A social and economic impact assessment of cockle mortality in the Burry Inlet cockle fishery, south Wales UK

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FINAL REPORT

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ATP	Abusive Transfer Pricing
BHGA	Burry Inlet Hand Gatherers Association
BI	Burry Inlet
BWD	Bathing Waters Directive
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CoVar	Covariance (normalized estimate of variability)
CPR	Common Pool Resources
cSAC	Candidate Special Area of Conservation
CSO	Combined Sewage Overflow system
CCW	Country Side Commission Wales
CPI	Consumer Price Index
DCWW	Dwr Cymru Welsh Water
DSP	Diarrhetic Shellfish Poisoning
EAW	Environment Agency Wales (now NRW)
GVA	Gross Value Added
IFCA	Inshore Fisheries and Conservation Authorities
JSA	Job Seekers Allowance
LA	Local Authority
MAFF	Ministry of Agriculture Fisheries and Food (now CEFAS)
MLS	Minimum Landing Size
MSC	Marine Stewardship Council
NNR	National Nature Reserve
NRW	Natural Resources Wales
NWSFC	North Wales Sea Fisheries Committee

OAR	Open Access Resources
SSSI	Site of Special Scientific Interest
SPA	Special Protection Area
SWD	Shellfish Waters Directive
SWSFC	South Wales Sea Fisheries Committee
TAC	Total Allowable Catch
TREAG	Three Rivers Estuary Action Group
TR	Three Rivers estuary
RDA	Regional Development Agency
RPI	Retail Price Index
SPS	Selwyn's Penclawdd Seafood Ltd
SD	Standard Deviation
PSFA	Penclawdd Shell Fishermen's Association
PSP	Penclawdd Shellfish Processing Co. Ltd
UWWTD	The Urban Waste Waters Treatment Directive
WG-IFU	Welsh Government Inshore Fisheries Unit
WG-MFD	Welsh Government Marine and Fisheries Division
WWF	World Wildlife Fund
WWTW	Wastewater Treatment Works

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1 EXECUTIVE SUMMARY

Mortalities of larger, more valuable cockle 2 and 3 year-classes have recurred on the Burry Inlet (Loughour) Estuary (BI) since 2002 and on the nearby Three Rivers Estuary (TR) since 2005. The aim of this report is to estimate the economic impact of the mortality on the south Wales cockle industry, related businesses and wider Welsh economy. Stakeholder interviews, direct observation, secondary literature, production and price data supplied by industry and government agencies is used to characterise value-chains, historic livelihood, regulatory and production trends. Lack of intermediate expenditure data (wages, energy rents etc.) prevented estimates of losses on foregone gross value added (GVA) across the Welsh cockle value chain. Analysis was instead focused on estimation of first-sale value losses for whole cockle from the BI using a range of baseline output and price scenarios (lack of historic value data precluded similar assessment for the TR). Value-chain analysis indicated that the burden of mortality losses fell most heavily on independent gatherers; whilst processers are able to source much of their raw materials needs from other Welsh, English and European fisheries, gatherer access to other cockle fisheries is much more restricted.

BI recorded landings averaged 2901t/year (SD 1363t) from 1987 to 2001 (pre-mortality), and 1,162t/year (SD 916t) from 2002 to 2014. TR landings averaged 857t/year (SD 1,271t) from 1987 to 2004 (pre-mortality) and 1,155t (SD 2,559t) from 2005 to 2014 with an exceptional production year in 2005 heavily biasing the latter average. Whereas a minimum BI landing size of 19mm was enforced prior to the crisis, today most cockle range from 12-17mm. Consequently, the real (Retail Price Index (RPI) adjusted) mean first-sale value of BI cockle has steadily declined from over £1,000/t at the start of the mortality-era to only £400/t in recent years.

Nominal and real price (inflation adjusted) first sales losses were estimated for three baseline reference periods covering years from 1987 to 2001 (BRP1, BRP2 and BRP3[1]) and three price scenarios (S1, S2 and S3), resulting in nine alternative nominal and real price first sale loss estimates. Two years, 2003 and 2004 were excluded from the BI mortality era as outlier years due to the fact that they had high output of residual amounts of large cockle (and exceptional above historic average prices) despite the fact that significant cockle mortalities had already been recorded during these years. Thus total BI losses were estimated over an 11 year 'post-mortality' period; 2002 to 2014 minus 2003 and 2004.

S1 used historic BI output and price / value data, however, due to unfulfilled European demand the real value of cockle has increased since the mortality onset. To reflect this the Dee Estuary cockle fishery in North Wales provided a useful disease-free' positive control having come under a regulating order limiting access to 50 licenced hand-gatherers since 2008, a system that had prevailed on the BI since 1965. Consequently, S2 used official Natural Resource Wales (NRW) Dee price data from 2008 to 2014 to estimate prices that might have

[1] BRP1 = 1987-1996; BRP2 = 1998-2001; BRP3 = 1987-2001 The baseline reference periods reflect the fact that there were two distinct value trends; with a lower average value during BRP1 and higher average value during BRP2 and hence the time period selected will have a material impact when calculating the subsequent economic losses arising from the impact of the cockle mortality syndrome.

been achieved in the BI fishery had it not experienced the loss of larger cockles. Finally S3 repeated the same analysis but using industry-supplied mean annual price data from the Dee which yielded value estimates double those of the NRW-supplied values for the same cockle fishery; the reason for this significant discrepancy is assumed to be that the former is probably being based on crude (mixed size cockle) rather than output-weighted (size specific) price averages.

Total BI losses in the worst case scenario (BRP2: 1997-2001, RPI adjusted Dee industry-supplied prices and applying a 17% under-reporting correction (see section 4.7 for details)) amounted to £53.9m over 11 years or £4.9m per year. Alternatively, using a longer 15 year baseline (BRP3 1987-2001) and NRW-supplied Dee annual value data gave a loss of £15.8m (£1.4m per year) applying the same under-reporting correction. In a separate assessment the South Wales Sea Fisheries Committee (SWSFC, now defunct) Molluscan Working Group estimated losses of £11.96m (£2.39m/year) to £20.77m (£4.15m/year) for combined Burry Inlet and Three Rivers losses from 2003 to 2007 i.e. on an annualised basis, comparable to the worst-case scenario outlined above. An even higher gatherer estimate of £70m losses 'in south Wales' between 2002 and 2012 (i.e. £6.4m per year; no assumptions given) was cited in media reports. During interview one gatherer indicated annual earnings of around £60,000 in 2002 had fallen to £9,000 in recent years, probably reflecting best and worst case scenarios. Furthermore, accounts collected from two other gatherers indicated mean profits ranging from £2,000 to £18,500 between 2009 and 2014. Overall, based on the findings of the report, the authors' 'most robust' estimation of first-sale economic losses is £32,405,569 or £2,945,961/year since 2002 (BRP3, S3 and RPI prices and +17% under reporting adjustment)'. See Section 6.3 for further detail. This figure would be considerably higher if it had been possible to consider the wider impact on the Welsh economy as part of a total Gross Value Added (GVA) analysis. Findings and assumptions of an earlier (2003-2007) loss estimation conducted by SWSFC are also reviewed and reasons for variance with results of the current study highlighted.

The number of licensed gatherers for the BI fishery has been fixed at 36 for a number of years which represents a significant decrease from a peak level of 67 in the years prior to the mortality. Since assuming responsibility for the fishery in 2010, NRW has maintained this level due to the status of the fishery and to ensure it is the appropriate level of exploitation to satisfy the Habitats Risk Assessment (HRA) required under the EU Habitats Directive. Despite this reduction, only around one third of the existing licensees were found to be regularly active. A licence waiting list (now closed) has also declined from 155 in 2005 to 89 in 2014; low-turnover means this system elevates the mean age of licensees; most are between 40-60 years of age and all but two are male. All gatherers must rely on other part-time or seasonal occupations to augment their income.

The economic impact of mortality in the BI must be considered alongside changes that have occurred in the wider UK cockle-sector. The economic fundamentals of the UK cockle-sector have under gone significant change over the last two decades driven by (i) expansion into major European markets for tinned produce and (ii) capital requirements to make processing facilities compliant with more stringent EU food hygiene regulations. Two vertically integrated European companies now dominate UK production, processing and distribution; Lenger Seafoods Ltd (Dutch) and DANI Foods Ltd. (Spanish). Shortly before the persistent nature of the mortality problem became apparent, these companies acquired most of the processing capacity around

the BI, investing heavily in two primary processing plants (Selwyn's Penclawdd Seafoods Ltd and Penclawdd Shellfish Ltd) and a secondary processor (Parson's Pickles).

Today the processing sector in south Wales could be considered an example of 'industrial inertia', with the company's continuing to operate around the BI despite the loss of many of the factors that originated them. This is facilitated by growing reliance on external supply of raw-material, principally from other UK and European cockle production areas. One primary processor sourced only 6.7% of its mean annual supply from the BI From 2002 to 2007, declining to 4% from 2008 to 2014. Only 32t came from the BI in 2014 and the BI plant is now effectively 'moth-balled' leaving just one major buyer for whole cockle from the BI and TR. Pickling remains one of the few options for this undersized product for which there is negligible demand on European markets. Thus the contribution of BI cockle to the single local (and UK's only) pickling plant; 'Parsons Pickles' accounted from 17-47% of the plants total annual supply from 2005-2014.

The report concludes with management recommendations under continuing cockle mortality loss and recovery scenarios, the key ones being:

- Assuming mortality levels decrease, consistent and increased output from a regulated TR fishery might provide critical mass to retain significant local primary processing investment. Regulatory costs for the TR and BI could be mitigated by inclusion of a closed season as is applied on the Dee Estuary (processors and gatherers have already diversified supply and income options). This may also bring other environmental benefits. Given many practical uncertainties in the first instance a limited Regulatory Order feasibility trial could be conducted on one of the more productive and observable TR cockle beds.
- We recommend a cost-benefit review for continuing the MSC certification of the BI fishery, including an appraisal of whether there are opportunities, perhaps through increased support for marketing, for certification to provide more tangible benefits to the gatherers and other stakeholders in the supply chain. Other possible benefits of certification to consider include; i) the contribution of useful (and cost effective) additional information with regard to stock assessment and defined management outcomes from MSC audits, and ii) improved credibility and reputation of regional public-sector environmental management efforts from independent third party auditing.[2]
- Gatherers have correlated more serious sewage spill events with acute mortality episodes though whether, and to what extent sewage effluents contribute to on-going chronic mortalities is highly contentious. Nevertheless on-going improvements in the management of sewage treatment and effluent disposal should continue to take high priority. Improved management may contribute to upgrading of the *E. coli* classification of BI and TR cockle beds, potentially supporting direct marketing of high-value whole-live cockle by gathers. To be effective such efforts must be coordinated with improved regulation

[2] It is understood that NRW are already at an advanced stage of conducting an internal review of MSC certification for the BI fishery (NRW, pers. comm.).

of other potential contamination sources. It should be noted that improved sewage management may reduce nutrient inputs that were likely to have contributed to the productivity of the cockle fishery.

- Despite a need for more substantive youth employment opportunities in the Llanelli area, the current BI licence waiting list system denies access to younger would-be participants. Those on the list also feel they are losing entitlement when quotas are increased in good years. We recommend the waiting list continue to be closed to new entrants with a view to finally closing it entirely[3]. A replacement lottery-based system could also see applications weighted against socially desirable criteria. Existing licensees should also be incentivised to mentor younger new entrants.
- A TR-type temporary permit-system could be applied during exceptional 'windfall-years' to ensure some equity of benefit to the wider community.
- Normalised economic comparisons between sites and years are complicated by lack of size-specific harvest and price data. Such data could also be of value for stock assessments. As gatherers have historically been paid 'on-grade' it may be that such information is most readily collectable from primary processors responsible for grading.[4]
- NRW and local business could look to form/be part of a consortium, with industry and academic collaboration taking integrated approach to the shellfish mortality causes, environmental, social and economic impacts; for example under the EU Horizon 2020 program.

[3] According to NRW, the Dee Fishery has aspirations to achieve the same (NRW, pers. comm.).

[4] Last season saw the Dee Fishery paying an 'all-in' price for cockles, primarily from a specific bed, due to very high meat yield figures which, if this trend continues, could lead to a potential loss of size related data.

2 INTRODUCTION

2.1 THE BASIS ON WHICH THE REPORT HAS BEEN PREPARED

Historical pre-mortality and current landings data were largely sourced from South Wales Sea Fisheries Committee (SWSFC, now defunct) reports, the Welsh Government Marine and Fisheries Division (WGMFD) and Natural Resources Wales (NRW). The extent of cockle mortality experience by these fisheries is readily available from other studies and reports, which are summarised for context.

Two separate 5-day field visits were made by the consultants to the Burry Inlet during August (V1) and October (V2) 2014. During V1 two postal survey formats designed to gather economic information from gatherers and processors were developed and tested (Appendix 9 and Appendix 10). Group meetings were also held with local stakeholders including primary and secondary processors, gatherers and local officials. A value-chain mapping exercise was also undertaken with these stakeholders and requests placed for secondary historic cockle production and value data. Processors were approached to assist in the mobilisation of financial information and historical changes in value-chain configuration, coordination and benefit distribution.

A poor response to the postal surveys prompted the second visit in mid-October with the aim of gathering additional information through individual face-to-face interviews and direct observation of the fishery. Difficulties were again encountered eliciting the detailed quantitative historic data targeted in the two survey formats under field conditions. Consequently the survey formats were used as semi-structured interview checklists yielding more summary quantitative data (consistent with on-the-spot recall capacities) and rich qualitative data (e.g. on livelihood impacts) that provided interpretive power. Additional interviews were also conducted by phone to seek clarifications and fill data gaps.

