Health survey of Lundy Island crustaceans - Integration of scientists and fishermen.

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Report prepared by Dr Emma Wootton.

Swansea University.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

Summary

- A collaborative approach between fishermen and scientists was employed to survey the health of crustaceans within the Lundy marine reserve (No-Take Zone).
- Gross external characteristics were recorded on individual lobsters and Brown crab. Blood samples were also taken for molecular diagnosis of disease and population genetics studies.
- Initial results revealed significant differences in the population dynamics and health of lobsters and Brown crab between the un-fished, No-Take Zone and the fished, Refuge Zone.
- Fishermen were taught all sampling techniques. They proved extremely competent, hence subsequently assisted in data collection.
- The integration of fishermen and scientists was very successful. The study could not have proceeded without the partnership.
- Both parties benefited from the collaboration. Fishermen were taught how to collect robust scientific data, whilst scientists gained valuable information from the fishermen's local ecological knowledge (LEK).
- LEK included valuable information on spatiotemporal seasonality in lobster distribution and behaviour, interspecies pot competition and general environmental observations.
- The study confirmed that collaborative fisheries research (CFR) is a promising tool for improving assessment and stakeholder participation in marine reserve monitoring and adaptive management.
- CFR is considered to have economic, social and scientific benefits.
- The participating skipper, Mr Geoff Huelin, expressed much interest in carrying out future survey work on his fishing vessel.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

1. Introduction.

Marine protected areas (MPAs), including marine conservation zones (MCZs) and marine reserves (No-Take Zones) are designed to protect habitats of ecological importance**,** with the aim of restoring species biomass, density, size and biodiversity (Lubchenco et al., 2003; Lester et al., 2009; PISCO, 2011). The potential benefits are, therefore, considered to be both ecological conservation and fisheries sustainability. High increases in biodiversity and species density commonly associated with MPAs, however, may not always be advantageous. Classical epidemiological theory predicts that high population density will increase the prevalence and intensity of pathogens (Kermack and McKendrick, 1927). Thus, disease may be of considerable concern in marine reserves where high host abundance can occur and infections are no longer 'fished out' (Dobson and May, 1987; McCallum et al., 2005; Wood et al., 2010). This 'health' aspect of MPA monitoring is commonly overlooked; however, it needs to be addressed if the efficacy of MPAs is to be fully ascertained.

In this respect, during Summer 2010, Swansea University undertook a survey to investigate the health of lobsters and Brown crab within the Lundy Island MCZ. Scientists, in conjunction with local fishermen, not only recorded gross external characteristics of individuals, but also took blood samples. This detailed sampling technique provided information on population structure and disease status, at both the organism and genetic (DNA) level. For comparison, sampling sites were both inside and outside the Lundy No-Take Zone (i.e. Refuge Zone v. No-Take Zone).

Undertaking field sampling at this level of intricacy requires high expertise in local fisheries as well as in scientific design, sampling and analysis. Hence, collaboration between fishermen and scientists is an efficient and effective means of maximising knowledge and data. The success of the initial study into Lundy lobster and crab health (Summer 2010) would not have been possible without involvement of fishermen. As a consequence, a second sampling trip to Lundy (courtesy of SEAFISH and Swansea University) was carried out by the same team of scientists and fishermen during August 2011 (2nd -5th August, 2011). The 2011 survey was very similar to the one undertaken in 2010; however, more emphasis was placed on training fishermen in health survey techniques.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

2. Materials and methods.

2.1. Sample site- Lundy Island, Bristol Channel, UK.

Lundy Island (5 km x 1.25 km) is located in the Bristol Channel, UK (Fig. 1). Lundy and its surrounding waters (approx. 30km^2) were designated a Marine Nature Reserve (MNR) in 1986, and included a Refuge Zone (RZ; up to 1.5km offshore), where pot fisheries (for crabs and lobsters) were authorised, but trawl and net fisheries prohibited. However, in 2003, a statutory No-Take Zone (NTZ; 3.3km^2) was imposed within the existing RZ on the Eastern shore of the Island. Within the NTZ, all fishing (including potting) and removal of wildlife is forbidden. In January 2010, Lundy's MNR status was superseded by the 2009 UK Marine and Coastal Access Act, and thus became the UK's first Marine Conservation Zone (MCZ). Both the RZ and NTZ are maintained within its MCZ status.

