Shellfish flesh waste in bait

October 2008

Produced by Andy Fitzgerald for a project funded by Seafish's Industry Project Fund

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Shellfish Flesh Waste in Bait Report

For:
Sea Fish Industry Authority

Final

October 2008

Andrew FitzGerald

Shellfish Flesh Waste in Bait

Executive Summary

Shell waste is a major problem with UK production of waste from calcareous shellfish (excluding *Nephrops* and shrimp) of around 75,000t/yr of which potentially ~20,000t is flesh.

Although there are many theoretical options for the use of waste shell few are commercially viable, often due to the costs of separation and cleaning. Previous work has shown it is possible to separate the flesh from the shell and supply the ‘free of flesh shell’ for use in aggregates; however this leaves the problem of what to do with the fleshy material.

The current “Proof of Concept” project has focused on the use of shellfish waste derived flesh waste in commercial bait. A comprehensive set of trials with bait sticks prepared from scallop (King & Queen), whelk, and crab waste demonstrated that the fleshy waste from shell is a suitable material for baits.

Whelk and crab waste formed very good baits for lobster attraction and were comparable to standard baits for whelk attraction

1. Background

1.1 Project Outline

Shellfish waste constitutes a major financial and operational burden to the primary processing industry and has been identified as a limitation to the development of the sector in some regions. Shellfish processors want simple, local, cost-effective outlets for shell.

1.2 Scope of Report

The basis of the current study originated in the production of clean calcareous shell for aggregate applications from a previous Seafish Shell Aggregates study (Ref. SAL) In consequence the shellfish flesh waste streams considered in the current report include crab, whelk and scallop (king and queen). The significant waste arisings from Nephrops and shrimp have not been included within the current study in addition to the use of finfish waste arisings.

Although bait is required for a number of capture fisheries including crab, lobster, whelk, nephrops and shrimp the focus of the current report has been upon bait for crab, lobster and whelk.

Input has been provided from Seafish, Resource Efficiency Knowledge Transfer Network, Cornwall Sea Fisheries Committee and the Shellfish Association of Great Britain (SAGB) with specialist input from the National Lobster Hatchery Padstow. A number of shellfish processors have also contributed.

1.3 Bait Market

Bait is used as an attractant to lure crab, lobster, whelk, nephrops and shrimp into pots or creels for capture. A large variety of different bait types are used according to species, season and availability. Studies show different species like different baits. Generally, lobsters are attracted to gurnard, herring and mackerel, crabs are attracted to white fish and whelks are attracted to fresh crab.

Fishermen have to buy bait at £400-600/t which can be a significant proportion of vessel operation costs. For the 30,000-35,000t/yr of crab, lobster and whelk landings to the UK there is an estimated requirement of 6,000-7,000t/yr of bait with a total cost to industry estimated as £3-3.5m/yr. There have been increasing difficulties with bait prices over recent years with some traditionally used ‘trash’ fish now being utilised in other sectors.

The use of seafood processing waste for bait has long been accepted for some by-products such as ‘frames’ (finfish remains after filleting) and is a legally permitted application.

2. Trial bait production

2.1 Shellfish Flesh Waste Characteristics

Different samples of shellfish by-product were used to develop the baits. These included scallop (King and Queen), brown crab and whelk. These were tested for dry solids (DS) which is important when considering the quantity of polymer binder to add to the bait components.

Dry Solids Content of the Shellfish flesh waste

Sample	K. Scallop	Q. Scallop	Crab	Whelk
% Dry Solids (%DS)	31%	21%	30%	31%

%DS determinations were conducted gravimetrically drying test samples to constant weight in a 90ºC oven over 24hrs.

The physical characteristics of the waste components dictate how well the bait stick will bind together, whilst the chemical characteristics of the bait influence the attractiveness to the individual target species.

Physical Characteristics of the shellfish flesh waste

King Scallop Waste

Comments: Fresh material with moderate odour. Wet material with available liquor. High sand content. By adding 15% by weight of water a homogenised paste of material was produced

Queen Scallop Waste

Comments: Fresh material with low odour. Despite the lowest %DS of 21%t this material had a low moisture ‘rubbery’ feel with little free liquor. No sand or shell contamination was apparent. By adding 15% by weight of water a homogenised paste of material was produced..

<table>
<tr><td>Crab Waste

Comments: Fresh material having high shell content with odour and some free liquor. l. By adding 15% by weight of water a homogenised paste of material was produced</td><td>Whelk

Comments: Fresh material containing some shell with odour and some free liquor. Some shell content apparent. By adding 30% by weight of water a homogenised paste of material was produced. Additional water was required because of its cohesiveness.</td></tr>
</table>

2.2 Bait Mixes

Pot bait needs to maintain cohesive integrity for the majority of the pot soak time (generally 1-2 days). However, from a fishing effectiveness perspective the pot bait should partially dissolve, allowing a plume of scent to attract the target species. Good bait will therefore balance both the handling and fishing properties.

There are a number of potential variables in bait formulation that will affect its stability and dissolution rate, including;

- Proportion of paste to solid
- Raw waste from single species or mix of species
- Binder content
- Bait processing temperature

Bait Composition – Proportion of paste to solids
To help bind the bait together and provide good dissolution, a proportion of the raw material was homogenised. Maintaining a 'solid' component (i.e. not macerating the whole bait mass) helped to provide a stronger structural framework to the bait. The water stability tests therefore used a mix of 'paste' and 'solid' components.

