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Shell waste in aggregates (B54)

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Shell Waste in Aggregates Project Report

For:

Sea Fish Industry Authority

Final Report

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Strategic Review of Shell Waste Management

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Executive Summary

Shell waste is a major financial and operational burden on the shellfish industry. Although there are, in theory, many uses for shell, there is no singular solution to treat or utilise these materials as by-products and little infrastructure to take shell across the UK. Where infrastructure exists, it is often disjointed or only works on a localised level. Seafood processors are often unaware of potential opportunities. Most processors rely on disposal outlets which can cost up to £150 per tonne of waste making it a very costly problem.

This study has undertaken an assessment of the load of potentially suitable shellfish waste for aggregate applications which has been presented on a regional basis. In summary, ~43,000t of shell aggregates could be available from the current production of cockle, crab, mussel, oyster, whelk, queen and king scallops. An assessment has been made regarding the availability of these different shell types.

Shell aggregates are simple solutions that can be produced with a minimal level of investment to provide treatment separating 'clean' shell from residual flesh. The use of shell described in this report is for 'technical' purposes and not related to food chain applications that require full treatment under Animal By-Product Regulations. Aggregate by-products are generally of low value but providing shell for such uses can reduce waste disposal costs. In some cases the supply of shell for use in aggregates may only provide a cost-neutral solution for processors, although in other cases an economic return and small profit is feasible. Scope exists for the development of high value niche products (but of generally low bulk), although these specialist uses are beyond the scope of the current project and report.

Cost models indicate that the production of 'free of flesh' shell maybe nearly half the cost of producing shell by-products to full Animal By-Product Regulations using a heat treatment process at ~£33/t and ~£74/t respectively. Actual costs will vary between businesses according to the tonnage treated and local cost burdens.

A market review has also been conducted to help identify near and medium term markets. A range of uses are available although the current market is limited. New applications are possible if waste material is presented as a marketable by-product, prepared and produced with consistent quality and quantity. Research and development will be needed to help develop some market applications which could benefit from a clear national lead and representation.

Although some processors are currently treating their waste to produce clean shell there is generally a gap between processors who produce a waste and the market which needs a product. There may be scope for a regionally based network of facilities to help bridge this disconnection. However, the viability of any such regional solution will need to be both market led and responsive to the needs of processors. It is uncertain whether the lack of financial incentive or the level of risk inhibits the creation of this regional approach.

This project helps meet the medium term objective for Seafish by raising awareness of possible ways to generate economic return from waste and in the development of a regional approach to facilitate further development.

1. Overview

1.1 Project Outline

Shell 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. This could include the use of shell in aggregates. Aggregate applications range from low value, bulk products to added value, niche products that require greater product development and placement.

1.2 Scope of Report

This document provides a strategic overview of the potential for aggregate applications with shell waste.

Considerations of waste treatment, waste quantities and market considerations have been used to help develop this assessment from a national perspective. Appendix I includes the Market Development study produced by Specialist Aggregates.

Input has been provided from Seafish, Shellfish Association of Great Britain (SAGB) the Environment Agency and the National Industry Symbiosis Programme (NISP). A number of shellfish processors, shell and equipment suppliers have also contributed.

1.3 Terms of Reference

Target species included in the study and definitions of 'waste' and 'aggregate' are important to limit the terms of reference for this study.

Shell types – Scallop (king and queen), whelk, mussel, cockle, crab carapaces. Emphasis on major quantities of calcarious shell types (i.e. not including nephrops).

"Aggregates" –Defined as *the physical use of a shell in a free flowing or bound medium.* In consequence, the project aims to look at simple, easy use applications which do not require complex processes which alter the form of the product.

"Waste" –Defined as *output of no current value to the shellfish processor*. A number of shell 'wastes' may not enter official disposal routes or enter landfill (e.g. cockles) yet can remain un-utilised. This study shall assume a wider variation of definition than an output that presents a cost of disposal as the distinction from a by-product with value can be dependant on a number of other variables.

1.4 Strategic Framework

In 2005 Seafish reported its 'Strategic Framework for Seafood Waste Management' which identified molluscan shell based applications as one of the quickest, easiest and most cost effective use to implement on a local-regional scale. The Strategic Framework presented a 3-phase approach for the seafish industry to deal with its current waste issues.

> *"In the short-term (2005-2007), the immediate priority is to raise awareness throughout industry and provide information to help companies achieve compliance as soon as possible. The initial emphasis for addressing the problems is to establish collaborative groups in key target regions who will evaluate and deliver solutions appropriate to that region.*
>
> *In the medium-term (2005-2010), it is desirable to promote awareness of routes that can generate economic return and develop targeted, collaborative groups to develop these further. "*

This project helps develop the short and medium term objectives in terms of working towards delivery of regional solution that provide economic return.

