fortunately, rays have been shown to have a high discard survival rate, depending on capture and handling methods (Catchpole et al., 2007; Ellis et al., 2008; Ellis et al., 2018). This is reinforced by evidence given to support the exemption of skates and rays from the Landing Obligation in European Union fisheries (MMO, 2018).

⁸ <https://www.gov.uk/government/news/undulate-ray-by-catch-allowance-in-the-english-channel>

AIMS AND OBJECTIVES

It is important to highlight, this project collaborated only with fishermen who adhere to the voluntary code of conduct, use iVMS and wish to sell their ray catches through Reserve Seafood. Out of 32 boats, 19 boats actively target rays within the Reserve. These fishermen were all involved in this study.

Project aims:

1. To determine the number of commercial fishing vessels targeting rays within the Reserve and the spatial extent of their fishing activities.
2. To investigate the main capture methods employed by the fishermen to evaluate the sustainability of the local fishery.
3. To quantify the catch composition of rays and the number of discards.
4. To identify additional appropriate management measures to further enhance the sustainability of the fishery.

Project objectives:

1. To assess current government landing statistics across the UK and acquire local landings volume into nearby ports.
2. To conduct multiple qualitative interviews with fishers to gather baseline data and anecdotal information on the fishery.
3. To carry out on-board research on multiple fisher vessels targeting rays. Morphometric data (size, sex and maturity) will be collected for landed and discarded rays. In addition, the types of fishing gear, soak times and the condition of the captured rays will be recorded.

METHODOLOGY

1. Qualitative interview data: commercial fishermen (see questionnaire in Appendix 1)

Within the Reserve, there are 19 fishermen targeting rays, all of whom were interviewed between July and August 2018. The breakdown of the number of fishermen targeting rays from each port is shown in Table 2. Interviews were carried out either face to face at one of the ports or on the phone. Fishermen were asked to answer several open and closed questions such as describing their netting gear and providing details of the most commonly caught species, average quantity and size of captured and landed rays. Additional information on the survival rates of ray discards, time of year they targeted ray and recommended management measures were also asked to inform potential conservation measures for the local fishery. Finally, the fishermen mapped their target areas for ray within the Reserve.

Table 2. Number of fishermen targeting rays at each port.

Port	Number of fishermen
Axmouth	8
Beer	3
Lyme Regis	5
West Bay	2

2. On board observer surveys

All data collection was conducted on board fishing vessels within the Reserve during October 2018 to February 2019. During this time, eight boat trips were carried out on four different boats from three of the four ports: Beer, Axmouth and West Bay. It is important to note a few fishermen also use sole nets to catch flat fish, which have a much smaller mesh size (5.5 inch), resulting in ray bycatch. These data are also included in the results but excluded when necessary. GPS coordinates of each fishing site were also recorded.

After each haul, all rays caught were identified and biological data (total length, disc width and sex) were recorded. The disc width and total length of all rays were measured to record the size class of the captured ray population, as well as calculate the number of sexually mature rays. This is measured from nose to tail (Total Length (TL)) for ray species. Thornback ray typically reach sexual maturity at 60 cm TL (Fowler et al., 2005). These data will be used to assess the number of rays caught and number of rays landed above MLS (40cm disc width), locally enforced by the Southern IFCA, and to help inform further conservation measures.

The condition of the captured rays was also noted and scored (0 to 4) on a qualitative scale: (0) Dead, (1) Scavenged, (2) Very sluggish, (3) Sluggish, or (4) Lively. This is a recognised, and robust method used in previous studies to assess the mortality of rays taken in coastal fisheries (Ellis et al., 2018).

Using these data, BLUE will be able to assess the population structure, abundance and diversity of different ray species currently within the Reserve and the impact of the capture methods on net-caught rays. The distribution of juvenile and adult rays will indicate the extent of the mature stock levels and juvenile abundance to help determine the current population dynamics. The relationship between the number of dead rays and soak times will help advise on appropriate soak times to minimise captured ray mortality in set nets.

3. Data analyses

Regression analysis was used to determine relationships between thornback ray total lengths and disc-widths. Chi-square tests were used to test for differences between male and female thornback rays and if they were discarded or sold, using MINITAB (MINITAB Inc, version 13.20).

The univariate and non-parametric multivariate techniques of the Principle Coordinate Analysis (PCO) package contained in PRIMER 6.1⁹ (PrimerE Ltd: Plymouth Routines in Multivariate Ecological Research) was used to explore relationships between discarded and sold thornback rays and different disc-width measurements. Similarities of sizes between discarded and sold thornback rays were examined using PERMANOVA, based on square-root transformed data in Bray–Curtis similarity matrices, using 4999 permutations.

RESULTS

1. Qualitative interview data: commercial fishermen

The results from the qualitative interviews revealed that set nets are the main fishing method used by 19 fishermen targeting rays. Mesh sizes for ray nets ranged between 10.5 and 12.5 inches, but the bycatch from sole nets is also included in the data analyses. Net length will vary between 200 m to 1000 m however multiple nets may be used at a time. Fishermen will tend not to exceed 1300 m of ray nets in total at any one time (pers. comms, anonymous, fisher from Beer). Net soak times were noted to range between 24 and 72 hours and fishermen perceived discarded rays to have a very high survival rate with eight fishermen predicting between 80-99% of discards survived.

