2023-03

The socio-economic impact of Marine Protected Areas in Jersey: A fishers' perspective

Blampied, SR

http://hdl.handle.net/10026.1/20359

10.1016/j.fishres.2022.106555
Fisheries Research
Elsevier BV

Fisheries Research 259 (2023) 106555

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

The socio-economic impact of Marine Protected Areas in Jersey: A fishers' perspective

Samantha R. Blampied [a,*], Emma V. Sheehan [a], Martin J. Attrill [a], Francis C.T. Binney [b], Sian E. Rees [a]

[a] University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK
[b] Government of Jersey Marine Resources, Natural Environment, Howard Davis Farm, La Route de la Trinitie, Trinity JE3 5JP, Channel Islands, UK

ARTICLE INFO

Handled by Cameron Speir

Keywords:
Marine Protected Areas
Fisher well-being
Static
Mobile
Socio-economics

ABSTRACT

Marine Protected Areas (MPAs) are advocated as tools to support sustainable fisheries and biodiversity by excluding the most destructive fishing practices. Some MPAs protect the whole-site of habitat mosaics from bottom-towed fishing but most only restrict damaging activities from specific evidenced conservation features. Social and economic factors influence the success of an MPA but the impact of spatial management changes to local fisheries is rarely captured in post MPA designation monitoring. In Jersey, Channel Islands, two offshore MPAs were designated in 2017 that are managed following the whole-site approach. This study provides an insight into the overall economic importance of key fishery species (whelk (*Buccinum undatum*), brown crab (*Cancer pagurus*), scallop (*Pecten maximus*), lobster (*Homarus gammarus*), and spider crab (*Maja brachydactyla*) to local fishing fleets and the impact of the MPAs on local, small-scale fishers in Jersey. Total landings (kg and £) in Jersey pre and post MPA designation were calculated from logbook and primary sales data and a structured interview was developed and tested as a research tool to document the impact (positive and negative) of the MPA designation on local fishers. Specific questions were designed to elicit both quantitative and qualitative data relating to the participants ($n = 21$) fishing activity; support for the MPAs; income and job satisfaction; subjective well-being and current sales strategies. The results demonstrate that one mobile gear vessel respondent was displaced from traditional fishing grounds as a result of the MPA designation. Fishers also reported an increase in static fishing inside the MPAs, post designation. Generally, there are high levels of support for the MPA from static fleet respondents. In the first year since designation there have been no reported changes to catch (kg, £). Mobile gear fishers reported a lower subjective wellbeing and satisfaction with their job and income than static gear fishers, despite greater profits. The major concern reported by the mobile fleet that contributed to their stress levels, was not attributed to the MPA designations but related to conflict with French static net fisheries operating outside of the MPAs. Ongoing support for Jersey's fishers and securing a sustainable and fulfilling livelihood will require further spatial management of fisheries outside of the MPAs with a possibility of setting gear or effort limits on static fishereis within the MPAs.

1. Introduction

The ocean provides a range of ecosystem services that underpin human wellbeing (Millennium Ecosystem Assessment, 2005; UNEP, 2006). Demand on ocean resources has been increasing, particularly on seafood as a source of food and income, and in 2018 approximately 59.5 million people were employed globally in the primary sector of fisheries (FAO, 2020; UNEP, 2006). The sustainable management of ocean resources is essential to support human well-being (Reimer and Devillers, 2021; UN General Assembly, 2015). The United Nations Sustainable Development Goals (SDGs) have outlined a number of targets to achieve sustainable development of natural resources (UN General Assembly, 2015). SDG Goal 14 in particular applies to the sustainable use of oceans, seas and marine resources. The implementation of Marine Protected Areas (MPAs) to conserve biodiversity that underpins social and economic development is integral towards achieving this goal.

* Corresponding author.
E-mail addresses: s.blampied2@gov.je (S.R. Blampied), emma.sheehan@plymouth.ac.uk (E.V. Sheehan), martin.attrill@plymouth.ac.uk (M.J. Attrill), f.binney@gov.je (F.C.T. Binney), sian.rees@plymouth.ac.uk (S.E. Rees).

https://doi.org/10.1016/j.fishres.2022.106555
Received 18 May 2022; Received in revised form 6 November 2022; Accepted 9 November 2022
Available online 23 November 2022

Fisheries are a socially and economically valuable industry that operate both inside and outside MPAs. Ultimately, fisheries depend on ecosystem functions and processes to enable the exploitation of commercial fish species (Dobson et al., 2006; Staples and Funge-Smith, 2009) and it is only within MPAs where these functions and processes are protected. It remains that the exploitation of fish species above ecologically sustainable limits is one of the biggest threats to this resource (Pauly et al., 2005), and despite both national and international management measures, there are still declines in fish stocks (Claudet et al., 2020; Halpern et al., 2008). Along with persistent fishing effort, there are various fishing methods globally that also damage the habitats that fish depend upon at various points in their lifecycle. Mobile fishing gear such as trawls and dredges that drag along the seafloor are considered one of the most destructive due to the abrasion of the seabed that can have negative impacts to both habitats and associated species (Hall-Spencer and Moore, 2000; Hiddink et al., 2017; Thrush and Dayton, 2002; Tillin et al., 2006). Mobile bottom-towed fishing gears (hereafter referred to as mobile gear) can also cause conflict with other fishing sectors by intersecting spatially with static gear fisheries (Hattam et al., 2014), causing direct damage to target species (Beukers-Stewart and Beukers-Stewart, 2009; Kaiser and Spencer, 1995), and through degradation of habitats that support other commercially important species (De Grave and Whitaker, 1999; Stewart and Howarth, 2016; Thrush and Dayton, 2002).

The restoration and recovery of marine biodiversity can be realised through the exclusion of mobile fishing gears inside MPAs (Davies et al., 2021; Sheehan et al., 2013b). Typically, MPAs are established to protect or enhance biodiversity (Lester et al., 2009; Zupan et al., 2018) but they are also important for securing socio-economic benefits through increased provision of ecosystem services (Costanza et al., 1996; Dasgupta, 2021) and by conserving ecosystem function that can support greater fish biomass, including commercial species biomass (Beukers-Stewart et al., 2005; Brown et al., 2010; Willis et al., 2003). While highly protected MPAs are most beneficial to improve the status of biodiversity (Edgar et al., 2014; Lester and Halpern, 2008; Sala and Giakoumi, 2018), the level of protection afforded to MPAs varies greatly (Day et al., 2012; Greathead et al., 2020). Despite the evidence, it may not always be socially or politically acceptable to achieve a high level of protection, given the range of ocean livelihood dependencies.

Fisheries and MPAs have traditionally been in conflict (Hattam et al., 2014; Rees et al., 2013b), with social and economic costs of MPA management measures felt in the fishing sector. These costs are not equally distributed (Hattam et al., 2014), with some sectors experiencing losses in catch and increased distances to fishing grounds (Mangi et al., 2011), compared to others that will benefit from reduced fishing pressure within the MPA boundary (Rees et al., 2021b). Conflict may increase between stakeholders where there is a perceived benefit to one group over another (Agardy et al., 2011). MPAs that have excluded mobile gear while allowing other extractive activities to continue have resulted in low levels of support from mobile fishers (Rees et al., 2013b). There are clear synergies between conservation objectives of MPAs and fisheries management (Rees et al., 2020). It is argued that linking the social and ecological systems in MPA placement and purpose with small scale fisheries objectives may improve the ecological and socio-economic outcomes for both fisheries and conservation (Rees et al., 2020; Reimer and Devillers, 2021). Setting both social and ecological baselines within a long term MPA monitoring programme is therefore key to determine whether MPAs are meeting principle objectives. This is crucial to the long term success of an MPA, as MPAs that do not meet their objectives risk losing trust from stakeholders in management authorities, with detrimental effects on desired conservation objectives (Pendleton et al., 2018).

The most immediate and documented impact of MPAs is the shift in fleet dynamics, through the displacement of fishing, changes to gear types and effort; and this can have implications on social factors in the form of increased conflict, loss of or changes to expected income or increased competition for the same resource (Mangi et al., 2011; Rees et al., 2021b). These changes in fleet dynamics may have consequences for fish stocks and benthic habitat health, with increased fishing effort of excluded gear types outside of the MPAs and a proliferation of permitted gear types within the MPA. Movement of permitted fishing methods into the MPAs may reduce the expected benefits of an MPA, such as increased abundance of exploitable species (Davies et al., 2021), and therefore expected income. Increased potting effort inside an MPA may result in reduced catch of commercial crustaceans (Mangi et al., 2011; McClanahan and Mangi, 2000; Rees et al., 2021a), masking a potential fishery economic benefit to potting sectors from the exclusion of bottom-towed fishing. Quantifying such shifts in small scale fleets is problematic due to a lack of VMS data from small (<12 m) vessels, and therefore relatively little spatial information is available both pre and post MPA designation. It is therefore necessary to obtain this information through other means to improve the monitoring and management of MPAs.

It has been shown that stakeholder engagement and support can influence the ability of a MPA to meet its conservation and socio-economic objectives (Gall and Rodwell, 2016; Giakoumi et al., 2018; Rees et al., 2013b), as effective stakeholder participation in the designation process can help manage expectations of MPAs (Pomeroy et al., 2005). In order to align the objectives of MPA and fisheries management, there is a need to track the performance of MPAs and associated socio-economic impacts that may underpin the ability of an MPA to provide both conservation and fishery benefits. Understanding the attitudes of key stakeholders is an important consideration of ongoing monitoring and will aid in the determination of MPA success, and effective management and enforcement (Gall and Rodwell, 2016).