2. Shell Quantity Review

An estimate of the availability of shell for use in aggregates indicates that there is potentially around 43,000t/yr of shell waste that may be suitable for aggregate applications. The figures have been calculated using data on shellfish production in the UK and applying ratios of shell, whilst making assumptions about the extent of processing, product formats etc. Because of limitations in the data it is impossible to provide a more exact overview of shell quantities. A summary is provided below for the target species: crab, cockle, mussel, oyster, queens, scallops and whelks.

Shell quantities and current issues

Shell type	Estimated quantity (Tonnes per year)	%	Comments
Cockle	20224	47%	• Seasonal fishery • Unknown current uses • Could already be fully utilised in local applications
Crab	4345	10%	• Produced all over the UK • Chitinous exoskeleton • Ensuring the shell can be full free of flesh • may require a more expensive treatment route • limited range of market applications.
Mussel	3616	8%	• current low level of processing generates a relatively small quantity of waste • Amount of organic material left in the shell • May require more expensive processes
Oyster	51	0%	• Negligible production but in high demand
Scallop	6602	15%	• Produced all over the UK • Flat shell is major problem • Existing outlets exist but small scale
Queens	4610	11%	
Whelks	3358	8%	• Cooked product • Processing damages shell • Existing outlets exist but small scale
TOTAL	42,808	100%	

Regional production of shell

Region	*Cockles*	*Crabs*	*Mussels*	*Oysters*	*Queens*	*Scallops*	*Whelks*	***Total***
SE	13115	464	433	18	0	408	825	**15,263**
SW	402	1091	382	20	1	2186	283	**4,365**
S.Wales	3821	41	131	1	0	21	289	**4,303**
NW+N Wales	2827	39	1713	2	1685	256	867	**7,389**
NE	0	868	13	0	1	200	891	**1,974**
Scot S	18	88	69	1	2695	746	43	**3,660**
Scot N Islands	41	494	171	3	19	606	160	**1,495**
Scot W	0	513	69	1	40	733	0	**1,356**
Scot E	0	620	34	1	4	1271	0	**1,930**
NI	0	126	602	6	165	174	0	**1,073**
Total	**20224**	**4345**	**3616**	**51**	**4610**	**6602**	**3358**	***42,808***

3. Legislative Overview for Shell Treatment and Use

The production, utilisation, handling, transport and disposal of all waste, particularly animal waste, are strictly regulated by numerous pieces of complex waste legislation.

Of primary importance for all animal waste, including shellfish, are the Animal By-product Regulations (ABPR) which came into force in 2003.

Many other pieces of legislation stipulate additional requirements for waste activities. These include; Waste Framework Directive 91/156/EEC, Environmental Protection Act 1990, Pollution Prevention and Control Regulations 2000, Waste Management Licensing Regulations 1994, Landfill Tax Regulations 1996, EU Landfill Directive, Food and Environment Protection Act 1985 amongst others.

With such a complex array of legislation applicable to waste disposal, it is difficult to get a comprehensive overview. Also legislation is constantly changing. It is essential that any waste developments are legally compliant so businesses must contact the relevant regulators before proceeding with any waste treatment, utilisation or disposal activity.

Table 1 summarises the main legal requirements for processing and using shellfish waste. It does not go into detail on planning permission and other similar legal requirements.

3.1 Implication of regulatory requirements for uses of shell

The extent of licensing directly affects the costs and potential revenue streams for shell treatment and use.

Producing free of flesh shell can be relatively simple and cost-effective for a seafood processor. However it may only enable a small number of uses for that shell. Typically these are low value, bulk uses such as applying to land to improve drainage. For these types of uses for free of flesh shell, the processor may only be able to recoup the costs of the shell-cleaning process (zero-cost) or at best earn small revenue.

Although higher value opportunities do exist for the use of flesh free shell these will require additional processing to, for example, extract speciality chemicals or produce material in an appropriate physical form, in order to realise such market opportunities.

Producing shell for use in a wider number of products, such as fertilisers or animal feed etc, requires the shell to be treated to full ABPR and other regulatory requirements. Typically this requires a much higher level of development, infrastructure and investment. Although the value of the end uses will typically be high, the costs of realising that value are also significant. These types of specialised products are usually only cost-effective on a large scale.

