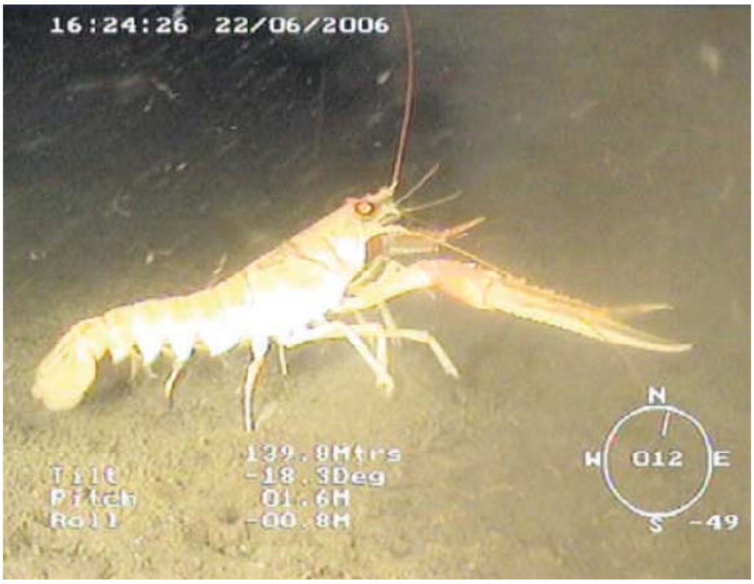
Lokaskýrsla

vegna AVS verkefnisins:

Aukin arðsemi humarveiða

(R 031-06)



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Háskóli Íslands og Vinnslustöðin í Vestmannaeyjum

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1 Ágrip

Aukin arðsemi humarveiða

Í þessu verkefni (AVS: 031-06) voru skoðaðir ýmsir þættir sem hafa áhrif á nýtingu og gæði humars. Verkefnið var sett upp sem rannsóknanámsverkefni (PhD) í samvinnu Háskóla Íslands og Vinnslustöðvarinnar í Vestmannaeyjum. Ráðinn var nemandi til verksins, Heather Philps og hóf hún námið vorið 2007. Heather kom frá Skotlandi þar sem hún lauk BS og MS gráðu við Háskólan í Aberdeen ásamt því sem hún starfað og tók þátt í að reka humarvinnslu á Isle of Sky. Tafir urðu strax í byrjun verkefnisins þar sem ekki tókst að finna hæfan nemanda fyrr en í lok fyrsta árs verkefnisins. Því var ekki unnt að ljúka verkefninu áður en styrktímbilið rann út. Sótt hefur verið um áframhaldandi styrk til næstu 18 mánaða. Verkefninu var skipt í 5 hluta: 1) athuganir á árstíðabundnum gæðum og ástandi humars, 2) áhrif veiða og meðhöndlun á gæði og verðmæti humars, 3) þróun aðferða til að aldursgreina humar, 4) lífssaga humars og mat á nýliðun og útbreiðslu ungviðsstiga og 5) Samanlögð áhrif allra þátta á arðsemi humarveiða. Helstu niðurstöður rannsóknanna á árunum 2007-2008 sýndu að löskun humars við veiðar var breytileg milli báta og tengdist m.a. lengd trollsins. Veiðar með lengra trolli ullu meiri skaða sem kom fram í tap á klóm og brotinni skel. Athuganir á mismunandi meðhöndlun humars virtust ekki benda til að meðhöndlun hefði áhrif á gæði hvað varðar tíðni skyrhumars. Tíðni skyrhumars var hinsvegar háð árstíma og var hann algengur í júní en að mestu horfinn í júlí. Þróuð var aðferð til að aldursgreina humar út frá þéttleika litarefna í augnstilkum. Þessi aðferð verður notuð til að aldursgreina humar á næstu vertíð, 2009. Einnig var hafin söfnun á ungviði og er stefnt að því að safna humarlirfum á mánaðar fresti yfir allt árið 2009. Hafinn er undirbúningur að gerð lífhagfræðilíkans sem tekur tillit til allra þátta er hafa áhrif á arðsemi humarveiða. Stefnt er að því að líkanið verði fullgert snemma á árinu 2010.

2 Content

3 Almenn lýsing á verkefninu

Megin markmið þessa verkefnis var að auka arðsemi humarveiða með því að skoða þá þætti sem hafa áhrif á nýtingu og gæði humars úr sjó.

Verkefnið var sett upp sem rannsóknanámsverkefni (PhD) í samvinnu Háskóla Íslands og Vinnslustöðvarinnar í Vestmannaeyjum. Auk þess komu að verkinu fjöldi fagaðila, bæði innlendir og erlendir. Myndaður var faghópur innlendra sérfræðinga og hagsmunaðila og fundaði hann reglulega á meðan á verkefninu stóð.

Nemandinn, Heather Philp var að mestu staðsett í Vestmannaeyjum með aðstöðu hjá Vinnslustöðinni og háskólasetrinu, en auk þess við Hafrannsóknastofnunina og Líffræðistofnun HÍ.

Verkefnið hófst í maí mánuði 2006. Tafir urðu strax þar sem ekki fannst nægilega hæfur nemendi til starfsins fyrr en í byrjun Janúar 2007. Auglýst var eftir nemenda á Íslandi yfir vor og sumar 2006 og síðar um haustið í Evrópu, Bandaríkjunum og Ástralíu. Alls bárust 43 umsóknir erlendis frá og af þeim voru 12 mjög góðar. Einum umsækjenda, Heather Philp, var boðið í viðtal í byrjun janúar 2007. Hún kom mjög vel út enda hafði hún starfað við humarvinnslu frá 13 ára aldri og m.a. í stjórnunarstöðu hjá Amazon Seafood, Skotlandi. Auk þessa stundaði hún nám við Háskólann í Aberdeen og lauk þar BS og MS prófi ásamt því að vinna við greiningu á gögnum úr stofnstærðarmati Skota á humri (Fisheries Research Service in Aberdeen). Heather hafði því mikla reynslu sem ljóst var að myndi nýtast vel í þessu verkefni. Heather var ráðin til verkefnisins í apríl mánuði árið 2007. Vegna ofangreindra tafa þá tókst ekki að ljúka verkefninu fyrir lok ársins 2008, þegar styrkurinn rann út. Því hefur verið sótt um áframhaldandi fjárveitingu og er stefnt að því að ljúka þessu verkefni á árinu 2010.