Pastes were produced by adding varying amounts of water to the solid before liquidising. A 15% water addition was sufficient for most ingredients although a 30% water addition was required for whelk. Domestic food preparation equipment has been utilised throughout the current study.

Bait Composition – Raw Ingredient Mixes

'Single species' baits and 'Mixed species' baits were produced and tested to provide a range of handling properties. Additionally, varying compositions might allow scent adjustments therefore improving fishing efficiencies for specific target species.

Binder Content, Handling and Concentrations

Genugel® carregeenan binder produced by CP Kelco was chosen as an 'off-the-shelf' food grade material commonly used in meat gelling applications. Genugel® is provided as a fine powder which was dissolved in boiling water to provide a 5% working stock solution. Although the binder should remain in liquid phase, >70ºC a surface crust formed despite immersion in a water bath unless maintained at boiling point. At 100ºC the 5% solution was still highly viscous but could be removed and dispensed with a pre-heated 50ml syringe. Water loss (10-20%) through evaporation was apparent during bait preparation and as such there will be a degree of error within the reported binder content.

All binder content calculations are based upon binder % DS in the final bait. In consequence a 1% binder equates to a 20% V/V addition of the binder stock to the bait materials.

The Genugel® was effective in binding all materials although a significant variation in performance was noted between samples despite a similar % DS. Binder handling required careful temperature control with setting at 50ºC. Initial formulations (Tests 1.1, 1.2, 1.3) attempted hot binder injection to a cold bait mass – this did not work as the binder set immediately. Subsequent tests heated both paste and solid components to 50ºC before the injection of the binder. This produced a good result from a cohesion perspective. However, it is not known whether the increased temperature of the bait will have decreased is scent performance. Furthermore, the need to provide a low temperature heating to raw bait ingredients will clearly have an implication to the cost and requirements of any potential commercial bait operation.

Sea Temperature

The optimisation of bait integrity and dissolution is likely to be influenced by sea temperature and therefore may require a 'summer' and 'winter' formulation. For the purposes of the current study a 'summer' temperature regime is followed although is unlikely to be valid in winter. It is recommended that any potential follow-on work should consider bait performance under both summer and winter conditions.

3. Bait Testing Methodology

3.1 Water Stability

Stability tests were necessary to ascertain whether the different bait mixes and sticks were suitable for use. Good bait will maintain some integrity of the mass after 1 day but with some dissolution indicating a release of 'scent'

Sea trial stability tests were conducted by placing bait sticks into trays within a barrel (see picture below) that was placed in the sea for 24 hours. Also one set of soak tests within a static tank was also undertaken.

Full details of the results of the water stability testing are provided in Appendix A, Table 1, 2 and 3 for Test 1, Test 2 and Test 3 respectively. A summary of the results is included in Section 4, with detailed results in Appendix A.

Sea test equipment comprising meshed holding trays contained within a 60L barrel

Sea Tests – meshed Trays (with test baits)	Sea Tests – Barrel to hold trays
	

3.2 Animal Behavioural Tank Tests

A series of behavioural tank tests were performed at the National Lobster Hatchery (NLH) Padstow Cornwall to compare the test baits against standard potting baits.

3.2.1 Test Animals

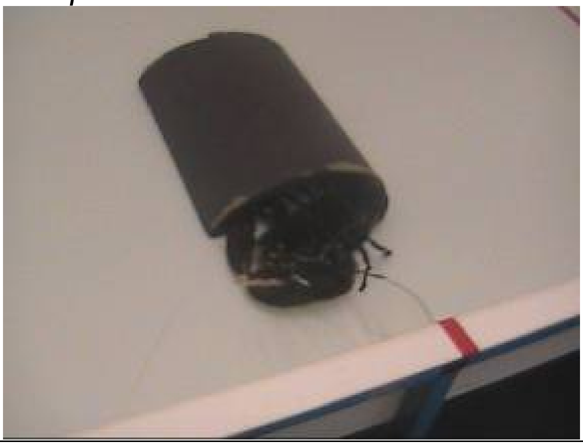
Tank tests were performed on the European lobster, common whelk and the edible brown crab.

Live lobsters were obtained from NLH – ex-berried hen stock that had been maintained within the NLH system for 2 months. All stock had unbanded claws for the duration of the trials so as to present a more natural feeding habit. Although the stock used was in good health it is not know to what degree they have adapted to life in an artificial environment with a diet of frozen mussel. It has been assumed for the purposes of the trial that the lobster results obtained for the females will be representative of both sexes.

Live whelks were obtained directly from commercially landed stock. It is not known to what degree the whelk stock performance may have been compromised by handling conditions. All of the initial stock from the initial batch died whilst over 50% of the stock died from the second batch. Whilst in the trials surviving animals were highly variable in their activity rates ranging from 0% (never going for bait) to 100% (always going for bait) with an average over the 7 surviving animals of 59% activity.

Live crabs were obtained fresh from a commercial vivier facility in Padstow. Of the initial stock of x3 animals one died prior to the trial onset and had to be replaced. There seemed to be no differentiation between the test animals in their overall level of activity.

European Lobster



Common Whelk

3.2.2 Experimental Design

The methodology of the tank tests was devised in consultation with the NLH staff following review of the selected behavioural and physiological publications (see References).