Fishermen typically start targeting rays in September and continue through the winter until the beginning of May. This minimises the risk of catching juvenile rays and ensures a high proportion of net-caught rays have a disc width greater than 40 cm. This is supported by one fisherman stating, “ray species caught are typically much greater than 40 cm. Anything below 60 cm we tend to throw back”. Another fisherman added, “it’s not worth landing species sized 40 cm as you lose 60% of the fish when you take out the rump”. Furthermore, the current poor prices and low marketability caused a few fishermen to comment they would prefer to return smaller rays (≤ 50 cm) until prices increased. They believed it was a waste to land fish to Plymouth Trawler Agents for such a low return of £0.24 and £0.33 for size 5 and 4 thornback ray, respectively (pers. comms, anonymous, fisher from Lyme Regis).

The average quantity of ray catches can also vary depending on the time of year, tides (increased catches during spring tides) and the amount of gear in the Reserve (pers. comms, anonymous, fisher from Axmouth). However, fishermen would usually expect to catch between 10-50 individuals per fishing trip. Regarding species composition, thornback ray was the most commonly caught species with some fishermen quoting 60 - 80% of their ray catch to be thornback ray. Other species included undulates, small-eye, blondes, cuckoo and spotted ray. One fisherman explained, “the species of ray caught depends on the sediment you’re fishing on. If you shoot your nets on soft sediment, the catch proportion is likely to be 60% thornback ray and 40% undulate ray. Whereas on hard sediment, it’s likely to be 70% thornback ray and 30% undulate ray”. Another fisherman highlighted larger species tend to spend more

⁹Anderson M.J., Gorley R.N. & Clarke K.R. 2008. PERMANOVA+ for PRIMER: *Guide to Software and Statistical Methods*. PRIMER-E: Plymouth, UK

time on harder sediment so fishermen will target these areas to avoid catching smaller juveniles on the softer sandy sediment.

Lastly, fishermen were asked to recommend effective management measures to ensure the long-term sustainability of their fishery. 42% of fishermen suggested implementing a minimum landing size would be a good start. One fisherman said a maximum landing size would also be beneficial to protect larger females producing more eggs, as well as returning all pregnant females.

Three fishermen proposed a closed season as they reasoned there was already a natural closure in the summer to avoid catching juveniles and spider crabs near the shore. However, quite a few fishermen opposed this. One fisherman stated, “No point having a closed season as every time you shoot your nets you always get rays coming up. If I catch them in my net, I want to be able to sell them and I can't if I want to abide by the voluntary code of conduct to sell the rest of my catch through Reserve Seafood”.

As a solution, they suggested enforcing an annual landing limit which would create more flexibility throughout the year. Increasing net mesh size was also suggested, as well as limiting the amount of netting gear. Three fishermen refused to suggest management measures and one fisherman explained, “the measures fishermen use now are adequate”; a second fisherman said, “anything introduced would likely be what the fishermen were already doing”.

Interviews were completed by asking the fishermen to map the areas within the Reserve they frequently set their nets to target rays. All 19 fishermen participated, and this is shown in Figure 4. Fishing effort is mainly focused in the west of the Reserve, inshore, between Axmouth and Lyme Regis. This may be due to most netters originating from Axmouth Harbour. However, the location of the on-board observer surveys (black triangles) are further west due to the majority of participating vessels originating from Axmouth and Beer. Further surveys should be conducted out of Lyme Regis and West Bay to assess fishing patterns to gain a comprehensive understanding of fishing effort within the Reserve.