Fyrsta árið, 2007, fór að mestu í söfnun upplýsinga m.a. hvað varðar rannsóknir og veiðar á humri við Ísland sem og á öðrum svæðum. Þannig leiltaðist Heather við að finna hvar þekkingar var þörf um leið og sett var upp framkvæmdaráætlun fyrir árin 2008-2009. Verkefnið tók nokkrum breytingum frá upphaflegri umsókn. Megin breytingarnar fólust í því að lögð var minni áhersla á að meta áhrif veiðarfæra, sjávar og umhverfisþátta á humarslóðina sjálfa. Þessi í stað var lögð meiri áhersla á að meta gæði og ástand humars og finna orsakir fyrir slæmu ástandi (hvað varðar skyrhumar, löskun á skel og gæðum/ástandi vöðva). Einnig var lögð áhersla á að safna upplýsingum um lífssögu humars og reyna að meta útbreiðslu ungviðis frá einu svæði til annars. Stefnt var að því að bera þessar upplýsingar saman við niðurstöður úr öðru verkefni um stofngerð humars (verkefni á vegum Matís). Einnig var lagt til að prófa nýja aðferð til að aldursgreina humar en þessi aðferð hefur ekki verið notuð áður. Í lokin var stefnt að því að nota niðurstöður úr öllum þáttum verkefnisins til að auka skilning á lífsháttum og vexti í tengslum við umhverfisþætti sem og fiskveiðistjórnun og nýtingu humars.

Verkefninu var skipt upp í 5 verkþætti sem fólu í sér:

1. Athuganir á árstíðabundnum gæðum og ástandi humars
2. Áhrif veiða og meðhöndlun á gæði og verðmæti humars
3. Þróun aðferða til að aldursgreina humar
4. Lífssaga humars og mat á nýliðun og útbreiðslu ungviðsstiga
5. Samanlögð áhrifa allra þátta á arðsemi humarveiða

4 Staða þekkingar

In Iceland, the production yield of the lobster processing industry is considerably lower than that of other major processing countries. In Scotland for example, a fifteen per cent loss of yield is expected when processing landings from a three-day fishing trip. By comparison, up to thirty per cent is rejected from the whole production in Iceland. This is likely due to a combination of production techniques and underlying aspects of the lobster biology. In particular, meat quality may be affected by nutritional status and infection by disease-causing agents such as the parasite Hematodinium spp. (Ridgway et al, 2007; Parslow-Williams et al, 2001). Shell quality can be affected by moult stage and condition (Alvarez-Fernandez et al, 2005). These biological factors vary in occurrence and severity throughout the year, therefore it is important to identify peak periods of poor lobster quality that coincide with the fishing season in order to reduce production loss.

The Nephrops fishing industry is particularly lucrative due to the high unit value of the species. For example, in Scotland where more than one third of all landings are made, the fishery is worth almost £100 million at first sale. In Iceland, potential value is lost because of poor on-board handling practices and sub-optimal fishing techniques. Further, there is a failure to exploit new developments in the international market. Consequently, the industry in Iceland is not maximising its economic possibilities.

The annual dynamics of lobster populations are somewhat mysterious due to the difficulty in aging crustaceans; unlike many marine organisms, these do not have hard structures maintained over time that can be used to determine their age. Consequently, the distribution of age classes within a localised group of animals and the patterns of growth are not usually known. These parameters are particularly important for monitoring the year-on-year changes in availability to the fishery and for determining suitable harvest levels. As a consequence of this particular problem, mismanagement of *Nephrops* stocks in other areas within the species' range has led to well-documented stock collapse (ICES, 2004).
It is becoming very important to find successful ways of determining the age of commercially fished crustacean species. In addition to resolving understanding about key biological parameters about the population, it is necessary to know more about factors such as growth and lifespan in order to predict appropriate stock harvest regimes. The significance of this issue in Nephrops management has increased recently because it is a very high value species worth more to national fisheries than groundfish landings. Consequently, a series of European meetings will take place during 2009 to discuss the shortcomings of current management methods and to establish acceptable new techniques. The method of aging Nephrops being investigated in this project is at the absolute forefront of new scientific methods and will provide the most important information necessary to manage the resource. Once developed for lobsters in Iceland, it can be adapted for lobsters in other European regions too.

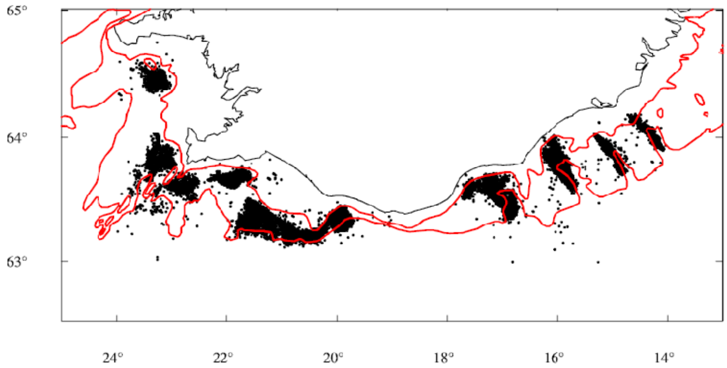


Figure 1. Location of lobster towes durting the lobster season in 2000-2004.
100 and 200 m depth contours are shown.

In Iceland, the distribution of lobster populations is limited to 100-300 m dept along the continental slope south and southwest of the country (Figure 1). Abundant data on distribution and population parameters exist, based on numerous surveys conducted by the Marine Research Institute. However, little information exit on seasonal variation in reproduction and larval emergence. It is important to know about a species reproductive strategy in order to understand their biology. When the species is the target of a high value fishery, it becomes even more vital since effective management depends on knowing the level of harvest that can be gained from the fishery. Over-fishing in the absence of this knowledge can mean that the fishery collapses and takes many years to recover, if at all. There is a strong indication that the biennial reproductive cycle of Nephrops in Iceland is changing as water temperature increases (Hrafnkell Eiriksson, MRI; pers. Com). Consequently, old management considerations may no longer be valid.

5 Progress and Results

5.1 Seasonal variation in health & condition

In 2007, a working relationship was created with other scientists working in related fields in Iceland, Canada and Scotland. A series of trials were carried out during the summer of 2007 to ascertain the extent of the soft meat problem and to relate it to parameters such as lobster size, idiopathic muscle necrosis and shell damage. No relationship was found but the occurrence of soft meat reached as high as 80% in some catches during the summer.

In 2008, a special effort was made to accumulate knowledge and develop the technical skills needed to analyse the production quality in clearly defined terms as well as to explore live lobster health so that relationships between health & quality could be investigated. To this end, a course was attended at the Technical University of Denmark entitled “Physical and biochemical methods for analysis of fish as food” where methods were learned such as protein analysis, enzyme degradation over storage time and the effect of oxidation on texture and quality. In addition to this, a relationship was created with the course co-ordinators, Drs Bo Jørgensen and Flemming Jessen,that has proved invaluable throughout the year when they have provided advice on new procedures.