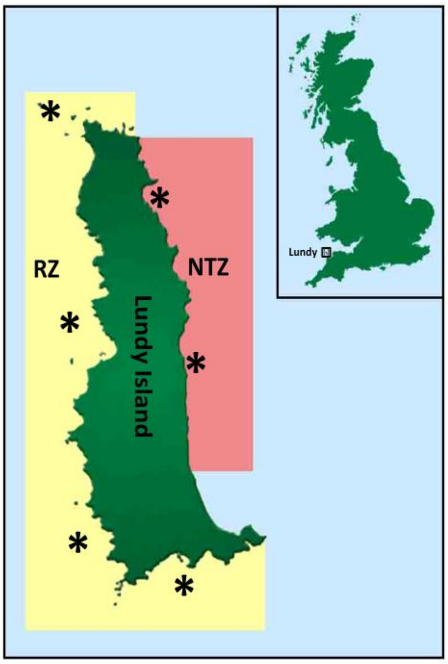


Figure 1. Map of Lundy Island, Bristol Channel, UK. Asterisks (*) show approximate positions of sampling sites. NTZ; No-Take Zone (coloured red) where removal of all wildlife (except those needed for scientific monitoring) is prohibited. The NTZ has been statutory since 2003. RZ; Refuge Zone (coloured yellow) where pot fisheries for crabs and lobsters are authorised, but trawl and net fisheries are banned.

2.2. Crustacean collection.

Sampling was undertaken onboard FV 'Our Jenny' during 2nd-5th August 2011. Permission was obtained from Devon and Severn IFCA and Natural England prior to sampling. European lobsters, *Homarus gammarus*, and Brown crab, *Cancer pagurus*, were sampled in the Lundy Island MCZ. Six sampling sites were equally spaced around the island, and were located both within the RZ and NTZ (Fig. 1), in order to compare the two zones. Standard baited commercial parlour pots (with escape gaps closed) were deployed in strings of 35, with one string per sampling site. Pots were immersed ('soaked') for 24 hours, after which the pots were retrieved, emptied of all catch, and then re-baited and redeployed in a similar position. All captured lobsters and crabs were immediately examined (and sampled) and then returned to the water

2.3. Examination procedure.

Gross external characteristics of individual lobsters and crabs were recorded to assess both the population structure and individual lobster health. The parameters recorded are detailed below.

2.3.1. Population structure: Gender (including whether females were egg-bearing, i.e. ovigerous) and size (carapace length, CL; mm) of each lobster and crab were recorded to provide size-frequency distributions for each zone (RZ and NTZ). For size analyses, lobsters and crabs were classified as either small or large, based on the Minimum Landing Size (MLS) for each species. Small individuals were those less than the MLS, whilst large individuals were those greater than the MLS. This size categorization allowed for assessment of fishing effort on population structure.

CPUE was calculated as the mean number of lobsters (or crabs) per pot, based on equal sampling effort.

2.3.2. Crustacean health: To obtain an overall indication of animal health, exoskeletal (ie. shell) parameters including injury, cheliped (ie. claw) loss and prevalence and severity of shell disease, were recorded in every individual. Classification details of each parameter are summarised below.

Shell disease (SD): Presence of exoskeletal lesions exhibiting characteristic blackening (melanisation) and erosion (microbial infection). Severity of shell disease was classified as either low or high.

Exoskeletal injury: Puncture wounds, and other minor injuries, not exhibiting exoskeletal erosion (which is only associated with shell disease). Particular attention was paid to the chelipeds (claws), as they exhibited the majority of injury. Only severe injury was recorded from the cephalothorax and abdomen, because small scratches and abrasions were hard to visualise. Puncture wounds and severe injuries inflicted during captivity within lobster pots was not recorded.

Cheliped (Claw) loss: Absence of chelipeds and/or the presence of dwarf regenerating chelipeds. Individuals exhibiting shell disease and/or exoskeletal injury were also digitally photographed for further analysis of their exoskeletal health status.