Table 1: Stakeholder categories and numbers interviewed

Stakeholder Category	Location	Numbers interviewed
licensed Cockle Gatherers	Burry Inlet	8
licensed Cockle Gatherers	River Dee	1
Primary Cockle Processors	Penclawdd	2
Secondary Cockle Processors	Burry Port	1
Local councillor	Llanelli	1
NRW staff	Neath, Port Talbot	4
Food standards	Swansea	1
Welsh Govt. (Fisheries)	Swansea/ Cardiff	2

2.2 DATA VALIDITY

Great effort was made to validate key data that could have an impact on assessing economic losses through triangulation of sources and assessing data provenance (e.g. through reports on concurrent disease outbreaks, closures etc.). Difficulties were compounded by a paucity of meta-data on many of the available government and industry datasets. In some cases, most notably for price and value data, contradictions between available sources raised doubts about the precision of data. Historic under-reporting was likely to be the greatest source of systematic bias in output data, a problem likely to be greater for a permit-based, casual entrant fishery like the Three Rivers than a regulated, restricted access fishery like the Burry Inlet. Whilst the actual extent of any such under-reporting is extremely difficult to assess, based on stakeholder interviews, a crude-correction factor was included in the loss estimation scenarios. Our BI economic loss estimation approach, assumptions and results are also compared and contrasted with an earlier assessment (2003-2007) conducted by the SWSFC (SWSFC, 2007; Section 6.3 and Appendix 8).

Based on experience in other fishery sectors, the potential for a range of other 'market-failures' including transfer-pricing, price-fixing collusion etc. were also considered (Section 4.7). No evidence of these practices was recorded during this study.

3 OVERVIEW AND HISTORY OF THE FISHERY

3.1 BACKGROUND

The north and south cockle beds of the 'Burry Inlet' (BI) and those of the nearby 'Three Rivers' (TR) estuaries in South Wales are amongst 22 designated shellfish waters in Wales under the EC Shellfish Waters Directive (2006/113/EC: Fig 1). Only seven are certified by the food standards authority (FSA) for commercial gathering and human consumption based on regular bacteriological monitoring (Table 2). Production from the remaining fisheries is considered too low and/ or erratic to merit such investment[5].

The areas fished in the Burry Inlet, covering 3-4 square miles, is considerably smaller than some of the UK's east coast cockle fisheries e.g. the Thames (with 70 square miles of beds) and Wash. However, their consistently high historic productivity and significance to the local economy meant that in 1965 the Burry Inlet became the first Welsh cockle fishery to be closely managed under a licensing system or Regulating Order restricting the number of entrants (Section 3.3.1). In 2008 the Dee Estuary (2008) in north Wales became the second Welsh cockle fishery to be so regulated. Both these fisheries are currently managed by Natural Resource Wales (NRW), which is funded by the Welsh Government. Wales's other cockle-fisheries (including the Three Rivers: Table 1), characterised by more erratic and smaller average harvests, are directly managed by the Welsh Government (Marine and Fisheries Division) through issuance of temporary permits during periodic opening linked to regular stock assessments. Recurring mass chronic mortalities observed since 2002 in the Burry inlet (detailed in Section 3.4) have resulted in significant changes to the fishery including; the way it is managed, industry working practices and the value of the fishery.

Whilst viable populations and even high biomasses are maintained, landings are now dominated by smaller less valuable cockles and harvesting is now generally only commercially viable between April to October (although some level of year-round fishing occurred in the past and gathering continued from the BI fishery until late December in 2014). In addition to the ecological considerations, culturally cockles are recognised internationally as an iconic Welsh product and the local industry has traditionally been an important source of livelihood but this has been under threat due to very low economic returns.

A similar pattern of losses began on the Three Rivers from 2005. Whereas access to the BI has been limited to no more than 67 licensees since 1965, the TR is periodically opened too much larger numbers of casual entrants through a temporary permit-system (Section 3.3.2, Appendix 5). Probably for this reason losses on the TR, which though erratic can be as productive as the BI in a good year, have received far less attention (Section 5.2).

Further background on the geography of the BI and TR fisheries is presented in Appendix 2.

[5] Currently the Welsh Government has stipulated that it is the fishermen's responsibility to only fish areas that are FSA classified with enforcement responsibility imposed on relevant Local Authorities (NRW 2013).

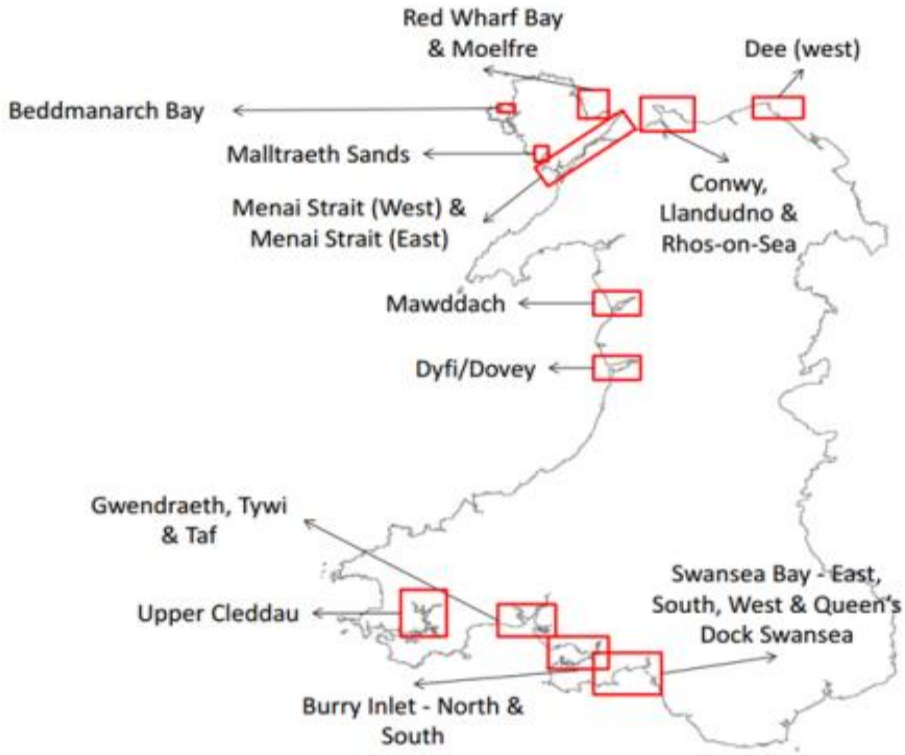

Figure 1: Designated shellfish waters in Wales

(Source: Hartley, 2014)

Table 2: Management characteristics of cockle fisheries in Wales

SN	Fisheries	Management	Regulatory Body	FSA Classification
1	**Burry Inlet**	Regulating Order	NRW	B/C
2	**Three Rivers**	Permit	WG-FMD	B
3	**Angle Bay**	Permit	WG-FMD	-
4	**Dyfi ***	Permit/ Open Access	FMD/ NA	B
5	**Mawddach**	Permit	WG-FMD	-
6	**Dwyrd/Glaslyn**	Permit	WG-FMD	-
7	**Forydd ***	Open Access	NA	-
8	**Traeth Melynog**	Permit	WG-FMD	-
9	**Malltraeth**	Permit	WG-FMD	B
10	**Red Wharf Bay**	Permit	WG-FMD	B
11	**Cymran Strait**	Permit	WG-FMD	-
12	**Beddmanarch bay**	Permit	WG-FMD	-
13	**Traeth Lafan**	Permit	WG-FMD	B
14	**Dee**	Regulating Order	NRW	B

Notes: All these fisheries fall within designated Marine Protected Areas (MPA)
NRW = Natural Resources Wales, WG-FMD = Welsh Govt. Fisheries & Marine Division
FSA = Food Safety Agency (2013 shellfish waters bacteriological classifications)
* The Forydd and parts of the Dyfi estuaries are out-with the former South Wales Sea-fisheries Committee (SWSFC) jurisdiction and therefore still beyond Welsh Govt. control (NRW 2013)

3.2 THE BURRY INLET FISHERY

An organised fishery has existed on the Burry Inlet since Roman times (Woolmer 2010). Cockles are continuously distributed throughout the estuary though the location of beds with the most harvestable commercial concentrations varies from year to year with changes in sediment characteristics and other factors. Figure 2 shows beds mapped by two gatherers during the current study and Figure 3 the results of a similar effort in 2010 (Woolmer 2010). Gatherer interviews also pointed to long term cyclic shifts in productivity; southern beds being reported as more productive up to 1960's with the situation reversing thereafter.

Figure 2: Cockle Beds mapped by BI cockle gatherers Oct 2014

(Note: red-outline indicates beds with commercial activity over the last 2-3years)

Figure 3: Local cockle bed and place names on the Burry Inlet identified by Woolmer (2010)

The same basic gathering methods have been practiced with relatively little change for centuries with cockle harvesting limited to hand-gathering (raking, riddling, bagging, carrying, clearing dead cockle). Cockles are harvested by hand-raking at low-tide and sieved in-situ (using a sieve of around 18" diameter with oblong mesh with width set at the minimum legal size: MLS – Section 4.2.3) allowing smaller animals to re-burrow and breed (Plate3a and 3b). If healthy and undamaged discarded cockles re-burrow generally survive and continue to grow well. These hand-fishing methods, practiced on all Welsh Cockle fisheries also result in negligible by-catch of other species (SWFC 2005).

Plate 1: Burry Sands cockles sieved with 18" diameter, 10mm mesh riddle yielding 17-18mm cockles

Plate 2: Sieved cockles returned to sand to re-burrow

(Source: Consultant visit 17 Oct 14)

Contingent on stock-levels, gatherers on the BI are licenced to gather for 12 months of the year (compared to only 6 months from June/ July to December on the Dee). Fishing is thus undertaken in summer and winter often in extreme weather conditions. Danger from tides and bad weather are minimised by the gatherer's expert local knowledge (Misstear 2012).

3.3 GOVERNANCE

Primary responsibility for regulation of the BI and TR fisheries lies with Natural Resources Wales (NRW) and the Welsh Government Marine and Fisheries Division (WG-FMD), respectively. A key difference between the management of these two fisheries lies with the way access is granted (discussed below). In 2012 NRW (formally the Environment Agency) took over regulatory responsibility from the South Wales Sea-fisheries (SWSFC). The transition saw some changes in management approaches particularly in stock assessment and quota allocation methods, though little change to licensing regulations. A more detailed review of governance differences and trends for the BI and TR cockle fisheries is provided in Appendix 4. Both sites are marine protected areas (MPAs) as well as falling under a wide range of national and EU environmental designations which are summarised along with sewage contamination issues in Appendix 3.

3.3.1 Burry Inlet

The Burry Inlet cockle fishery is governed by the Burry Inlet Cockle Fishery Regulating Order (1965). The associated licensing scheme was designed to regulate the quantity of cockles taken by imposing:

- limits on the number of gatherers
- area limits
- daily quotas
- cockle size limits

3.3.2 Three Rivers

The fishery is governed by a permit system introduced in 1998. Permits are issued free of charge to anyone who applies for one upon presentation of formal identification documents. The permit system may be more equitable than the licensing system used for the Burry Inlet because it is less restrictive, however it results in a much less stable fishery with tremendous pressure on the regulator to open the fishery as soon as cockle stocks appear adequate.

3.4 COCKLE MORTALITIES

The common cockle (*Cerastoderma edule*) lives 2-3 centimetres below the surface in mud, sand and muddy gravel substrates in shallow sub-tidal and intertidal zones; the latter habitat offering scope for hand-gathering. Cockles grow best within a salinity range of 15 – 35 ppt though can tolerate levels down to 10 ppt. They spawn at around 18 months, typically living for 2-4 years and potentially up to 9-10 years. Spawning normally occurs in summer at age of around 18months at a shell diameter of 15-20mm, though under the prevailing mortality conditions most spawn is by fast growing 12month old individuals with shell diameter >15mm. As each animal can release more than 1million eggs, stocks have the capacity to recover quickly after seasons of poor spat-fall or survival.

3.4.1 Natural Loss Causes

Inter-annual cockle production is naturally highly variable due to a range of interacting factors under varying degrees of anthropogenic influence. Causal factors include disease, predation, recruitment failures, pollution eutrophication, over-fishing and climate change, which can have a range of environmental impacts including: algal blooms, eutrophication, physical water quality effects (e.g. temperature, salinity) and increased storm events (Woolmer at al 2013).

Their shallow burrowing depth means cockles can be washed out en-masse during storms and young cockle are also particularly vulnerable to cold weather on spring-tides. Oyster-catchers which can consume up to ¼ kg each per day are the principle natural cockle predator. Poor recruitment and harvests in the 1970's were attributed to large numbers of overwintering oyster-catchers leading to (unique) culls in 1973 and 1974. Flocks numbering up to 20,000 were estimated to have taken 30-50% of the cockle biomass; 5-10 times that of the fishery. Plate 3 shows debris of juvenile cockle around 12-15mm at an oyster catcher feeding station between tides on the Burry Inlet. Second winter cockles of 15-22mm i.e. the favoured harvest size - are

normally the most preferred size which have been observed to sustain up to 90% mortality on the BI (Hancock and Urquhart 1964).