In addition, a course on lobster health diagnostics was also attended at the University of Arizona Veterinary College in July. Techniques taught included histology methods, blood screening for invasive pathogens, nutrition indicators, bacterial analyses and diseases affecting crustaceans. The course convenor, Professor Don Lightner is a leading world authority in lobster health and nutrition. Since the course, his advice has been sought and given on issues with histology. He has also made himself available to discuss ideas for new methods to determine nutritional status of lobsters in Iceland.

This year, data collection and analysis of lobster health and condition factors from a series of surveys was started. The intention is to create a profile of changes in these parameters over the course of a year and to relate them to product quality changes, in particular shell and meat properties. Each month 100 lobster traps are deployed in an area 5 nautical miles east of Vestmannaeyjar. After being in the water for a period of two days, they were retrieved and emptied of their catch. The lobsters were placed into individual crates and stored in an on-board tank before being transported to the holding facility. Approximately 200-300 lobsters were caught from which a subsample of 50 males and (where possible) 50 females were randomly selected. These are measured for carapace length, weight, hepatosomatic index, moult stage, reproductive stage, health status (evidence of pathogens, blood cell count), nutritional status and proximate composition.

The deliverables and milestones were mostly met as planned including the construction of holding facilities for live lobster storage, the purchase of necessary equipments (including consumable, lobster traps and associated gear), and preparation of protocols. However, it was initially intended to begin sample collection at the start of the fishing season with the expectation of completing this by the following one in 2009. In actuality, the fishing season started later than originally planned with the result that there was a conflict of survey timing during the summer period. It was decided to defer the start of the survey schedule until the end of summer so in August and September a period of several weeks was used to learn both the fishing techniques (use of traps to catch live lobsters) and the best storage conditions in the holding facility. A season of extraordinarily stormy weather meant that the first survey did not take place until December.

5.1.1. Results

These are preliminary results pending the completion of the survey schedule during 2009. The surveys undertaken in December and January indicated that the male to female ratio was high, with females representing a very small proportion of the catch (Table 1). The maximum female size was approximately 55 cm; in commercial sales terms, this is a size Medium. By comparison, most of the males were classified as size ‘Large’ through to ‘Extra Extra Large’ (Figure 2). It would be expected that as the year progresses, the female proportion of the catch would increase. This would have the effect of reducing the average size of lobsters caught. The length to weight ratio also varied between sexes. Figures 3 shows that as size increases, the relative increase in weight is less for females than for males. Consequently, an increase in female occurrence in the catch will also reduce the average weight of lobsters caught.

The condition of the lobsters was measured using the Hepatosomatic index which is the ratio of liver weight to whole body weight, expressed as a percentage. This was found to be consistent across both months, with that of females again being slightly lower than of males (Figure 4). It is expected that this will increase throughout the next several months as food becomes more available. The condition of lobsters will significantly affect their suitability for export as a live product with high levels of energy reserves (high HS Index) enabling a longer storage time and improved survivability.

Table 1. Proportion of females in the catch

Survey month	*Number of males*	*Number of females*	*% female proportion*
December	174	27	13
January	245	24	9

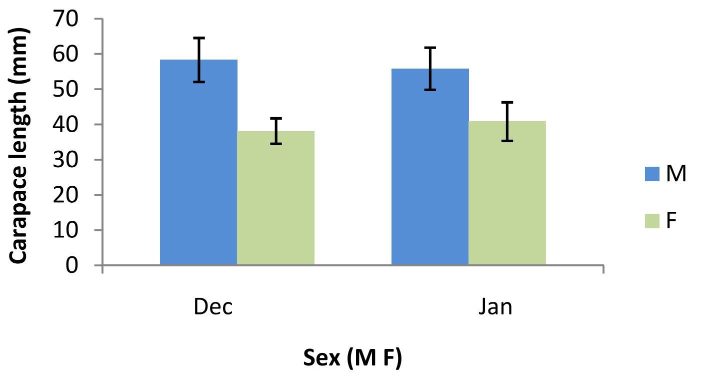
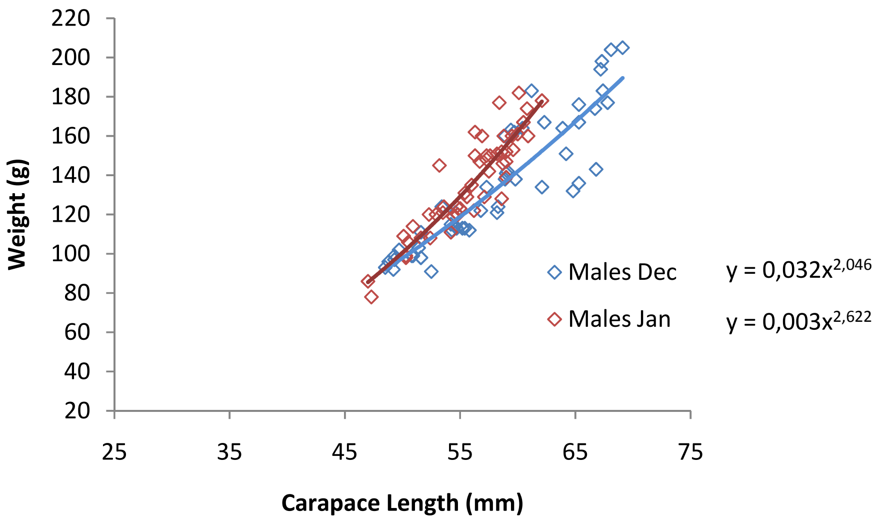


Figure 2. Size of lobsters expressed as carapace length (mm)

It was found that the size of males was significantly different to that of females in both December (student's t-test, t=13.7055 p<0.0001) and January (student's t-test, t=12.2020 p<0.0001). In addition, the size of males caught in December differed from those in January (student's t-test, t=2.4804 p=0.015) although the female size did not.