2.4. Blood samples.

A small blood sample (approx 250 µl) was taken from each individual using a needle and syringe filled with analytical grade ethanol. All blood samples were subsequently stored on ice onboard the fishing vessel. Blood samples enable both the molecular diagnosis of disease and genetic analysis of population connectivity to be investigated.

2.5. Training of fishermen in health survey techniques.

The skipper and crew of FV 'Our Jenny' were trained in all of the above procedures, including the more difficult tasks of categorising severity of shell disease and taking of blood samples. Scientists taught the fishermen how to systematically record all the external characteristics of each crustacean in a scientifically-robust manner. Fishermen were also taught how to safely take blood samples from the crustaceans. Safety was addressed in terms of the fishermen using needles and syringes, as well as for the well-being of the crustacean. The importance of storing blood samples under chilled conditions was also highlighted. The final aim was for the fishermen to assist in data collection during this survey.

2.6. Data analysis.

Data was analysed with the aim of determining differences (in catch population structure and health) between the fished Refuge Zone (RZ) and un-fished No-Take Zone (NTZ) at Lundy Island. Statistical analysis was carried out using SPSS Statistics (IBM Corporation, New York, USA). Data on lobsters and crabs were analysed separately. Due to the small sample size of some individual sites (particularly in the RZ), data from all sampling sites within each zone were pooled for analyses. This allowed for a direct comparison between the NTZ and RZ. For frequency data analyses, data were adjusted for equal sampling effort. Statistical analyses were performed using SPSS Statistics (IBM Corporation, New York, USA). Cross tabulations (e.g. Fisher's exact test of independence) were used on frequency data, whilst unpaired T-tests were used on mean size data. Catch Per Unit Effort (CPUE) was calculated as the mean number of lobsters per pot, based on data from equal fishing effort.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

3. Results.

Differences between the crustacean populations of the No-Take Zone (NTZ) and Refuge Zone (RZ) are described below. It is important to note that lobster and crab pot fisheries are prohibited in the NTZ, whilst still permitted in the RZ. Summarized catch data for lobster and Brown crab are presented in Table 1 below.

Table 1. Summary of catch data for the Lundy Island crustacean health survey, 2011.

Species	Parameter	Refuge Zone (RZ)	No-Take Zone (NTZ)
European lobster (*Homarus gammarus*)	No. of individuals caught	148	261
	No. of berried females	0	3
	Percent of individuals >MLS	32	58
	CPUE	0.70	1.24
Brown crab (*Cancer pagurus*)	No. of individuals caught	98	9
	No. of berried females	0	0
	Percent of individuals >MLS	16	44
	CPUE	0.47	0.04

MLS: Lobsters = 90mm CL (males and females); Brown crab = 140 mm CL (females), 160 mm CL (males).

3.1. Lobster populations.

A total of 423 lobsters were sampled during the survey However, due to equalization in sampling effort, only 409 individuals were used in frequency analyses (Table 1). Eight percent of caught lobsters were carrying Devon and Severn IFCA tags. All tag numbers and relevant lobster statistics were reported to the IFCA.