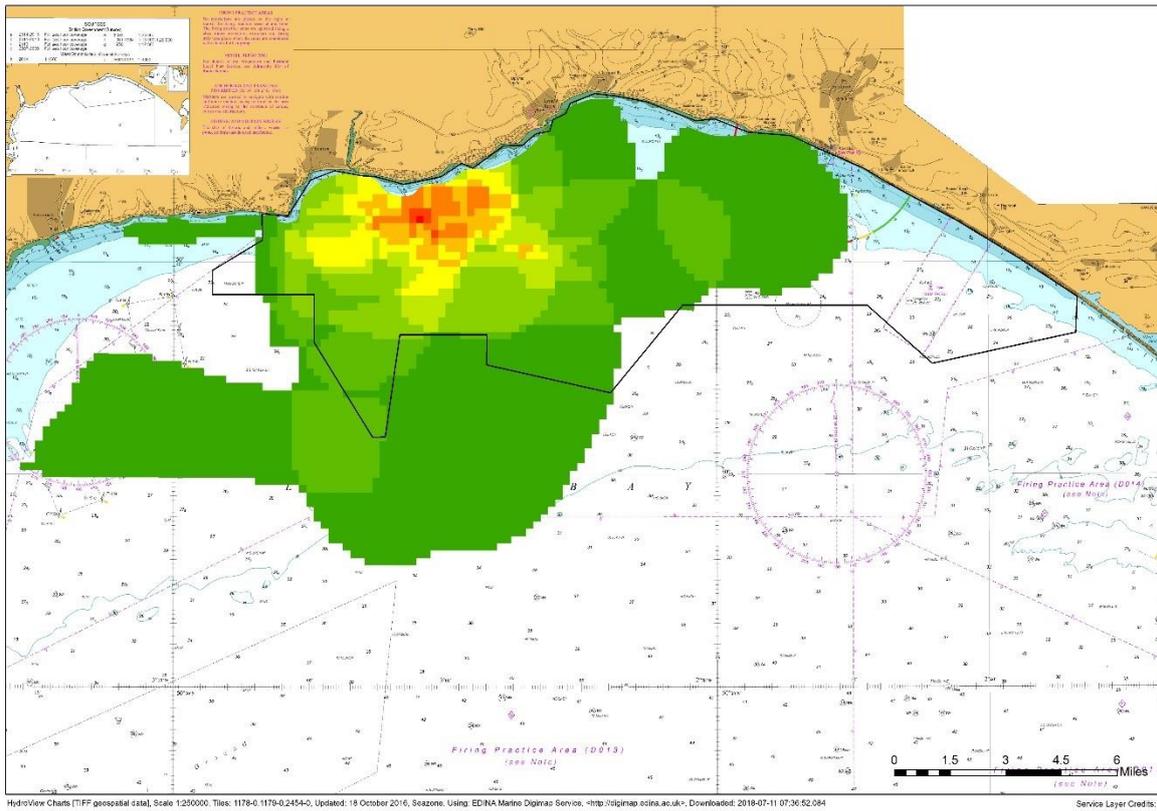


Figure 4. Heat map of the spatial distribution of the commercial fishing fleet, using static nets to target ray within the Reserve.

2. On board observer surveys

a. Abundance data

The total number of measured ray species caught within the Reserve was recorded between October 2018 and February 2019. Thornback ray were the most commonly caught ray species, almost 15 times higher compared to other ray species. During the five-month study 58 individual thornback rays were caught compared to four spotted rays, the second most abundant ray species caught (Fig. 5).

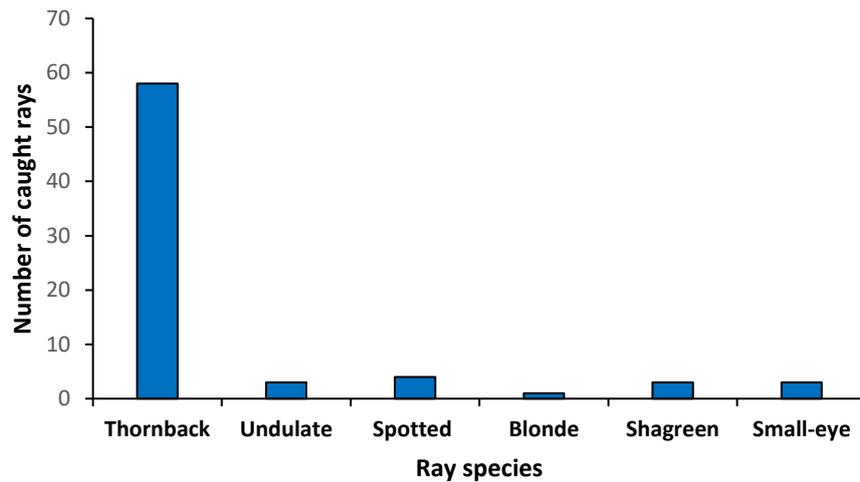


Figure 5. Abundance of each ray species caught and measured within the Reserve between October 2018 and February 2019.

Data collection was limited during this study and additional data were sent from two fishermen. A Lyme Regis fisherman sent one entry and a Beer fisherman sent nine entries. The combined data illustrate a similar pattern with thornback ray in highest abundance, with 311 individuals caught. Undulate rays are the second most abundant species caught, with 53 individuals (Fig. 6).

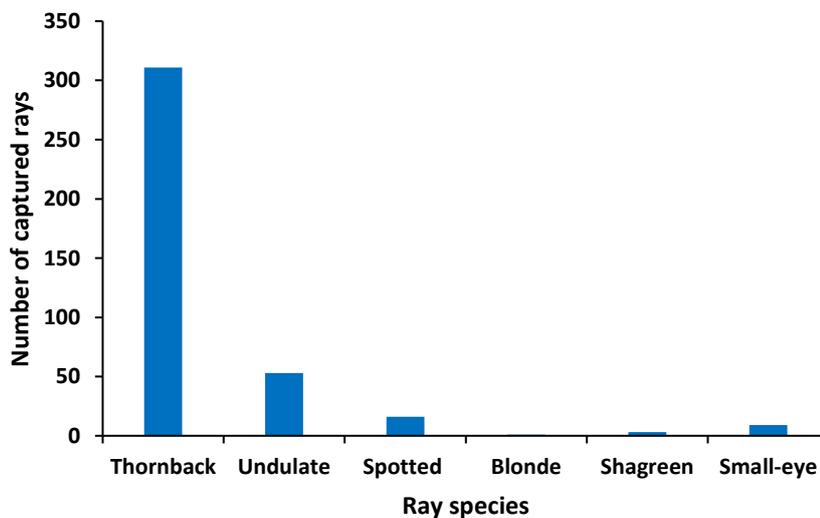


Figure 6. Total abundance data of ray species caught within the Reserve between October and February 2019 using data from on board surveys and provided by fishermen.