Assumptions:

- Soak time optimal (30min soak prior to test)
- Minimised visual feeding indication
- No sex differentiation in bait preference
- Tank configuration does not compromise hunting process
- Bait aging (smell) constant. (try to keep bait fresh in freezer and thaw/store for same periods.)
- Baits of comparable odour release potential (try to ensure same mass and mass/surface area ratio

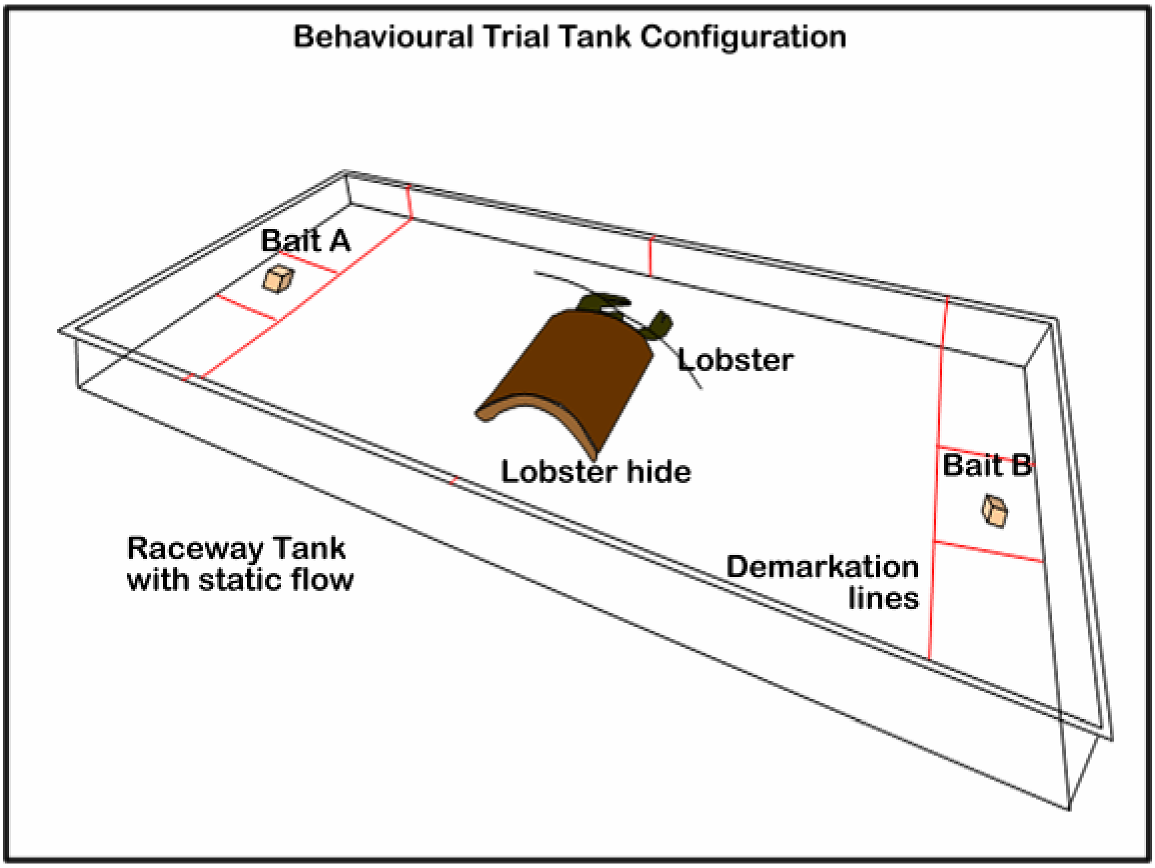
Dye testing was required to establish that a static diffusion tank configuration worked as well as a laminar flow tank. 0.5ml of 40% fluoreoscein dye was introduced at the bait release position and the time of travel to the tank centre recorded and monitored on video. The test was repeated under ‘no lobster’ and ‘lobster present’ conditions. Lighted conditions were necessary as the dye could not be seen under red-light.

The presence of lobster in the tank affected the laminar flow patterns in the tank significantly affecting the time taken for the dye to diffuse (see Table below). This is a random effect depending on how sedentary the lobsters are thereby introducing significant variation into the tests. Laminar flows rates from literature ranged from 3mm/s to 0.8cm/minute – neither of which would be sufficient to make a significant difference to the impact of the lobster. It is concluded that the static test condition presents a more reproducible test condition (difficulties obtaining laminar flow) and that either tank configuration would need to take account of inter-lobster variation.

Dye Test Condition	*Test Distance* (mm)	*Time of Travel* (s)	*Diffusion Rate* (mm/s)
Static (no lobster)	600	570	1.1
Static (with lobster)	600	195	3.1

3.2.3 Tank Test Methodology

Behavioural testing of trial baits can be assessed by the time for the target animal to acquire the bait and by bait selection. Following consideration of scientific literature and the dye diffusion test, it was decided that the testing regime would encompass both of these indicators. A test tank was configured with a central animal ‘hide’ where the target animal was located whilst zones for the location of x2 baits were demarked at either tank end. In this way ‘Side A’ and ‘Side B’ presented a choice to the target animal of either test bait or standard bait. The sequence of presentation was changed on successive tests to prevent any 'learned' behaviour. A series of controls including a 'no-bait' option was also used.



Test Tank Notes: Tank dimensions: 1.8m x 0.6m x 0.15m

The test tank was filled with full salinity seawater (~17C) obtained from clean supply tanks (i.e not recirculated water with potential for previous scent tainting. After each test the tank was fully cleaned down with fresh water prior to re-filling.