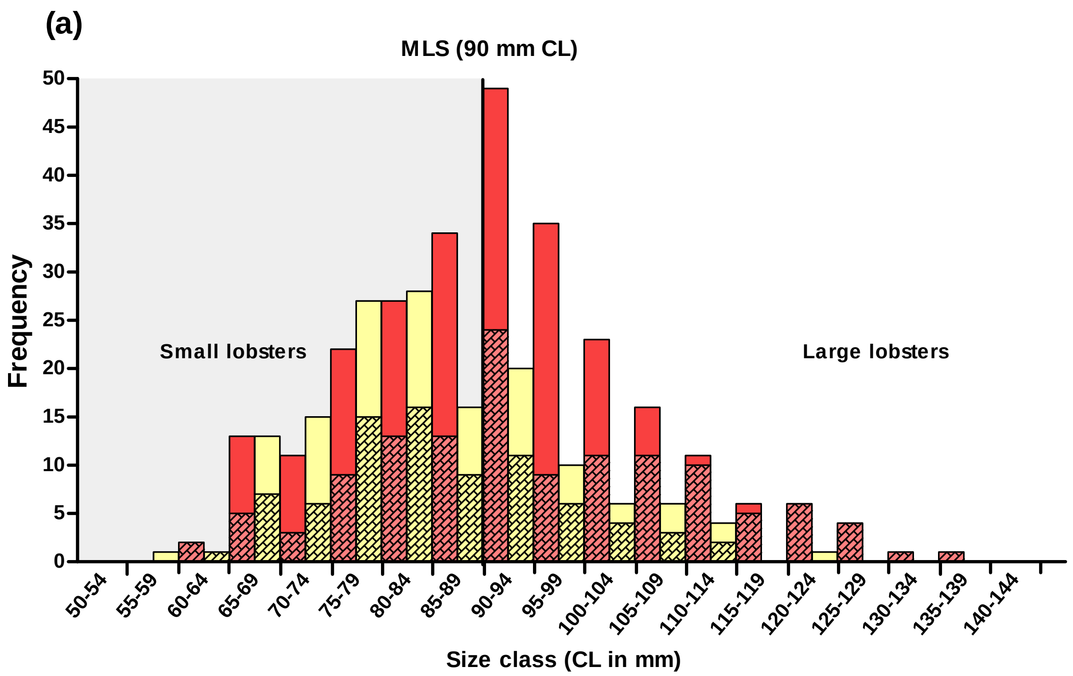
3.1.1. Population structure (Fig. 2).

Population structures are based on catch size-frequency distributions (Fig. 2a), due to the selectivity introduced through pot sampling. Table inserts (Fig. 2b and c) summarize data on lobster frequency and mean size (CL). Based on equal sampling effort, a greater number of lobsters were caught in the NTZ than in the RZ (NTZ=261 v. RZ=148), with the catch per unit fishing effort (CPUE) being 1.77 times greater in the NTZ than the RZ (1.24 v. 0.70). In addition, the NTZ population comprised of 58.2% large lobsters (i.e. >MLS), whereas the RZ population comprised of only 31.8% (Fig. 2b). This is clearly presented in the size-frequency distribution (Fig. 2a), where the frequency of small lobsters is very similar between the RZ and NTZ up to a CL of 85 mm, but then rapidly deviates above this size group, with the NTZ showing a significantly greater number of large-sized (>MLS) lobsters ($P < 0.0001$).

There was no significant difference in the gender ratio (M:F) between the 2 zones (NTZ= 1.00:1.05, RZ =1.00:0.85), and approximately equal numbers of males and females were found in both zones.

Mean CL measurements (Fig. 2c) show that lobsters (both male and female) from the NTZ were significantly larger than those from the RZ ($P<0.0001$ and $P=0.0096$, males and females, respectively).

Very few ovigerous ('berried') female lobsters were caught during the survey. Only three small ovigerous females were caught in the NTZ (87, 88, and 90 mm CL). None were caught in the RZ.



(b)

Gender and size (CL)		Frequency	
		RZ	NTZ
Males	Small (<90 mm)	54	45
	Large (>90 mm)	26	82
Females	Small (<90 mm)	47	64
	Large (>90 mm)	21	70

(c)

Zone and gender	CL in mm (mean ± SE)
RZ Males	84.39 ± 1.29
RZ Females	84.18 ± 1.51
NTZ Males	95.60 ± 1.45
NTZ Females	88.65 ± 0.95

Figure 2. Lobster catch population structure at Lundy Island. (a) Size-frequency histogram of lobsters from the RZ (yellow) and NTZ (red). (b) Frequency of small (<MLS) and large (>MLS) lobster. (c) Mean size (CL) of lobsters.

3.1.2. Lobster Health.

Gross external characteristics and blood samples were used to assess the health status of lobsters in the NTZ and RZ. Analysis of health data is still in progress, and dissemination of the results is subject to successful peer review of the findings.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

None of the lobsters examined exhibited clinical signs of disease such as lethargy and weakness, despite the presence of injury and/or shell disease. Both injury and shell disease were predominantly on the chelipeds (claws). Injury was commonly in the form of puncture wounds to the exoskeleton (shell).