To understand how MPAs impact local fishing communities and identify where these impacts can be minimised, improved engagement and communication with the fishing community is essential. This study aims to set a baseline of the socio-economic impacts (positive and negative) of a MPA designation to better inform fisheries and MPA co-management approaches that will provide long term benefits for biodiversity and linked livelihoods. We undertake this study in a case study area of Jersey where two MPAs have recently been designated. Specifically, we aim to:

1) Characterise the primary sectors (mobile and static) of the fishing fleet and their economic value (pre and post MPA designation).
2) Document the levels of support for and perceived compliance within the MPAs.
3) Quantify the impact of the MPAs to local fishers in terms of fishing frequency and location.
4) Assess the impact of the MPAs on fisher wellbeing across mobile and static sectors.
5) Investigate differences in turnover and profit between static and mobile fleets.
6) Determine the sales strategies of each sector (pre and post MPA designation).

2. Case study site

Jersey's marine environment supports mobile, static and Self-Contained Underwater Breathing Apparatus (SCUBA) diving fisheries, targeting a range of benthic, demersal and pelagic fish, but primarily benthic shellfish comprising lobster (*Homarus gammarus*), brown crab (*Cancer pagurus*), spider crab (*Maja brachydactyla*), scallop (*Pecten maximus*), and whelk (*Buccinum undatum*). To protect areas of fragile habitat and high biodiversity associated with two offshore reefs in Jersey's territorial waters, two Marine Protected Areas (MPAs), which excluded mobile fishing gear, were designated in 2017 (Chambers et al., 2020) around the Minquiers and Ecrehous (Fig. 1). Within the MPAs, static fishing (pots, nets, and lines), scallop diving, and low water fishing are permitted. Unlike many MPAs in the UK, Jersey's MPAs are not 'feature' based in that only specific features of conservation interest are

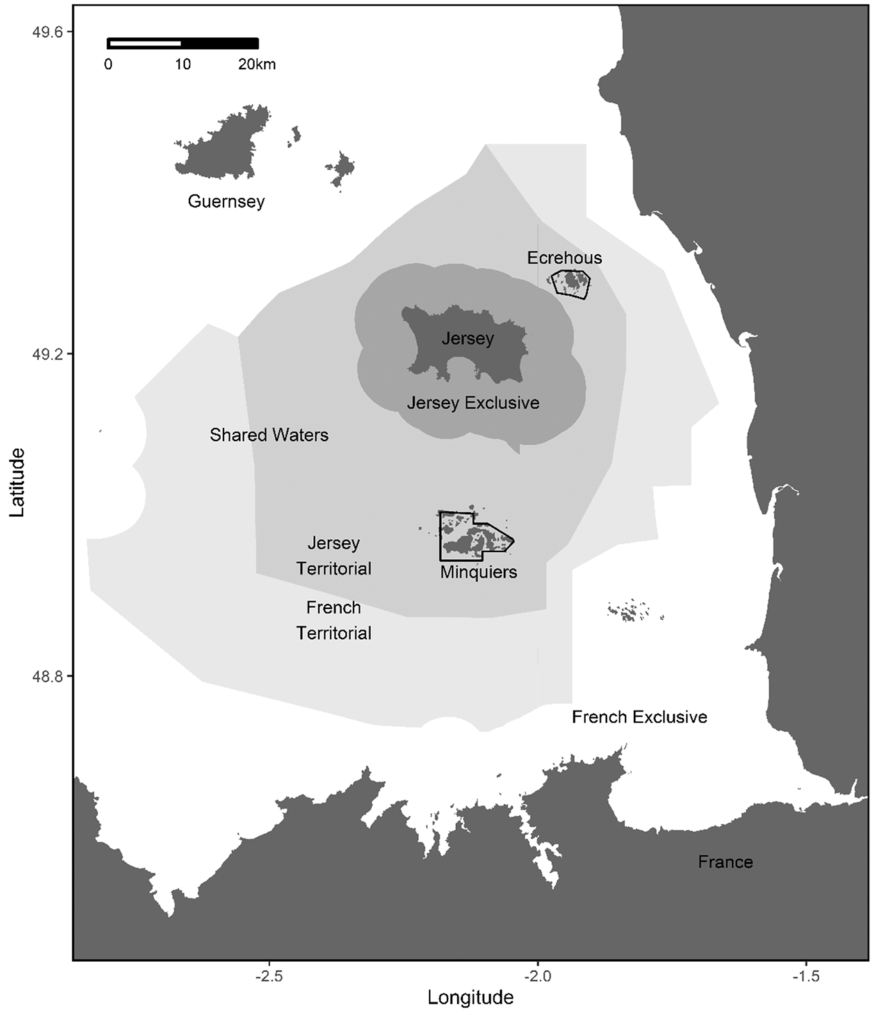

Fig. 1. Location of MPAs at the Ecrehous and Minquiers (transparent polygons) in relation to Jersey and France and each nations territorial boundaries.

managed within the MPA (Solandt et al., 2020). Instead the MPAs follow a whole-site approach whereby mobile fishing is not permitted anywhere within the MPA boundaries, representing an ecosystem based approach to fisheries management (Pikitch et al., 2004; Pitcher et al., 2009; Solandt et al., 2020).

The majority of the static fleet are made up of fishers using pots, targeting either crab and lobster, or whelk. The highest value fishery in Jersey is the static crab and lobster fishery, which comprises approximately 70% of all fisheries landings value (Marine Resources, 2019). Crab and lobster are caught using a mixture of pots (inkwells, creels, D-pots and parlour pots). The mobile fishing sector is the smallest in terms of number of vessels (5% of all vessels) and primarily comprises vessels equipped for dredging for scallops. The MPAs are located in an area of shared waters that is fished by both Jersey and French vessels but fall within Jersey's territorial waters and are therefore under Jerseys' jurisdiction. Static gear fishing and scallop diving occurs both inside and outside the MPAs in Jersey. As a result of the MPAs being fished locally by small vessels without Vessel Monitoring Systems (VMS), and by French vessels from which landings data were not attributable to the MPAs, it was unknown how many fishers were operating in the MPAs prior to the closures.

3. Methodology

3.1. Data collection

The research used a combination of quantitative and qualitative approaches to capture information on the social and economic impacts experienced by stakeholders in Jersey following the designation of the two MPAs. The data only represents the Jersey perspective. French stakeholders were not approached due to ongoing political sensitivity over fishing rights in Jersey's territorial waters as a result of the UK's withdrawal from the European Union that resulted in previous fishing agreements between Jersey and France being legally void.

3.1.1. Catch composition of the Jersey fleet

Landings data and primary sale prices supplied by the States of Jersey Marine Resources team was used to calculate overall landings weight and value for the whole Jersey fleet. It was not possible to attribute this information to the MPAs and is instead used to highlight the key commercial species targeted by the fishing community.

3.1.2. Interviews

A questionnaire was developed to collect data on fisher perceptions, change in fishing activity, well-being, and sales strategies resulting from the exclusion of mobile gear from the two MPAs (Appendix). Questionnaires were used to guide face-to-face interviews (n = 21), but postal surveys were also used when fishers were not available to attend an interview, postal surveys were only included where answers were sufficiently detailed (n = 2). Quantitative data were gathered by asking respondents to give scores on a Likert-type scale between 1 and 10. Qualitative data was generated from several open-ended questions relating to changes in their fishing strategies and views on current management. Information relating to income was obtained by asking respondents to state annual turnover and estimated percentages of associated annual costs from which profit could be estimated. Sales strategies were assessed by asking respondents, as a percentage, where each landed species was sold to, and whether this had changed between 2017 and 2018. Responses were recorded on paper during the interview and, where respondents permitted, interviews were recorded using a dictaphone to aid in transcribing responses post-interview. Ethical approval was granted from University of Plymouth prior to conducting work involving human participants.

3.1.3. Fishing sectors

The respondents were split into mobile and static sectors depending on their primary fishing method. This was considered a necessary distinction as the mobile fleet was the only sector that had been excluded from the MPAs and therefore were expected to report differing opinions to the static sector. The static sector is a combination of potting, netting and diving fishers due to the tendency of netting and diving being used to supplement potting activities rather than being a sole fishing method. At the time of the survey, there were 149 vessels registered as commercial fishing vessels in Jersey, and 73 of these considered to be full time (>100 days fished a year). Only primary owners of vessels were surveyed. It was not possible to ascertain which fishers predominantly operate in the vicinity of the MPAs from vessel logbooks as the areas they must report their catch from are large and are not specific to the MPAs. Instead, fishers operating close to the MPAs (inside or adjacent to the boundaries within the five years preceding their designation or, for static fishers, following designation) were identified though liaison with the Government of Jersey (Marine Resources pers. comm), and through communication with local fishers. Upwards of 40 fishers were contacted in addition to targeted posts on relevant social media outlets to increase the number of fishers reached, but many declined to being interviewed or did not show up to interview. This resulted in a total of 21 fishers surveyed (18 full time, 3 part time). Commercial vessel lengths in Jersey vary between 3.6 and 18.5 m, with an average length of 6.8 m. Of those surveyed, vessel length varied between 5.8 and 17 m with an average of 8.6 m. The larger average vessel size is likely a reflection of full-time vessels, such as the majority of those owned by the fishers surveyed, being of a larger size. To confirm how representative these fishers were in representing the broader fishing interests beyond the MPAs we calculated the contribution of these fishers to overall fishing effort in Jerseys waters through matching the vessel identifier (PLN) with the number of reported trips taken. We surveyed 57% of the mobile gear fleet (n = 4), who undertake 64% of all Jersey registered mobile gear fishing in Jersey's waters (Table 1). We surveyed 12% of the static gear fleet (n = 17), who undertake 19% of all Jersey registered static gear fishing in Jersey's waters (Table 1). The percentage of fleet was calculated from the number of vessels interviewed compared to all vessels. Many fishers work part time and so the percentage of fishing activity was derived from trips per year (2017 and 2018) of interviewed vessels compared to total trips for all vessels from the Government of Jersey Marine Resources database*. In addition to fishing effort, these vessels were considered representative of the primary fishing activities in Jersey for the two sectors considered (mobile and static) as mobile fishing is predominately scallop dredging (all mobile gear respondents were scallop dredgers) and static fishing is predominately pots, with some diving (static respondents were typically potting fishers with some supplementing their fishing with diving, and only two respondents were full-time scallop divers).