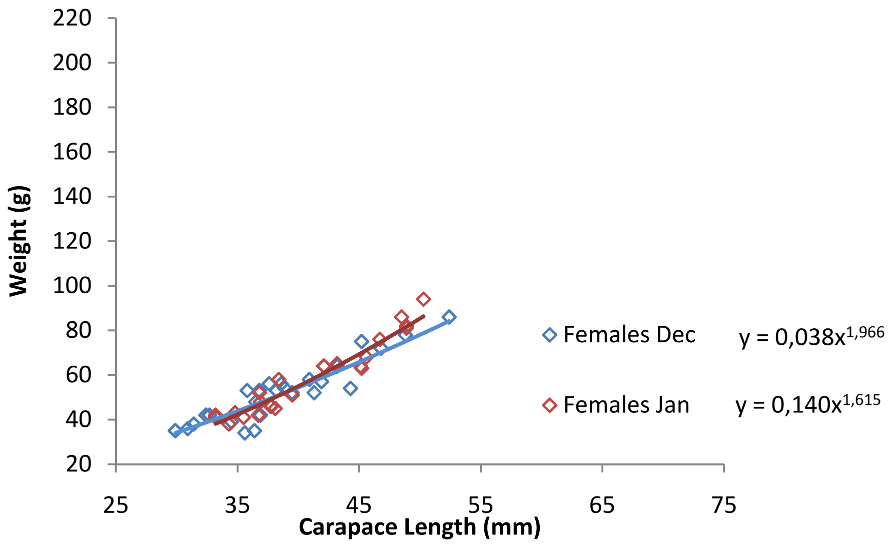


Figure 3. Length to weight ratio of males in December and January (above). Length to weight ratio of females in December and January (below)

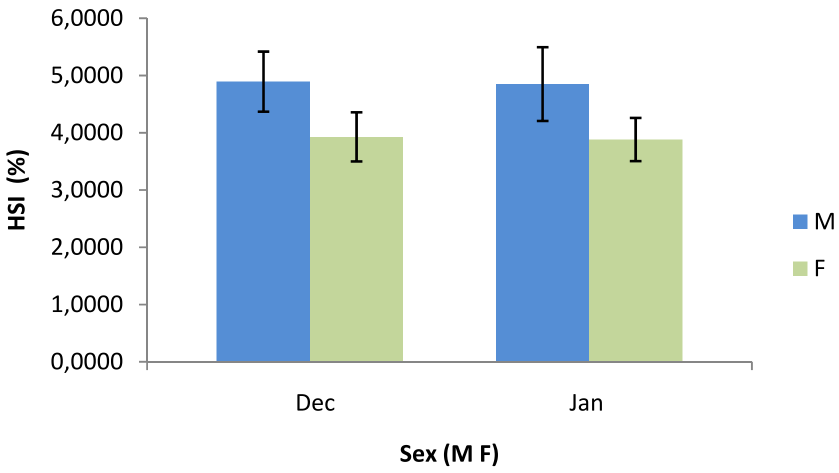


Figure 4. Hepatosomatic Index of males and females in December and January

The difference in HSI between males and females was found to be significant in both December (student's t-test, t=8.1456 $p<0.0001$) and January (student's t-test, t=6.8287 $p<0.0001$) although no differences were found within the sexes between the months. This is likely to be because the females are diverting more of their reserves towards reproductive efforts.

5.1.2 Work In Progress

Other data associated with health and condition is in the process of being analysed; protein content of the muscle, lipid content of the liver, histology and infection screening. These are the most important factors likely to affect the product quality. There are a further ten trap surveys outstanding and a quarterly trawl survey; the next of these is will take place as soon as weather permits.

5.2 Investigation into the effects of fishing and post-capture handling on quality and value

5.3.1. Progress in 2007-2008

In 2007, the level of damage incurred by lobsters due to fishing and handling practices was investigated, enabling the economic performance of the fishery to be evaluated. A review of current market opportunities and problems was carried out and it was found that there was considerable pressure on the domestic market due to poor meat quality and that new opportunities in international markets were not being utilized due to lack of knowledge. A method for grading the extent of damage through a catch and through the processing line was developed in order to identify key areas in the process that should be improved.

In 2008, a series of comparative fishing trials were carried out during the summer to investigate the effects of fishing activity and on-board handling. The new fishing technique of trapping lobsters was experimented with and a trial carried out into survivability of lobsters in a holding facility, although these results are not available yet. In the first investigation, the level of damage to the catch experienced by two separate boats was evaluated. The first vessel was slightly larger with a length of 42 meters and engine power of 728kW; Vessel 2 was 40 meters width and engine power of 662kW. The fishing net of Vessel 1 was 50m and had 4 cod ends whilst that of Vessel 2 was 50m with 2 cod ends. Over the course of a four day trip on each boat, a 15kg sample was taken from two 3.5 hours tows per day as the catch came aboard. At the end of the trip on Vessel 2, a small subsample (40 lobsters) was taken from one tub from each of the fishing days and stored at -20^{o}C for later meat quality analysis for comparison in the on-board handling trial (see below).

Fishing tows are normally 4-4.5 hours long so it was initially decided to undertake a series of tows that were either 3.5 or 5 hours long to determine the effects of fishing time on catch quality. However, following a single attempt to fish for 5 hours using Vessel 1, it was clear that the size of the catch was so great that not only were most of the lobsters damaged but it was also dangerous to be hauling and taking aboard. It was decided that this aspect of the experiment would be abandoned until a new agreement could be made with the fishing company to trial different fishing times – less than 3.5 hours and the operation risks becoming uneconomic because more time is spent loading and unloading the net than actually fishing so special approval must be given. The remainder of the trip and that on

Vessel 2 took tows of 3.5 hours only. The results of the 5 hour tow are displayed graphically for interest but not included in further analysis. It is hoped to complete the time-related aspect of the study during the summer of 2009.

The on-board handling trial investigated two methods of storage of the catch in terms of damage level and meat quality. The first method followed the Scottish model whereby the catch is immediately sorted to remove damaged lobsters (these are tailed and stored separately – they do not feature in further analysis). Whole lobsters are carefully washed and treated with sodium metabisulphite, a commonly used preservative and antioxidant that reduces the characteristic enzymatic browning experienced by dead crustaceans. They were then heavily iced and stored in small fish boxes with now more than 20kg per box. The second model followed the Icelandic procedure where the damaged lobsters were again removed from the catch. The undamaged component was washed in a machine that works by tumbling the lobsters whilst applying jets of pressurized water. They then were treated with the same sulphite preservative, heavily iced and stored in large tubs.

Figure 5. Containers used during the comparisons of onboard handling

One tub and ten boxes from two tows per day were labeled to allow easy identification in the processing plant. This gave a total of two tubs and twenty boxes from each storage time (t=24 hours, 48 hours or 72 hours). A 15kg sample was randomly selected from each of the storage methods for each day and each tow (i.e. sample 1 = storage time of 72 hours, tow 1 of the day, stored in boxes). The data from each of the two daily tows was combined to give a daily total per storage time and storage method. Parameters recorded included damage, meat quality (in terms of cooked texture – firm or soft ‘skyrhumar’), bacterial loading and k-value. K-value is measure of the ratio between nucleotides and is a recognized technique for indexing freshness – a low k-value indicates a fresh product.