To date, analysis has found no significant difference in cheliped (claw) loss between the 2 zones, however, significantly more injury was found in lobsters from the NTZ (P=0.0001) compared with lobsters from the RZ.

3.2. Brown crab populations.

A total of 191 Brown crab were sampled during the survey. However, due to equalization in sampling effort, only 108 individuals were used in frequency analyses (Table 1). Most strikingly, 98 of the 108 crabs were caught in the RZ, hence statistical analyses between the RZ and NTZ were very limited.

3.2.1. Population structure (Fig. 3).

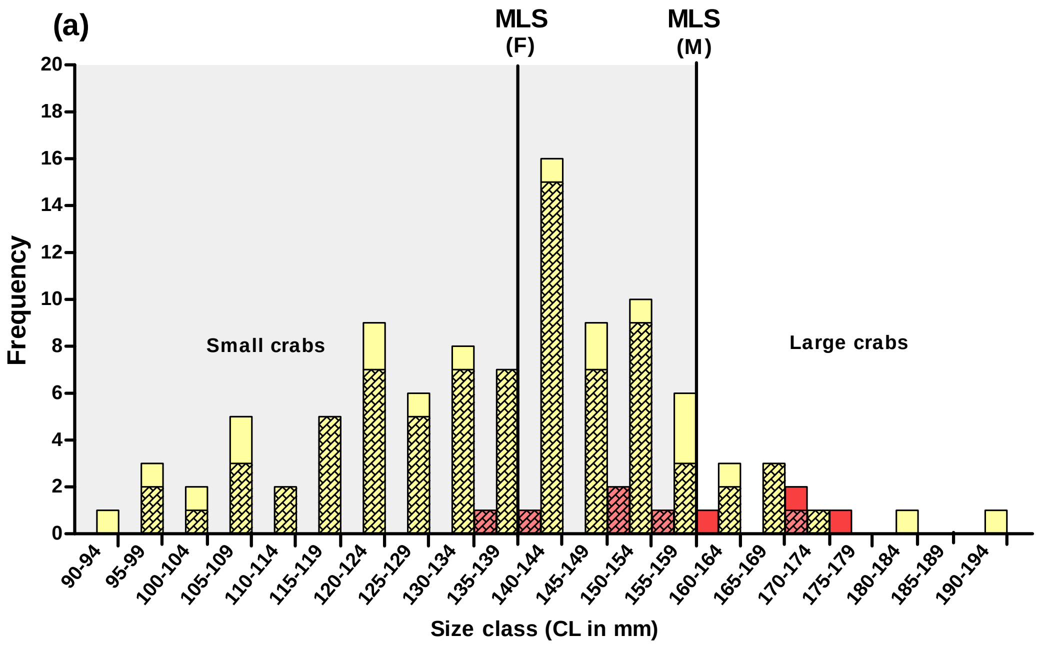
Population structures are presented as catch size-frequency distributions (Fig. 3a). Table inserts (Fig. 3b and c) summarize data on crab frequency and mean size (CL). Based on equal sampling effort, a greater number of crabs were caught in the RZ than in the NTZ (RZ=98 v. NTZ=9), with the catch per unit fishing effort (CPUE) being 11.7 times greater in the RZ than the NTZ (0.47 v. 0.04). The RZ population comprised of only 16.3% large crabs (i.e. >MLS), whereas the NTZ population comprised of 44.4% large crabs (Fig. 3b).

There was no significant difference in the gender ratio (M:F) between the 2 zones (NTZ= 1.00:0.5, RZ =1.00:0.24), however, males were the predominant gender in both zones.

Mean CL measurements (Fig. 3c) show that male crabs from the NTZ were significantly larger than those from the RZ (P=0.024). There was no significant difference in the mean size of female crabs.