b. Size distribution
 i. Minimum Landing Size

Eighty-three percent of all measured rays were above the minimum landing size of 40 cm (Fig. 7). Some of these data were collected from bycatch in sole nets, using smaller mesh sizes of 5.5 inches. Out of the eight on-board surveys, seven sole nets and nine ray nets were hauled, respectively. Therefore, excluding the bycatch data, 96% of all rays caught in nets with 10.5-inch mesh size were above 40 cm.

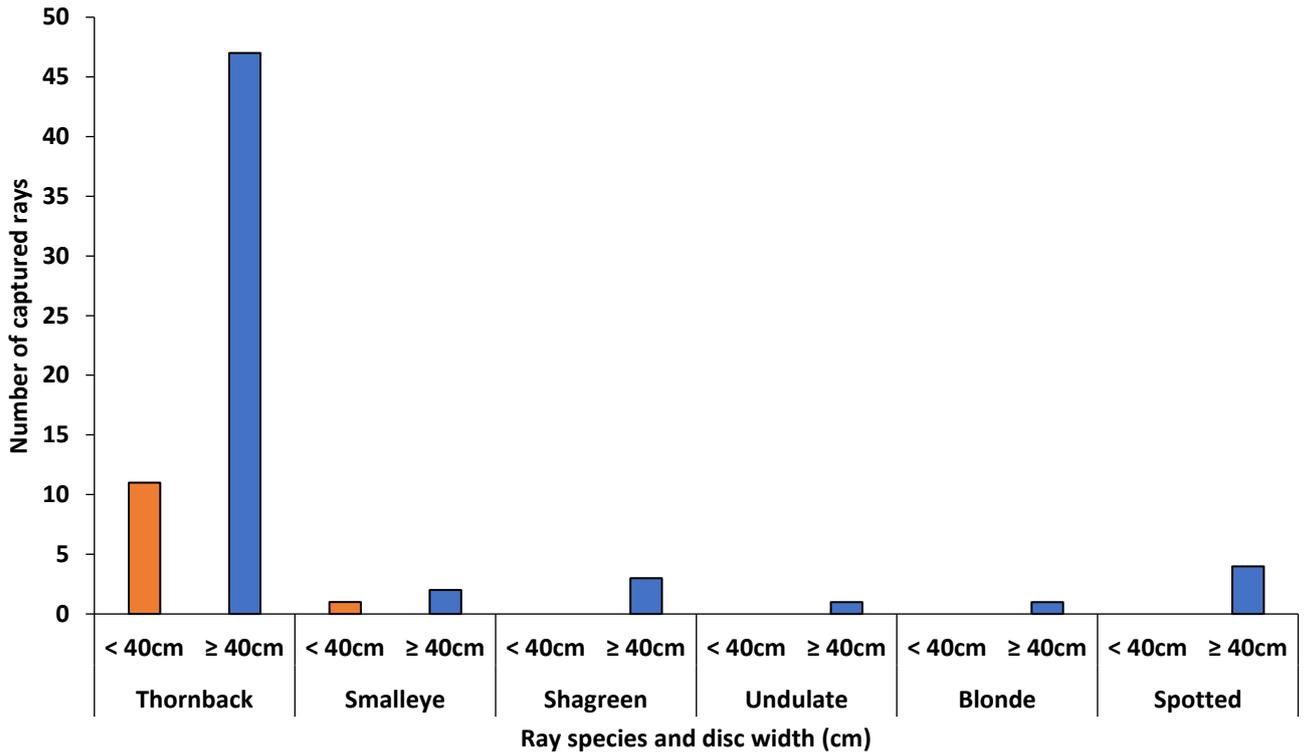


Figure 7. Number of rays caught above and below 40 cm (MLS enforced by Southern IFCA) for each species, including bycatch data.

ii. Sexual Maturity

Thornback rays attain sexual maturity at 60cm TL. The results show fewer juvenile rays were caught in the larger mesh size which highlights the selectivity of the fishing gear to target adult rays and reduce the number of discards (Fig. 8).