Table 1
The primary fishing method of fishers interviewed presented as a percentage of the fleet and a percentage of fishing activity for each sector averaged over 2017 and 2018.

Sector	Number of registered vessels	Number of interviews	Percentage of fleet	Percentage of fishing activity*
Mobile	7	4	57	64
Static	142	17	12	19

3.2. Data analysis

3.2.1. Catch composition of the Jersey fleet

Catch composition was calculated from landings data of all Jersey vessels. Commercial fishers in Jersey are required to submit logbooks, which state their catch in kilograms for every fishing trip. Data for trips between 2015 and 2018 were obtained from the Government of Jersey Marine Resources team and used to calculate yearly landings for commercial species that contribute 99% of landings by weight (kg).

Landings value (first sale wet weight) of key target species in Jersey was calculated by multiplying the landings weight by the primary sale value to give an annual landings value (£) per target species for mobile, static and diving vessels. Data on primary fish sales in Jersey were based on quarterly buying prices (wet weight) from a local vendor (The Fresh Fish Co) between 2015 and 2018.

3.2.2. Interviews

The Likert scores from respondents were used to assess the distribution of responses in relation to the overall average, stated values are the mean, ± standard deviation. Income and associated costs were assessed by calculating averages of percentage costs separately for the mobile and static sectors. The percentage of profit was used to estimate the monetary value of profit from each respondent's annual turnover. Sales strategies were assessed by averaging responses for each sector. For all analyses, fishers were categorised into two groups: static (potting and diving) or mobile, representing the predominant gear type used.

4. Results

4.1. Catch composition of the fleet

The primary species targeted by the fleet are shellfish (Fig. 2), consisting of whelk (*Buccinum undatum*), brown crab (*Cancer pagurus*), scallop (*Pecten maximus*), lobster (*Homarus gammarus*), and spider crab (*Maja brachydactyla*). Whelk landings have been increasing overall over the four years, with the largest increase observed in 2018 (838,942 kg), compared to 2017 (345,999 kg). Lobster landing were in consistent decline over 2015–2018, with the largest decrease observed between 2017 and 2018 where landings dropped from 237,837 kg to 196,019 kg (Fig. 2). Spider crab landings increased each year, with 207,449 kg landed in 2017 and 293,569 kg in 2018. Brown crab landings peaked slightly in 2016 (348,500 kg) but declined in subsequent years, with the lowest landed weight observed in 2018 (292,987 kg). Overall scallop landings were relatively uniform across the years (Fig. 2).

These five species constitute 94% of all fisheries landings and are worth approximately £ 7.5 million annually over the period considered (2015–2018). Of these, lobster is notably the most economically valuable species with an average of £ 4.1 million per year in primary sales (Fig. 3). The primary sale price of fish to vendors has been relatively stable between 2015 and 2018 (Fig. 3), with changes in total value a reflection of the change in landed weight. Over the time period surveyed in the interviews (2017 and 2018), there was an increase in the landings, and therefore value, of spider crab (£444,748 in 2017 and £657,700 in 2018), whereas there was a decline of almost £ 1 million in lobster landings value from £ 4,622,932 in 2017 to £ 3,731,496 in 2018 (Fig. 3). Scallops caught by the mobile sector showed a small increase in landings

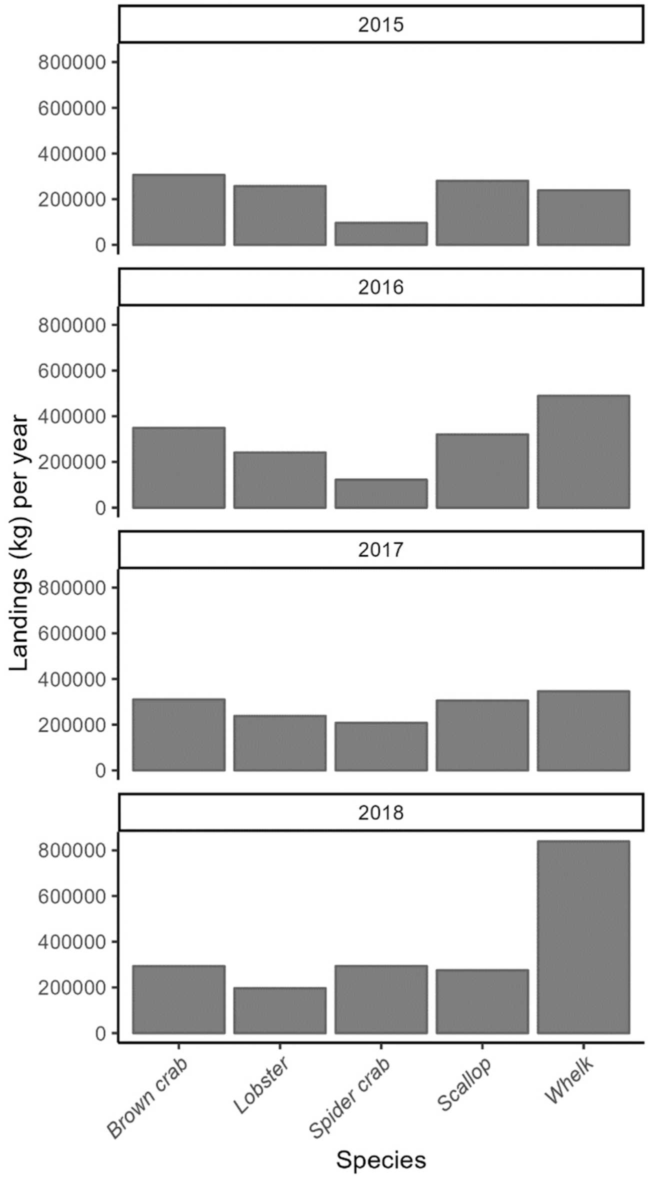

Fig. 2. Commercial landings (kg) between 2015 and 2018 in Jersey showing the top 5 species that contribute to 94% of landings by weight. The remaining 6% of commercial landings consists of 46 species.

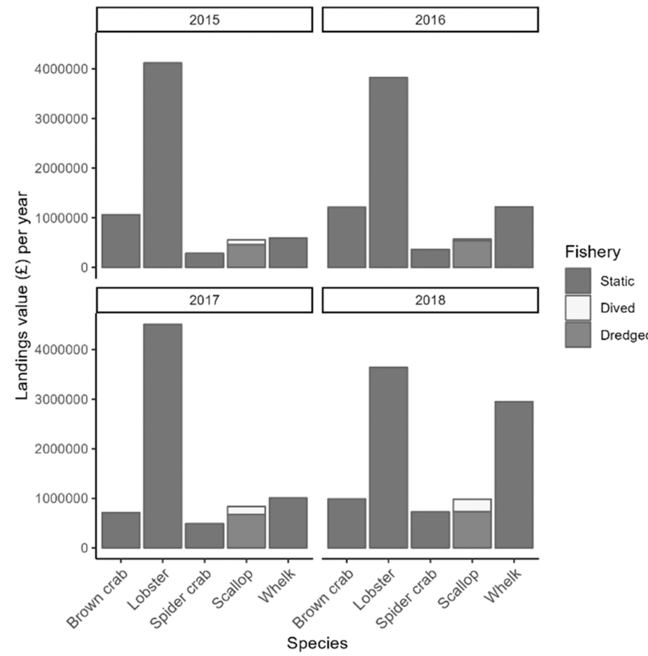

Fig. 3. Landings value (£) per year (2015–2018) for the top five contributing species to Jersey's fisheries value, landed by Jersey vessels from the three primary sectors (mobile, static and diving).

value from £ 673,084 in 2017 to £ 747,697 in 2018, as did dived scallops from £ 164,734 in 2017 to £ 252,571 in 2018, the highest value of dived scallops in the four years presented (Fig. 3). Brown crab landings value increased from £ 731,046 in 2017 to £ 1,005,712 in 2018 but this was due to a dip in landings in 2017, with landings value in 2018 in line with those from 2015 and 2016 (Fig. 3).

4.2. Interviews

Static fishing vessels primarily pot for crab and lobster but some fishers also use nets, lines, and diving to supplement their catch. Only two respondents solely targeted scallop (*Pecten maximus*) through diving and so these were grouped with the static sector. The mobile sector was represented by four respondents who primarily employed dredges to target scallops. Of all the respondents, 17 were found to actively fish in the vicinity of at least one of the MPAs.

4.3. Support for the MPAs

Amongst the respondents to the survey (n = 21), support for the MPA was almost identical for both MPAs (Ecrehous and Minquiers) except for one respondent that answered 10 (strongly support) for the Minquiers and 8 for the Ecrehous, with the reason provided relating to the small size of the Ecrehous MPA. The results presented are overall support for both MPAs together, with the support averaged for the one respondent which gave differing results (Fig. 4a).

The majority of static fishers supported the MPAs, with a mean of 8.9 (± 2.3), whereas mobile gear fishers responded with varied, but typically low, levels of support for the MPAs with a mean of 4.8 (± 3.9) (Fig. 4a). While support in the static sector was high, three fishers raised concerns that the MPAs were too small and another that the Minquiers MPA was not well placed as the majority of seabed there had not previously been targeted by mobile gear fishers and therefore was considered largely an MPA which would secure the long-term protection of the habitat but offers no overall biodiversity gain.