Plate 3: Oyster catcher feeding debris at Burry Inlet

(Source: consultant visit 17 Oct 14)

Young mussels (<1 year old) can bind stones and shells to form a 'crust' known as 'crumble' on top of areas of cockle bed which can prevent hand-raking. Crumble used to be removed periodically using dredger vessels under the authority of SWSFC and with approval of the Countryside Council for Wales (CCW). Although of no intrinsic commercial value the crumble does provide a food sources for wild fowl such as oyster catchers.

3.4.2 Mass mortality trends on the Burry Inlet, Three Rivers and Wash Estuaries

Burry Inlet (BI): Although relatively modest in size, the BI traditionally provided one of the most consistently productive cockle fisheries in Europe. Chronic mass cockle mortalities in the BI have been observed every year since the summer of 2002. Heavy losses were compounded by the periodic closures of the fishery for approximately 18-20 months following detection DSP causing bio-toxins in cockle flesh by CEFAS[6]. On resumption of gathering in 2003 most of the larger adult (19mm+) 2001 and 2002 year classes were lost. Heavy mortalities of remaining 1 year old cockles occurred again in 2004 during moderately warm weather in May and July. Despite the very low residual 1 year old spawning stock, the 2004 spring spat-fall proved one of the largest in living memory. The on-going decline of larger 2-3 year-old cockle classes meant that henceforth harvests became dependent on the regulating body relaxing the size restrictions. In July 2004 the SWSFC decreased the size limit from 19mm to17.5mm (MLS; i.e. entering their second summer) on densely packed south-side cockle beds (Ochwr Draw 'School' Beds – see Figure 2 and Figure 3). However most of these died before they could be harvested resulting fishing ending in September. In May 2005, permission was granted to

[6] Differential results between laboratories gave rise to the suggestion that there may have been false positives.

collect under-sized cockles of the 2004 year class when they became marginally marketable at around 14 months old.

Heavy sewage discharges associated with a broken pipe and discharge of primary effluent from storage lakes are alleged to have occurred in June and July of 2005 which, if true, would have compounded already severe mortalities[7]. CEFAS estimated mortality levels of 99.5% (north-shore) and 96% (south-shore) between their May and November stock assessment surveys. The south beach was closed for bathing in June and contemporary reports noted 'the smell of decaying cockles spread for miles inland' in late July (Plate 4 and Plate 5). In 2006 SWSFC again permitted fishing of undersize cockle (<17.5mm MLS), this time to a reduced number of interested licence holders. However even 13/15mm cockle on high ground started dying by the end of May with almost total mortality by the end of August. In the same year for the first time in its history the SWSFC permitted fishing of cockle spat itself (i.e. 2006) in areas where it had grown well such as the middle bank (Figure 2 and Figure 3).

Plate 4: Mass cockle mortalities at Pwll Bank, Burry Inlet north-shore July 2005

Plate 5: Close up of dead cockles at Pwll Bank, Burry Inlet, July 2005

(Source: SWSFC Molluscan Working Group, 2007)

Over successive years this pattern has essentially repeated itself with minor variations; mortalities tend to be greatest during warmer weather, typically from late May, in high-density areas on dry sands on neap tides. Mass mortalities have become less common in recent years; replaced instead by more chronic and apparently less density-dependent losses, possibly due to older year classes now being so scarce. Previously hand gathered cockles would normally be fished over a 2-3-year period post settlement based on more stable populations composed of several age-classes i.e. settlement in a given year might, on average, be expected to contribute around 30%, 60% and 10% of the harvests in three succeeding years. Today, the fishery remains dominated by 1-years olds which grow rapidly, fatten, spawn and gradually die from late spring with cumulative losses of up to 90% by autumn. This makes the fishery very dependent on the previous year's spat-fall. However spat-fall and harvest of one-year olds in successive years still tends to be poorly correlated (Figure 4) as their success in turn depends on other factors particularly the weather/temperature conditions of just one intervening winter.

[7] Pollution investigation reports at the time found no evidence to support this allegation.

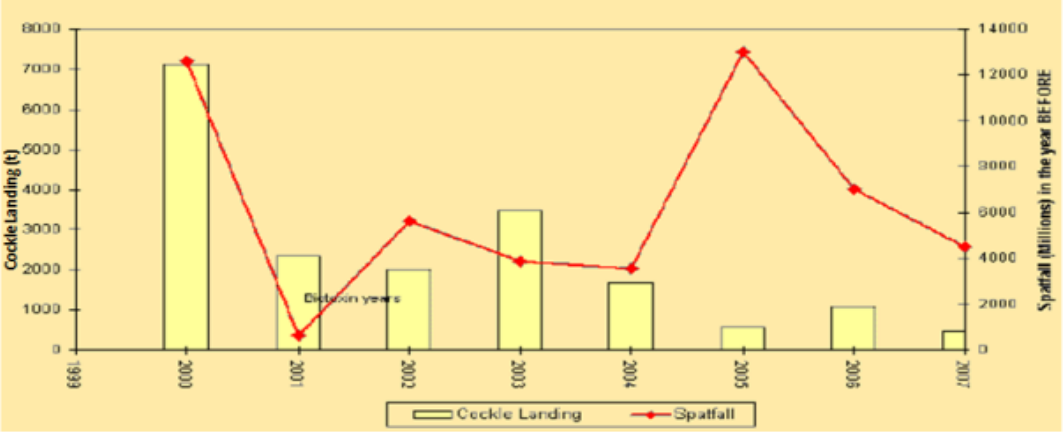

Figure 4: Burry Inlet cockle landings 199-2007 and spat fall levels in the previous year (Source: SWSFC Molluscan Working Group 2007)

The Three Rivers: As an unregulated fishery with lower economic value than Burry Inlet, mortality events have been less well studied and documented. Mortalities were observed in the Laugharne beds between April to June 2005 and the first mass loss of up to 6000t (2003 and 2004 year classes) occurred on the Llanstephan beds in late July 2005. Strangely denser cockle beds (2004 year class only) on the Gwendraeth beds survived and became the focus of the 2006 fishery along with areas of the Laugharne beds unfished in 2005. However most of these cockles died by the end of summer. As in the Burry Inlet in 2005 problems were compounded by a sewage 'flush' which also lead to bathing closures from early June 2006 and loss of a prospective 1,000t fishery. In 2007 limited mortalities were observed from as early as February including for the first time, under one year old juveniles (potentially weather related). Chronic (rather than mass) mortalities then persisted in the Laugharne, Gwendraeth and Llanstephan beds for which a 4000t September tonnage had been estimated. Mortalities peaked in mid-June, correlating again with a sewage flush event. Gathering ended in mid-July with mortalities still on-going. No in-depth causal studies of the kind undertaken on the Burry Inlet have been conducted. Management by the Welsh Government (Marine and Fisheries Division) instead relies on 'snap-shot' stock assessments on which to base fishery opening decisions. Poor stock-levels linked to on-going mortality have meant that only one sizeable harvest occurred in the last five years when the fishery was opened for several weeks in 2010. This yielded close to 2000t of relatively low value smaller cockles (NRW Pers. Com. 2014).

3.4.3 Mass Mortality Causes?

In 2008, the Welsh Government commissioned the Environment Agency Wales (now NRW) to co-ordinate an investigation into the causes of cockle mortalities on the Burry Inlet and to make management recommendations linked to findings (Elliot et al, 2012). The study conducted over 3-years from 2009-2011 was developed in collaboration with Hull, Bangor and Swansea Universities, CEFAS and the Countryside Council for Wales. In addition to a review of secondary literature, this comprehensive study evaluated the health of the cockles and other estuarine fauna, population dynamics, water and sediment quality based on field sampling at two Burry Inlet sites and a control site in the Dee Estuary (with no mortality problem) between March to July 2009. The study began with stakeholder consultations to map potential causes and also went on to review

management options based on comparisons with other cockle areas (the Dee, Thames, Wash, Morecambe Bay and other UK and European fisheries). Although the study assessed the functioning ecology linked to human activities in the area, detailed socio-economic assessments were largely beyond the scope of the study.

Findings pointed to the multi-factorial nature of the problem with the added complexity of different factors potentially prevailing in different years as well as uncertainties between causes and effects. Nevertheless the study concluded that nutrient conditions were conducive to good growth and found no clear evidence to implicate pollution in water or sediments as a primary mortality cause. Rather, results pointed to a combination of high parasite loads, over-crowding, energy imbalance and/or loss of condition after spawning as the most probable primary causal factors (with sedimentation conditions as a lesser effect). The report will contribute to a new NRW Burry Inlet management plan currently in development, incorporating specific measures to address these factors. However, inconclusiveness around the findings clearly contributed to a lukewarm response to the report by some of the gatherers interviewed, who remain convinced of a linkage with inadequately treated sewage effluents (Figure 5). Consequently, some of the same gatherers are processing a formal complaint regarding the enforcement of EU-directives and regulation linked to CSO discharges in support of their on-going claims for compensation for loss of livelihood.


'Sewage spills' may be cause of cockle deaths

Figure 5: Some gatherers blame cockle mortalities on sewage spills

(Source: Llanelli Star 23 Jul 2014)

Other fisheries: Woolmer et al (2013) undertook a comprehensive review of cockle mass mortalities in England and Wales, observing that such events have been reported with increased frequency and intensity over the last 50 years (unidentified mortality problems have also been reported in the Wadden Sea fishery in Holland). The authors differentiate between typical and atypical events of the type experienced on the BI and

TR. Atypical mortalities were considered to share some or all of the following characteristics: lack of any single clear causative agent, they often start with mass mortality of all year classes, acute or chronic seasonal mortalities are punctuated by periods of recovery. Ultimately both typical and atypical follow one of two pathways: recovery of all year classes or localised extinction of some or all classes until environmental conditions permit recovery. The authors identify seven fisheries recording mass mortalities with atypical characteristics: the BI, TR and Angle Bay in S. Wales, Traeth Lafan in N. Wales (Fig 1 and Table 2) and in England the Wash and Horseshoe Point slightly further north. These events also overlap with a 22% reduction in classified commercial cockle beds in England and Wales and England. On the Wash, the largest of these fisheries, atypical mortalities predominantly affecting 2 year old cockle caused chronic loss of 35% to over 90% of stocks on different beds in 2008. The management authority responded by banning mechanised harvesting (i.e. suction dredging), permitting only hand-raking in affected areas for several years thereafter (Elliot et al 2012). The BI (and TR) differs from these other atypical examples both in terms of the duration and periodicity of mortality recurrence (if not intensity of loss). Unfortunately despite collation of extensive comparative empirical evidence, it is fair to say that there has been little progress toward prediction with any certainty of how, when or if the problem is likely to be resolved on the BI and TR.

3.4.4 r/K selection

In ecological 'r/K' selection theory (MacArthur and Wilson, 1967), cockles are classed as 'r' selected species meaning they mature quickly, have short generation times and gestation periods, are highly fecund and have the ability to disperse offspring widely with little parental investment. This is a common strategy in unstable or unpredictable environments where ability to reproduce quickly is more critical than investment in the quality of off-spring. 'r-selected' species are therefore natural opportunists in contrast to k-selected 'equilibrium' species i.e. adaptations which would allow them to compete other species are or little value in this context of environmental variability. Although still a contested theory (Ito 1980, Parry 1981), the increased investment in spat production and exponential population growth in response to environmental pressure(s) is highly consistent with this view. This would also suggest that were environmental pressures to be removed then a reversion to longer generation times and larger adult year-classes could be expected.

This increased shift towards r-selection also has implications for the choice of economic loss estimation approach. As the shift is an attribute of the mortality problem itself, estimates based on stock expectation calculated as the difference between recorded production outcomes and juvenile stock assessments during mortality years risk over-estimating production potential compared to pre-mortality years. For this reason we base our estimation approach on a series of short and longer term pre-mortality era historic production averages (Section 6.2).

4 THE COCKLE VALUE CHAIN

4.1 FISHERY TIMELINE AND SOCIAL HISTORY

The BI fishery was known for the comparatively large number of people it regularly employed in the past. This is both a testament to the productivity of the fishery and the preservation of low-intensity hand gathering methods to the present day. A detailed historic timeline of the fisheries social and regulatory history from the late 19th century to the present day is presented in Table 16 (Appendix 6) and summarised below.

The first clear indication of the emergence of cockling in the region was noted in 1862 when a cockle fishery was marked on Llanrhidian sands in an Admiralty chart. Thereafter records show the fishery gained importance initially as a means for women to supplement the family income. Traditionally women harvested cockles whilst men worked in industrial manufacturing and local mines. At the start of the 20th century, around 500 people were estimated to be working in cockle gathering and processing (Bulstrode 1911). This included 250 exclusively female gathers in Penclawdd each collecting 60-150kg per day using donkeys to recover their harvest (Plate 26). An additional 150 female gatherers from Ferryside and Llansaint on the Three Rivers Estuary also worked the more reliable BI. Consistent with these observations, Wright (1927) reported 500-600 families were involved in the BI fishery. Landings were cooked near the gatherers homes and most of the output of this cottage-industry was also locally retailed by the gatherers themselves - dividing their time between the various production and marketing activities.

The introduction of horse-drawn carts permitted gatherers to increase their individual harvest to around 500kg per day (Plate 7). The possibility of recovering more cockles within narrow tidal-limits also required a matched increase in physical effort and inevitably more male gatherers entering the industry as a full-time occupation and primary source of household income. Simultaneously, the numbers of women who had previously gathered cockles to augment family income began to decline. The introduction of a hand-dredge (Appendix 4) finally banned by the SWSFC in 1969 further re-enforced this trend.