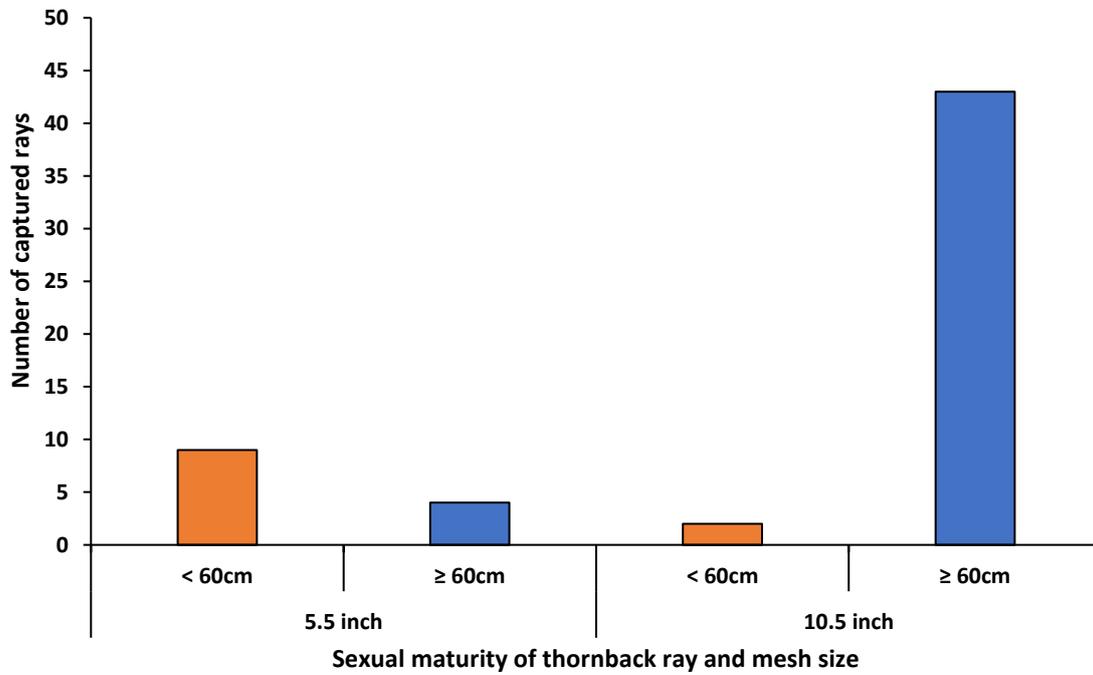


Figure 8. Difference in the number of sexually mature rays caught in two different mesh sizes.

Regression analysis (Fig. 9) determined that we could use disc-width as a proxy for thornback ray size with significant confidence (Fig.9, Regression analysis, total length vs. disc width: $F_{1,42} = 485$, $p \leq 0.001$, $R^2 = 92\%$). Of interest and highlighted within the red-dashed circle are data illustrating a cross-over of different sizes between discarded and sold thornback rays. Some large thornback rays were discarded, with some small rays landed and sold. Figure 9 can also be used to estimate sexual maturity and demonstrates that 60cm TL corresponds to 40cm DW. This can be used to inform a MLS above 40cm which ensures all captured and sold rays are sexually mature.

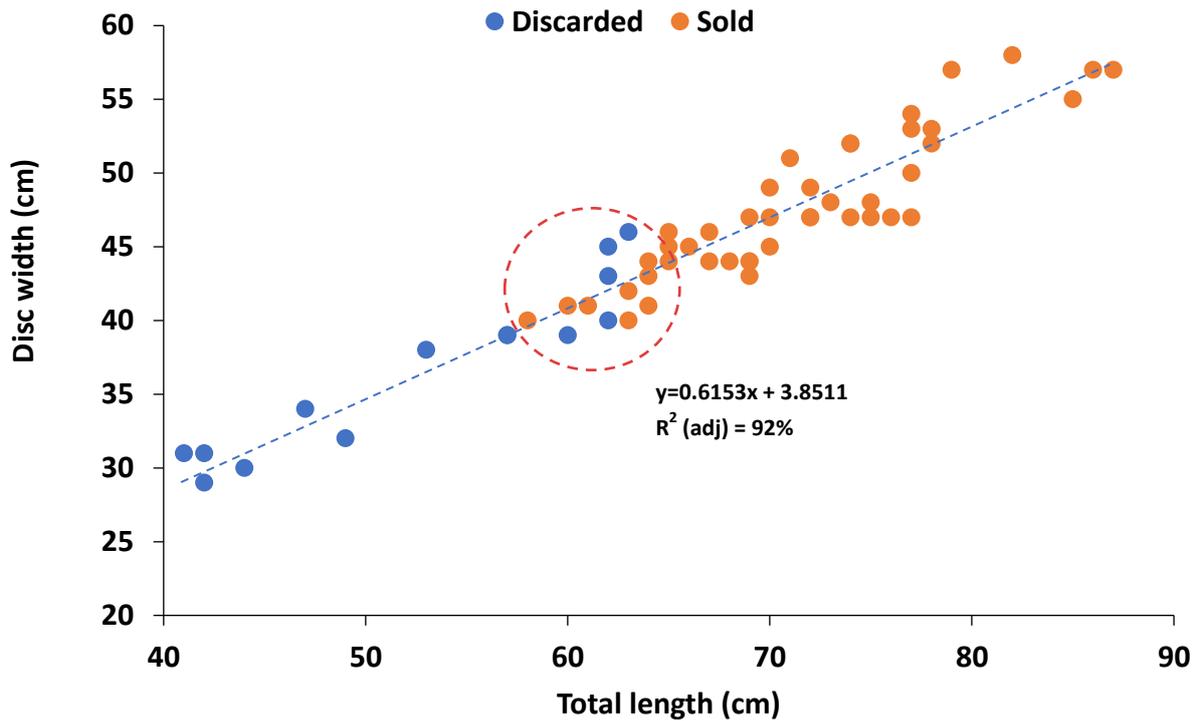


Figure 9. A very strong relationship between total length and disc-width of discarded and sold thornback rays. As total length increases, disc-width proportionally increases. Highlighted in the red-dashed circle = grouping of discarded and sold thornback rays of different sizes.