To ensure that lobsters would hunt by scent rather than by sight the trial room was blacked out and illuminated by a photographers red light (as used in darkrooms). A literature review showed that lobster sight is greatly diminished at around 600nm, which is still within the human visible spectrum. Lobsters were acclimated for an artificial 12hr:12hr light:dark regime using artificial light at night and red light operation in the day. All stock was maintained between tests in a holding facility as described overleaf:

<table>
<tr>
<td></td>
<td>Stock Holding Facility

Upper Level – Whelk tank

Middle Level – lobster tank
(note: x3 lobsters held unbanded in isolation baskets)

Bottom Level – Biofilter + recirculation pump sump
(note: pump outlet linked to upper tanks via a chiller to adjust holding temperature to the same level as that of the through-flow water used in the test tank)</td>
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</table>

Testing Procedure

- Remove bait stick sample from storage in freezer
- Pre-soak/thaw test bait prior to test (30min)
- Test animal (Individual animal tests (for lobster / crab) un-banded) placed in tank and allowed to acclimate for 30 min. In the case of lobsters and crabs consider placing hide and starting the test once the animal has settled in hide.
- Test animal on low ration diet (the same animals repeatedly for a number of tests (marked with identifier))
- Test animal removed prior to bait consumption (at set point)
- Vary (and record) which bait is introduced first

Number of Tests

- For lobsters and crab x1 animal /test - X9 tests/condition (triplicates (x3) for x3 animals)
- For whelk x7 animals /test (whelks identified with coloured banding).

Recording

- Bait choice
- Time to bait
- Test temperature
- Animal ID

4. Trial Results

Water stability testing (Section 3.1) was effective in demonstrating that a polymer binder can be used to obtain a bait stick that is both stable for extended soak times and water soluble to allow gradual scent release.

The animal behavioural tests were an effective technique to screen a large number of test variables in a short period of time without the excessive cost and risk of sea trials.

Detailed results for lobster, live crab and live whelk are provided in Appendix B. A summary of the results is provided below:

Live Lobster – Summary of results

		Test bait taken first		
Bait Type	**No. of Tests**	**Yes**	**No**	**% Bait Preference**
Single Composition				
Whelk	7	7	0	100%
Crab	9	7	2	78%
Scallop	8	1	7	13%
Mix Composition				
Whelk : Scallop (50:50)	6	3	3	50%
Whelk : Crab (50:50)	6	1	5	17%
Scallop : Crab (50:50)	6	2	4	33%

Live Crab – Summary of results

		Test bait taken first		
Bait Type	**No. of Tests**	**Yes**	**No**	**% Bait Preference**
Single Composition				
Whelk	3	0	3	0%
Crab	3	0	3	0%
Scallop	3	0	3	0%

Live Whelk – Summary of results

		Test bait taken first		
Bait Type	**No. of Tests**	**Yes**	**No**	**% Bait Preference**
Single Composition				
Whelk	11	5	6	45%
Crab	11	5	6	45%
Scallop	11	4	7	36%

5. Discussion

The animal behavioural results provide a number of interesting observations:

Different target species show marked differences in bait performance. Lobsters responded very well to whelk and crab with a higher bait preference than even the ‘standard’ gurnard bait. Whelks performed satisfactory to whelk and crab (45% bait preference is comparable to standard bait) but slightly less well to scallop. Crab did not respond at all to any of the test baits. It is possible that the reported preference of crab to more odorous baits might reflect a different chemical amino acid profile. As such, any follow on work should aim to repeat tests with aged material.

It had been hoped that mixing different types of shellfish bait could help improve the attractiveness of a poorly performing bait but there was only sufficient time to test lobsters with the mixed baits. Indeed the whelk : scallop mix performed well (50% = as good as a standard bait) which would suggest a marked improvement to the stand alone scallop performance (17%). However, the whelk : crab mixed bait performed poorly - whist the performance of the constituent parts in isolation had worked well. Further tests are required.

Individual animals showed large differences in levels of activity within the tests in how they responded to the baits. Some lobsters were markedly quicker to the bait than others (i.e. two of the test lobsters averaged <35minutes to the bait, whereas in the remaining tests, other test lobsters averaged >70minutes to the bait). To minimise variation lobsters of a comparable size were selected, however as size is not just a function of age it is possible that individual animals may just respond more quickly because they are more voracious eaters.

The rate of scent diffusion will also be influenced by individual variation with a more mobile lobster being more likely to increase the speed of scent detection.

Individual whelks also demonstrated significant difference in activity varying from 0-100% with an average of 59% response to the bait during the test time. Considering the source of the whelks it is possible that activity levels may have been a response to individual health. There were insufficient numbers of tests upon the crabs to obtain any clear relationships.

Improvements in the methodology would be useful in any further work. For example, homogenising the bait into a reservoir of water which could be injected via a peristaltic pump would remove dissolution effects and allow free animal movement towards the bait. It would also eliminate the need for operator intervention to rapidly remove the bait to prevent the animal from feeding.

6. Financial and Market Issues

6.1 Selection of Bait Preparation Method

Bait preparation can be achieved by a number of methods each of which will present different properties and different costs.

6.1.1 Binder Based Bait

The trials used binders to produce a bait stick. From this work it is possible to create a bait stick that has good bait properties being both cohesive enough to stay together in the water over a soak time, yet allowing sufficient dissolution that a good scent is generated within the water column to attract the target species. Indeed the variable binder content could probably allow production of a range of baits with different 'hardness' to cater for longer soak times or different water temperatures. However, there are a couple of key problems with this approach:

-Energy costs: The use of a heat stable binder clearly requires a heat stage to allow melting of the binder so that it can set to form a solid at operating temperatures. Heating large volumes of shellfish waste which is largely water would require significant energy which in the current climate of rising fuel prices is unlikely to be popular unless a significant earning potential exists. Bait production is likely to present low margin and could therefore present a high operating cost.