The studies made use of the damage index developed in 2007 whereby animals were classified as "1" Undamaged; "2" Minor damage, an example of this being missing swimmerets or walking legs; "3" Serious damage which includes missing claws and splits between the head and body; and "4" Reject which is where the lobster is damaged beyond possible sale as a whole product. In the case of minor damage, there is no immediate effect on sales value but these injuries could introduce spoilage bacteria which could affect storage. A small amount of animals showing serious damage is acceptable but if large proportions are, for example, missing single claws there will be complaints from customers.

5.3.2 Results

The results of the comparison in damage between vessels are shown below in Figure 6. Apart from the single 5 hour tow, the number of tows was 6 from each vessel. The number of lobsters recorded for damage in each group was as follows: Vessel 1 n=568, Vessel 2 n=504, 5 hour tow n=78. Using a chi square analysis, the only damage category to show a difference in the proportions between vessels was 'serious' (χ^2 = 2.463 p=0.007; figure 6).

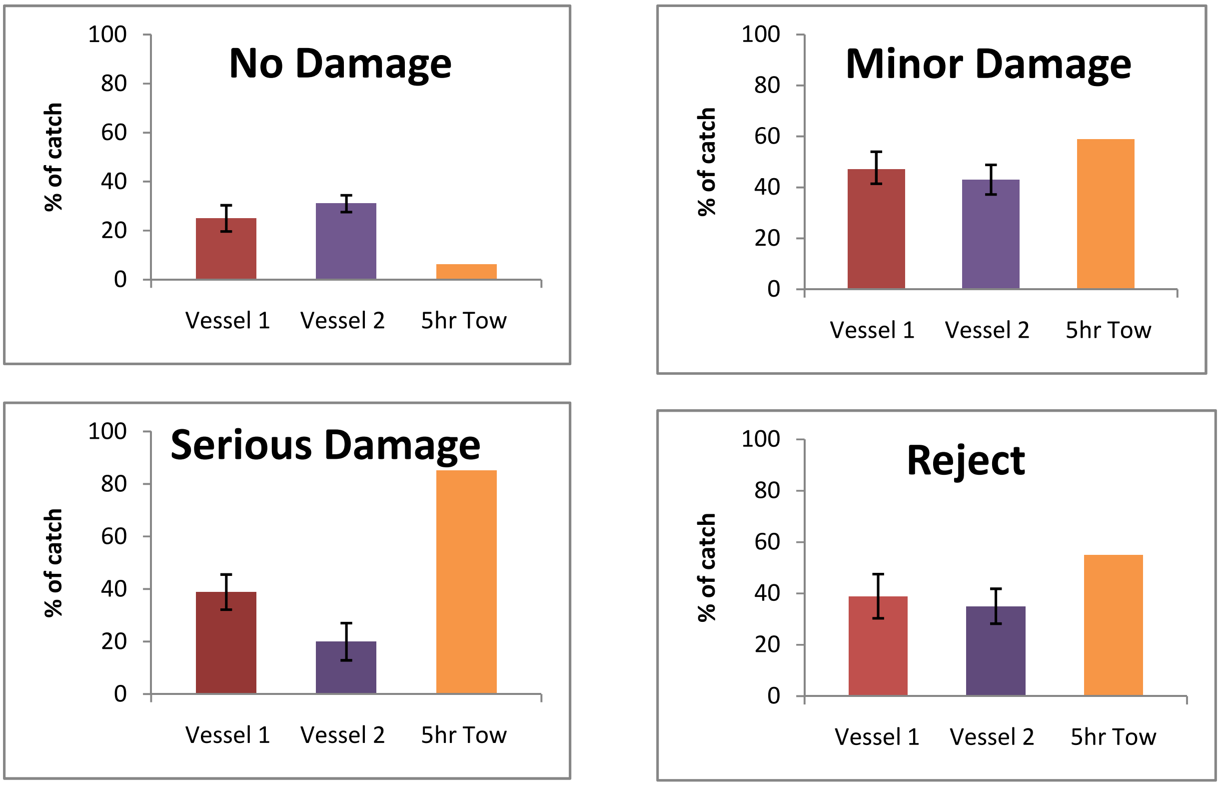


Figure 6. Comparisons of damage of catch among two lobster vessels and a 5 hour tow

The comparison of on board handling procedures also identified that the damage category 'serious' showed the only significant difference in quality between treatments. This was true for each of the storage times (T= 24 hours χ^2 = 7.133 p=0.008; T=48 hours χ^2 = 11.208 p=0.0008; T=72 hours χ^2=7.615 p=0.006). Figure 7 displays the results of the trial. The number of lobsters recorded at each storage time was: 24 hours n=368, 48 hours n=404, and 72 hours n=406.

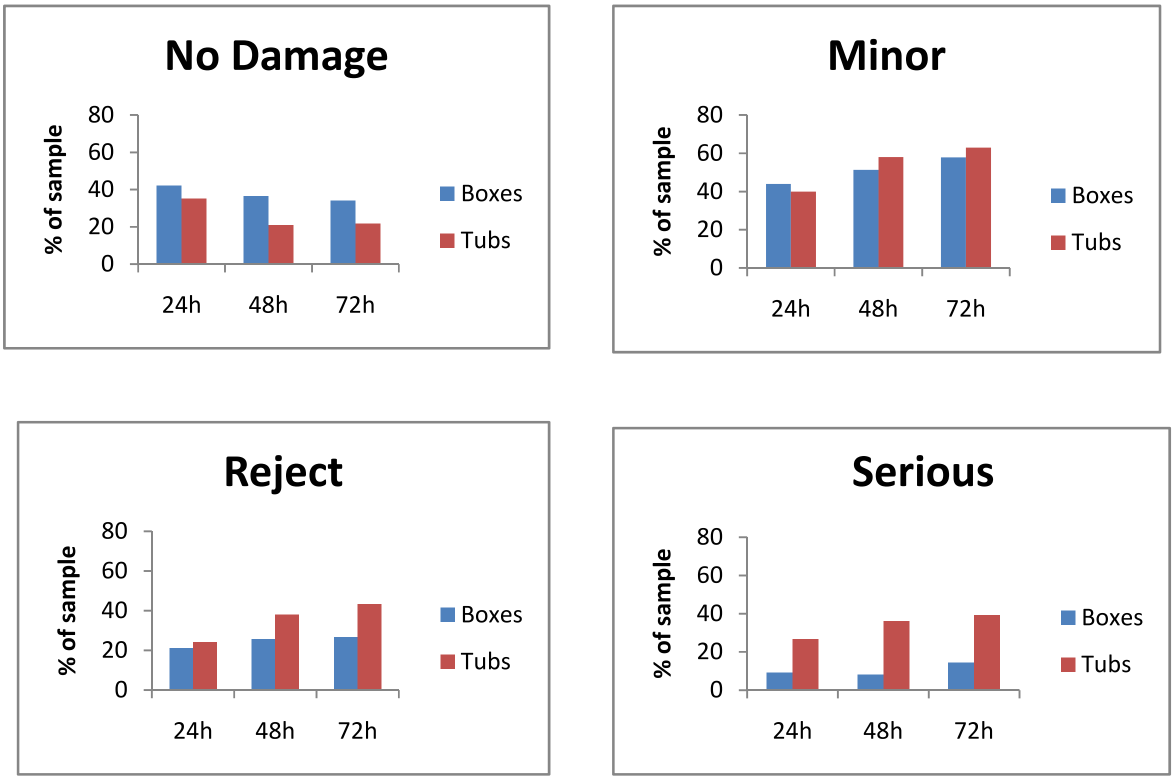
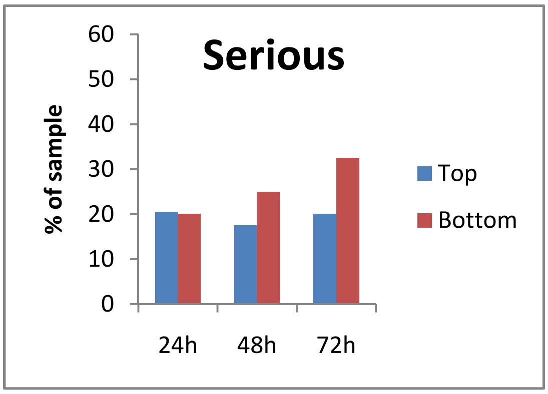