4.4. Perceived compliance

The level of compliance with local fishing regulations was generally perceived by fishers to be good (1 = complete compliance and 10 = complete non-compliance) by both static (mean 2.8 ± 2.2) and mobile (mean 2 ± 1.2) sectors. The mobile sector responses showed a general consensus that compliance levels were high (Fig. 4b), with just one respondent stating that one or two were not following the rules, and another observing that the compliance of French vessels is high due to most having Vessel Monitoring Systems (VMS) which enables remote observation of the location of vessels at sea. Where there were perceptions of non-compliance with the MPA byelaws the responses were varied. These included a perception that part-time and recreational fishers were being less compliant with the rules than full-time fishers, that compliance is declining over time, that undersized catch was being landed, and that mobile gear vessels were 'pushing the limits' of the MPA boundaries. Two static fishers commented that they perceived compliance with the MPA byelaws was lower amongst French vessels,

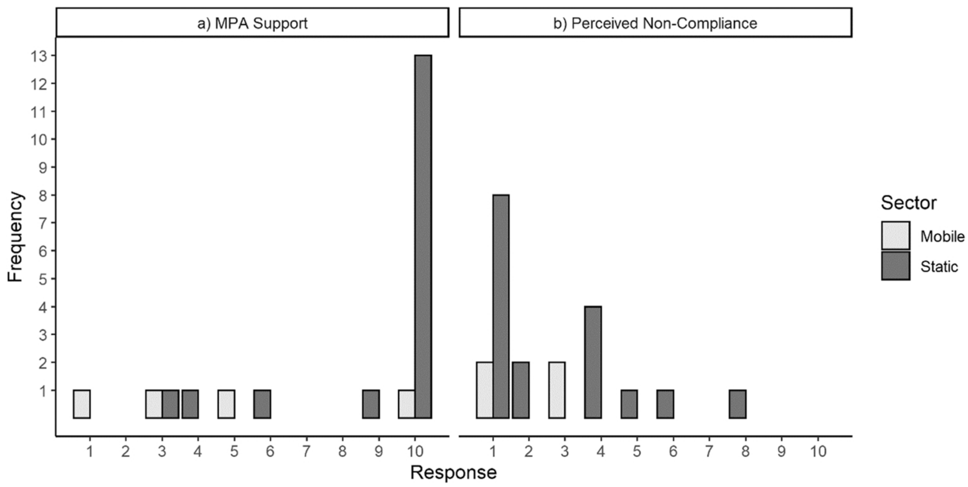

Fig. 4. Likert scale responses for each stakeholder group. Responses to the questions: a) to what extent do you support the MPAs (1 = not at all; 10 = completely), b) what do you perceive the levels of non-compliance are within the MPAs (1 = complete compliance; 10 = complete non-compliance).

which is counter to the view of the mobile fisher. This may reflect the higher numbers of smaller French vessels using static gear that do not require VMS, compared to the majority of mobile vessels that do. Many of the comments from static fishers related to non-compliance of broader regulations, such as the size of catch, rather than the specific MPA regulations that exclude the use of mobile gear within the MPA boundaries.

4.5. Fishing location and frequency

Reported changes in fishing location were used as a proxy for displacement. Four static fishers reported a change to their fishing location following the designation of the MPAs, but where this occurred, the change was reported to be minimal (mean = 1.6 ± 1.2) (Fig. 5a). Three of the four static fishers reported this change was related to moving their pots into the MPAs or spending more time scallop diving inside the MPAs. Only one static fisher reported a change in fishing location due to displacement of mobile fishing into potting areas outside of the MPAs. One mobile fisher reported a minimal change in fishing location and another commented that their fishing location had not changed but stated they would have started dredging for scallops at the Ecrehous had the MPA not been in place. Fishing frequency was unchanged for all but one static fisher who reported diving more frequently in the Ecrehous MPA since it had been designated, reporting that the scallops were of better quality (Fig. 5b).

4.6. Well-being: job and income satisfaction

There was no discernible change in reported job and income satisfaction between 2017 and 2018 for either sector (Fig. 6a and b) and satisfaction for mobile respondents were low (job satisfaction mean per year = 3.8 ± 2.8; income satisfaction mean per year = 3.8 ± 2.1) compared to static respondents (job satisfaction mean per year = 7.1 ± 2; income satisfaction mean per year = 6.8 ± 1.8). Reasons for low levels of job satisfaction from mobile fishers related to low profits, too many restrictions and displacement from fishing grounds due to French netting vessels. Static respondents generally reported moderate to high levels of job and income satisfaction in both 2017 and 2018. Reasons provided included enjoying the lifestyle and being happy with their levels of catch. There was a strong overlap in comments relating to job satisfaction and income satisfaction, with the primary reasons of lowered job satisfaction relating to changes in income over this time period. There was no general consensus in the reasons given by mobile fishers for low levels income satisfaction, and these included: perceived high overheads, less profits than expected and restrictions in exporting scallops to France during the French closed season. Key concerns

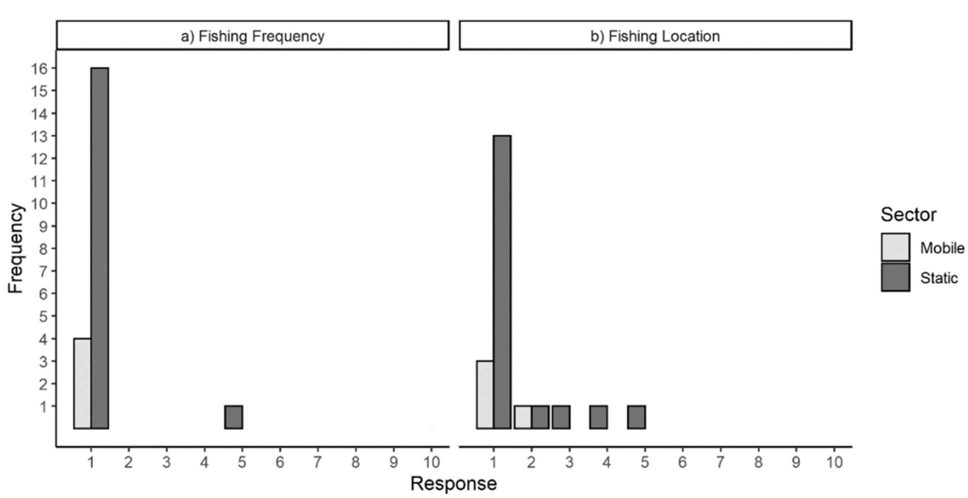

Fig. 5. Likert scale responses for each stakeholder group. Responses to the questions: a) to what extent have the MPAs changed how often you fish (Fishing Frequency) (1 = not at all; 10 = completely) b) to what extent have the MPAs changed where you fish (Fishing Location) (1 = not at all; 10 = completely).

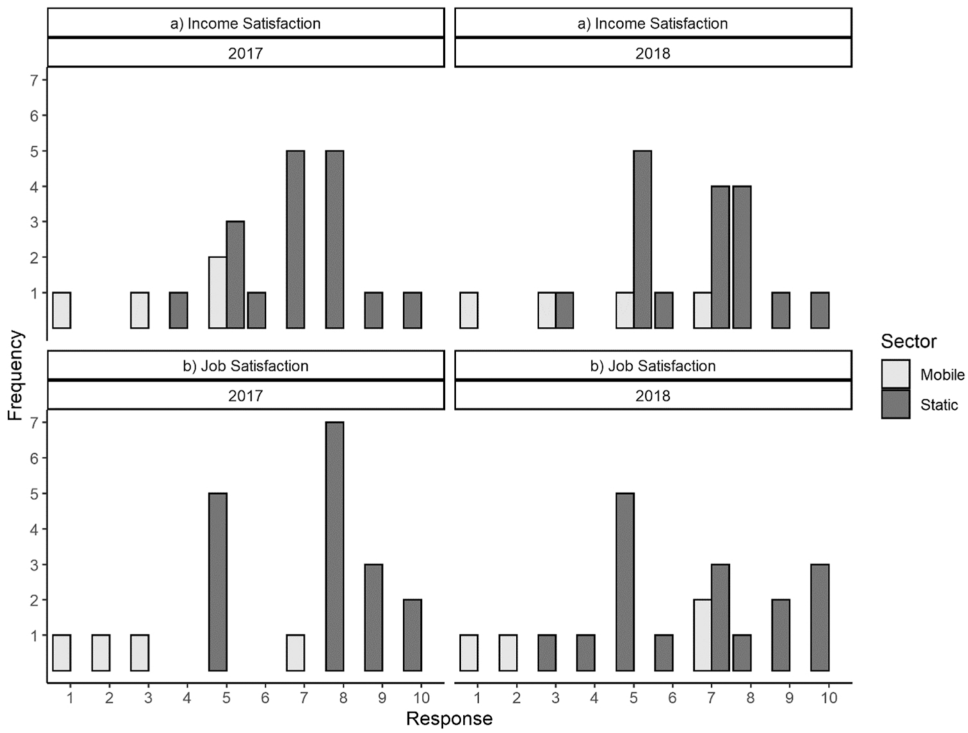

Fig. 6. Likert scale responses for each stakeholder group split for 2017 and 2018 for questions relating to well-being. Responses to the questions: a) how satisfied are you with your fishing income (1 = completely dissatisfied; 10 = completely satisfied), b) how satisfied are you with your fishing (job satisfaction) (1 = completely dissatisfied; 10 = completely satisfied).

communicated by several static respondents that had reported reductions in their job and income satisfaction were: competition created by high levels of potting from other vessels, an increase in spider crab combined with a decrease in brown crab and lobster resulting in less profitable catch, restrictions on bass fishing, an inability to diversify their catch, and boat maintenance and loan repayments reducing their profits.