-Equipment costs: There is no standard off-the-shelf equipment for this application and as such a future commercial operation would need to fabricate its own system which would be expensive for the initial capital cost. Any servicing or repairs would also present a significant maintenance cost.

-Staff costs: The production of a pre-formed bait with a binder will only work if the temperature regime for both the flesh waste and the binder stock are prepared with almost scientific care (i.e ~50ºC for the flesh and >90ºC for the binder). To underheat material would cause failure of the mix whereas to overheat the material would denature the protein and could well change the performance of the bait. The staff costs would reflect this need for precision in both the time required in bait preparation and the level of staff which could be employed for this task.

6.1.2 Alternative bait production methods

The use of bait bags is widely practiced in the US with products ranging from more expensive units with drawstrings and are designed to prevent loss to 'sea lice' to long tubes of cheap plastic netting which require sealing. All of the products featured seem to be plastic and non-degradable

Examples of Bait Bag Materials from the USA

Mussel sock can be obtained in 100% cotton, which is designed to be biodegradable within a couple of weeks. This technology is well suited to bait production with low material costs, handling costs and is likely to be handled on conventional casing machines.

Mussel Sock containing whelk and crab mix

6.2 Financial Information

A cost illustration is provided below giving indicative costs for the production of bait sticks. This is based on a Seafood Processing & Bait Production Facility Converting 5t/wk into >500,000 0.5kg bait sticks

		Notes	**£/yr**	**£/bait stick**
Production Costs	Staff	*1*	30000	0.058
	Equipment Depreciation	*2*	17500	0.034
	Overheads	*3*	18538	0.036
	Total		**66038**	**0.127**
Sales		***4***	78048	0.150
Profit		***5***	12010	0.023
Disposal cost saving		***6***	15610	

Notes:

1 ***1.5 staff full time on £20000/yr/person***

2 ***£35k depreciated over 2yr***

3 ***Overheads include power and materials***

4 ***Bait price at £0.30/kg or £0.15/stick (standard bait £0.40 to £0.60/kg)***

5 ***15% profit***

6 ***Assumed disposal cost of £60/t***

7. Conclusions

This ‘proof of concept’ project has presented a number of positive findings to support the potential for the production of bait sticks using shellfish flesh waste by-product.

- Comprehensive formulation, soak and animal behaviour tests were carried out using a range of shellfish processing waste to produce bait for a variety of target species.
- Initial tank tests worked very well, showing that transforming shellfish waste into bait is a possible solution. Preliminary results show that performance for some target species is better than others and that further work is required to optimise performance for all species.
- The wider benefits of using shellfish waste for bait include that it is effective on a local level thus being relatively sustainable, it reduces transport costs for waste disposal and reduces operating costs for two sectors of industry. In particular it offers a cost-effective solution which is not overly complex and is legally permitted.
- Further work is required to assess the bait market/production, for more comprehensive tank tests, to undertake pilot bait stick production and to conduct sea trials. Bait production could earn a minor profit of around £40-50/t, thus potentially turning a cost into revenue.
- The utilisation of shellfish flesh as bait may allow cost effective separation / cleaning of shellfish waste, with the development of clean shell by-products also providing an opportunity.

Acknowledgements

This project has been produced as a partnership with Seafish, Resource Efficiency Knowledge Transfer Network, Cornwall Sea Fisheries Committee and the Shellfish Association of Great Britain (SAGB) with specialist input from the National Lobster Hatchery Padstow. Particular thanks are due to Michaela Archer, Richard Caslake, Adrian Whyle, Sam Davis, Katie Arnold and Dom Boothroyd.

A large number of people have helped in discussions relating to this project all of whom are thanked for their assistance. Of great assistance for their samples and knowledge were a number of shellfish processors. Thanks are due to Richard Spear, Trevor Bartlett and Matthew Aitken.

This project was funded by Seafish.

Appendix A – Water Stability Testing Details

Table 1 - Test 1, Tank Testing *(Note 1)*

Test Code	Waste Source	Binder Conc. w/v	Processing Waste Paste %	Processing Waste Raw %	Comments	Plate No.
			Scallop	Scallop		
1.1	Scallop	0.80%	50%	50%	Binder to cold mass - no binding	
	Scallop	1.60%	50%	50%	Binder to cold mass - no binding	1.1a
			Whelk	Crab		
1.2	Mix	0.80%	50%	50%	Binder to cold mass -Poor binding: loss of cohesion after 1hr	1.2a, b
			Whelk	Whelk		
1.3	Whelk	0.20%	50%	50%	Binder to cold mass -Moderate binding: gradual loss of cohesion after 1hr	1.3a, b, c, d, e, f
	Whelk	0.80%	50%	50%	Binder to cold mass -Moderate binding: gradual loss of cohesion after 1hr	
			Whelk	Scallop		
1.4	Mix	0.80%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 3dy. Some dissolution after 1hr	1.4a, b, c, d, e, f
			Q. Scallop	Q. Scallop		
1.5	Q. Scallop	0.80%	50%	50%	Binder to warm mass -Excellent binding: no loss of cohesion after 3dy. Little dissolution.	1.5a, b, c, d, e, f