As the intensification of hand-fishing increased, the lack of any formal regulation started to put excessive pressure on the cockle stocks. This prompted the SWSFC to impose the first minimum landing size (MLS) limit of ¾" (18.3mm square) in 1921 to protect breeding stock. However enforcement was a challenge and whilst this was compatible with market demand for whole-live product, gathering of 5/8" (15.4mm square) stock for cooking remained the norm. The level was lowered to an intermediate 11/16" (17.1mm square) in 1953, revised back to ¾" (18.3mm) after the first scientific stock assessment by MAFF in 1959 and finally standardised at the current metric 19mm square level after the Burry Inlet regulating order was introduced in in 1965 (Table 16).

Prior to the regulating order, a reduced number of 40-50 gatherers regularly worked the Llanrhidian sands, casual entrants increasing the number to around 80 when stocks were plentiful (Hancock and Urquhart 1964). Only 23% of these gathers were men; the majority were still women. However, as the men were likely to be more dependent on the fishery they were also given greater priority in the issue of the first 50 licensed

gatherers whilst women were more likely to go on the waiting list further skewing the gender balance in favour of men. Today only 3 women hold licenses, all granted in the 1960's and 1970's pointing to on-going lack of female recruitment in primary production.

Plate 6: Burry Inlet cockle gathering using donkeys (1920's)

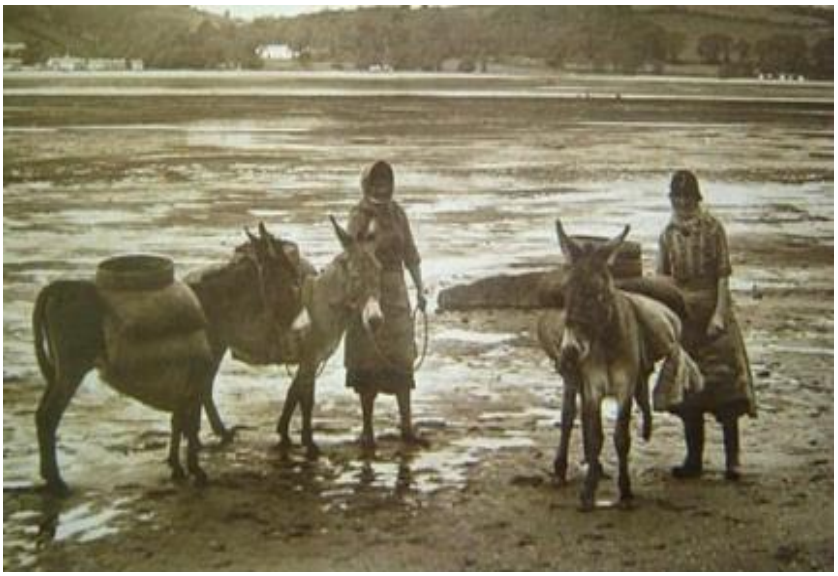

Plate 7: Burry Inlet cockle gathering using horse drawn carts (1950's)

4.2 THE COCKLE VALUE CHAIN

The configuration of the contemporary supply chain is shown in Figure 6 and described in the following sections. Up to the early 1990's the Burry Inlet fishery essentially remained a cottage industry. However, whilst restrictions on intensive harvesting practice helped conserve the small-scale gathering base, changing markets and investment needs associated with more stringent EU food safety regulation have since driven considerable consolidation in the processing sector. Although most harvest is still cooked by local primary processors, the number has declined from a peak of nine in the 1980's to the current situation of just three Lack of local supply during the mortality era has also increased the dependence of the single remaining secondary processor on raw materials sourced from other regional fisheries especially the Thames, Wash and Dee.

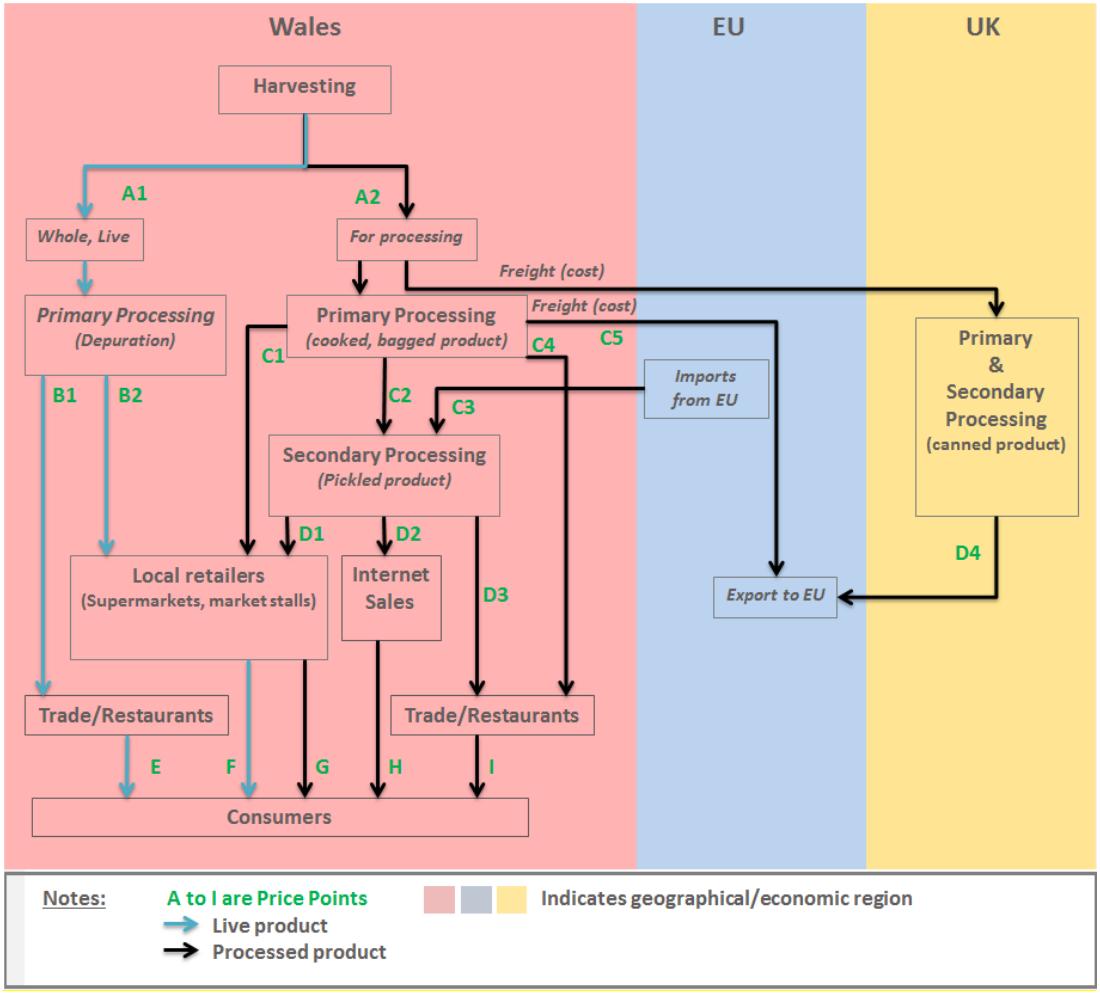

Figure 6: Overview of the cockle supply chain
(Source: consultant interviews with value-chain intermediaries)

4.3 GATHERERS

BI and TR gatherers today use the same basic hand gathering techniques that have been practiced for generations. Cockles are raked, sieved and rinsed, collected in buckets each carrying 20-21kg and transferred to net-sacks each carrying individual licence numbers on plastic-tags (Plates 8 and 9).

Plate 9: Cockle gatherer Dai Turner at work in the 'Rudder Gutter' north-shore (Oct 2014)

Plate 8: Cockle gatherer Clive Rees with the mornings under-quota catch (147 Kg) of two gatherers (Oct 2014)

(Source: consultant visit 17 Oct 14)

One simple modification that has evolved is the use of battery powered-bilge pumps and hose for rinsing cockle in the sieve. However the main change in practice has been the introduction of 4-wheel drive vehicles in the from the mid-80's (Plate 10) prior to which gatherers remained dependent on horse-drawn carts (and boats) to recover cockles (Section 4.1). This meant those based on the southern and northern shores were each more likely to focus effort on more local beds all other things being equal. Today, reduced vehicular travel-time between the two main northern and southern centres of the fishery; Llanelli and Penclawdd (less than 9 miles and 20 minutes by vehicle) gatherers from both shores are now more likely to concentrate their efforts on the most productive beds where ever they may be located on the inlet. Although the concentration of all primary processing around Penclawdd on the southern shore still necessitates regular journeys to the south by north-based gatherers, the same enhanced mobility also makes this less of an impediment to regular participation by those based further afield.

Although hand-gathering of cockle is always undertaken independently vehicle-use is often shared. Two extended-family members observed doing this during October field-work also pooled and shared (equally) income from their landings. This necessitated working in close proximity - whilst a third 'independent' gatherer ranged around the same area moving his vehicle more frequently. To endure, such cooperation requires trust in equivalence of returns to individual effort. The joint-effort was also clearly more intense in this instance, the pair collecting almost twice as much cockle as the third independent gatherer on the morning in question. The most active gathering team, working all three days gathered 180kg, 147kg and 300kg i.e. 60%, 49% and 100% of the 300kg daily quota. Although there are no formal contractual obligations, most gatherers maintain long term affiliations and exclusive supply arrangements with individual processors (Section 4.4).

Plate 10: Four wheel drives head out to north-shore beds on neap low water tide (Oct 2014)

Plate 11: Tractor and trailer for harvesting cockles from the back-shore (Oct 2014)

(Source: consultant visit 17 Oct 14)

Production intensification of larger English cockle fisheries especially The Wash and the Thames has had a significant supply impact on the wider market in which the BI and TR operate (Section 5). The mechanisation trends underlying this intensification are discussed in Appendix 4.

4.4 PROCESSORS

Potential for rapid decomposition coupled with the high costs of transporting whole live cockle (of which at least 50% by weight is shell) has always necessitated co-location of primary processing capacity within short journey times from cockle-beds. Today ever more stringent quality requirements for an internationalised market make it essential to ensure as little time as possible elapses between landing, processing and delivery to the client, necessitating good logistics as well as modern processing storage and distribution facilities. Today, just three primary processors serving the Burry Inlet and the Three Rivers fisheries remain, all clustered in Penclawdd on the south shore of estuary. One secondary processor, Parsons Pickles Ltd. a bottling plant is located in Burry Port on the North Shore.

Mergers and acquisition: The greater structure and increased reliability of supply following the introduction of the 1965 regulating order saw the first wave of processing consolidation. In the 1960's and early 1970's Severnside Foods owned by the Jones brothers from Bristol and based in Birkenhead, Merseyside dominated cockle marketing in the UK and Europe. The company also established a factory in Penclawdd; one of the owners marrying into a local family. However rapid over-expansion contributed to the companies collapse in the 1970's. A Dutch-based company, Hazelwoods Foods then took on a dominant buying role up to around 1994/95 when the company divested itself of its shellfish division (citing high capital investment required to bring its facilities in line with EU food hygiene regulations[8]).

[8] http://www.independent.co.uk/news/business/hazlewood-sells-shellfish-unit-1567877.html

By the early 1990s six local processors remained operational around the Burry Inlet (Boulter 1994) down from 9 in the 1980's (Gatherer, Pers. Com.); all still primarily servicing local UK and Irish retail markets. Scale-opportunities associated with the ongoing internationalisation of the (wholesale) cockle market (Section 4.4) together with growing capital requirements linked to the introduction of more stringent EU/UK shellfish food safety control laws in the early 1990's continued to drive further consolidation. Developments in cockle cooking methods linked to such legislative change are briefly summarised below to highlight their influence on the current industry configuration.

Despite cooperation efforts, following successive buy-outs ultimately the original small, family-owned factories in Penclawdd were replaced by two large, modern foreign-owned factories Selwyn's Penclawdd Seafoods Ltd and Penclawdd Shellfish Ltd located in the adjacent village of Crofty. With processing capacities of around 10-12t of cockles per hour, both were designed to export product to new markets in continental Europe (Section 4.4). A detailed description of the contemporary local primary and secondary processing value chain now concentrated entirely around the BI and its recent history is given in Appendix 7. We finish this section by summarising changes in public-health legislation and their role in industry consolidation over recent years.

Health Regulation and consolidation: Prior to 1992, the Public Health (Shellfish) Regulations 1934 for designated shellfish beds (i.e. with commercial significance and some perceived risk of bacterial contamination) stipulated 'treatment by steam under pressure for 6 minutes' as a minimum heat treatment requirement. However with no precise stipulation of pressure or detail on how the processing should be conducted in practice, often just sufficient heat (as steam or hot water) was applied as was required to separate the cockle meats from shells (Ayers 1979). Extended heat treatment also significantly decreased yield, made meat texture increasingly tough and rubbery and could also affect flavour. Thus cooking practices typically prioritised commercial above public-health goals resulting in episodic consumer health problems. In the worst instances a number of typhoid outbreaks were attributed to poor cockle processing in the early 20th century. In the 1980's a correlation was found between cockle consumption (presumed to be incorrectly processed) and an elevated local occurrences of hepatitis A in south -east England with the authors recommending a need for stricter treatment controls (O'Mahony et al 1983).