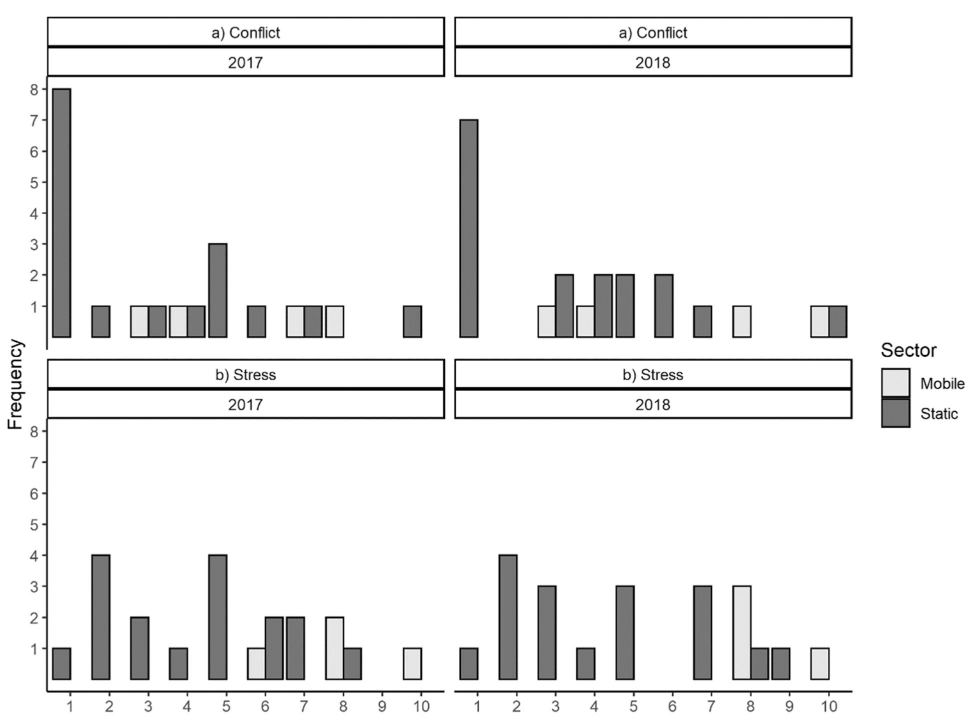

Fig. 7. Likert scale responses for each stakeholder group split for 2017 and 2018 for questions relating to well-being. Responses to the questions: a) what level of conflict did you experience (1 = no conflict; 10 = high levels of conflict), b) what level of stress did you experience (1 = no stress; 10 = high levels of stress).

4.7. Well-being: conflict and stress

In response to the question: what level of conflict did you experience (1 = no conflict; 10 = high levels of conflict), reported levels of conflict were greater on average in the mobile respondents (mean per year = 5.9 ± 2.7), than the static respondents (mean per year = 3.4 ± 2.7) (Fig. 7a). All four mobile fishers reported this was related to conflict with other gear, primarily nets but also pots, from French vessels only. There was no conflict perceived within the local mobile gear sector nor with other local vessels from other sectors. Where conflict was perceived by static fishers, five stated this was due to conflict within the static sector from both Jersey and French vessels targeting the same ground with pots. Three reported conflict with netting vessels from France and another three reported conflict with mobile sectors, from both Jersey and French mobile vessels, which have resulted in static fishers having to relocate their pots.

Reported stress levels (1 = no stress; 10 = high levels of stress) were high for mobile fishers (mean per year = 8.3 ± 1.3) (Fig. 7b) for various reasons, including: too many restrictions, concerns over large French vessels reducing stocks and issues relating to boat maintenance. Static responses were variable but similar overall in both years and lower than mobile responses (mean per year = 4.4 ± 2.3). Four static fishers reported high stress levels as a result of conflict with other fishers, three as a result of too many restrictions and another three due to concerns over declines in catch, particularly declines in brown crab relating to a recent increase in the regulation for Minimum Landing Size. Other factors affecting stress levels were licence repayments and costs associated with boat maintenance. Neither the mobile nor static respondents reported the designation of the MPAs as contributing to their stress levels.

4.8. Economics: fleet income breakdown

The average self-reported turnover of the mobile respondents was almost double than that of the average self-reported turnover of the static respondents. The mobile respondents also reported 5% higher associated costs on average (Table 2). The average annual profit of the mobile sector is approximately £ 50,000, which is much greater than the static sector which had an average annual profit of £ 30,000 (Fig. 8). There was one exception from the static sector which had an annual turnover and profit that were double that of the mean for the mobile sector and more than three times the average of the static sector.

4.9. Sales strategies

The sales strategies for lobster, brown crab and spider crab were almost identical. The majority of crustacean catch from both mobile and static sectors is sold to local vendors, with the majority of the rest being exported to France and a small portion through private sales (Fig. 9). Private sales refer to catch that is sold directly to restaurants or the public, typically for a greater value than can be achieved by selling catch to vendors. Sales strategies for scallop in the mobile sector were more varied, with around a third each sold to local vendors, exported to France or sold through private sales. Static catch of scallop (dived scallop) was primarily sold privately, and the majority of the rest was sold to local vendors. Catch can be exported to France through local vendors or directly landed in France by fishers but this was not discernible from the interview responses. Finfish from the static sector were almost all sold though vendors, with a small portion being sold through private sales. Sales strategies remained relatively unchanged for static respondents between 2017 and 2018, with one respondent reporting a reduction in direct landings to France, and another reporting an increase in direct landings to France. Sales strategies remained unchanged for mobile respondents.

5. Discussion

The MPAs in Jersey were primarily designated to protect habitats of ecological importance, not as fisheries management tools, though the objectives are not dissimilar. This study has identified a range of perceptions towards the newly established MPAs within a fishing community, and the social impacts experienced by representatives of different sectors. While the reported mean results from respondents were not tested for statistical significance due to the small sample size, they highlight a snapshot of some of the social impacts experienced by the fishing fleet and serve as an example of the issues that may be encountered in future MPA designations. This study contributes to the existing literature that evidences the benefits of stakeholder engagement and highlights that stakeholder knowledge can help shape MPA design which in turn may improve buy-in from local fishing communities. Jersey fisheries are dominated by static fishers, particularly those using pots to target crab and lobster, and lobster was identified to hold the greatest value to fisheries. Due to the exclusion of mobile gear from the MPAs and the continuation of static fisheries, the MPAs were expected to be better received by static fishers. As anticipated, the fishers' perceptions of the MPAs differed between mobile and static fleets, with greater support reported from static respondents. This was despite only one mobile gear vessel respondent reported being displaced from traditional fishing grounds as a result of the MPA designation. This divide in opinion between sectors was also shown by Rees et al. (2013b, 2021b) where static respondents typically scored more positively than mobile respondents to the exclusion of mobile gear from the MPA in Lyme Bay. However, not all mobile gear respondents had completely negative perceptions of the MPAs in Jersey, with one respondent in full support of the MPAs, highlighting that perceptions are not only different between sectors but between individuals within sectors also.

The MPAs are offshore and primarily fished by small vessels that do not require VMS (real time monitoring of the location of fishing effort) making the enforcement of regulations is problematic. Other studies have shown that compliance with MPA regulations is improved when there is support from local stakeholders (Gall and Rodwell, 2016; Giakoumi et al., 2018; Read et al., 2011; Rees et al., 2013a) and this is particularly important in Jersey where there is limited ability to detect illegal fishing activity within the MPAs. Compliance levels were generally reported by respondents to be high, particularly for larger mobile gear vessels that are required to have VMS. However, it was also reported that mobile gear vessels were 'pushing the limits' of the MPA boundaries, which may have consequences for expected benefits, such as overspill of fishery species into surrounding fishing areas. MPAs that are not perceived to be meeting prior expectations may lose support of stakeholders (Gall and Rodwell, 2016; Giakoumi et al., 2018; Rees et al., 2013b), so it is important to communicate the expected benefits and costs and to consider compliance when assessing the progress of an MPA.

In the first year since designation there have been no reported changes to catch (kg, £), which is likely related to few fishers having to change their fishing location or fishing frequency following the designation of the MPAs. It is important to understand landings across long

Table 2
Average annual turnover for each sector and the average percentage of turnover given to the various associated costs.

Sector	Average turnover	Avg. Fuel costs (%)	Avg. Harbour dues (%)	Avg. Maintenance costs (%)	Avg. crew costs (%)	Avg. Capital payments (%)	Other (insurance/bait/parking etc.)	Avg. profit (%)
Mobile	157,500	12	5	28	7	5	11	32
Static	80,000	12	3	20	5	8	15	37

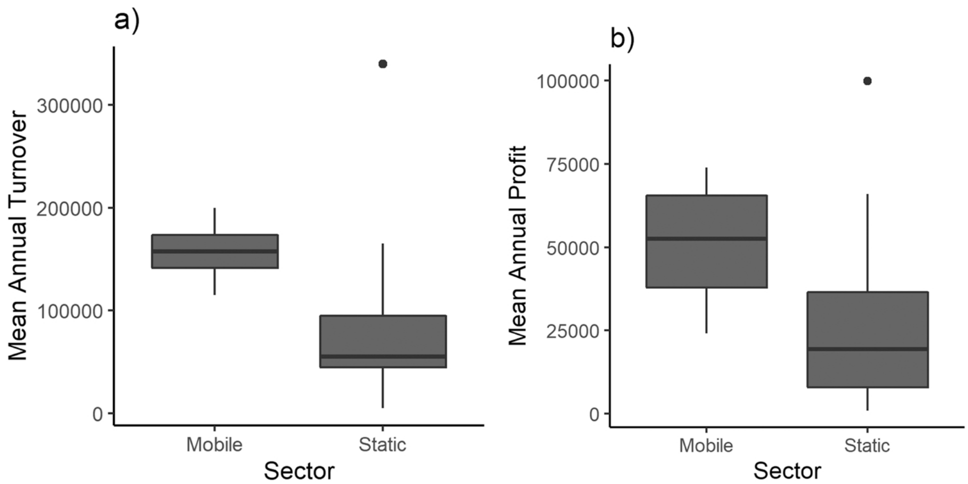

Fig. 8. a) Average annual turnover and b) average annual profit for the mobile and static respondents.