Note 1: Tank Testing 06/06/08-09/0608. Temp.: 6C-22C. Observations: Hourly to 6hr, 1/2 day, 1 day, 2 days & 3 days. 500g /sample

Table 2 - Test 2, Sea Testing *(Note 2)*

Test Code	*Waste Source*	*Binder Conc.* w/v	*Processing Waste* Paste %	Raw %	*Comments*	*Plate No.*
			Scallop	Scallop		
2.1	Scallop	0.80%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy	2.1a, b, c
	Scallop	0.40%	50%	50%	Binder to warm mass -Good binding: gradual loss of cohesion over 1dy	
	Scallop	0.20%	50%	50%	Binder to warm mass -Good binding: gradual loss of cohesion over 1dy	
			Crab	Crab		
2.2	Crab	0.80%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	2.2a, b, c
	Crab	0.40%	50%	50%	Binder to warm mass -Good binding: gradual loss of cohesion over 1dy - surface dissolution	
	Crab	0.20%	50%	50%	Binder to warm mass -Good binding: loss of cohesion over 1/2dy - surface dissolution	
			whelk	Scallop		
2.3	mix	0.40%	50%	50%	Binder to warm mass -Good binding: loss of cohesion over 1/2dy - surface dissolution	2.3/2.4a, b, c
	mix	0.40%	25%	75%	Binder to warm mass -Good binding: gradual loss of cohesion over 1dy - surface dissolution	
			whelk	crab		
2.4	mix	0.40%	50%	50%	Binder to warm mass -Good binding: loss of cohesion over 1/2dy - surface dissolution	2.3/2.4a, b, c
	mix	0.40%	25%	75%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	

Note 2: Sea Testing 09/06/08-10/0608. Temp.: 14C-16C.Observations: 1/2 day & 1 day. 200g /sample

Table 3 - Test 3; Sea Testing *(Note 3)*

Test Code	*Waste Source*	*Binder Conc.* w/v	*Processing Waste* Paste %	Raw %	*Comments*	*Plate No.*
			Whelk	Whelk		3.1a, b, c
3.1	Whelk	0.80%	0%	100%	Binder to warm mass -Good binding: Complete loss of cohesion after 1/2dy	
	Whelk	0.80%	25%	75%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
	Whelk	0.80%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - little surface dissolution	
	Whelk	0.40%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
			Scallop	crab		3.2a, b, c
3.2	mix	0.80%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
	mix	0.80%	25%	75%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
	mix	0.40%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
	mix	0.40%	25%	75%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
			whelk	crab		3.3a, b, c
3.3	mix	0.80%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	

	mix	0.80%	25%	75%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
	mix	0.40%	50%	50%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	
	mix	0.40%	25%	75%	Binder to warm mass -Good binding: no loss of cohesion after 1dy - some surface dissolution	

Note 3: Sea Testing 24/06/08-25/0608. Temp.: 15C-17C.Observations: 1/2 day & 1 day. 200g /sample

Test Code 1.1 - Scallop 50:50 (Paste:solid). 1.6% binder

Plate 1.1a Start

Comments: Hot injection of binder into cold bait mass. No cohesive bait stick obtained despite increasing the binder mass to 1.6%

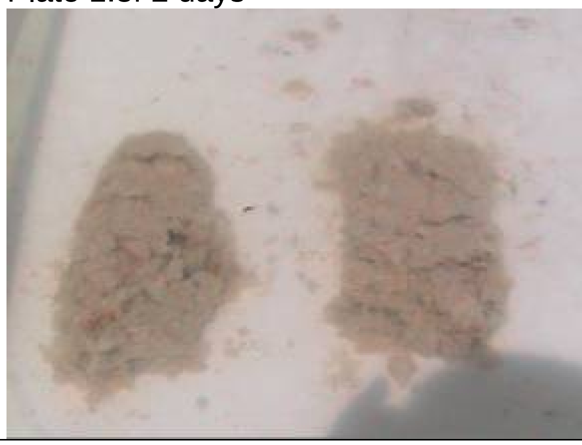
Test Code 1.2 - Mix 50:50 (Whelk Paste: Crab solid). 0.8% binder

Plate 1.2a Start

Plate 1.2b 1hr

Comments: Hot injection of binder into cold bait mass. Rapid bait breakdown

Test Code 1.3 - Whelk 50:50 (Paste:solid). 0.2% and 0.8% binder

Plate 1.3a Start 0.2% binder  0.8% binder 	Plate 1.3b 1 hr 
Plate 1.3c 3hr 	Plate 1.3d 16hr 
Plate 1.3e 1 day 	Plate 1.3f 2 days 

Comments: Hot injection of binder into cold bait mass. This provided poorly bound bait, which rapidly started to break apart upon immersion. It is probable that the binder set too quickly and did not mix in the paste matrix. It is likely that the natural stickiness of the whelk was all that held the stick together. Compare to Test 3.1 with good performance for the same composition following injection into warm bait mass

Test Code 1.4 - Whelk P: Scallop 50:50 (Paste:solid). 0.8% binder

Plate 1.4a 0 hrs

Plate 1.4b 3 hrs

Plate 1.4c 14 hrs

Plate 1.4d 1 day

Plate 1.4e 2 days

Plate 1.4f 3 days

Comments: Hot injection of binder into warm bait mass. Good cohesive bait stick.