Figure 7. Comparison of damage to lobsters from two on-board storage methods

The final analysis was to compare the level of damage at the top of the tub against that of lobsters at the bottom of the tub. This is shown for the damage categories 'serious' and 'reject' below in Figure 8. The experiment was carried out post hoc and using only a small sample taken from one tub for each storage time (number of lobsters recorded at each time was 24 hours n=78, 48 hours n=69, 72 hours n=84). Although no comparisons were found to be significant in this analysis, the graphs suggest a difference may be there and the experiment will be repeated during summer 2009 with a larger sample size.



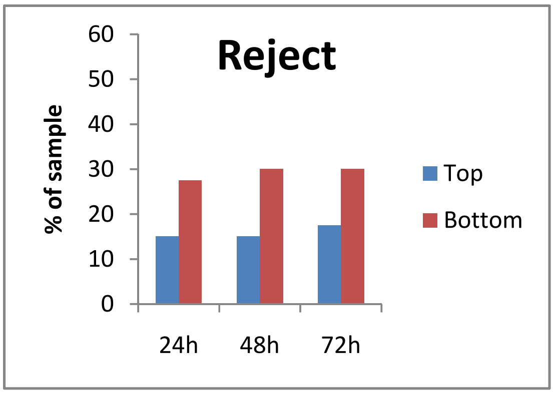


Figure 8. Comparison of damage to lobsters at the top and bottom of the tub

Meat quality analyses were carried out on lobsters from both on-board handling treatments (n=20 for each treatment and each storage time) and lobster from Vessel 2 (n=20 for each storage time). Using a chi square analysis, it was found that the rate of occurrence of soft meat or 'skyrhumar' was the same for all treatments and vessels, however, the proportion increased with time post capture. The significant period of increase was found to be in the first 24 hours (χ^2=12.913 p=0.007). These results are shown below in Figure 9.

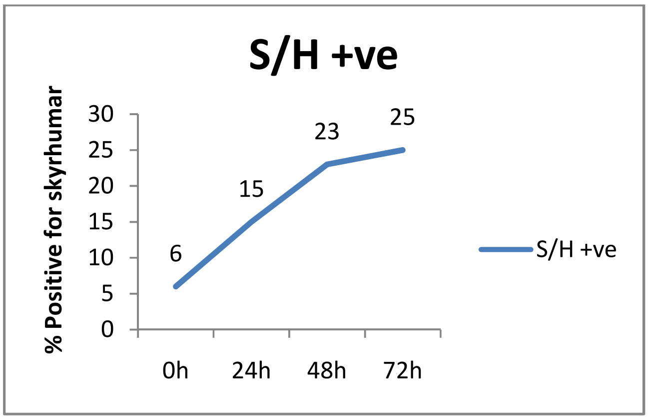


Figure 9. Proportion positive for skyrhumar at different storage times

The difference in k-value for the treatments was explored using ANOVA followed by the post hoc Tukey test where appropriate. At each of the storage times, a difference was detected and further analysis revealed that the k-value for storage in boxes and in tubs both differed from storage on Vessel 2 but not from each other. These results are described in Table 3 and displayed in Figure 10.

Table 3. Results of ANOVA to compare k-value between treatments at different storage times

Storage time	F Value	P Value	Tukey test significance		
			Boxes vs tubs	Boxes vs Vessel 2	Tubs vs Vessel 2
24 hours	9.3	0.0007	Not sig	<0.01	<0.01
48 hours	6.38	0.005	Not sig	<0.05	<0.05
72 hours	24.94	0.0001	Not sig	<0.01	<0.01

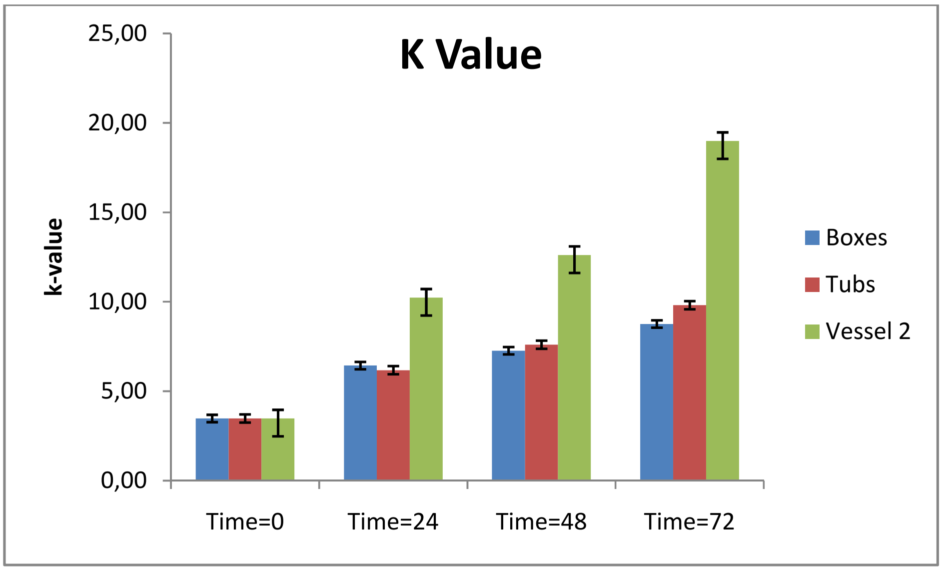


Figure 10. K-value for the different treatments at the different storage times.