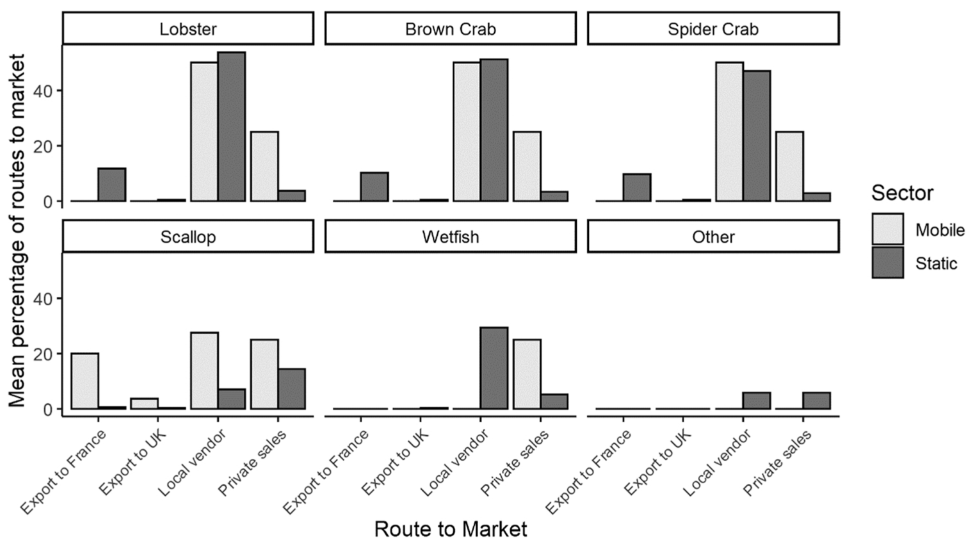

Fig. 9. Mean percentages of catch sold through various routes as reported by mobile and static respondents.

timescales and the economics of the fleet as a baseline for future comparison following the designation of MPAs. This may also provide an insight into which sectors may be economically affected by changes in spatial management, which may allude to perceptions and support for the MPA from different fishing sectors. In time, an MPA can be expected to improve landings as the protection of essential fish habitat can support a greater abundance of commercial species (Davies et al., 2021). Jersey fisheries are valuable (~£7.5 million annually) but as there is no accurate spatial information for most vessels it is impossible to evaluate the impact of the MPAs on fishing activity or the subsequent economic value from landings. In previous studies where this information is available, there have been economic benefits to static fisheries due to increases in catch of high value species within the MPA following the exclusion of mobile gear (Rees et al., 2021b).

There was a strong reported dependence on shellfish for both sectors but static fishers who took part in this research have indicated that there has been a decline in brown crab and lobster catches that is affecting their livelihoods. They indicate that the long-term sustainability of their fishing activity should be a primary concern for local fisheries managers. The intensification of some fishing activity within MPAs is not new as the spatial management measures for MPAs often partially benefit some sectors of the fishery over others (Rees et al., 2021b). Without pre-emptive fisheries management, it can be seen that potting activity can increase within MPAs which have excluded mobile gear (Mangi et al., 2011; Rees et al., 2021a,b). While only three static respondents reported an increase in their fishing effort inside the MPAs one year after their designation, there may be more instances of displacement into the MPAs that is unaccounted for in the small sample size of this study. Improved monitoring of spatial fishing effort is needed to allow for accurate assessments of fishing displacement.

The decrease in lobster landings across Jersey's waters, not just from those fishers reporting to fish within the MPAs, plus an increase in fishing effort (Marine Resources, 2019), is a concern for the fleet as the majority of vessels rely on lobster as their main source of income. The reports of declines in lobster in Jersey does not reflect stock assessments of lobster on the southwest coast of the UK that indicate lobster landings are relatively stable in the southwest English Channel (Cefas, 2020b; Cornwall IFCA, 2018; Southern IFCA, 2020), suggesting that the decline in lobster is localised to Jersey, and potentially a reflection of the high potting levels reported by respondents. Further reducing the profitability of catch is the reported increase in low value spider crab landings in addition to a decline in brown crab. The decrease in brown crab landings is also being experienced by Jersey's fishers operating inside and outside the MPAs. More recent reports from Jersey (Marine Resources, 2019) and the UK (Cefas, 2020a) suggest that brown crab catches are also declining in the English Channel and may not be solely related to exploitation levels. At present, local fishers do not attribute any changes in landings to the MPAs. More accurate spatial fishing information is needed to monitor levels of potting and determine a threshold limit that will reduce overexploitation of crab and lobster and also reduce pressure on benthic habitats for which the MPA is designated to protect.

Overall, the stress levels reported by mobile fishers was higher on average, and job satisfaction lower than average, compared to their static counterparts, but this was not reported to be attributed to the MPAs. Similar to results from Lyme Bay (Rees et al., 2021b), the mobile fishers reported lower levels of income satisfaction on average than static fishers, despite reporting overall higher profits on average than static fishers. In previous studies, the implementation of coastal MPAs in which mobile gear is restricted has resulted in strong social impacts to fishers operating mobile gear vessels, including the need to travel further to fishing grounds outside of the MPAs (Hattam et al., 2014; Rees et al., 2013b), increasing travel expenses and raising safety concerns in the event of bad weather while far from a home port. However, the two MPAs in Jersey have not had this effect due to the fact they are located away from the mainland coastline (7–20 km), with fishing grounds open to mobile gear both closer to Jersey and beyond the MPAs which means increased travel costs are unlikely to be contributing to stress levels or income satisfaction. Impacts on subjective well-being (stress and job satisfaction) is largely reported, in this case study area, to be linked to conflict to other fishers, particularly French static net fisheries outside of the MPAs, and financial concerns (licence and boat repayments). The reported fisher conflict outside of the MPAs suggests that additional spatial management could improve the well-being of the mobile fleet by reducing overlap with other sectors and securing 'patches' of desirable ground to maintain their income. However, as mobile fishing degrades ecosystems overtime (Stewart and Howarth, 2016), this may result in areas of unviable fishing grounds if fishing levels are not managed sustainably, further reducing the well-being outcomes for mobile fishers.

The exclusion of mobile gear, in particular dredging practices, can improve habitat integrity (Sheehan et al., 2013b) which can lead to an improved supply of ecosystem services (Rees et al., 2020). Improved ecosystem function and flow of ecosystem services are most likely to benefit the static gear sector as the MPAs protect the reef habitats on which their target species depend. Additionally, the MPAs provide a space where they can set their gear that is not in conflict with mobile gear. Benthic shellfish, including those of commercial importance, can be physically damaged by mobile fishing gears (Beukers-Stewart and Beukers-Stewart, 2009; Kaiser and Spencer, 1995), decreasing their densities (Veale et al., 2000). It is expected that benthic shellfish would benefit from the exclusion of mobile fishing but the time frame within which change can be expected must also be considered. At the time of interviews, the MPAs had been established for one year, and so changes in species abundances in response to the protection measure was unlikely to have occurred, and therefore social benefits relating to changes or increases in catch will yet to have been realised. One static fisher reported an improvement in the quality of scallop but not in the abundance of scallop, which is expected as they take approximately four years to reach Minimum Landing Size (MLS) (Marshall and Wilson, 2008). The same can be expected of crab and lobster, with lobster in particular taking up to seven years to reach MLS (Schmalenbach et al., 2011). Older MPAs have greater human well-being benefits associated with them (Ban et al., 2019), and with time the MPAs in Jersey may gain support from stakeholders if they are deemed to be improving fisheries sustainability or at the very least not negatively impacting on fisher well-being. However, these benefits may not be realised if levels of permitted fishing within the MPAs are not managed sustainably, and the concerns of mobile gear fishers linked to resource rights and space outside the MPA are ignored.

To avoid conflict with stakeholders many MPAs are placed in areas to provide protection to specific features (habitats and species) of conservation importance but avoiding areas of commercial economic value, providing few opportunities for the restoration and recovery of ecosystems (Devillers et al., 2015, 2020). Only one mobile fisher reported that the MPAs had displaced them from previous fishing grounds, but uncaptured in this study is the displacement caused to French mobile gear vessels from the MPAs, which is likely to have been considerable for some vessels (personal comm. Government of Jersey). Additionally, with improving technology on fishing vessels, it is not to say that fishing effort and the pressure from mobile gear would remain the same, so the MPAs, and the whole-site management measures may be a future proofing mechanism from further incursions into the reefs. Given the uncertainty in the current use of the reefs by French vessels and potential future demand and access for the shellfish within the reef systems protection of these critical ecosystems within the MPAs has immediate benefits for long term sustainability as long as there is continued compliance.

One of the points raised by several static fishers was that the MPAs are currently too small. In this case study area, original proposals for larger MPAs were rejected by several Jersey and French stakeholders due to their overlap with commercially important fishing grounds (pers. comm. Marine Resources). It is here that the disconnect between sustainable fisheries and areas protected for biodiversity (hosting areas important for the life history of commercial fish species) is most apparent. Whilst the ecological effectiveness (relating to biodiversity metrics) of small MPAs is debated in the literature (Edgar et al., 2014; Turnbull et al., 2018), the well-being outcomes (relating to social benefits) of small MPAs can be more positive than those of large MPAs (Ban et al., 2019). Especially if the MPAs are local and managed by communities, leading to a sense of empowerment within the community (Ban et al., 2019). While it is important to ensure MPAs achieve their biological objectives, there is also a need to consider social and economic indicators to better understand potential trade-offs of MPAs designation and to improve management of future MPAs.