A Principle Coordinate Analysis (PCO) was used for visualising the correlations of the discarded and sold thornback rays (Fig. 10). Two significantly distinct groups highlighted by blue circles 1 and 2 were found (PERMANOVA, main test, $F_{1,42} = 95.5$, $p \leq 0.001$). Group 1 had similar disc-width sizes of discarded and sold thornback rays measuring more than or equal to (\geq) 40 cm. Group 2 contained only discarded thornback rays with disc-widths less than or equal to (\leq) 40 cm.

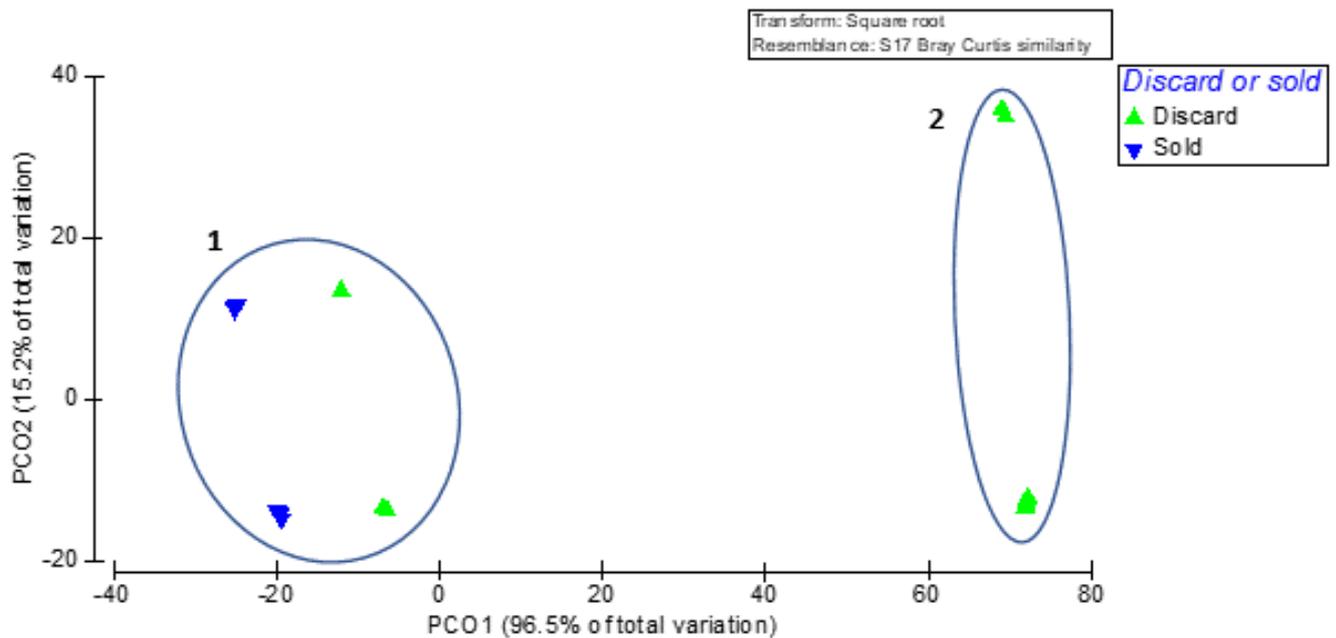


Figure 10. A Principle Coordinate Analysis (PCO), illustrating similarities and differences between disc-width measurements of discarded and sold thornback rays. Blue circles = groupings of similar disc-width measurements.

iii. Condition of caught rays

The arbitrary and qualitative 'condition' scale demonstrated that almost all rays, 97%, were lively (condition rating 4) when hauled from the nets during the on-board surveys (Fig. 11). Three per cent of the total netted rays had a condition rating of three (sluggish). All captured rays were alive when hauled onto the boat.