Test Code 1.5 - Q. Scallop: Scallop 50:50 (Paste:solid). 0.8% binder

Plate 1.4a 0 hrs 	Plate 1.4a 3 hrs 
Plate 1.4a 14 hrs 	Plate 1.4a 1 day 
Plate 1.4a 2 days 	Plate 1.4a 3 days 

Comments: Hot injection of binder into warm bait mass. Very cohesive bait stick.

Test Code 2.1 - Scallop : Scallop 50:50 (Paste:solid). 0.8%, 0.4% and 0.2% binder

Plate 2.1a 0 hrs

Plate 2.1b ½ day

Plate 2.1c 1day

Tray layout:

0.8%	0.4%
Empty	0.2%

Comments: Hot injection of binder into warm bait mass. Cohesive bait sticks at all binder concentrations – breakdown of 0.4% and 0.2% sticks

Test Code 2.2 – Crab : Crab 50:50 (Paste:solid). 0.8%, 0.4% and 0.2% binder

Plate 2.2a 0 hrs

Plate 2.2b ½ day

Plate 2.2c 1day

Tray layout:

0.8%	Empty
0.4%	0.2%

Comments:
Hot injection of binder into warm bait mass. Cohesive bait sticks at all binder concentrations – partial dissolution of all sticks although integrity largely maintained in 0.8% and 0.4% after 1 day.

Test Code 2.3 - Whelk:Scallop, various mixes (Paste:solid). 0.8% binder
Test Code 2.4 - Whelk:Crab, various mixes (Paste:solid). 0.8% binder

Plate 2.3/2.4a 0 hrs

Plate 2.3/2.4b ½ day

Plate 2.3/2.4c 1day

Tray layout:

Whelk : Scallop 25:75	Whelk : Crab 25:75
Whelk : Scallop 50:50	Whelk : Crab 50:50

Comments: Hot injection of binder into warm bait mass. Cohesive bait sticks at all binder concentrations. More cohesive for samples with lower whelk paste content

Test Code 3.1 - Whelk - Various Paste:Solid mixes and binder content

Plate 3.1a 0 hrs

Plate 3.1b ½ day

Plate 3.1c 1day

Tray layout:

Whelk : Whelk 50:50 (0.4%)	Whelk : Whelk 0:100 (0.8%)
Whelk : Whelk 50:50 (0.8%)	Whelk : Whelk 25:75 (0.8%)

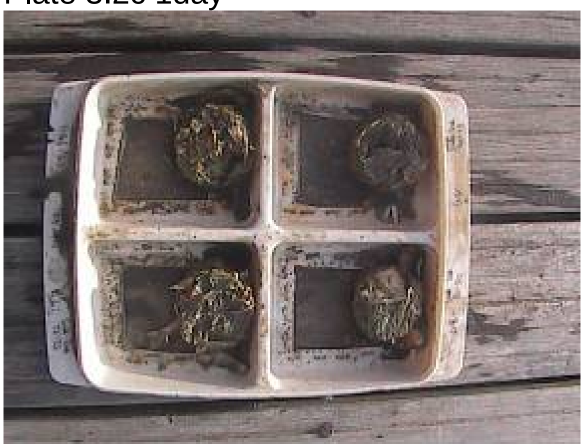
Comments: Hot injection of binder into warm bait mass. Bait sticks with good initial cohesion for all mixes. High breakdown rate for 0:100 (paste:solid) mix. Minimum breakdown or dissolution from 0.8% 50:50 mix.

Test Code 3.2 - Scallop:Crab, various mixes (Paste:solid). 0.4% and 0.8% binder

Plate 3.2a 0 hrs

Plate 3.2b ½ day

Plate 3.2c 1day



Tray layout:

Scallop : Crab 50:50 (0.4%)	Scallop : Crab 25:75 (0.8%)
Scallop : Crab 25:75 (0.4%)	Scallop : Crab 50:50 (0.8%)

Comments: Hot injection of binder into warm bait mass. Cohesive bait sticks at all binder concentrations. All baits provided some dissolution with no massive loss of cohesion after 1day.

Test Code 3.3 - Whelk:Crab, various mixes (Paste:solid). 0.4% and 0.8% binder

Plate 3.3a 0 hrs

Plate 3.3b ½ day

Plate 3.3c 1day

Tray layout:

Whelk : Crab 25:75 (0.4%)	Whelk : Crab 25:75 (0.8%)
Whelk : Crab 50:50 (0.4%)	Whelk : Crab 50:50 (0.8%)

Comments: Hot injection of binder into warm bait mass. Cohesive bait sticks at all binder concentrations. All baits provided some dissolution with no massive loss of cohesion after 1day.

Summary of Water Stability Tests

Date Range	Test Nos.	Test Period	Test Equipment	Temp. Range
06/06/08-09/0608.	1.1, 1.2, 1.3, 1.4, 1.5	Hourly to 6hr, 1/2 day, 1 day, 2 days & 3 days	Tank Testing on 500g sample	6C-22C
09/06/08-10/0608	2.1, 2.2, 2.3	1/2 day & 1 day	Sea Testing on 200g sample	14C-16C
24/06/08-25/06/08	3.1, 3.2, 3.3	1/2 day & 1 day	Sea Testing on 200g sample	15C-17C