According to fishers interviewed for this research, the primary route to market for crab and lobster catch was to local vendors as this is considered the most reliable and convenient route for many fishers. By selling to local vendors (wholesale) the fisher receives the first sale market price for the goods and then the vendors finds secondary markets to trade goods for profit. Jersey fishers also report that this sales strategy may achieve less per kg than if they were to sell to a private buyer such as a restaurant. However, this restaurant market is limited. Mobile gear caught scallops were sold to a combination of local vendors, exported to France and sold privately. Dive caught scallops was primarily sold through private sales. Elsewhere, creating a premium for traceable and sustainable seafood has benefitted small scale fishers operating sustainably within MPAs (Blue Marine Foundation, 2016; Rees et al., 2021b). In the current economic climate following the UK's exit from the EU, export of seafood to France is becoming increasingly difficult due to the customs requirements of the 'third country' status now imposed on Jersey that has restricted markets. Alternative sales strategies with a local sustainability brand may provide a mechanism to support Jersey's small-scale fishers and should be explored further if traceability of catch from the MPAs can be improved.

6. Conclusion

Effectively managed MPAs are needed to help mitigate human impacts on the marine environment and support sustainable fisheries. In doing so, pressure will be placed on fishing communities that may be displaced from traditional fishing grounds or be subject to increased conflict with other fishing gears due to changes in fishing activity that result from change in management. To understand where and when negative impacts can be reduced, and positive impacts can be highlighted, engagement and communication with the fishing community is needed. This engagement is also key to improving buy-in from the fishing community by providing a platform through which they can voice their concerns. This research has provided a snapshot of fisher perceptions from a subset of the fishing community in Jersey. It was found that both mobile and static sectors depend on shellfish species but that the high value species that static fisheries depend on (lobster and brown crab) are in decline. There were no reports of increased catch relating to the MPAs, which was expected due to the young age of the MPAs. The greater level of support for the MPA reported by static fishers may pertain to reduced conflict with mobile fishers, but the reports of increased static fishing in the MPAs may prevent the long-term sustainability of static fishery target species, ultimately negatively impacting the static fishery. The MPAs were identified through interviews as having had little effect on fisher wellbeing, but the information gathered during the interviews has highlighted key issues being experienced by the fleet beyond the MPAs, regarding declines in target species and conflict with fishing gear from French vessels. Future work involving interviews with the French fleet is needed to broaden the scope of this research. It is also recommended that comparable socio-economic studies are conducted should further MPAs be created, either in Jersey or elsewhere, to increase the understanding of the range of social impacts experienced by local fishing fleets. While the level of protection afforded the MPAs in Jersey may be high compared with many other MPAs in Europe, the observed decline in fisheries landings and value over time suggests that habitat conservation and fisheries management are not sufficiently aligned, even though the goals are common. The MPAs alone are not sufficient to create a sustainable fishery and these results indicate that additional management, focussed on recovering target species, is needed to compliment the MPAs.

Funding

This work was supported by the Blue Marine Foundation, The Howard Davis Farm Trust and the Ecology Trust.

CRediT authorship contribution statement

S.R.B, S.E.R, F.B, M.J.A and E.V.S have all made substantial contributions to conception and design of this research. F.B. assisted in the acquisition of data and fieldwork logistics. S.R.B led the analysis and interpretation of data and S.R.B and S.E.R led the writing of the manuscript. All authors contributed to the critical revision of manuscripts and have given their approval for publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Acknowledgements

We are grateful to everyone who helped make this research possible. The authors would like to thank the local fishermen who gave up their time to be interviewed, Chris for allowing the use of the St. Helier Yacht Club for interviews, and the Government of Jersey Marine Resources team for providing the required datasets.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.fishres.2022.106555.

References

Agardy, T., di Sciara, G.N., Christie, P., 2011. Mind the gap Addressing the shortcomings of marine protected areas through large scale marine spatial planning. Mar. Policy 35 (2), 226–232. https://doi.org/10.1016/j.marpol.2010.10.006.
Ban, N.C., Gurney, G.G., Marshall, N.A., Whitney, C.K., Mills, M., Gelcich, S., Bennett, N. J., Meehan, M.C., Butler, C., Ban, S., Tran, T.C., Cox, M.E., Breslow, S.J., 2019. Well-being outcomes of marine protected areas. Nat. Sustain. 2, 524–532.
Beukers-Stewart, B.D., Vause, B.J., Mosley, M.W.J., Rossetti, H.L., Brand, A.R., 2005. Benefits of closed area protection for a population of scallops. Mar. Ecol. Prog. Ser. 298, 189–204. https://doi.org/10.3354/meps298189.
Beukers-Stewart, B.D., Beukers-Stewart, J., 2009. Principles for the Management of Inshore Scallop Fisheries around the United Kingdom.
Blue Marine Foundation, 2016. Lyme Bay Fisheries and Conservation Reserve Ecological and Fisheries Data.
Brown, B., Soule, E., Kaufman, L., 2010. Effects of excluding bottom-disturbing mobile fishing gear on abundance and biomass of groundfishes in the Stellwagen Bank National Marine Sanctuary, USA. Curr. Zool. 56 (1), 134–143. https://doi.org/10.1093/czoolo/56.1.134.
Cefas, 2020a. Edible crab (Cancer pagurus) Cefas Stock Status Report 2019. Report to Defra.
Cefas, 2020b. Lobster (Homarus gammarus) Cefas Stock Status Report 2019. Report to Defra.
Chambers, P., Morel, G., Binney, F., Jeffreys, G., Blampied, S., 2020. Chapter 21 - Crossing Jurisdictions: The Implementation of Offshore Marine Protected Areas in an International Fishery. Marine Protected Areas: Science, Policy and Management. 411–436.
Claudet, J., Loiseau, C., Sostres, M., Zupan, M., Claudet, J., Loiseau, C., Sostres, M., Zupan, M., 2020. Underprotected marine protected areas in a global biodiversity hotspot. One Earth 2 (4), 380–384. https://doi.org/10.1016/j.oneear.2020.03.008.
Cornwall IFCA, 2018. Cornwall IFCA Monthly Shellfish Permit Statistics Analysis Lobster (Homarus gammarus) Pot Fishery Summary Statistics 2016–2018 Lobster (Homarus gammarus) Pot Fishery Summary Statistics 2016–2018, 1, pp. 2016–2019.
Costanza, R., Costanza, R., Arge, R., Groot, R., De, Farber, S., Grasso, M., Hannon, B., 1996. The value of the world's ecosystem services and natural capital. Nature *387*.
Dasgupta, P., 2021. The Economics of Biodiversity: The Dasgupta Review. HM Treasury, London.
Davies, B.F.R., Holmes, L., Rees, A., Attrill, M., Cartwright, A., Sheehan, E.V., 2021. Ecosystem approach to fisheries management works—how switching from mobile to static fishing gear improves populations of fished and non-fished species inside a marine-protected area. J. Appl. Ecol. 58 (11), 2463–2478.
Day, J., Dudley, N., Hockings, M., Holmes, G., Laffoley, D., Stolton, S., Wells, S., 2012. Guidelines for Applying the IUCN Protected Area Management Categories to Marine Protected Areas.
De Grave, S., Whitaker, A., 1999. Benthic community re-adjustment following dredging of a Muddy-Maerl matrix. Mar. Pollut. Bull. 38 (2), 102–108.
Devillers, R., Pressey, R.L., Grech, A., Kittinger, J.N., Edgar, G.J., Ward, T., Watson, R., 2015. Reinventing residual reserves in the sea: are we favouring ease of establishment over need for protection. Aquat. Conserv. Mar. Freshw. Ecosyst. 504, 480–504. https://doi.org/10.1002/aqc.2445.
Devillers, R., Pressey, R.L., Ward, T.J., Grech, A., Kittinger, J.N., Edgar, G.J., Watson, R. A., 2020. Residual marine Protected Areas Five Years On: Are We Still Favouring Ease of Establishment over Need for Protection? pp. 1758–1764. ⟨https://doi.org/10.1002/aqc.3374⟩.
Dobson, A., Lodge, D., Alder, J., Cumming, G.S., Keymer, J., McGlade, J., Mooney, H., Rusak, J.A., Sala, O., Wolters, V., Wall, D., Winfree, R., Xenopoulos, M.A., 2006. Habitat loss, trophic collapse, and the decline of ecosystem services. Ecology 87 (8), 1915–1924. https://doi.org/10.1890/0012-9658(2006)87[1915:HLTCAT]2.0.CO;2.
Edgar, G.J., Stuart-Smith, R.D., Willis, T.J., Kininmonth, S., Baker, S.C., Banks, S., Barrett, N.S., Becerro, M.A., Bernard, A.T.F., Berkhout, J., Buxton, C.D., Campbell, S. J., Cooper, A.T., Davey, M., Edgar, S.C., Försterra, G., Galván, D.E., Irigoyen, A.J., Kushner, D.J., Thomson, R.J., 2014. Global conservation outcomes depend on marine protected areas with five key features. Nature 506 (7487), 216–220. https://doi.org/10.1038/nature13022.
FAO, 2020. The State of World Fisheries and Aquaculture. Sustainability in Action.
Gall, S.C., Rodwell, L.D., 2016. Evaluating the social acceptability of marine protected areas. Mar. Policy 65, 30–38. https://doi.org/10.1016/j.marpol.2015.12.004.
Giakoumi, S., McGowan, J., Mills, M., Beger, M., Bustamante, R.H., Charles, A., Christie, P., Fox, M., Garcia-Borboroglu, P., Gelcich, S., Guidetti, P., Mackelworth, P., Maina, J.M., McCook, L., Micheli, F., Morgan, L.E., Mumby, P.J., Reyes, L.M., White, A., Possingham, H.P., 2018. Revisiting "success" and "failure" of marine protected areas: a conservation scientist perspective. Front. Mar. Sci. 5, 1–5. https://doi.org/10.3389/fmars.2018.00223.
Greathead, C., Buhl-mortensen, L., Dannheim, J., 2020. A generic framework to assess the representation and protection of benthic ecosystems in European marine protected areas. Aquat. Conserv. Mar. Freshw. Ecosyst. 30, 1253–1275. https://doi.org/10.1002/aqc.3401.
Hall-Spencer, J.M., Moore, P.G., 2000. Scallop dredging has profound, long-term impacts on maerl habitats. ICES J. Mar. Sci. 57 (5), 1407–1415. https://doi.org/10.1006/jmsc.2000.0918.
Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R., Watson, R., 2008. A global map of human impact on marine ecosystems. Science 319 (5865), 948–952. https://doi.org/10.1126/science.1149345.