3.2 Animal By-Product Regulation – Approved Uses

Certain activities deemed of ‘low risk’ have been allowed by the UK authorities from an APBR perspective (from DEFRA and enforced through the State Vet). There is then scope to pursue additional relevant applications using a ‘low risk’ permit scheme within the Environment Agency Waste Management Regulations.

Seafish has undertaken extensive consultation regarding the use of shell for seabed enhancement purposes and for cultch (settlement substrate for seed shellfish such as native oysters) in particular

Suitable fish waste can be utilised for bait purposes as a lure for fish for within potting. However, although fish frames are commonly employed little fish waste material is of suitable composition or form to be good bait. Anecdotal evidence has suggested that the use of bulk cooked crab forms poor bait. There may however be scope to formulate baits using waste material. This application has been proposed as an area requiring further work which has been recommended in Section 7.

Table 1 - Main legal requirements for shell treatment and use

What type of shell	Use, Treatment or Disposal	Main Regulations that apply	Legislative Requirements	Regulator/Enforcement Body
Dirty raw shells • including shells as they come off the production line • shells with flesh left remaining <u>AND</u> Free of flesh raw shells only i.e. shells from which all the flesh has been removed.	Disposal or recovery routes such as rendering, composting, digestion etc	Animal By-Products Regulations (ABPR)	Must only be sent to premises approved for ABPR treatment	Animal Health approve and Local Authorities enforce
			Transport must be done in accordance with the ABPR and storage must be in premises approved under the ABPR	Local Authorities
		Waste Management Licensing Regulations Pollution Prevention Control Regulations	Sites treating waste such as composting sites and anaerobic digesters must be licensed under the WMLR, be registered exempt from the need for a licence or be permitted under the PPC	Environment Agency (SEPA in Scotland) or Local Authorities
	Land application: use as a fertiliser or soil improver	Waste Management Licensing Regulations Environmental Protection Act	Using any waste derived material for treatment of land for agricultural benefit or ecological improvement.	Environment Agency (SEPA in Scotland)
			In England and Wales the Environment Agency will apply their Low Risk Regulation position. This enables mollusc or crustacean shells from which the flesh has been completely removed, for: (i) the production of aggregates; (ii) use in gardens as a substitute for lime; (iii) construction, e.g. gabions, lime plasters etc, (iv) construction, maintenance and repair of footpaths; (v) use in land drainage or (vi) ornamental use Providing the production of free of flesh shell is registered under ABPR . For large scale uses, full licensing under WMLR may be required.	
			Transport must be undertaken by authorised waste carriers unless you are carrying your own waste. If transporting ABPs carriers do not need to be registered waste carriers as they are exempt. However, they will need to register as a professional collector from 15 November 2006.	

		ABPR	ABPs must first be processed in accordance with the ABPR before they are used as organic fertilisers or soil improvers	Animal Health approve and Local Authorities enforce
			If organic fertilisers or soil improvers are applied to pasture land, grazing restrictions will apply before any animals can have access or crops for animal feed are grown. If materials are applied neat, animals can never graze on this land.	Animal Health approve and Local Authorities enforce
	Animal feed to non-ruminants e.g. chicken and pig feed	ABPR	Must only be sent to premises approved for ABPR treatment	Animal Health approve and Local Authorities enforce
			Transport must be done in accordance with the ABPR and storage must be in premises approved under the ABPR	Local Authorities
Free of flesh raw shells <u>only</u> i.e. shells from which all the flesh has been removed.	Production of free of flesh shell by a seafood processor for technical uses	ABPR	General approval issued for technical uses, such as (i) the production of aggregates; (ii) use in gardens; (iii) the construction, maintenance or repair of footpaths; (iv) use in draining the land; or (v) ornamental use.	Animal Health needs to register the processors shell cleaning activity
	Use of free of flesh shell in aggregates, footpaths, land drainage or ornamental use	Waste Management Licensing Regulations	In England and Wales the Environment Agency will apply their Low Risk Regulation position. This enables mollusc or crustacean shells from which the flesh has been completely removed, for: (vii) the production of aggregates; (viii) use in gardens as a substitute for lime; (ix) construction, e.g. gabions, lime plasters etc, (x) construction, maintenance and repair of footpaths; (xi) use in land drainage or (xii) ornamental use Providing the production of free of flesh shell is registered under ABPR . For large scale uses, full licensing under WMLR may be required.	Refer to the Environment Agency, SEPA in Scotland.