Summary Water Stability Test Results

Test	Bait Type (Note 1)	Comment
1.1-1.3	Scallop, Whelk/Crab Whelk: Cold mix	Poor baits – no or little cohesion
1.4	Whelk/Scallop Warm mix	Good bait – No loss of cohesion. Partial dissolution after 1hr
1.5	Q.scallop Warm mix	OK bait - No loss of cohesion. Minimal dissolution for days
2.1	Scallop	Good bait – No loss of cohesion. Partial dissolution
2.2	Crab	Good bait – No loss of cohesion. Partial dissolution
2.3	Whelk /scallop	Good bait – No loss of cohesion. Partial dissolution
2.4	Whelk/Crab	Good bait – No loss of cohesion. Partial dissolution
3.1	Whelk	Good bait – No loss of cohesion. Partial dissolution
3.2	Scallop/Crab	Good bait – No loss of cohesion. Partial dissolution
3.3	Whelk/crab	Good bait – No loss of cohesion. Partial dissolution

Note 1: Various binder concentrations and paste:solid ratios. 2.1-3.3 all warm mix

Appendix B – Behavioural Trial Results

Lobster Results

Date	Test Bait (Note 1)	Duration (min)	Animal Ref.	Test Bait Taken First?		Standard Bait
				Yes	No	
18/06/2008	Whelk	50	"test"	y		Gurnard
19/06/2008	Scallop	95	"test"		n	Mussel
21/06/2008	Crab	75	b1	y		Gurnard
	Crab	68	a1	y		Gurnard
	Whelk	85	a1	y		Gurnard
	Whelk	110	b1	y		Gurnard
22/06/2008	Whelk	78	c	y		Gurnard
	Scallop	56	a1		n	Gurnard
	Scallop	44	c		n	Gurnard
	Crab	96	a1	y		Gurnard
23/06/2008	Crab	105	b1	y		Gurnard
	Scallop	15	c	y		Gurnard
	Scallop	82	b2		n	Gurnard
	Whelk	40	c	y		Gurnard
24/06/2008	Scallop	128	a2		n	Gurnard
	Whelk	56	b2	y		Gurnard
	Crab	20	c		n	Gurnard
25/06/2008	Whelk	53	a2	y		Gurnard
	Crab	41	a2		n	Gurnard
	Crab	44	b	y		Gurnard
	Scallop	18	c		n	Gurnard
27/06/2008	Crab	36	c		n	Gurnard
	Scallop	32	b		n	Gurnard
	mix (w:s)	26	a		n	gurnard
28/06/2008	mix (w:s)	42	b		n	gurnard
	mix (w:c)	22	c		n	gurnard
	mix (s:c)	68	a	y		gurnard
	mix (s:c)	40	c	y		gurnard
30/06/2008	mix (w:c)	42	b	y		gurnard
	mix (w:s)	27	c	y		gurnard
	mix (w:c)	35	a		n	gurnard
	mix (s:c)	32	b		n	gurnard
01/07/2008	mix (w:c)	27	c		n	gurnard
	mix (w:c)	25	b		n	gurnard
	mix (w:c)	15	a		n	gurnard
02/07/2008	mix (s:c)	33	c		n	gurnard
	mix (w:s)	42	a		n	gurnard
	mix (w:s)	22	b	y		gurnard
	mix (w:s)	17	c	y		gurnard
03/07/2008	mix (s:c)	55	a		n	gurnard
	mix (s:c)	33	b		n	gurnard

Live Crab Results

Date	Test Bait	Duration (min)	Animal Ref.	Test Bait Taken First?		Standard Bait
				Yes	No	
07/07/2008	Scallop	6	b		n	Fish
07/07/2008	Whelk	30	c		n	Fish
07/07/2008	Crab	29	a		n	Fish
08/07/2008	Scallop	36	a		n	Fish
08/07/2008	Whelk	25	b		n	Fish
08/07/2008	Crab	54	c		n	Fish
09/07/2008	Scallop	52	c		n	Fish
10/07/2008	Whelk	62	a		n	Fish
10/07/2008	Crab	58	b		n	Fish

Live Whelk Results

Date	Test Bait	Duration (min)	Animal Ref.	Test Bait Taken First?		Standard Bait
				Yes	No	
01/07/2008	Crab	29	White	y		Green crab
	Crab	**59**	Black		n	Green crab
	Crab	28	Green	y		Green crab
	Crab	**19**	Brown		n	Green crab
07/07/2008	Crab	48	Blue	y		Green crab
	Crab	**12**	Brown		n	Green crab
07/07/2008	Crab	**60**	Black		n	Green crab
	Crab	**7**	Brown		n	Green crab
08/07/2008	Whelk	**68**	White		n	Green crab
	Whelk	56	Black	y		Green crab
	Whelk	**12**	Green		n	Green crab
	Whelk	**14**	Blue		n	Green crab
	Whelk	**13**	Brown		n	Green crab
	Scallop	14	Black	y		Green crab
	Scallop	**42**	Blue		n	Green crab
	Scallop	28	Brown	y		Green crab
10/07/2008	Crab	**11**	White		n	Green crab
	Crab	**91**	Black		n	Green crab
	Crab	28	Green	y		Green crab
	Crab	**71**	Blue		n	Green crab
	Crab	42	Brown	y		Green crab
11/07/2008	Whelk	9	White	y		Green crab
	Whelk	11	Black	y		Green crab
	Whelk	12	Green	y		Green crab
	Whelk	7	Blue	y		Green crab
	Whelk	**10**	Red		n	Green crab
	Whelk	**13**	Brown		n	Green crab
11/07/2008	Scallop	**31**	White		n	Green crab
	Scallop	**26**	Black		n	Green crab
	Scallop	43	Green	y		Green crab
	Scallop	**47**	Blue		n	Green crab
	Scallop	**16**	Red		n	Green crab
	Scallop	11	Brown	y		Green crab