Hattam, C.E., Mangi, S.C., Gall, S.C., Rodwell, L.D., 2014. Social impacts of a temperate fisheries closure: understanding stakeholders' views. Mar. Policy 45, 269–278. https://doi.org/10.1016/j.marpol.2013.09.005.
Hiddink, J.G., Jennings, S., Sciberras, M., Szostek, C.L., Hughes, K.M., Ellis, N., Rijnsdorp, A.D., McConnaughey, R.A., Mazor, T., Hilborn, R., Collie, J.S., Pitcher, C. R., Amoroso, R.O., Parma, A.M., Suuronen, P., Kaiser, M.J., 2017. Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance. Proc. Natl. Acad. Sci. USA 114 (31), 8301–8306. https://doi.org/10.1073/pnas.1618858114.
Kaiser, M.J., Spencer, B.E., 1995. Survival of by-catch from a beam trawl. Mar. Ecol. Prog. Ser. 126 (1–3), 31–38. https://doi.org/10.3354/meps126031.
Lester, S.E., Halpern, B.S., 2008. Biological responses in marine no-take reserves versus partially protected areas. Mar. Ecol. Prog. Ser. 367, 49–56. https://doi.org/10.3354/meps07599.
Lester, S.E., Halpern, B.S., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B.I., Gaines, S. D., Airame, S., Warner, R.R., 2009. Biological effects within no-take marine reserves: a global synthesis. Mar. Ecol. Prog. Ser. 384, 33–46. https://doi.org/10.3354/meps08029.
Mangi, S.C., Rodwell, L.D., Hattam, C., 2011. Assessing the impacts of establishing MPAs on fishermen and fish merchants: the case of Lyme Bay, UK. Ambio 40 (5), 457–468. https://doi.org/10.1007/s13280-011-0154-4.
Marine Resources, 2019. Government of Jersey Marine Resources Annual Report 2019.
Marshall, C., Wilson, E., 2008. Great scallop, (Pecten maximus) - MarLIN – marine life information network biology and sensitivity key information review. Aquac. Int. 305–318.
McClanahan, T.R., Mangi, S., 2000. Spillover of exploitable fishes from a marine park and its effect on the adjacent fishery. Ecol. Appl. 10 (6), 1792–1805.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Synthesis.
Pauly, D., Watson, R., Alder, J., 2005. Global trends in world fisheries: impacts on marine ecosystems and food security. Philos. Trans. R Soc. B Biol. Sci. 360 (1453), 5–12. https://doi.org/10.1098/rstb.2004.1574.
Pendleton, L.H., Ahmadia, G.N., Browman, H.I., Thurstan, R.H., Kaplan, D.M., Bartolino, V., 2018. Debating the effectiveness of marine protected areas. ICES J. Mar. Sci. 75 (3), 1156–1159. https://doi.org/10.1093/icesjms/fsx154.
Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E.D., Link, J., Livingston, P.A., Mangel, M., McAllister, M.K., Pope, J., Sainsbury, K.J., 2004. Ecosystem-based fishery management. Science 305, 14–16.
Pitcher, T.J., Kalikoski, D., Short, K., Varkey, D., Pramod, G., 2009. An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. Mar. Policy 33, 223–232. https://doi.org/10.1016/j.marpol.2008.06.002.
Pomeroy, R.S., Watson, L.M., Parks, J.E., Cid, G.A., 2005. How is your MPA doing? A methodology for evaluating the management effectiveness of marine protected areas. Ocean Coast. Manag. 48, 485–502. https://doi.org/10.1016/j.ocecoaman.2005.05.004.
Read, A.D., West, R.J., Haste, M., Jordan, A., 2011. Optimizing voluntary compliance in marine protected areas: a comparison of recreational fisher and enforcement officer perspectives using multi-criteria analysis. J. Environ. Manag. 92 (10), 2558–2567. https://doi.org/10.1016/j.jenvman.2011.05.022.
Rees, A., Sheehan, E.V., Attrill, M.J., 2021a. Optimal fishing effort benefits fisheries and conservation. Sci. Rep. 11 (3784), 1–15. https://doi.org/10.1038/s41598-021-82847-4.
Rees, S.E., Ashley, M., Evans, L., Mangi, S., Sheehan, E.V., Mullier, T., Rees, A., Attrill, M. J., 2021b. An evaluation of the social and economic impact of a marine protected area on commercial fisheries. Fish. Res. 235 https://doi.org/10.1016/j.fishres.2020.105819.
Rees, S.E., Attrill, M.J., Austen, M.C., Mangi, S.C., Rodwell, L.D., 2013a. A thematic cost-benefit analysis of a marine protected area. J. Environ. Manag. 114, 476–485. https://doi.org/10.1016/j.jenvman.2012.10.048.
Rees, S.E., Rodwell, L.D., Searle, S., Bell, A., 2013b. Identifying the issues and options for managing the social impacts of marine protected areas on a small fishing community. Fish. Res. https://doi.org/10.1016/j.fishres.2013.04.003.
Rees, S.E., Sheehan, E.V., Stewart, B.D., Clark, R., Appleby, T., Attrill, M.J., Jones, P.J.S., Johnson, D., Bradshaw, N., Pittman, S., Oates, J., Solandt, J.L., 2020. Emerging themes to support ambitious UK marine biodiversity conservation. Mar. Policy 117. https://doi.org/10.1016/j.marpol.2020.103864.
Reimer, J., Devillers, R., 2021. Benefits and gaps in area-based management tools for the ocean Sustainable Development Goal. Nat. Sustain. 4 (4), 1–9. https://doi.org/10.1038/s41893-020-00659-2.
Sala, E., Giakoumi, S., 2018. No-take marine reserves are the most effective protected areas in the ocean. ICES J. Mar. Sci. 75 (3), 1166–1168. https://doi.org/10.1093/icesjms/fsx059.
Schmalenbach, I., Mehrtens, F., Janke, M., Buchholz, F., 2011. A mark-recapture study of hatchery-reared juvenile European lobsters, Homarus gammarus, released at the rocky island of Helgoland (German Bight, North Sea) from 2000 to 2009. Fish. Res. 108 (1), 22–30. https://doi.org/10.1016/j.fishres.2010.11.016.
Sheehan, E.V., Stevens, T.F., Gall, S.C., Cousens, S.L., Attrill, M.J., 2013b. Recovery of a temperate reef assemblage in a marine protected area following the exclusion of towed demersal fishing. PLoS One 8 (12). https://doi.org/10.1371/journal.pone.0083883.
Solandt, J.L., Mullier, T., Elliott, S., Sheehan, E.V., 2020. Managing marine protected areas in Europe: moving from "feature-based" to "whole-site" management of sites. Mar. Prot. Area. Sci. Policy Manag. 157–181. https://doi.org/10.1016/B978-0-08-102698-4.00009-5.
Southern IFCA, 2020. SIFCA Lobster Assessments 2010–2018 (unpublished).
Staples, D., Funge-Smith, S., 2009. Ecosystem Approach to Fisheries and Aquaculture: Implementing the FAO Code of Conduct for Responsible Fisheries.
Stewart, B.D., Howarth, L.M., 2016. Quantifying and managing the ecosystem effects of scallop dredge fisheries. Dev. Aquac. Fish. Sci. 40, 585–609.
Thrush, S.F., Dayton, P.K., 2002. Disturbance to marine benthic habitats by trawling and dredging: implications for marine biodiversity. Annu. Rev. Ecol. Syst. 33, 449–473. https://doi.org/10.1146/annurev.ecolsys.33.010802.150515.
Tillin, H.M., Hiddink, J.G., Jennings, S., Kaiser, M.J., 2006. Chronic bottom trawling alters the functional composition of benthic invertebrate communities on a sea-basin scale. Mar. Ecol. Prog. Ser. 318, 31–45. https://doi.org/10.3354/meps318031.
Turnbull, J., Shah Esmaeili, Y., Clark, G., 2018. Key drivers of effectiveness in small marine protected areas. Biodivers. Conserv. 27 (9), 2217–2242.
UN General Assembly, 2015. Transforming Our World: the 2030 Agenda for Sustainable Development.
UNEP, 2006. Marine and Coastal Ecosystems and Human Well-Being: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment.
Veale, L.O., Hill, A.S., Hawkins, S.J., Brand, A.R., 2000. Effects of long-term physical disturbance by commercial scallop fishing on subtidal epifaunal assemblages and habitats. Mar. Biol. 137 (2), 325–337. https://doi.org/10.1007/s002270000357.
Willis, T.J., Millar, R.B., Babcock, R.C., 2003. Protection of exploited fish in temperate regions: high density and biomass of snapper Pagrus auratus (Sparidae) in northern New Zealand marine reserves. J. Appl. Ecol. 40 (2), 214–227. https://doi.org/10.1046/j.1365-2664.2003.00775.x.
Zupan, M., Bulleri, F., Evans, J., Fraschetti, S., Guidetti, P., Garcia-Rubies, A., Sostres, M., Asnaghi, V., Caro, A., Deudero, S., Goni, R., Guarnieri, G., Guilhaumon, F., Kersting, D., Kokkali, A., Kruschel, C., Macic, V., Mangialajo, L., Mallol, S., Claudet, J., 2018. How good is your marine protected area at curbing threats? Biol. Conserv. 221, 237–245. https://doi.org/10.1016/j.biocon.2018.03.013.