No ovigerous ('berried') females were caught in either zone.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk



(b)

Gender and size (CL)		Frequency RZ	Frequency NTZ
Males	Small (<160 mm)	73	5
Males	Large (>160 mm)	6	1
Females	Small (<140 mm)	16	0
Females	Large (>140 mm)	3	3

(c)

Zone and gender	CL in mm (mean ± SE)
RZ Males	134.7 ± 1.89
RZ Females	135.5 ± 6.50
NTZ Males	150.8 ± 4.91
NTZ Females	169.0 ± 3.79

Figure 3. Brown crab catch population structure at Lundy Island. (a) Size-frequency histogram of crabs from the RZ (yellow) and NTZ (red). (b) Frequency of small (<MLS) and large (>MLS) crab. (c) Mean size (CL) of crabs.

3.2.2. Brown crab health.

Gross external characteristics and blood samples were used to assess the health status of crabs in the NTZ and RZ. Due to the very small sample size in the NTZ (9 crabs), a statistical comparison between the health of NTZ and RZ Brown crab is not valid.

However, comparisons of 3 parameters (i.e. shell disease, injury and claw loss) were carried out on crabs solely from the RZ. When comparing males with females, there were no significant differences in any of the 3 parameters. Comparisons between large and small crabs, also did not reveal any significant differences.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

3.3. Training of fishermen in health survey techniques.

Considerable effort was made by fishermen and scientists to train the skipper, Mr Geoff Huelin, and crew of FV 'Our Jenny' in crustacean health survey techniques. All fishermen were extremely keen to get involved and integrate with the scientists (Fig. 4). Fishermen were already extremely proficient in handling, sizing and sexing crabs and lobsters as these are prerequisites for sorting catch. They very quickly identified and categorized injury and shell disease on individual animals, and proved competent in providing robust scientific data. Fishermen were also very capable of taking blood samples. Their successful blood-taking ability was enhanced through their extensive experience of handling crabs and lobsters, as well as their capacity to work on a moving platform in rough weather conditions. The fishermen were also happy to share their local ecological knowledge (LEK) with the scientists. LEK included valuable information on spatiotemporal seasonality in lobster distribution and behaviour, interspecies pot competition and other general environmental observations.

The skipper, Mr Geoff Huelin, expressed much interest in carrying out future survey work on his fishing vessel.

A CD containing photos on training of the fishermen accompanies this report.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

Figure 4. Teaching fishermen survey techniques onboard FV 'Our Jenny' during the Health survey of Lundy Island crustaceans, August 2011.

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

4. Discussion.

The aim of the present study was not only to gather data on the health of crustaceans within the Lundy marine reserve (No-Take Zone; NTZ), but to integrate scientists and fishermen in the data collecting process. Both aspects of the study proved highly successful. A total of 432 lobsters and 191 crabs were surveyed, resulting in a potentially valuable data set on exoskeletal health, molecular diagnosis of disease and population genetics. Due to the large number of samples, screening and analysis is still in progress.

Population structure analysis (based on catch data) revealed several significant differences between the NTZ and RZ, for both lobsters and Brown crab, at Lundy Island. These differences were interpreted as 'positive' or 'negative'. The classification of observed differences may be subjective; and will depend upon the hypothesis being tested. Furthermore, these 'positive' and 'negative' observations are based on present-day understandings. Unpredictable future environmental and economic climates will undoubtedly influence our subsequent interpretation of the effects of marine reserves on commercial species. The predominant results of the present comparative study are discussed below.

Our survey revealed that, for lobsters, the CPUE was 1.77 times greater in the NTZ compared with the RZ. In addition, there were significantly more large lobsters (i.e. >MLS) in the NTZ, which is probably a direct consequence of cessation of fishing. The mean size of lobsters (for both males and females) was also significantly greater. These increases in lobster abundance and size are classic positive effects of marine reserves (NTZs) on commercial species (e.g. Babcock et al., 1999; Rowe, 2002; Goni et al., 2003; Pande et al., 2008); thus highlighting potential conservation benefits of highly-protected waters. Increases in abundance and size of lobsters may result in 'spillover' of both adults and larvae into adjacent waters (e.g. Rowe, 2001; Goñi et al., 2010; Pelc et al., 2010). Adult 'spillover' may benefit local fisheries in terms of increased CPUE, whereas larval 'spillover' may influence a large oceanographic area through planktonic larval dispersal. Larval 'spillover' is often considered most beneficial (Jennings, 2001; Gaines et al., 2003; Moffitt et al., 2009) due to its pivotal role in population connectivity and persistence (Cowen and Sponaugle, 2009). This is paramount in the European lobster where there is no UK-wide ban on landing 'berried' females. Unfortunately, empirical demonstration of 'spillover' from marine reserves is extremely difficult, hence current 'spillover' theories remain highly controversial.