To deal with increased output following the start of mechanised hydraulic-dredging in the Thames Estuary from 1968 continuous rotary 'Monobloc' steam cookers were introduced from Holland from as early as 1970 Although, these unpressurised systems were effectively highly efficient shucking devices – temperatures and contact times were still insufficient to guarantee meats were adequately cooked or sterilised – especially under winter conditions (Ayers 1994). Nevertheless with progressive improvements, including separate heat steam shucking and boiling water meat-sterilisation phases, continuous production systems became widely adopted by a declining numbers of consolidating processors across the country. Finally a watershed moment occurred with the introduction of The Food Safety (Live Bivalve Mollusc and Other Shellfish) Regulations 1992. This required shellfish production areas to be designated in terms of their bacterial contamination and public health risk and henceforth Shellfish from B or C classified beds i.e. including the BI and Three Rivers must be

depurated (for any live sales) or be cooked in equipment approved to ensure a minimum 90°C meat core temperature for a minimum of 90 seconds.

A UK-wide survey of cockle processors in the early 1990's found that the Burry Inlet remained the only area still reporting use of traditional batch-cooking methods. Six small local companies reported continuation of the practice (Boulter 1994) which the 1992 legislative changes instantly made redundant. The remaining companies sought ways to cooperate to acquire a new compliant though costly system developed by the (then) MAFF Torry Research Station – known as the 'Torry type continuous cooker'. In this system cockles are cooked in boiling water for a period a time determined by the cockle size, post-harvest duration and season.

4.5 MARKETS

Prior to 1990's more than 90% of locally produced cockle were cooked and eaten in Wales and any surplus sold in Swansea, Neath and other local markets (Mainwaring 20014 Pers. Comm.). Gatherers traditionally took place from Monday to Wednesday and the rest of the week spent processing and marketing them as far as Cardiff. From the 1960's vans were used for open-air market, Gower caravan sites, beach and house to-house sales along with the Welsh delicacy laverbread (*bara lawr*) produced from seaweed (principally Purple Laver, *Porphyra umbilicalis*) and other local produce. Traditionally cockles were fried with bacon and laverbread for breakfast, though local demand for both products has declined particularly amongst the younger generation.

Today, Holland, France, Spain and Portugal are the major consuming and producing countries in mainland Europe. The Dutch fishery is of particular interest; with cockle production on average double that of the UK in recent years (Table 4). Up to the 1970's large Dutch Dredge fisheries were operated by British Cockle Merchants to supply the then strong demand at competitive prices in the UK. A serious failure of the Dutch cockle fishery in 1969 further increased demand, gathering effort and prices for British cockles over the next few years (Franklin 2001). As outlined above this relationship has effectively been reversed over the last few decades with Dutch and Spanish multi-nationals now dominating the UK industry to supply strong mainland European demand. Even following an 'austerity-related' downturn in the Spanish market, the EU market is generally under-supplied and export segments still offer greatest profitability if suitably sized cockle can be procured.

Prior to the mortality (and international merger and acquisitions) era, throughout the year live whole cockles from the Burry Inlet i.e. ≥19mm, were sent daily to the main seafood wholesale markets in London (Billingsgate), Birmingham (the Bullring) and Bristol. Selwyns for example, used refrigerated transport to distribute and sell whole and cooked product across the UK selling directly to London's Billingsgate and Birmingham and markets, eschewing the less profitable supermarket sector. As part of its business strategy Selwyn's envisaged re-establishing channels to markets including Billingsgate and to get its vans retailing product in south Wales again, though without success.

Export markets: Once acquired by foreign interests both Selwyn's and Penclawdd Shellfish Processing Co. Ltd (PSP) demonstrated similar export-orientated marketing strategies. Although most cockles from the Burry Inlet are still cooked locally greater profits are now associated with sales of end-products to UK retailers and export to the UK, Spain, Holland, France and Portugal for canning. Spain is a major market where it is commonplace to eat cockles straight from tins or use them as a key ingredient of national dishes like paella. These continental markets pay a higher premium for larger cockle sizes whilst there is less discrimination between smaller grades on the UK market. Thus 'undersize' cockle from the Burry Inlet (and Three Rivers) is more likely to retained for domestic consumption, either as a cooked product (possibly mixed with larger grades) – or as a pickled product for which size is also less sensitive.

A recent WG-MFU report (2014) gives an idea just how export-dependent the south Wales industry has come. The report cited that of 525t[9] of cockle output recorded from the Burry Inlet in the 2013/14 production year, 95% (500t) were destined for export and only 5% (27t) for domestic markets. At first sight this seems somewhat inconsistent with lack of continental demand for small cockle. Additionally some 90t of cooked-cockle was procured by Parsons from PSP for pickling in the same year i.e. pickled products being destined mainly for UK sales. However the PSP factory also procures significant amounts of cockle from other fisheries, notably the Dee which may explain the variance. For example of 1046.5t recorded landings from the Dee in 2008; 45% (473t) went for primary processing by companies in Penclawdd (SWSFC returns data).

In the 1990's, to succeed in the primary continental market for canned cooked-product Selwyn's had to compete with the newly established international PSP/Lenger entity for limited supplies. It began paying a premium to around 200 gatherers formally gathering for the Dutch company on the non-regulated Three-Rivers Ferryside, Llansteffan and Laugharne cockle beds followed by other further such sites around the UK. The subsequent buy-out of Selwyn's by DANI in 2003 saw the two companies competing for UK supplies on a more even footing with their similar mix of UK acquisitions.

Local direct marketing: As at least 50% of cockle weight is shell, unless a high premium exists i.e. for larger whole cockles it is only economic to cook or send them to relatively local markets. In addition to supplying Parson's Pickles with smaller cooked product for pickling (see below), PSP also sell cooked produce to local markets in Neath and Swansea. To improve acceptability on this market during the main summer months, the company was also reported to have frozen some 20-30t of larger sized meats to mix with smaller product (Gatherer, Pers. Com.). In addition some larger sized cockle is depurated at the Crofty factory for live sales to the continent, mainly Spain. Selwyn's were also reported to be purchasing small amounts of cooked product from PSP for local sales. Today only two local families regularly operate traditional seafood stalls selling cockles, laverbread and other local produce on Swansea and Llanelli markets; one family associated with PSP, the other an independent husband and wife team both holding BI gathering licenses. During the visit the latter businesses was selling small amounts of larger (19mm) live cockle of selectively gathered in small quantities,

[9] Worth a total of £210,800 i.e. averaging £400 per ton at first landing.

whilst smaller grades were cooked for ready-to-eat sales (with salt & vinegar: Plates 12-15). During the winter when supplies are least reliable and meat quality declines, the business sources individually quick frozen (IQF) cockles from Holland with a 10% glaze. IQF product was reported to last much longer in storage (up to 12 months) than block-frozen product; the norm for commodity processing by local processors. Sales of fresh laverbread had recently been depressed after 17 cases of salmonella were detected in south Wales in March[10].

Plate 12: Licensed cockle gatherers Peter and Anne Mainwaring at their Llanelli market stall Oct 2014

Plate 13: Anne Mainwaring manning her Llanelli market stall in the 1970's

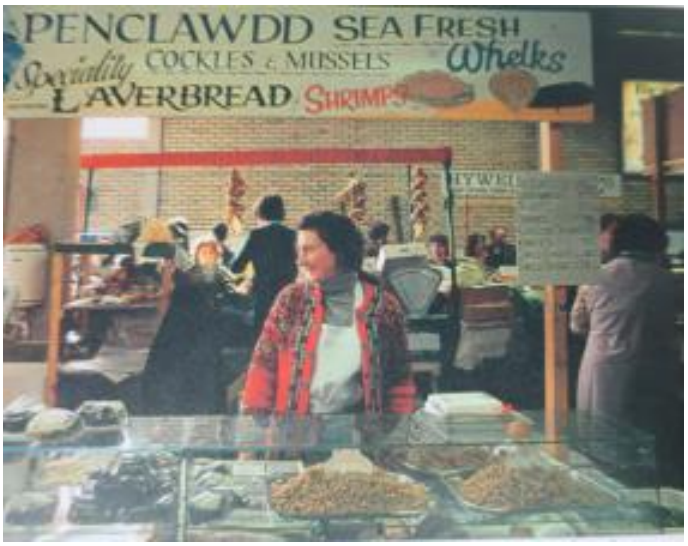

Plate 14: Large, >19mm live cockle gathered near Burry Port

Plate 15: Cooked ready-to-eat cockle meat

Markets for pickled cockles: Parsons Pickles now has the distinction of being only factory in the UK producing pickled cockles on a commercial scale, all other brands being imported. The company with annual

[10] Although the link with laverbread consumption remains unconfirmed Penclawdd Shellfish Processing Ltd voluntarily withdrew their fresh product from the market in March.

turnover of around £5 million derives around 60% of its annual income from its bottled cockles (C. MacDonald Pers. Com.). With six vehicles and trailers, it supplies markets in the UK and Ireland principally through seven national supermarket-chains (Asda, Morrison, Sainsbury's, Tesco's, Castell and Howell, Home Bargain, B&M). It also markets smaller amounts to food-service (public-houses) and buffet product-mixes directly online. The main competition comes from Ocean Crown supplying Lidl and The Coop and Van Smirren Seafoods supplying Tesco's and Sainsbury's with imported products. Market growth for canned and pickled shellfish was reported to be particularly robust in the budget retail end of the market e.g. B&M and Home Bargain with sales up 5% year on year in the current year.

Plates 16 to 20 show the diversified range of seafood products produced by Burry inlet processors.

Plate 16: Locally produced 120g tinned laverbread Asda Supermarket Llanelli Oct 2014

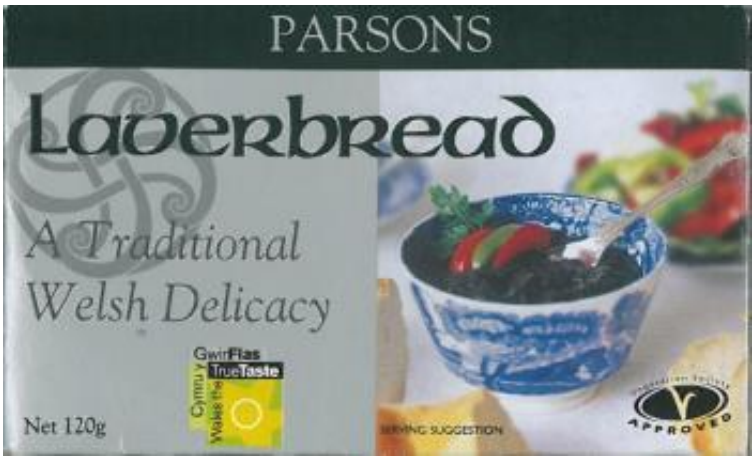

Plate 17: Fresh laverbread product from Penclawdd Shellfish Ltd

Plate 18: Jars of Parsons Pickles pickled cockle product for retail sales

Plate 19: Parsons Ltd pickled cockles and mussels in local supermarket

Plate 20; Nori-style seaweed snacks produced by Selwyn's Ltd (for online sales)

(Source: Consultant Oct 2014)

4.6 COORDINATION

The regulating order and hand gathering restrictions on the Burry Inlet Fishery have clearly limited the degree of vertical integration that followed the mechanization of (dredge) fisheries on the Wash and Thames Estuaries or the rise of the 'gang-master' culture that became prevalent on non-regulated fisheries, notably Morecambe bay. This has preserved a cadre of small-scale self-employed producers working the Burry Inlet fishery, supplying what is now a highly consolidated processing sector. This also meant that foreign investors continue to engage through experienced local processing-entrepreneurs who understand the complex formal and informal customary relations and rights which still surround the fishery. These entrepreneurs have also become UK-wide purchasing agents for the same companies.

Licensed gatherers are currently represented by and strengthened in their lobbying efforts by two producer organisations the 'Burry Inlet Hand Gatherers Association' (BHGA) and the 'Penclawdd Shell Fishermen's Association' (PSFA). A third group the 'Burry Inlet Waiting List Association' represents aspiring licensees. The primary role of the organisations was to make representation to the management authorities i.e. the SWSFC, then NRW. The BHGA helped scored a notable success for it is members lobbying the introduction of 4x4 vehicles to the fishery in the early 1980's. Whilst relations between the producer organisations and the management authorities have on occasion been strained in the past, the existence of two organisations serving a relatively small number of licensees also points to a degree of polarisation amongst producer interests. The PSFA was reported to have broken away from BHGA in the early 1990's, the PSFA becoming established to represent gathers that formed the PSP cooperative. Thereafter the two groups remained broadly divided in their loyalties to the two remaining large-commercial processors Selwyn's and Penclawdd Shellfish Processing Co. Ltd. Divisions between the two groups were further exacerbated by PSFA's lobbying for the abolition of hereditary licence transfer rights in the early 1990's, at a time when the then youngest 16 year-old heir to

Selwyn's business hoped, and finally succeeded[11], in obtaining his recently deceased grand-fathers licence (Kelsey 2012).

Today the BHGA appears once again to be the more active producer organisation; the Chair and Secretary taking a lead on the campaign to seek compensation for gatherers from the Welsh Government for loss of earnings associated with the cockle mortality. During the 2012/13 season, gatherer's staged a production strike as the price being offered by PSP then the only large-scale company still processing for small BI cockles averaging 11-12mm square fell from £400 to only £300 per tonne. Although not all the active gatherers complied with the strike which last 1-2weeks, PSP increased the price back to £400/tonne.