During the bacterial analysis, it was found that some of the samples for the box storage had been removed from the freezer for a period and then refrozen. Consequently, these were excluded from the analysis and only data from tubs in Vessel 1 and Vessel 2 are analysed. It was found that although the bacterial load of each increased with time and at an apparently faster rate in Vessel 2 than Vessel 1 (Figure 11), analysis with a fitted linear model did not detect any significant differences.

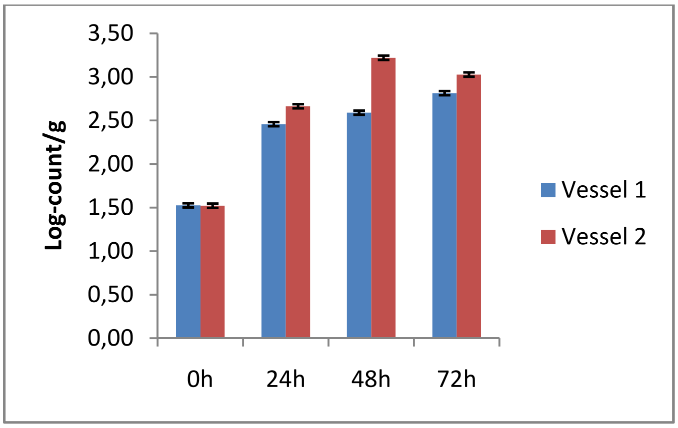


Figure 11 Log count of bacterial load from the two vessels at different storage times.

Conclusions

The type of damage inflicted on the catch varied between vessels as exemplified by the difference in amount of ‘serious’-type damage. The main criteria for this category of damage are loss if a claw or split between the head and abdomen. It is likely to be because the length of the net leading towards the cod end is greater in Vessel 1 than 2. When lobsters are stressed or disturbed, they instinctively form a defensive position with their claws raised and bodies arched. During the fishing activity, a longer trawl creates more opportunities for outstretched limbs to become entangled in the mesh and pulled off.

This feature of the animals’ behavior also explains the difference in this damage type revealed by the on-board handling trial. Animals washed in a tumbling machine are more likely to get their claws caught on the jets that spray water and on each other as they are tossed around. The effect of this is to not only dislodge claws immediately but to loosen them so that a greater number fall of during storage. In addition, storage in tubs places a greater strain on animals that are near the bottom than those on the bottom of boxes due to the difference in weight imposed (up to 200kg in tubs but a maximum of 20kg in boxes). Although the mini-experiment where the damage was compared between the top of tubs and the bottom did not reveal significant differences, a repeat of this aspect with a larger sample size will reveal whether this was a true result or due to inadequate representation.

The difference in meat quality between treatments and vessels was only evident in terms of k value. The fact that skyrhumar was equally represented between samples and increased with time suggests that although it is a post mortem change, the aetiology is an underlying aspect of the lobster biology. This theory is supported by the fact that during the trials which took place in June, skyrhumar was frequently detected in the factory production, however, by July this had almost disappeared. This indicates a seasonal peak in occurrence which definitely means a biological cause. The unfortunate consequence of this is that it is unlikely that a change in fishing or handling technique will do to mitigate this serious quality issue, although if the range and timing of the peak could be determined it is possible that fishing effort could be reduced to minimize the amount being caught.

The difference in k value was significant between vessels but not handling practices. Both vessels followed the Icelandic protocol for on-board handling with the additional treatment on Vessel 2 of the Scottish method. The Icelandic procedure makes use of large tubs which are insulated to conserve a cold temperature. However, the tubs also have the affect of preventing the refrigerated air in the hold from reaching the lower regions of the tubs, so if inadequate ice was used during storage, the effect would be to actually have a higher temperature over time in the bottom of the tub. This would increase the rate of nucleotide breakdown leading to a higher k value. To explore this further, during the summer of 2009, temperature loggers will be placed in tubs on board vessels 1 and 2 to monitor how this varies between the boats and over time.

Although bacterial count in Vessel 2 seemed higher than that of Vessel 1, not only was it found to be not significant but also within the acceptable levels for a seafood product. Guidelines from the European Commission on microbiological criteria or foodstuffs state that the surprisingly high count of 15,000 bacteria per gram (log count 4.18) is the point at which such products intended for human consumption can be considered spoiled. This indicates that not only is the general background carrying load of bacteria low for lobsters but current on board handling practices are adequate to prevent the flourishing of spoilage bacteria.

5.3.3 Work in Progress

A comprehensive report explaining the tests carried out and results achieved is being prepared. This will first be passed to Vinnslustöðin to ensure that there is no commercially sensitive information being distributed. A follow up trial will take place during the fishing season this summer to explore the effects of reducing the weight of catch placed per tub and to evaluate the economic implications; it would be ineffective to lose the benefits of reduced damage by increasing the cost of fishing activity (more time spent travelling to land than fishing, for example). It is also hoped that it will be possible to carry out the trial to compare the effect of different tow times, however again care must be taken to avoid making the fishing activity uneconomic by spending more time hauling and setting nets than actually fishing.

Concurrently, a trial is also taking place to investigate the effects of storage type on live lobsters by comparing a closed system with a water filtration and chilling facility against a flow-through system where the water is derived from a harbor bore. This is important for the emerging live lobster production industry because the first system is associated with a high level of investment (both in terms of initial installation outlay and running costs), whilst the second is a much cheaper alternative. Preliminary results seem to indicate that the closed system has a more positive effect on lobster storage health, however, it is impossible to say for sure as analysis is still ongoing and the full results of the study will not be available until April.

5.4 Development of aging techniques and investigation on the dynamics of the population of lobsters in Iceland

5.4.1 Progress in 2007-2008

During 2007, a thorough review of the literature was carried out and important connections with scientists working in this field of Nephrops biology were created. In Iceland, a working arrangement with Hrafnkell Eirisksson has been developed, whilst in Scotland, Fisheries Research Services (FRS) provided Heather with office space for a week to search through their extensive literature and data collection, and to discuss ideas with member of the Nephrops scientific group. An agreement with Dr Matt Sheehy of the University of Leicester was made to teach Heather the techniques that he has developed to age insects. A plan was made to adapt the techniques for use in aging Nephrops.

As the project developed, some changes were made to the original plan for this Work Package. This was due to a combination of natural evolution as new information becomes available and budget constraints. Specifically, following the first part of a course at the University of Leicester to learn the techniques that would be adapted for aging Nephrops, it was decided that these methods did not require a concurrent growth study where lobsters would be held in aquaria for a period of two years. Further, it was determined that the cost of mapping the sample area using an ROV outweighted the benefits of undertaking this aspect of the Task.