Previous studies on Lundy lobsters (Hoskin et al., 2011; Wootton et al., in prep) also revealed significant increases in abundance and size of NTZ lobsters, however, in these studies, the differences between the RZ and NTZ were far greater. Hoskin et al. (2011) reported 5 times as many lobsters in the NTZ, whilst Wootton et al (in prep) revealed a 7.7 times greater CPUE in the NTZ compared with RZ. The lower increase in lobster abundance in the NTZ during the present study (NTZ CPUE only 1.77 times greater than RZ CPUE) is probably due to limited temporal sampling (i.e. 3 days during August 2011), rather than a relative decrease in the number of lobsters in the NTZ compared with RZ.

Pot fishing for lobsters may introduce sample bias due to its passive nature. Capture is influenced by many factors including bait, animal behaviour and environmental conditions (e.g. Fogarty and Addison, 1997; Bell et al., 2001; Jury et al., 2001; Cobb and Castro, 2006). Hence, the present study is a 'snap shot' into current conditions and only provides an insight into general trends within the Lundy NTZ. Future monitoring studies should, ideally, be of a higher spatiotemporal resolution and

Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

involve additional sampling techniques, in order to elucidate detailed information on population dynamics.

Despite the 'snap shot' approach, the present study offers a general insight into the health of Lundy lobsters. Data analysis is still in progress, thus only a limited discussion can be included in this report. None of the injured/shell diseased lobsters showed clinical signs of disease, such as lethargy and weakness. This suggests that currently Lundy lobsters are in reasonable health, and such detriments are not deleterious to the lobster population. It is important to note, though, that damage to the exoskeleton (shell) via injury (e.g. puncture wounds) and shell disease lesions can allow entry to other lobster pathogens/diseases, which under high host density and potential stress can induce high mortality (Sindermann, 1990; Cawthorn, 2011).

Most fatal lobster diseases are currently associated with the American lobster, however, because many are temperature dependant (Battison et al., 2004; Glenn and Pugh, 2006; Cawthorn, 2011), increasing sea temperatures as a result of climate change may result in increased disease and/or geographic shifts in disease distribution (Harvell et al., 2002; Lafferty, 2009; Pascal and Buoma, 2009). Under these scenarios, American lobster pathogens may become more prevalent in European waters. Hence, health monitoring of high density lobster populations, such as in NTZs, could not be more critical in present day efforts in UK fisheries sustainability and conservation.

The species showing the most striking difference between the RZ and NTZ was the Brown crab, *Cancer pagurus*. This crustacean species showed contrasting trends to that of the lobster. A total of 181 crabs were captured in the RZ compared with only 9 in the NTZ. Based on equal sampling effort, the CPUE was 11.7 times greater in the RZ compared with the NTZ. A previous Lundy survey by the same group of scientists and fishermen in August 2010, revealed very similar results. Unfortunately, due to vast differences in abundance between the two zones, statistical analyses were very limited in both studies. However, we can propose and discuss several hypotheses for the low abundance of Brown crab in the NTZ.