4.7 MARKET FAILURES

In the past despite regulation, accounts of licence holders taking excess quota and undersize cockle when market opportunities arose were common. Incentives increased as crops became ever more valuable with growing internationalisation of the cockle market during the 1990's. This exacerbated litigation and conflict with various interested parties including poachers and those on the waiting list who felt their legitimate rights to the fishery were being adversely affected. Waiting list members have always tended to prioritise lower quotas and more licences as means of accelerating their access to the fishery, whilst those on the waiting list tend view 'bumper' crops as rewards for periods of lean production (SWSFC 2005). In 2012 17 cases of 'non-licenced illegal fishing' were recorded on the Burry Inlet (NRW Pers. Com.). Around half of these incidents were attributed to licence holders collecting above their quota[12] or using illegal methods such as less selective net bags rather than riddles to gather cockle. Although the NRW (and the SWSFC before it) appear to have done a good job at enforcing regulatory control and accountability, whether this represents good value for money compared to other fisheries priorities in terms of social value and equity is a more complex question.

At processor level potential issues may include provision of markets for unlicensed cockle harvests and 'abusive transfer-pricing' (ATP). ATP occurs when two companies that are part of the same multinational group trade with each other, artificially distorting the price at which the trade is recorded to avoid taxation e.g. by recording as much profit as possible in countries with more favourable tax regimes. Table 3 shows how corporate tax rates in the UK are lower than the other countries of relevance to the multi-nationals in question here i.e. implying there would be little incentive to 'move profits' overseas from UK entities. An incentive may exist if differential tax rates were to exist for raw materials and finished products. No evidence of ATP was recorded in this study.

[11] Hereditary transfers were subsequently banned and this remains the policy of NRW.

[12] NRW allow a 10% weight allowance above the prevailing quota to give gatherers a reasonable margin of error.

Table 3: Corporate tax rates in EU countries relevant to multi-national companies involved in the processing and trade of Burry Inlet cockles

Country	Corporate Tax Rate (%)	Comments
UK	23% (21% from Apr 15)	20% for profits <£300k, marginal relief between £300k - £1.5m
Netherlands	20%	25% for profits >200k€
Spain	30%	25% for SME
France	33.3%	36.5% for profits >3.5M€
Germany	30.2-33.3%	
Ireland	12.5%	

(Source: FITA country profiles[13])

The taking of so-called 'black-fish' i.e. fish which are caught, retained and sold illegally is also a recurrent problem in many fisheries; a recent Scottish scandal being a good example[14]. In the cockle-sector tax-incentives exist to under-report prices and landings. No evidence of price-fixing was found, which is much less likely due to the level of collusion required between the many independent gatherers and processors associated with hand-gathered cockle fisheries. Under-reporting of landing tonnage requires collusion between fewer parties and is therefore a greater risk. Significant steps have been taken by NRW to limit this practice (Appendix 5) with enforcement also simplified by a declining number of licenced gatherers on the BI. However several respondents acknowledged that this was a greater problem in the past, one reporting that it wasn't unusual for gatherers 'to declare 5-days catch and take a 6th day as cash-in-hand'. Quantification of this practice is clearly highly problematical; however based on the prior statement a 17% allowance will be included in one of the first-landing value loss assessments (Section 6.3).

[13] http://fita.org/countries/

[14] http://britishseafishing.co.uk/scottish-black-fish-scandal/http://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-17153085

5 BASELINE ECONOMIC VALUE OF BURRY INLET COCKLE FISHERY

5.1 INTRODUCTION

The south Wales BI and TR estuaries constitute one of four main traditional cockle fishing, areas together with: the Wash, the Thames Estuary and the Dee Estuary/ Morecambe Bay Region. Smaller fisheries of more local importance tend to have augmented these more commercial fisheries during recurrent periods of low production[15]. Natural fluctuations in supply have always resulted in a degree of supply inter-dependency between these major fisheries. Production trends for the BI/TR fisheries are therefore referenced alongside these other fisheries in the following sections. Historic trends in cockle first-landing value are then assessed; nominal prices are converted to real prices correcting for the effects of inflation (using consumer and retail prices indices) in preparation for economic loss analysis in section 6. The section concludes with a gross margin analysis along the value chain based on historic first-sales and cooked meat prices.

5.2 BASELINE PRODUCTION TRENDS 1931-2004

Based on available data Figure 7 and Table 4 show production trends for the BI and TR estuaries, other major UK cockle fisheries as well as Holland (Table 4) over 3 decades from 1975 to 2004 i.e. up to the first onset of mass mortalities in south Wales and licenced access to 55 gatherers under the Burry Inlet Regulating Order.

Results clearly show the wide inter-annual variability in annual output; total UK production ranged from 39,779t (1991) to as low as 5,355t (1984) compared to 77,586t (1989) and 2069t (2003/4) for Dutch fisheries over the same period. With their larger area and intensive suction dredge fisheries, the Thames (especially) and Wash together regularly account for well over on three quarters of total UK production. The Dee and Morecambe estuaries have also contributed one third to one half of total output in their 'best' years. However the fisheries that remained unregulated over this period i.e. the Dee, Morecambe, Three Rivers, and other UK also produced the most inconsistent landings; with coefficients of variation (CoVar; a normalised estimate of variability) ranging from 180% to 225% (Table 4). These elevated values reflect periods of 11 to 20 years with no recorded production over the 30-year reference period.

[15] E.g. Poole and Emsworth Harbours and Teignmouth on the North Norfolk Coast, the Humber Estuary as well as sites in Scotland normally too remote distant from main markets to be viable.

Table 4: Summary production statistics; UK and Dutch cockle fisheries 1975-2004

Fishery	Total (t)	Average (t)	Max (t) [Year]	Min (t) [Year]	STDEV[1] (t)	CoVar[2] (%)
Burry Inlet*	66,493	**2,216**	7,164 [2000]	224 [1975]	1,291	58
Three Rivers	15,932	**549**	4,727 [1993]	0 [19 years]	1,056	199
Wash*	117,011	**3,900**	10,220 [1977]	0 [I997]	2,997	77
Thames*	288,587	**9,617**	25,629 [1992]	1886.8 [1984]	5,922	62
Dee	41,352	**1,378**	16,195 [1987]	0 [16 years]	3,101	225
Morecambe	25,589	**853**	8,176 [2004]	0 [20 years]	1,775	208
Other UK	8,648	**298**	1,887 [1993]	0 [21 years]	518	180
Holland (all 1981-2004 only)	955,000	**39,792**	77,586 [1989]	2069 [2003/4]	23,984	60

(Data Sources: SWSFC returns for all estuaries 1975-2004, Dare 2004)

[1] STDEV = standard deviation of the mean

[2] CoVar = co-efficient of variation (a normalised measure of the standard deviation expressed as a percentage of the mean)

* Fisheries currently managed under regulating orders i.e. with restricted access to small numbers of license holders

By contrast the fisheries that were regulated during this period (the BI, Wash and Thames) had CoVar ranging from only 58% to 77% and only one year with no recorded production (the Wash in 1997). Output from Holland's well regulated fisheries also had a low CoVar of 60%. Although the BI contributes a relatively modest share of UK production, it produced the most consistent returns of all the fisheries over the reference period prior to the mortality era (CoVar 58%). This consistency also elevated its contribution in 'bad' industry years with its share ranging from 1.3% (1975 – its worst ever recorded year) to 35% (1984) and 32% (2000). Over the entire period it contributed on average 11.8% of annual UK production. In comparison the TR contributed from 0% i.e. the fishery was officially closed fishery in 14 of the 30 years, to 23% in 1993; with an average annual contribution of only2.8%[16].

[16] It should be noted that lack of regulation is also likely to be accompanied by greater likelihood of unreported catch with respect to both permit-based and illicit fishing compared to regulated fisheries.

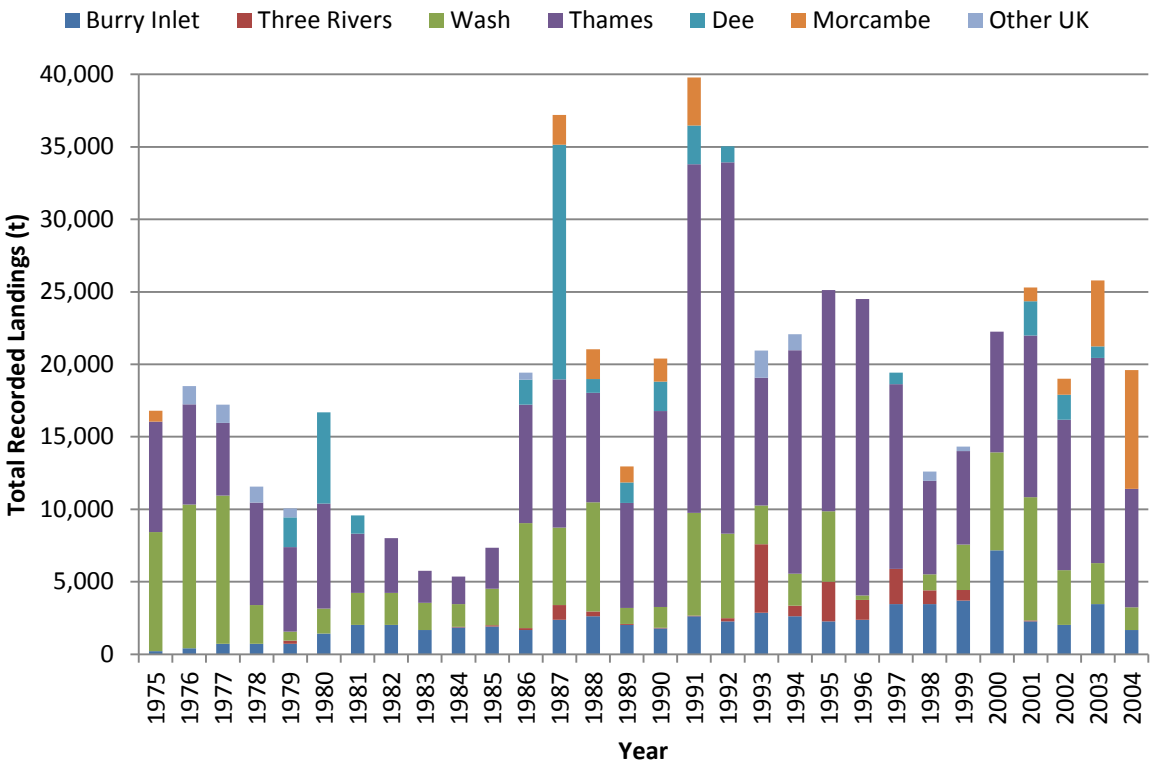

Figure 7: Total annual recorded landings for the Burry Inlet, Three Rivers and other major UK cockle fisheries 1975-2004

Figure 8 compares production trends for south Wales (predominantly the Burry Inlet) against the three other main producer regions in the UK, this time dating from 1931-1975. Although there is likely to be significant under-reporting during the war years and the 1950's (see foot note), results again highlight the relatively consistent long-term productivity of the BI fishery. Recorded landings averaged 2,242t (CoVar 61%), very close to the 1975-2004 30-year average (2216t, CoVar 58%: Table 4).

All four of the main UK production areas suffered major losses during a particularly severe winter in 1962/63 but most including the BI rapidly recovered thereafter (only Morecambe bay did not recover for many years). South Wales also enjoyed a series of above average production years following introduction of the BI regulating order in 1965 with landings averaging 3,837t over the 9-years to 1973. This may have been in part due to improved recording though significantly 1968 proved an exceptional year with a then record landing of 7140t; a scale of harvest not seen again until 2000 immediately prior to the mortality onset. Following these years of plenty the Burry Inlet then experienced a series of six of the leanest years on record with harvests averaging only 577t (min 224t, max 716t) from 1974 to 1979 (Figs 7 and 8).

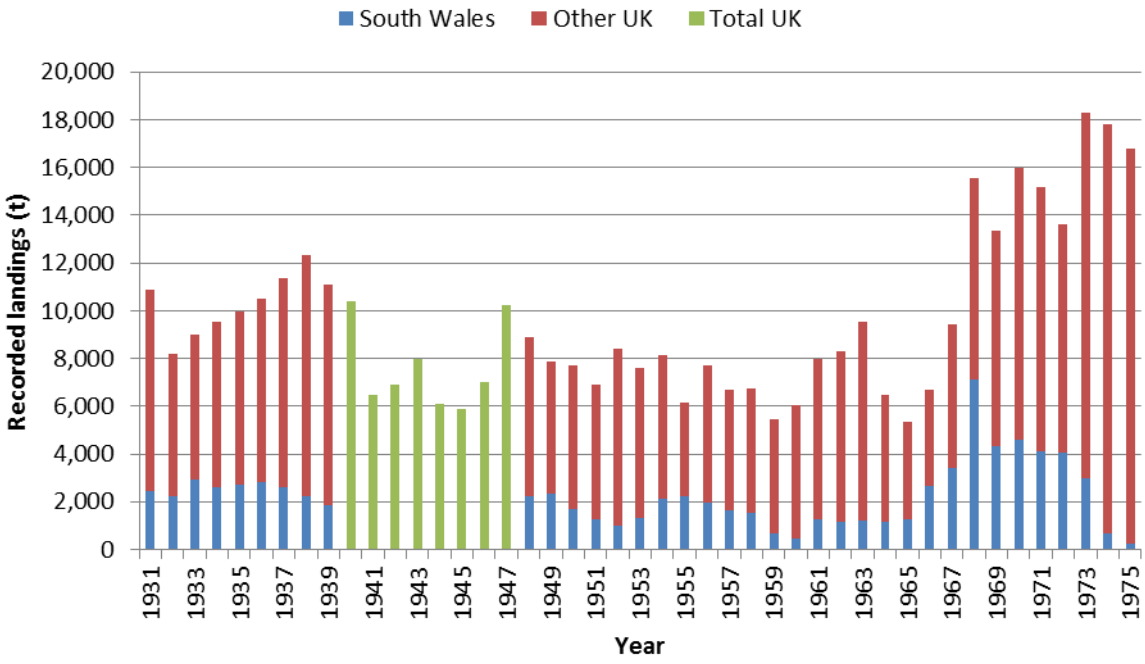

Figure 8: Total annual recorded landings for SW and other major UK cockle fisheries 1931-75

See note[17]

(Sources: Franklin 1972, Dare et al 2004)

5.3 PRODUCTION TRENDS DURING THE MASS MORTALITY ERA 2002 TO 2014

Burry Inlet: Annual recorded production from the BI over the 13-year 'mortality' period (2002 to 2014), averaged 1,017t (SD 915t, CoVar 90%: Fig 10), 46% of the baseline 30-year 2,216t average (Table 4). The scale of these losses were further amplified by their juxtaposition to a previous decade of consistently above average recorded-harvests (1992-2001) averaging 3,248t per year (min 2,269t, max 7,164t). The 7,164t harvest which occurred in 2000, shortly before the first mass mortalities, was described by gatherers as 'a 1 in a 100 year harvest', though in fact the previous comparable event occurred in 1968: Figure 8). Excluding this outlier reduces the average harvest to 2,813t over the same 10-year period and the average post-mortality harvest to 36% of this shorter decadal baseline.