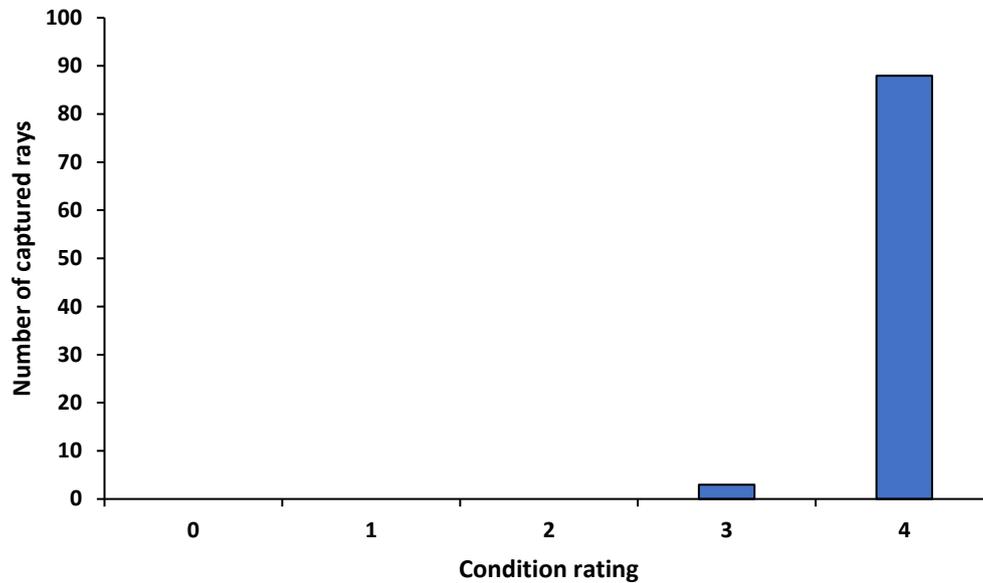


Figure 11. Arbitrary scale given to a 'condition rating' for netted ray species in the Reserve. Dead = 0, Scavenged = 1, Very sluggish = 2, Sluggish = 3, and Lively = 4.

Data limitations

It is important to acknowledge the data limitations of this study, (1) only eight on-board surveys were carried out, due to bad weather in January and February, (2) the small number of boats targeting rays in the scheme, and (3) the lack of capacity and resources for an observer to be constantly based in Lyme Bay. As a result of this, fishermen were urged to send data on the number and species of rays caught and landed to attain more abundance data. Only two fishermen sent additional data. This will be referenced when applicable.

DISCUSSION

The primary aim of this research was to gather data on the local ray fishery inside the Lyme Bay Reserve in order to assess the local fishery and inform appropriate management measures. This was achieved through qualitative interviews, combined with an on-board observer survey programme, using fishermen that currently target rays within the Reserve.

There are currently 19 boats targeting rays within the Reserve and every fisherman participated in the qualitative interviews. These fishermen use set gill nets with mesh sizes of 10.5 and 12.5 inches to target adult rays, which reduces the accidental bycatch of other demersal species and juvenile rays. This mesh size range is larger than the current EU

minimum. It was also noted that fishermen would usually return smaller, but legal-sized, rays due to poor market prices.

Unlike trawling, the set net method of fishing has a lower impact on non-target species and habitats as they are considered to be selective for target species and there is less by-catch and substrate damage than in mobile fishing methods (Pawson, 2003). Condition assessments showed that all rays hauled from the nets were found alive and in good condition. This is shown in the results from the on-board surveys declaring 97% of all caught rays to be in a “lively” condition. This could be due to their biological features such as their effective respiratory system reducing the need for ventilation; rough, protective skin made of denticles to minimise skin trauma; and the absence of a swim bladder which would greatly reduce the risk of barotrauma when hauled through different depths (Ellis et al., 2018). These features allow rays to stay in the nets unharmed for longer periods of time and would increase their chance of survival during longer soak times if an individual is discarded after being hauled. The exemption of skates and rays from the Landing Obligation in European Union fisheries supports permitting fishermen to return over-quota catches to sea.

Quantitative biological data from captured rays were gathered from on-board observer surveys. The results showed thornback ray to be the most abundantly caught ray species within the Reserve, comprising 81% of the species composition measured during this study. Onboard surveys were limited due to (1) only eight on-board surveys carried out, due to bad weather in January and February, (2) the small number of boats targeting rays in the scheme, and (3) the lack of capacity and resources for an observer to be constantly based in Lyme Bay. With this in mind, fishermen were asked to send through their own data to supplement the on-board surveys, however only two fishermen provided additional data. In total data for 393 caught rays were recorded from the on-board surveys and additional data from the two fishermen.

Thornback rays were the most commonly caught species (79% n=311), followed by undulate rays (14% n=53). The number of sexually mature rays was calculated using $TL = 60$ cm, with rays above this size considered to be sexually mature (Fowler et al., 2005). Analyses highlighted that thornback rays with a total length of 60 cm had a corresponding disc width of 40 cm. This suggests that the current MLS (40cm), enforced by Southern IFCA within the part of the Reserve where they have jurisdiction, is suitable as this ensures the majority of rays being caught are considered to be sexually mature. However, in order to ensure all caught rays are sexually mature ($TL > 60$ cm) throughout the Reserve, BLUE should propose the introduction of a MLS within Devon & Severn IFCA’s district and propose to the Reserve Consultative Committee an increase of the MLS to 45 cm or higher within the Reserve voluntary Code of Conduct.

The results show 96% of captured rays were sexually mature when nets with a 10.5-inch mesh size were used. This suggests that this mesh size is selective, targeting mature adult rays, and this evidence can be used to underpin appropriate mesh size recommendations for ray fishery management inside the Lyme Bay Reserve.