3.3 Contacts and further information on waste legislation

Regulators	
Defra - Animal By-products	http://www.defra.gov.uk/animalh/by-prods/default.htm
Defra - Animal Health	http://www.defra.gov.uk/animalhealth/
Environment Agency	http://www.environment-agency.gov.uk/
Environment Agency – low risk exemption	http://www.environment-agency.gov.uk/subjects/waste/1416460/1334460/ and http://www.environment-agency.gov.uk/commondata/acrobat/low_risk_jan08_1896068.pdf
Scottish Environmental Protection Agency	http://www.sepa.org.uk/
Sources of further information	
Defra guidance notes	http://www.defra.gov.uk/animalh/by-prods/qanda.htm http://www.defra.gov.uk/animalh/by-prods/wastefood/formerfoodstuffs.htm
Seafish Guidance on Seafood Waste Legislation	http://www.seafish.org/upload/file/legislation/ABPQAV2.pdf

4. Environmental Issues

4.1 Impact of Treatment on Shell Quality

Scallop, whelk and crab samples from a variety of sources have been analysed for a variety of soluble components. These enable an assessment of whether the shell would cause any environmental problems, for example leaching undesirable materials etc. A summary of nutrient and organic (BOD) leachable contents is as follows:

Parameter		Detection Threshold	Shell Sample Types (results presented for solids in mg/kg)					
Sample No.		(mg/kg)	1	2	3	4	5	6
	(Note 1)	*(Note 2)*	Whelk	K. scallop	Q. scallop	K. scallop	Crab	K. scallop
BOD	5 day ATU		139	34.6	248	192	24400	203
Ammonia	N		46	39.6	31.2	115	99.8	48.6
Chloride	Cl	<100	951	<100	299	1280	3100	430
Nitrogen	N	<10	<10	<10	<10	153	<10	<10
Nitrite	N	<1	<1	<1	<1	<1	<1	<1
Orthophosphate	P	<5	5	5	5	16.4	15.8	5
Sulphate	SO4	<100	593	<100	180	696	2590	181

Notes:

Note 1 Sample description - Soluble residuals will vary between different shell types and processes

Sample No	*Shell*	*Odour*	*Moisture*	*Process*
1	Whelk	Slight	High	Waste separation/ water clean
2	K. scallop	Neglible	Low	Chemical clean
3	Q. scallop	Neglible	Low	Water clean
4	K. scallop	Neglible	Dry	Drum water clean
5	Crab	Strong	Dry	Pasteurisation/drying
6	K. scallop	Slight	Moderate	Control

Note 2 Analysis on leachate (10:1 leach rate) recalculated to shell solids

The type of treatment process and the level of cleaning can have an important effect on the shell quality and ultimately the market that can be sought. 'Free of Flesh' shell samples can have a low odour although this can vary according to the cleaning process and the type of shell processed. Residual organics in a raw untreated wet sample are likely to give rise to odour related problems. This can also be the case with re-hydrated full ABPR samples where a significant organic component has been retained. A further consideration is that there is a potential for cross contamination in some systems handling differing waste streams where common equipment is used. This may particularly be the case where a concentrated by-product stream (e.g rotary kiln crab) is processed alongside a less concentrated material (e.g free of flesh scallop).

Work is ongoing with further samples and a widened scope of sample parameters.

4.2 Environmental Impact Case Studies

The previous section highlights that the quality of the cleaning process and the type of shell used will influence the level of soluble contaminants that could be leached from the shell. The sensitivity of the

application will also have major influence on the potential environmental impact. Cases should ideally be considered on a site by site basis although cleaner shell types will clearly provide greater scope in more sensitive applications. Some illustrations of different potential case studies are provided below:

-*Shell use in Open Drainage Applications*. Scallop shell has been proposed for use in a de-icing agent for road use in Aomori Prefecture, Japan (**http://www.japanfs.org/db/1825-e**). By March 2007 it was planned to process 6,000 tons of scallop shells annually from the 50,000t/yr of discards going to industrial waste. The scheme is a joint initiative with private and public bodies with support from academic institutions with the aim of producing a non-chlorine-based de-icer with less ecological risk than conventional calcium chloride de-icers. An American website indicates that the de-icer is a blend of scallop shell with apple pomice - another food processing waste product.

Although the concept of this product is attractive the potential ecological benefits would need to be weighed with the potential risks as both shell and apple pomice will contribute a significant BOD load to the melt water draining from the road. In the UK much of the urban drainage is routed to combined sewers which will take storm water to waste water treatment works, whilst major roads in rural areas will discharge via culverts to watercourses with limited potential for contaminant removal. There is a risk that the new de-icer could create water quality problems in sensitive waters receiving a discharge of contaminated meltwater.