[17] 'Other UK' & 'Total UK' landings include the Wash, Thames and Morecambe Dee regions. Landings to 1960 (do you mean 1940's?) were based on railway dispatch records; landings in the 1950's, when road transport became more important are therefore likely to be significantly under-reported.

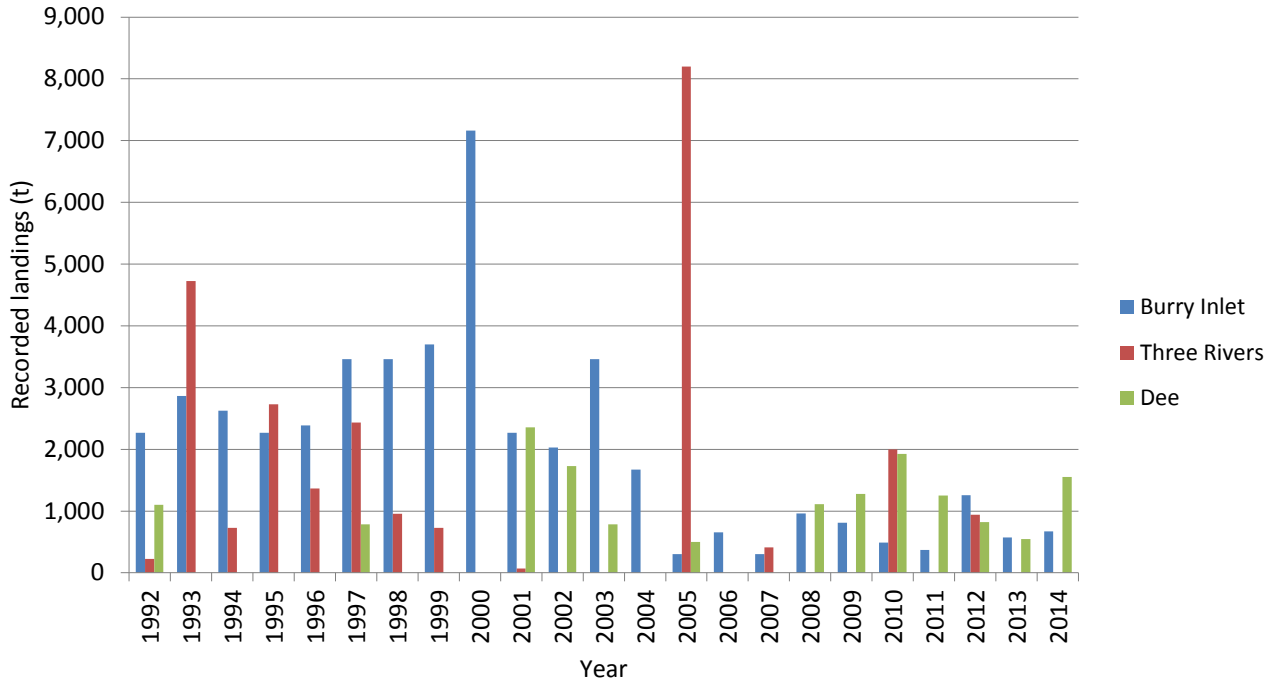

Figure 9 & Table 5: Total annual recorded landings (tonnes) for the Burry Inlet, Three Rivers 1992-2014 and Dee Estuary 1992-2011

Year	Burry Inlet	3-Rivers	Dee	Total
1992	2,269	227	1,101	3,597
1993	2,866	4,727	0	7,593
1994	2,627	727	0	3,354
1995	2,269	2,727	0	4,996
1996	2,388	1,364	0	3,752
1997	3,463	2,432	786	6,681
1998	3,463	955	0	4,417
1999	3,701	727	0	4,429
2000	7,164	0	0	7,164
2001	2,269	68	2,358	4,695
2002	2,030	0	1,730	3,759
2003	3,463	0	786	4,249
2004	1,672	0	0	1,672
2005	304	8,200	500	9,004
2006	658	0	0	658
2007	304	410	0	714
2008	960	0	1,110	2,070
2009	810	0	1,279	2,089
2010	489	2,000	1,925[18]	4,414
2011	369	0	1,250	1,619
2012	1,257	943	820	3,020
2013	573	0	545	1,118
2014	672	0	~1555	1,894
Total	**45,705**	**25,508**	**11,874**	**83,087**

(Sources: (i) SWSFC returns for the BI 1992-2009, TR 1992-2004 and Dee 1992-2007, (ii) WG-IFU returns BI 2010-2011 (iii) NRW returns for BI 2012-2014, Dee 2008-2011, (iv) KESFC summary for the Dee 2012-2014)

[18] Note: estimates for Dee production in 2010 varied widely according to source; from 657t (Kent & Essex SFC: KESFC), 1,031t (NRW) & 1,925t (SWSFC). Being the responsible body for the fishery in 2010, the SWSFC figure is cited above.

Despite mass mortalities annual BI output remained close to the long-term average for the first 3 post-mortality years with landings ranging from 1,672 to 3,463t between 2002 and 2004 (Figure 9 and & Table 5). Thereafter harvests remained consistently low, falling to just 304t in 2005, a maximum of 1,257t in 2012 and averaging only 606t per year between 2005 and 2014. The latter average represents only 22% of the corrected 10-year pre-mortality annual average. Such low levels had not been witnessed since the 1975 to 1979 record lean-years attributed to a combination of low spat-falls and overwinter survival. Unlike these years, already significant harvest losses were compounded by even greater reductions in unit-value due to small cockle size (Section 3.4.2).

Three Rivers: Although more erratic than the BI the TR also had a series good production years in the pre-mortality decade 1991-2001; with an annual mean of 1,395, CoVar of 107% and only 1 year with no recorded production. High catches in 1993 correspond with the 'cockle wars' which saw fighting between rival local and 'immigrant' gangs from England. The introduction of the permit on request system from 1998 as a mean by which returns would be collected from named individuals may have helped reduce under-reporting levels during official fishery openings thereafter. From 2000 a combination of poor stock levels, mass mortalities (first observed in 2005: Section 3.4.2) and temporary closures linked to water quality issues and undersized stocks resulted in negligible or no recorded yield in all but five of the years to 2014. Low and undersize stock estimates have resulted in concurrent closure of all the Three Rivers cockle beds since June 2012 under byelaw 24 which permits 'Temporary closure for the protection of shellfish'. The latest notice extends the closure to the 31st March 2015 (Welsh Govt. 2014). Stock surveys undertaken by the Marine and Fisheries Division between March to May 2013 indicated a total of only 872t of cockles within the entire Three Rivers Estuary, compared to 3,498t in March 2012. The latest survey in March 2014 indicated a total stock of 2,272t (+/- 624t) after a good spat-fall in 2013, though only around 2% (52t) is above the minimum legal 19mm square size which unlike the BI is still imposed on the TR fishery under Byelaw 13 (Shellfish minimum sizes) of the former SWSFC.

Two exceptional years stand-out amidst this poor run. In 2005 despite mass mortality on some beds, some 2000 gatherers under SWSFC permit landed around 8,200t of cockles; most of it in the opening month of August alone. The beds were then closed by Dec. The 'bonanza' was linked to an exceptional spat settlement in 2004. In the following year 50% of an estimated 1,000t stock of cockles suffered mass mortality between April and June. A second far lower but still respectable harvest resulted in a similar 'gold-rush', rapid depletion and closure of the beds in 2010.

The Dee: Figure 9 clearly shows how reported returns from the Dee Fishery have become far more consistent since its regulation in 2008. Between 1996 and 2008 the Dee beds remained closed, except for brief periods in 1997, 2001, 2002, 2003 and 2005. In marked contrast to this boom and bust situation, since regulation it has

reliably provided its 53[19] licence holders with an average of 20-25t of cockle and a sustainable income over the six months of the year that the fishery opens. However tight enforcement is still required for newly regulated fishery; the EAW brought 12 prosecutions for illegal cockling and suspended 15 licences over the 2011/12 'bumper' season when 1250t of cockle worth £2.5m was landed[20]. One respondent recounted how the Albert Fisher Group opened a processing factory in north Wales operated for just 2 years as unregulated fishing of under-size cockle on the Dee lead to erratic supply.

Processor returns: Figure 10 shows the diminishing contribution of the Burry Inlet fishery to one of the two major primary-processing companies operational in the UK (all processing operations) and the concurrent rise in the contributions of the Thames, Wash and Dutch fisheries over the last four years. From 2002-2007 the BI contributed an average of 560t/year (SD 289t), and 6.7% of the company's total annual cockle supply averaged over the same period. From 2008-2014, this declined to only 261t/year (SD 298t and 4% of average supply). No cockle was sourced from the BI in 2009 and only 32t in 2014 (to August). Figure 10 also highlights the erratic contribution of raw material from unregulated fisheries with significant contributions coming from Morecombe Bay sourced cockles over four years from 2003-2007, Southport in 2011 and 2012 and the Three-Rivers in 2005, 2010 and 2012. With the Wash fishery facing its own mortality issues since 2008 (Section 3.4.3), the Thames has now undoubtedly become the single most important source of cockle supply in the UK.

[19] Increased recently from 50 to 53 licence holders following the completion of a 2 year apprenticeship by three apprentices.

[20] http://www.bbc.co.uk/news/uk-wales-north-east-wales-17516575

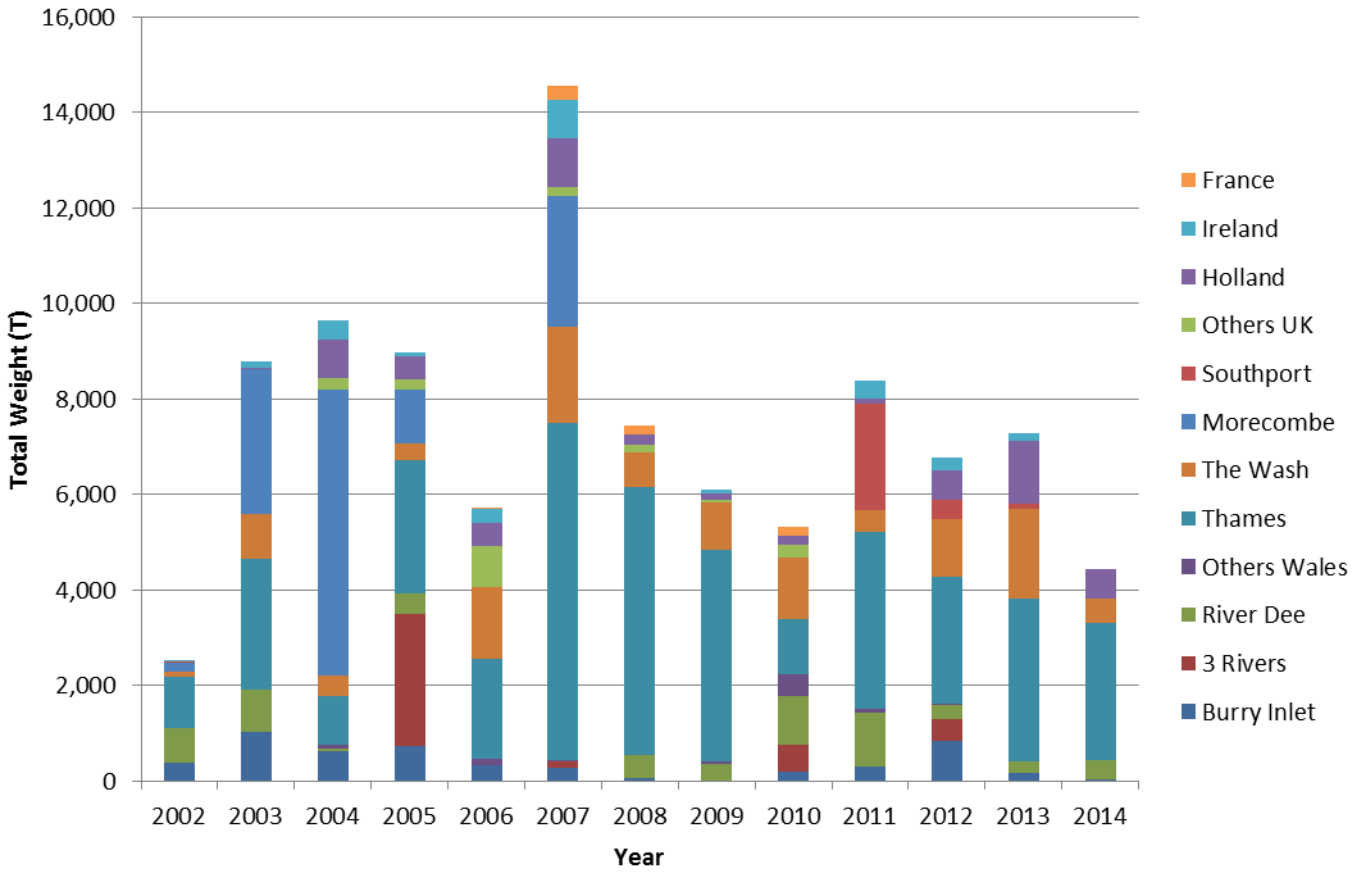

Figure 10: Weight (t) of cockles purchased by a BI processor from different UK cockle fisheries 2002-2014