Therefore, all efforts were focused on the techniques themselves. An extended course at the University of Leicester was taken during two separate periods (early spring and autumn). Lobster samples were collected and prepared in Scotland during February. This was deemed easier that transporting animals from Iceland since there are travel restrictions on the chemicals used to fix the samples (chloroform and xylene). After removing the heads of live animals and placing to a fixative for a period of at least 24 hours, the eyestalks were removed (Figure 12) and the cuticle stripped to reveal the optic nerve. The whole stripped eyestalk was embedded in paraffin then sliced microscopically finely along its length (Figures 13). When the region of interest was detected (Figure 14), the slices containing that section were fixed to slides and examined with a fluorescence microscope.

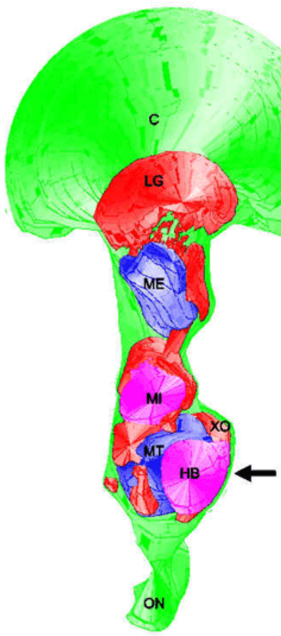
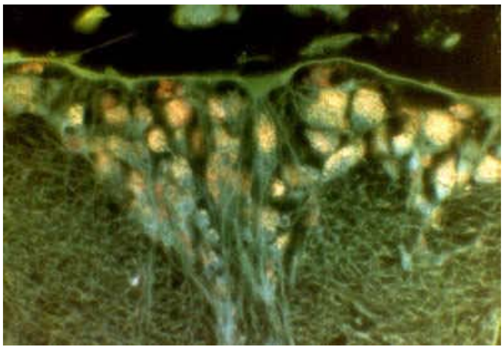


Figure 14. The region of interest that gave the most clear results was the hemiellipsoid body (indicated by the arrow).It was decided to use this for aging Nephrops.



The aim was to quantify the amount of a autofluorescing pigment, lipofuscin (Figure 15), which is known to increase in concentration linearly with age in the post-mitotic (for example, neural) tissue of all animals. Slices from a suitably identifiable nerve bundle (in our case the hemiellipsoid body) were used to determine the average concentration of lipofuscin in individual lobster post-mitotic cells. When this procedure is repeated on a large enough number of animals, a concentration-frequency histogram can be created and modes in the data used to identify year classes. Having identified the nerve bundle that gave the more clear results for Nephrops, the intention was to apply the procedure to Icelandic lobsters. A place was secured on the Hafro research vessel during the annual lobster survey in May and representative samples collected from each of the different fishing grounds. Unfortunately, upon processing the samples later in the season, it was found that the solution used to fix them was not entirely suitable for Nephrops and consequently many of them were corrupted. A thorough investigation using fresh samples and trying different variations of the fixative revealed that the xylene replacement that is commonly used in Iceland was the cause of the poor fixation. Therefore, future studies will make use of histoclear, the chemical used in the original technique development rather than tissue-tek, the substitute that had been made when trying the method in Iceland.

5.4.2 Work in Progress

Having spent extensive time working on adapting each of the steps (more efficient sample collection, improved fixing, processing and analyzing) of this method for use in Nephrops, it is now ready to be used on a much larger sample size. It is important to wait for the time of year when the female lobsters emerge from their burrows so that the sample collected is suitably representative of both sexes (this will be during the summer). At this time, the data collection will begin again and analysis completed no later than eight weeks after. This will ensure that the results can be contributed to the European Nephrops meetings later in the year.

5.5 Investigating the unique life history features of Icelandic lobster for management purposes

5.5.1 Progress during 2007-2008

In 2007, a review of current knowledge about Nephrops reproduction was carried out and information gathered with the assistance of Hrafnkell Eiriksson on the biology of Nephrops in Iceland. Contact was made with Vidar Oresland of the Swedish Marine Institute to help design traps suitable for catching larvae and collaboration was formalized with Dr Kai Logemann to utilize his CODE hydrodynamic model of the North Atlantic (highly resolved over Icelandic waters) to predict where lobster larvae settle.

In May of 2008 a small survey was carried out using plankton nets to detect the presence of lobster larvae in the water column. May was the earliest that they could have appeared, however, their absence means that female Nephrops are unlikely to hatch their eggs until June. This is consistent with Northern Ireland and Scotland. The summer period was spent making a set of twelve lobster larvae traps to be used the following season. A sampling area has been selected as a region 5 miles south of Vestmannaeyjar. Adult traps have been deployed in the area to confirm the presence of Nephrops.

5.5.2 Work in Progress

Currently, an investigation into the breeding cycle of adult Nephrops is taking place. Traps for adults are deployed monthly in the survey area and information gathered about the ration of males to females being caught. In addition, the ovary developmental stage of all females is being analysed and recorded. During May, data will also be collected during the annual Hafro lobster survey on the ovary maturation of lobsters from different fishing grounds. Analysis of the reproductive cycle results will be undertaken by Heather Philp and Hrafnkell Eiriksson. From late May 2009, the larvae traps will be deployed on a weekly basis to determine the timing & length of occurrence of lobster larvae in the water column. These data will then be introduced to the hydrodynamic model.

5.6 Development of an optimal management strategy for the lobster fishery in Iceland.

Bioeconomic models are increasingly popular tools for both management strategy analysis and optimization analysis. In the case of management and policy, the impact of alternative ideas on both the natural resource and human welfare can be evaluated. In much the same way, applying these tools to potential economic optimization schemes, a code of 'best practice' that delivers the greatest returns and minimizes unwanted costs (economic and environmental) can be generated and explored.

The data required to build the model is still being collected. Therefore this Work Package is still very much work in progress.

6 Conclusions and plans for 2009

During 2008 the main focus of the research was production yields from the fishery. To this end a series of investigations were carried out to investigate the effects of fishing practices on product quality. In addition, initial trials were carried out into the feasability of developing a live lobster export product. The data collected during this period will be introduced to the bioeconomic model.

Certain biological aspects of lobsters in Iceland are also important for increasing the value of the fishery (from lobster health through to the long term harvest strategy). Therefore, a series of surveys were initiated that will reveal vital information about seasonal changes and life history traits.

Analysis of production yields under different conditions and data collection of biological parameters will be completed during 2009. In addition, a refresher course on bioeconomic modelling with particular emphasis on fisheries will be attended. Armed with these data and tools, the model will be completed in 2010.

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