As an illustration if a scallop BOD of 100mg/kg (see previous Section), a shell application rate of 100g/m^2, and a 1cm rainfall event is assumed the resulting drainage water would have a BOD of 1mg/l. It is probable that the apple pumice component will also have a significant organic component that would further increase the BOD. The potential impact of the drainage water would be of more significance to a sensitive minor water course (Environmental Quality Standard for RE1 – River Ecological Standard 1 of 2.5mg/l BOD), whereas a river might provide considerable dilution or a less sensitive watercourse would be unaffected. It is therefore suggested that the use of shell in open drainage systems should take account of local conditions and sensitivities.

-*Shell for Lime Dosing to Rivers*. Crushed shell has been proposed for lime dosing to rivers to help improve alkalinity (Edwards and Martin, 2004). Both powder and sand are currently used at the following dose rates:

~200 tonnes limestone powder/year for every m^3/sec mean flow – applied continuously
~100 tonnes limestone sand/year for every m^3/sec mean flow – applied twice a year.

Assuming a scallop BOD of 100mg/kg (see above Section) and the above dose rates an additional BOD of ~0.0006mg/l and 0.06mg/l would result for powder and sand dosing respectively. Despite the significant overall masses of shell potentially used the resultant increase in BOD would be minor. Calculations for ammonia loads similarly show a minimal impact of over x10 less than the EQS RE1 0.25mgN/l standard.

However, for catchment dosing the overall heavy metal content of the shells is of greater significance as many of the acidic rivers may already be metal rich and therefore unable to take additional loads. For this reason Edwards and Martin (2004) tested cockle and whelk shell for a suite of heavy metals.

-*Shell Cultch Application to Estuaries*. Shell can be used for cultch to help support shellfisheries by encouraging settlement of new spat. Clean shell cultch has been proposed to help support the native oyster fishery by directly seeding shell to the seabed. As an illustration of the potential impact for using scallop shell nominal dose rates and depths can be assumed. If a scallop BOD of 100mg/kg is assumed (see previous Section) then a 1kg/m^2 shell applied to the seabed would yield a receiving water BOD of 0.02mg/l when diluted in 5m depth of water. Such an increase in BOD would be hard to distinguish above background levels.

-*Shell in Treatment Systems*. Shell is currently used in waste water treatment processes where any leached components are not within the open environment. Furthermore, in some cases such as the proposed use of shell for use in heavy metals removal systems from mine waters the presence of organics is positive to encourage microbial growth and is even enhanced by the addition of manure. Although it would appear

that these specialist applications would be ideal for the use of shell from an environmental impact perspective it should be noted that they do however require a tight physical specification.

5. Financial and Market Issues

5.1 Cost of Treatment

A cost illustration is provided below giving indicative costs for the treatment of waste shell in the production of a shell by-product. In essence the 'free of flesh' illustration produces clean shell for use with approved Technical purposes whilst the 'Heat Treatment' process is a full ABPR approved process. As assumptions have been used on the tonnage of shell treated, availability of finance, certain overheads and the provision of ancillary equipment it should be noted that the final output cost for treatment may be subject to considerable variation. It is therefore possible that a business with existing capital and facilities could produce shell by-product at a lower price. Alternatively, a business starting from scratch with no facilities, no finance and a lower shell tonnage could have much higher production costs.

Cost Illustration for the Cleaning and Treatment of Shell Waste

Costs			Free of Flesh[1]	Heat Treatment[2]
Capital Expenditure				
	Capital	*(Note 1)*	21880	279000
	additional equipment (£)	*(Note 2)*	25000	*(Note 2b)*
	Installation (£)	*Nominal*	5000	5000
	Total (£)		*51880*	*284000*
Operational Expenditure				
	Repayment period	*(Note 3)*	5	5
	Depreciated Cost		10376	56800
	Interest on loan	*(Note 4)*	1556	8520
	Power	*(Note 5)*	600	3000
	Disposal	*(Note 6)*	100	
	Labour	*(Note 7)*	20800	5200
	Total (£/yr)		*33432*	*73520*
Performance				
	Throughput (t/yr)	*(Note 8)*	1000	1000
	System duty period (hr/day)	*(Note 9)*	1	24
	Treatment Cost (£/t)		*33*	*74*

[1] "Free of Flesh" (FOF) process - ABPR approved for prescribed 'Technical' uses

[2] "Heat Treatment" from one of the approved ABPR processes. Sterilised, but retained organics is variable according to process

Note 1: Equipment only. No allowance for building or land

Note 2: Additional equipment: e.g. hopper, crusher and conveyor if relevant (drum press not included)

Note 2b: Additional equipment: e.g. odour control not included - may be species specific

Note 3: Depreciation period of 5yrs assumed

Note 4: 10% interest assumed.