First, lobsters maybe out-competing Brown crab for pot bait, hence, capturing of lobsters in preference to crabs. This interspecies competition has been observed by other scientists (Miller and Addison, 1995). In high density environments, such as NTZs, there is much competition for highly valued resources such as food (or bait), and lobsters appear to be the dominant species. Second, there may only be a very low abundance of Brown crab inhabiting the NTZ. This may result from lobsters excluding Brown crab from NTZ habitats. Lobsters are highly territorial, thus will compete for (and defend) resources such as shelter and food, Hence Brown crab may have been displaced to other areas. Alternatively, Brown crab (particularly small-sized individuals) may be prey (ie. a food source) for lobsters. Thus, the high density of lobsters within the NTZ may be eradicating Brown crab. This is known as a 'trophic cascade', whereby predation by top predators, such as lobsters, alters community dynamics, often resulting in reduced species density and biodiversity (e.g. Pinnegar et al., 2000; Shears and Babcock, 2003; Guidetti, 2006; Harbourne et al., 2009; Heithaus et al., 2008). This is a potential negative impact of marine reserves (NTZs), and it highlights that conservation benefits of such reserves are not equally distributed among species (O'Sullivan and Emmerson, 2011), and decisions on species affording protection may be prejudiced during the management process.

In contrast to our Lundy studies of 2010 and 2011, a study carried out during 2004-2007 revealed a small, but significant, increase in the abundance of Brown crab in the NTZ (Hoskin et al., 2011). The scientists sampled very similar locations, with very similar sampling gear, to our recent studies. The discrepancy between studies may, therefore, be due to temporal differences in sampling regime, or, in fact, further evidence of a trophic cascade. Deleterious trophic cascades in the Lundy NTZ have been previously documented by Hoskin et al. (2011). Their study revealed that the abundance of velvet crab had declined within the NTZ, between 2004 and 2007, due to lobster predation and/or competition. Thus, trophic cascades were evident at Lundy within the first 4 years of NTZ implementation. Current data on Brown crab, suggest that trophic cascades still exist in the Lundy NTZ, and further increases in lobster abundance (since 2007) within the NTZ have resulted in additional crab species, such as the Brown crab, being victim to lobster predation. Further detailed sampling, however, is required to validate the 'trophic cascade' hypothesis.

The second aim of the present study was to integrate fisherman and scientists in monitoring studies, in order to emphasize the value of combined knowledge and expertise. Fishermen provided invaluable local ecological knowledge (LEK) to the scientists, whilst scientists taught fishermen all necessary sampling techniques for intricate monitoring of crustacean population structure and health. The collaboration was highly successful; fishermen were very keen to learn techniques and proved extremely competent in the more difficult tasks of categorising shell disease severity and taking of blood samples, and scientists benefited from LEK not available in published literature. LEK included valuable information on spatiotemporal seasonality in lobster behaviour and distribution, interspecies pot competition and other general environmental observations. Hence, in the current climate of MPA design and designation, integration of scientists and fisheries stakeholders is vital to understanding MPA efficacy.

Undoubtedly, MPA designation will have some negative impact on fishermen, most likely through displacement of fishing activity. However, the present study has shown that fishermen are competent in collecting robust scientific data; hence, there is potential to integrate and employ fishermen in the huge task of monitoring designated MPAs. There is significant financial advantage to this; it will compensate fishermen for displaced fishing activity, lessen the monitoring burden on the more expensive institutions of academia and government bodies, and allow for more consistent sampling regimes due to the ability of fishermen to work in unfavourable weather conditions. Validation of fishermen's data by scientists and fisheries officers would also play a significant role.

In the USA, integration of scientists and fishermen is far more advanced than in the UK. The term 'Collaborative Fisheries Research' (CFR) has been employed to describe this relationship. Several CFR organisations have been established with the primary aim of including fishermen in the collection of data. (e.g. www.cfr-west.org/ , http://www.opc.ca.gov/ and http://seagrant.mlml.calstate.edu/research/ccfrp/). CFR is considered to improve the quantity and quality of data, and provide social as well as scientific benefits. A recent peer- reviewed publication (Kay et al., 2012), has further highlighted the value of CFR. The study involved fishermen in the collection of data on lobster size and abundance, within, and adjacent to, a marine reserve. It was a very similar CFR scenario to the present study on Lundy lobsters. In agreement with the present Lundy study, the authors concluded that CFR (including LEK) is a promising tool for improving assessment and stakeholder participation in marine reserve monitoring and adaptive management.

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Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk

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Dr Emma Wootton
Dept of Biosciences, Swansea University, SA2 8PP
e.c.wootton@swansea.ac.uk