A further aim of this research was to assess the effectiveness of current management measures and suggest additional or amended measures where these could increase protection of stocks,

for uptake within the Reserve's existing voluntary Code of Conduct. Most of the fishermen gave a positive response when asked about implementing management measures. Many of the fishermen interviewed (42%) were in favour of including a MLS with other measures proposed including (1) larger mesh sizes to specifically target adult rays, (2) establishing a maximum soak time of 72 hours, (3) returning pregnant females and (4) abiding by best-handling methods to carefully return undersized or prohibited species. These measures are proposed as an addition to the voluntary Code of Conduct in Appendix 2. Currently, most fishermen are already operating within these measures and therefore there is a high degree of confidence that the introduction of these measures will be supported when presented to the fishermen and the Reserve Consultative Committee.

The results from this study demonstrate that fishermen operating within the Lyme Bay Reserve are using environmentally responsible capture methods that selectively target adult rays which, combined with appropriate handling methods, should minimise mortality of discarded rays. The nets were typically set over gravel or sand sediment to target preferred ray habitats, thus avoiding impact on the protected reef features of the MPA.

CONCLUSIONS

This study set out to collect data on the current small-scale fishery targeting rays, mainly thornback ray, in the Lyme Bay Reserve. Thornback rays are a data deficient species. This novel study has begun to build a dataset of the species diversity and abundance of rays being caught during commercial ray fishing, and also assesses the capture methods of the local fishery using static gear. So far, the results are positive and show the low impact on the local ray population, notably demonstrated by the very high number of rays recorded to be in good condition. All landed and sold rays were above 40 cm and a high proportion of rays caught were sexually mature. These data will inform recommendations for additional measures to be introduced to the Lyme Bay Reserve voluntary Code of Conduct (see Appendix 2) and as evidence to support additional byelaw measures within the wider Lyme Bay area. The addition of species-specific management measures for rays will contribute to the progress being made by BLUE and the inshore fishery to develop and improve the conservation status of thornback ray and sustainability of the targeted fishery. If the data is also sufficient to achieve a favourable MCS Good Fish Guide rating for thornback ray in the Reserve, fishermen will be able to sell more of their catch under the Reserve Seafood brand. This will allow the fishermen to earn a higher price in recognition of their dedication to fishing sustainably and adhering to the voluntary codes of conduct.

RECOMMENDATIONS

- Collate landings data from individual fishermen operating within the Lyme Bay Reserve and from the MMO to understand CPUE.
- Carry out further on-board observer studies on a greater number of vessels that target ray to better understand the local fishery, fishing practices and landings.
- Use the data to inform improved management of the local ray fishery through introduction of additional measures to the Lyme Bay Reserve voluntary Code of Conduct:
 - MLS of 45cm (disc width) for thornback ray
 - Minimum mesh size for ray nets of 10.5 inch or more
 - Soak times not to exceed 72 hours when targeting rays
 - All pregnant females to be returned
- Further research should then be undertaken to assess the effectiveness of any conservation measures and how these measures affect the local ray stocks.
- Submit the data to the Marine Conservation Society (MCS) to inform a specific rating in their Good Fish Guide for ray species caught within the Reserve.
- Work with The Shark Trust to introduce and promote a Best Practice guide for handling and discarding skates and rays for commercial and recreational fishermen.

FURTHER RESEARCH

Due to the constraints of the survey efforts, data limitations and the variability in ray fishing over the winter 2018/2019, there are some research questions that have not been addressed in this study:

- Are there any discrete sub-stocks of ray species found in Lyme Bay and if so, what is their status?

Action: Conduct a tagging study on species of interest to establish local stock dynamics and to inform whether any local populations could/should be managed separately from the wider stock.

- What are the landing trends and how does this compare to Reserve Seafood landings?

Action: Review local landings, targeting boats that use the Reserve but may not be from local ports. This might be achieved through a request for landings information from the MMO and/or through a review of current landings data. Although this will have constraints as identifying individual landings from vessels is not currently possible.

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APPENDIX 1

SKATES AND RAY SURVEY
COMMERCIAL FISHERMEN FORM

Name	
Port	
Boat Name	
PLN number	
Boat size	
Number of crew	
Fishing gear	
Mesh size	
Time of year targeting rays	

Which species do you commonly catch? Please provide a rough percentage estimate.	
On average, what is the quantity of each skate and ray species caught?	
What is the average disc width for each species caught? (or size class?)	
How many juveniles do you catch?	
If you could hazard a guess, what is the survival rate of live discards?	
Do you currently follow any codes of best practice for handling discards?	
In your opinion, what management measures could be effective to make the Reserve a sustainable fishery for skates and rays?	
What route to market do you usually sell your skates and rays through?	

APPENDIX 2



Lyme Bay Fisheries and Conservation Reserve

Thornback Ray Code of Conduct

- Fishermen will only land thornback ray above 45cm (disc width)
- Mesh sizes for ray nets will be a minimum of 10.5 inch or more
- Soak times will not exceed 72 hours when targeting rays
- All pregnant females will be returned
- Fishermen targeting rays will adhere to the [Shark Trust's Best Practice: Sharks, Skates and Rays](#) good handling guide to carefully return undersized or prohibited species.