Note 5: Power: £0.10/ kWhr assumed. Duty time - FOF = 8hr/day assumed, ABPR = continuous
-For ABPR processes that require a heat stage power costs will be strongly influenced by water content of waste

Note 6: -Assumed clean shell & flesh utilised at cost neutral
-'Technical' treatment systems will produce dirty waste water requiring disposal.
- Assumed £1/m3 for liquor at 0.1m3 liquor/t of waste

Note 7: Labour assumed £10/hr @ 40hr/wk for 52 wk/year. FOF = 1 man full time, ABPR 1 man 2hr/day

Note 8: Waste Throughput: 1000t/250day = 4t/day

Note 9: Duty period: FOF system - 4t/hr / ABPR system - 1000t/yr continuous (maximum)

5.2 Market Study

The Market Study (Part 2) indicates that the current market for clean shell aggregate is both limited and only likely to provide a low level of return, possibly only sufficient to cover transport costs. Although this level of income may be enough to provide a cost neutral disposal route it is unlikely in itself to raise sufficient revenue to cover full treatment/processing costs. With work to develop shell products and markets a higher retail price can be obtained.

It is difficult for shells to compete against other aggregates. Virgin aggregates can be mass produced and bulk graded to recognised standard technical specifications. Recycled products do have an advantage over virgin aggregates under Defra's sustainability policy commitment to encourage the use of recycled materials in public schemes (Policy commitment - "Effective use of public procurement to drive markets and influence consumer behaviour." – Defra 2006). However, much of this commitment will be met by recycled aggregates and it is unclear whether this pledge will allow purchase of recycled products at a differential above virgin products.

Generally the best value aggregate applications for shell will be those where shells can out-compete virgin aggregates due to their specific physical and chemical properties. The future potential market for shell could be further enhanced with the development of products and markets. There is a need for certain applications for a tightly specified product in terms of particle size distribution and absence of organic contamination. This presents a potential hurdle to processors looking at utilisation routes for clean shell.

Further opportunities for shell are becoming available all the time. Although it is still relatively small-scale, there has been a recent increase in companies who want to source shell, with many offering payment for free of flesh shell.

6. Future Options for Strategic Development

6.1 Regional Infrastructure Issues

Suppliers Perspective - Individual processors may not be able to afford / or accommodate their own dedicated waste treatment facility. Furthermore, individual processors may not have the resources or inclination to develop their own utilisation applications. However, as processor operating margins are tight some shell waste producers may require company transparency to ensure an equitable cost structure.

Users Perspective - In most shell aggregate applications the potential user is looking at a 'like for like' replacement of a virgin aggregate with a recycled source. Mass produced aggregates are provided in well known and accepted standards which can present a challenge to the mixed shell by-product. There is a need for certain applications for a tightly specified product in terms of particle size distribution and absence of organic contamination. From a potential 'users' perspective sourcing of material of consistent quality and quantity would be easier from a few regional centres than a mass of individual processors.

Potential for a Regional Treatment Centre
Advantages:

-Ability to provide a range of consistent products and forms
-Ability to store stock to provide buffered consistent supply
-More bulk of material (from catchment area) to improve treatment cost efficiency
-Still close enough to processors and market to avoid excessive transport costs

Disadvantages:

-Possible unreasonable expectations from waste shell suppliers of by-product value.
-Maybe insufficient income from aggregate applications – may also need gate disposal fees
-Supply of material maybe undermined if other local solutions found.

6.2 Research Issues

There are a range of research areas that could help develop the use of shell in specific applications. An over view of some of these research areas is listed below:

- The use of shell in lime production for sustainable masonry applications presents an opportunity which is being explored by the University of Bristol.
- The use of shell in anaerobic water treatment systems for heavy metals removal is currently being explored by the University of Newcastle in mine water treatment systems for the Environment Agency.
- The use of shell in permeable paving within Sustainable Urban Drainage Systems (SUDS) has been proposed by the University of Coventry. Workers have already undertaken work looking at the efficiency of these systems for remove heavy metals, oils and microbial contamination from surface waters.
- Limestone power and sands are currently employed in large scale catchment dosing. Shell replacement has been explored by the Environment Agency with laboratory work undertaken on the potential use of cockle and whelk (Edwards and Martins, 2004). This study has provided samples of other species such as scallop for testing in addition to the further testing of leachable components. Ongoing research on lime dosing within catchments is currently being researched by the University of Wales, Cardiff.
- The use of flesh offal from shellfish waste within pre-formed baits for potting has been proposed with tank trials in association with the National Lobster Hatchery Padstow.

There is merit in pooling much of this research and making it widely available. A forum to represent the developmental needs of this research could provide a focus for proposals and the sourcing of appropriate funding.

7. Suppliers and Users Directory

7.1 Suppliers of Shell Cleaning and Treatment Systems

Treatment Type	Company name[1]	Company address / location	e-mail	Tel no	Web Link
Free of Flesh	Polar Systems Ltd	Austin Fields, Kings Lynn, Norfolk, PE30 1PH	sales@polar-systems.co.uk	01553 691472	http://www.polar-systems.co.uk/products_22.htm
ABPR - Heat treatment	BioNova	Unit 9 Parkengue, Kernick Industrial Estate, Penryn, Cornwall, TR10 9EP	sales@apwastehandling.co.uk	01326 370902	http://www.apwastehandling.co.uk/bionova/process.php

[1] Any additional company who provides free of flesh shell wishing to join the list please contact Michaela Archer on 01482 327 837 or M_Archer@Seafish.co.uk

7.2 Suppliers of Clean Shell

Type of shell				Contact name	Company name[1]	Company address / location	e-mail	Tel no	additional info
scallop	crab	cockle	whelk						
x				Richard Spear	Coombe Fisheries	Barnstaple	richard@coombefish.co.uk	01271 373273	
x			x	Matthew Aitken	West Coast Sea Products	Kirkcudbright		01557 331595	http://www.wcspltd.co.uk/
x			x	Peter Merrick	AM Seafoods	Fleetwood	petermerrick@amseafoods.co.uk	01253 772444	http://www.amseafoods.co.uk/
x				Trevor Bartlett	The Blue Sea Food company	Devon	trevor@tbsfc.com	01803 555777	
x	x			Vivian Cock	Western Waste	Penzance	none	01736 363492	scallop and crab shell in a range of sizes/grades
		x		Diane Thomas	Penclawdd Shellfish Processing	Nant-y-wrach Farm, Llanrhidian, SA3 1EU	mail@penclawddshellfish.co.uk	01792 851678	
		x		Alison Jones	Selwyns Ltd.	Lynch Factory, Marsh Road, Llanmorlais, Swansea, SA4 3TN	selwynsseafood@btconnect.com	01792 851945	

[1] **Any additional company who provides free of flesh shell wishing to join the list please contact Michaela Archer on 01482 327 837 or M_Archer@Seafish.co.uk**

7.3 Users of Clean Shell

Contact name	Company name[1]	Company address / location	e-mail	Tel no	additional info
Steve Le Chevalier	Specialist Aggregates	162 Cannock Rd, Stafford, ST17 0QJ	steve@specialistaggregates.co.uk	01785-665554	www.specialistaggregates.co.uk
Frank Pietrzak	Bord na Móna Environmental	4 Harbour Buildings, Waterfront West, Dudley Road, Brierley Hill, West Midlands DY5 1LN, England	frank.pietrzak@bnme.co.uk	01384-486978	www.bnm.ie/files/20050506020839_MONASHELL_ENG.pdf
Steven Coupe	Hanson Formpave	Tufthorn Avenue , Coleford , Gloucestershire , GL16 8PR	Stephen.Coupe@formpave.co.uk	01594-836999	www.hanson.co.uk/570/formpave.html
Jim Green	Testa Teres	Fleetwood	jimgreen@testateres.co.uk	01253 772504	www.testateres.co.uk/index.htm
Paul Edwards	Environment Agency Wales	Maes Newydd, Llandarcy, Neath Port Talbot, SA10 6JQ	paul.edwards@environment-agency.wales.gov.uk	01792 325610	
Nicola Henshaw	Minerals Resource Management Ltd.	UK wide	nicola.henshaw@srm-ltd.com	01524 853 053	www.srm-ltd.com

[1] Any additional company who provides free of flesh shell wishing to join the list please contact Michaela Archer on 01482 327 837 or M_Archer@Seafish.co.uk

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Appendix I – Shell Aggregates Report – Market Study

Shell Aggregate Report - Existing UK Markets

[1]Market Sector	Shell Types	Physical Form	Suitability	Value Of Product	Estimated Market t/pa	Market Place
Private Footpaths and Tracks	Cockle, Mussel, Scallop, Whelk	Uncrushed	Suitable	Very Low	20,000	Mature market within 5 miles of coast
Paths: Commercial, Parks, Sports and Leisure	Cockle, Mussel, Scallop	Crushed, Ungraded	Very Suitable	Moderate	< 2000	Niche within mature market. Generally within 10 miles of coast
Coloured Mulch for Ornamental Use	Scallop, Cockle	Cleansed, crushed & graded	Very Suitable	Moderate to High	Under 50	Niche within established fashion driven UK market
Concrete Products, e.g. aggregates	Scallop, Cockle	Cleansed, crushed & graded	Very Suitable	Moderate	Under 200	Developing niche market. Generally within 10 miles of coast
Clean & Waste Water Treatment	Cockle, Oyster	Sanitised, crushed & graded	Suitable	Moderate	>1000	Developing UK wide specialist market
Avian and Animal Feed Supplement	Cockle, Oyster, Scallop	Sanitised, crushed & graded	Suitable	Moderate	5000 [2]	Mature regional and national specialist market
Whole Decorative and Value Added Retail	Scallop	Sanitised, Selected Whole	Low	High	400 [3]	Mature UK wide fashion driven market
Food Packaging	Scallop, Crab	Sanitised, Selected Whole	Very Suitable	High	<2000	Mature national and international specialist market

[1]Applications for shell products must be covered by the relevant EA and ABPR legislation requirements

[2] Approx 2000 tonnes per annum supplied through imported oyster shell

[3] Market sector dominated by imported shells

Shell Aggregate Report - UK Markets - Development Potential								
[1]Market Sector	**Shell Types**	**Process Level**	**Capital Requirement**	**Operational Costs**	**Marketing Activity**	**Opportunities**	**Threats**	**Notes**
Private Footpaths and Tracks	Cockle, Mussel, Scallop, Whelk	Whole	Nil	Low	Low	Ongoing opportunity for local sales		Future may be uncertain for this major outlet for waste shell
Drainage[2] (filtration/attenuation/ditches)	All	Variable	Low	Low/Moderate	Moderate regional	Subject to academic review	No demonstration projects to show added value	Could be a major outlet in SUDS[2] for new urban developments
Clean & Waste Water Filtration	Cockle	Whole	Low	Low	Substantial national	Substantial regional opportunity within a national context		Developing market for the treatment of run-off and tertiary waste waters needing further investigation.
Paths: Commercial, Parks, Sports and Leisure	Cockle, Mussel, Scallop, Whelk	Cleansed, crushed, ungraded	Moderate	Low / Moderate	Moderate regional	Substantial regional opportunity	Limited local availability may inhibit capital investment	Development of an industry best practice standard could open up Corporate and Local Authority markets.
Decorative and Coloured Mulch	Cockle, Scallop	Cleansed, crushed & graded	High	Moderate	Substantial national	Potential national opportunity	Investment would be purely speculative	One-off events or fashion trends could substantially influence sales.
Concrete Products, e.g. aggregates	Cockle, Scallop, Whelk	Cleansed, crushed & graded	High	Moderate	Substantial national	Potential national opportunity	Sales may take a number of years to reach a critical mass	Success would depend heavily on third parties developing the market for their own products
Water Treatment[3]	Cockle, Oyster, Scallop, Whelk	Sanitised, crushed & graded	High	Moderate	Substantial national	Potential national opportunity	Limited local availability may inhibit capital investment	Acceptance of shell as a "natural" pH correction agent could substantially influence sales
Clean & Waste Water - Acid Neutralisation	Cockle, Oyster, Scallop	Sanitised, crushed & graded	High	Moderate	Substantial national	Potential national opportunity	Limited local availability may inhibit capital investment	Acceptance of shell as a "natural" pH correction agent could substantially influence sales
Avian and Animal Feed	Cockle, Oyster,	Sanitised,	High	High	Substantial	Regional opportunity	Market likely	Mature market

Supplement	Scallop	crushed & graded			regional & national	within a national context	to be increasingly regulated	serviced by a range of competitive products
Whole Decorative and Value Added Retail	Cockle, Mussel, Scallop, Whelk	Sanitised, Selected Whole	Low	High	Substantial national	Limited volume opportunity	Market strongly influenced by fashion trends	Future sourcing of overseas shell may positively influence the market
Food Packaging	Scallop, Crab	Sanitised, Selected Whole	Very High	High	Substantial national & International	Unestablished national and international opportunity	Market likely to be increasingly regulated	High capital cost precludes easy access to market.

[1]Applications for shell products must be covered by the relevant EA and ABPR legislation requirements

[2] SUDS (Sustainable Urban Drainage Systems) are a major new initiative for which shells could have an advantage over standard aggregates

[3] Large masses of limestone powder & sands currently used. Water Framework Directive could see increased demand