5.4 COCKLE VALUE

The economic value of cockles depends upon a range of qualities, particularly shell-size and meat yield (partially correlated), as well as supply factors, today associated with natural production variability and increasing demand across Europe. More locally, BI landings depend on total allowable catch linked to stock assessments, operationalised through NRW limits on licence numbers individual quota and fishing-days. Meat yield is highly influenced by seasonal environmental factors; for example the volume of boiled meat, the main commercial product, may fall by as much as a third and the protein content by half during winter. Conversely, despite the onset of spawning, yields rise rapidly from April onwards with improved feeding conditions and continue to rise to September when over-wintering losses start again. In general BI one-year old cockle yields were reported to have peaked at 17-18% during summer, falling to only 10-11% by late October. Cockles also burrow deeper to around 3" below the surface in winter, coming much closest to the surface in May to June. Thus all other things being equal, the quality and therefore the price of cockles is higher during the summer months. Similarly it takes less effort to harvest large compared to the same volume of smaller cockles and hence catch per unit effort is also greater during the summer period.

Meat yield also varies with cockle age. This relationship is shown in Table 6; large 2 year+ cockle (>19mm square) currently relatively abundant on the Dee Estuary yield 600-800 'pieces' (pc) of meat per kg of raw

material[21] (2 year old BI cockle were also reported to contain nearly seven times the flesh content of spat). The largest 1yr cockle (<17.5mm square) now available on the BI typically yields 1200-1400 pc/kg, whilst the smallest 8-12mm spat (around 6 months of age) at the limit of marketability gave yields as much as 1800-2500 pc/kg.

Table 6: Cockle size classification for shell-on and cooked cockles

	X Small	Small	Medium	Large	X Large	XX Large
Size (shell square mm)	8-12mm	14-17.5	17.5-19	19-22	>22	
Size (shell diameter mm)			19-21	21-26		
No. shell-on cockles/kg		130-60	100-130	70-100	20-70	10-20
No pc cooked meat/kg	1800-2500	1200-1,400	1,000-1,200	800-1,000	600-800	500-600
BI 2002 price (£/t) & [Share]*	NA	£500 (10%)	£900 (50%)	£1250 (30%)	£1800 (10%)	
River Dee 2014*		£600			£1,800	

* Processor estimates (Pers. Comm.)

(Source: gatherer and processor interviews)

The last cohort of 3yr old cockle (i.e. extra-large) was reportedly harvested from the Burry inlet was some 7-8 years ago (processor Pers. Comm.). The same respondent gave the size distribution estimate for BI in 2002 shown in Table 6. Both observations are consistent with records of the Pontarddulais Cooperative (Section 4.4) summarised in Figure 11. The figure illustrates the rapid decline in +2yr (medium, large and extra-large) cohorts and the concurrent increase in small one year cockle (<17.5mm square). The 2002 grade distribution and price structure (Table 6) was also reported to correspond closely those of the Dee Estuary cockle fishery in 2014.

[21] The Minimum Landing Size (MLS) on the Dee is currently set at 20mm which equates to a cockle of 22-25mm across the shell.

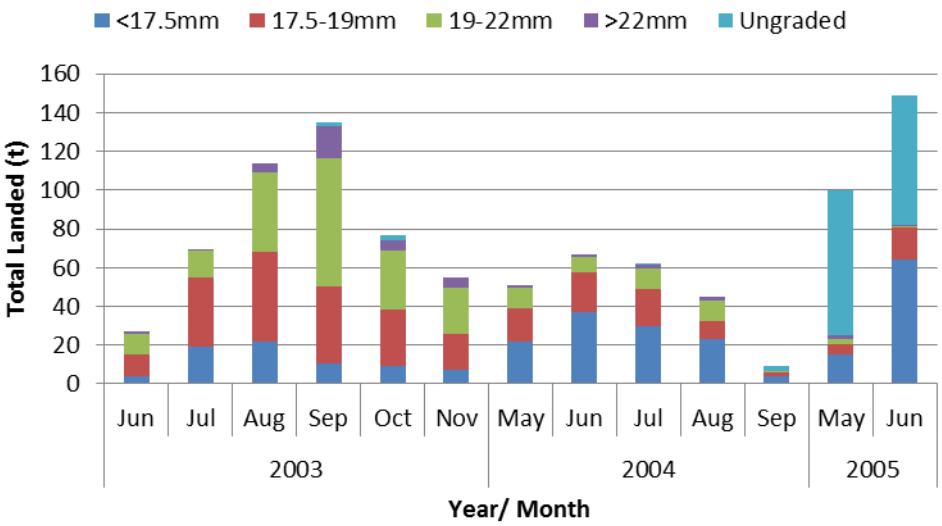

Figure 11: Collective landings by grade-size (mm square) reported by members of the Pontarddulais Cooperative from the Burry Inlet 2003-2005
(Source: Gatherer SWSFC return records – Note: ungraded = unsold 'shored' mortalities)

Historically there has also been considerable variation in growth-rates between different cockle fisheries. The Burry Inlet in particular has history of high productivity based on combined growth rate and stocking density. Table 7 shows how in the past Poole Harbour had one of the best growth rates, however it's cockle density averaged only 100/m2 compared to 500/m2 on the Wash and BI fishery. This made it less commercially exploited at the time despite its superior growth rates. Over recent years the Thames has consistently yielded cockle ranging from 500-800 shells per kg with most boats fishing only 2 days per week to harvesting 90-100t per season. Cockle below 14mm square is never taken. Ironically on Burry Inlet, steps taken to reduce sewage inflows to the estuary will probably also decrease the productivity of the fishery compared to historic levels.

There was some difference of opinion whether hand-gathering produced a superior product to dredging. One processor suggested hand gathered cockles close more quickly, taking in less detritus, reducing depuration requirement. Another felt that the rinsing action involved in the dredging process was superior to rinsing during hand gathering. All agreed mortality and loss due to shell damage was greater for dredged product, however here there have been significant improvements over recent years resulting in mean losses falling from 10% to 5% and according one respondent as low as 1%. Unfortunately since the vast majority of the cockles from different fisheries are combined at the processing stage, any potential quality related aspects that could differentiate between sourcing and harvesting methods are effectively lost. Furthermore the fact that both the BI and Dee cockle fisheries have been certified as sustainable fisheries under the Marine Stewardship Council (MSC) quality accreditation scheme has little or no value to the gatherers unless the cockles attain a premium price through the value chain and the processors are unlikely to want or need to go down this route. This raises the question as to whether or not there is any point in maintaining this accreditation and if it is deemed so, then there could be a case for additional support to be offered the Dee and BI cockle gatherers to help them find new markets which would recognise and reward the value that the MSC certification should bring them although it is unclear whether such an approach would result in anything more than a small, niche market.

Table 7: Pre-mortality era growth rates (shell diameter, mm) for the Burry Inlet, Poole and Wash fisheries and corresponding size classes

Fishery/ Age	6 months	1.5 years	3.5 years	5 years
No. growth rings	**1**	**2**	**4**	**6**
Size Class (shell diam.)*	**Small**	**Large to X Large**	**X Large**	**XX Large**
Burry Inlet (mm)	12	23	28	30
Wash (mm)	11	23	26	31
Poole Harbour (mm)	12	33	38	45+

* See Table 6

(Source: Franklin 1972)

In the past processors took variability in meat yield as well as shell-size into account in the offer of their first-sale prices. However competition for gatherers following Dani's entry to the market saw processors paying 'on-grade' (i.e. shell-size) only, a practice that persists to the current day. One of the processing respondents indicated this has had the effect of conferring an additional premium to their suppliers e.g. in 2014 £400/t is paid for Burry Inlet cockles regardless of meat yield which can vary from 8% to 16% of whole weight according to season. On the Dee, PSP has historically paid for harvests based on grade weight, grading being carried out on a portable grader adjacent to the sands however, 2014 saw a variation on this with buyers paying an 'all-in' price of 80p per kilo. This was for cockles with yields of >20% so proved to be a lucrative return on investment for the processors. Size grading was carried out afterwards but only to sort cockle sizes for further processing.

5.5 HISTORIC TRENDS IN COCKLE FIRST-SALE VALUE

Unfortunately no systematic size-specific historic data was available, hence the following analysis (and the associated economic loss analysis; Section 6.3) is based on records of total annual first-landing output and value from which mean annual prices are also calculated.

5.5.1 Nominal value and price trends

Figure 11 shows how after a steady increase from 1930 to the mid-1960's the nominal (i.e. uncorrected for inflation) total first-sale value of English and Welsh cockle landing rose dramatically from just under £100,000 in 1965 to £278,000 in 1971, with 26% (£72,280; RPI adjusted to £886,139 at 2014 prices) of landing value originating from south Wales in the same year. This made cockles the most valuable mollusc fishery in the country at the time, exceeding mussels, whelks, oysters etc. (Franklin 1972). The rise in value coincided with the introduction of the BI regulating order, though the introduction of hydraulic-dredge fishing vessels into the Thames fishery was likely to be a much more significant factor (Table 4). These were also the start of leaner production years for some important Dutch dredge-fisheries.

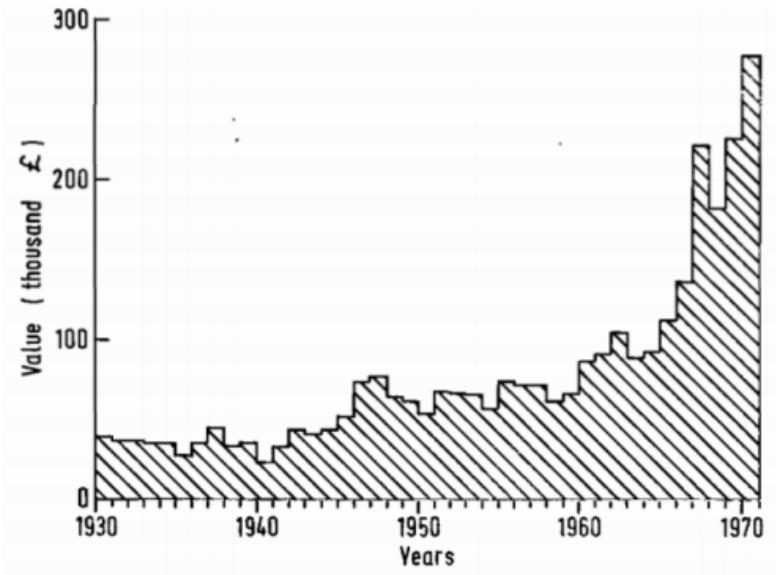

Figure 12: Nominal annual values of England and Wales cockle landings 1930-1971

(Source Franklin 1972)

The dominance of the Thames fishery continued to grow over succeeding decades. It's total first sales value exceeded £2 million for the first time in 2001 climbing in a series of 'saw-tooth' steps thereafter to reach a value of nearly £8 million in 2011 (Figure 13). The Wash fishery showed a broadly similar though less marked and more erratic trend with values fluctuating from £350,000 to £3.1 million over the same period.

Burry Inlet production and first-sale value remained relatively constant from 1987 to 1996 (Baseline Reference Period 1: BRP1) with annual landings ranging from 1,763t to 2,867t and value from £172,300 to £508,700 (Figure 13 and Table 8). Values rose sharply during 1998 to 2001 (Baseline Reference Period 2: BRP2), exceeding £1 million in 3 of these years for the first time. However, mean cockle price more than halved from £340/t in 1998/99 to only £162/t-£140/t in 2000/01 (Figure 14), the fall corresponding with rising production on the Thames and Wash. Despite BI tonnage more than doubling in 2000 compared to the previous two years, this resulted in the total first-sales value remaining almost constant at £1,162,000 - before falling again to only £350,138 in 2001 on production of 2,538t. The temporary surge in landings in 2003 and 2004 combined with high prices (£870/kg) saw first-sale values rise to new historic highs of £2.4 million and £3 million respectively (Table 8). A sequence of lean 'mortality era' years set in thereafter with first sales values ranging from only £210,000 to £377,000 from 2005 to 2014; corresponding with production levels ranging from 525t to 1,257t and prices from £300/t to £500/t.

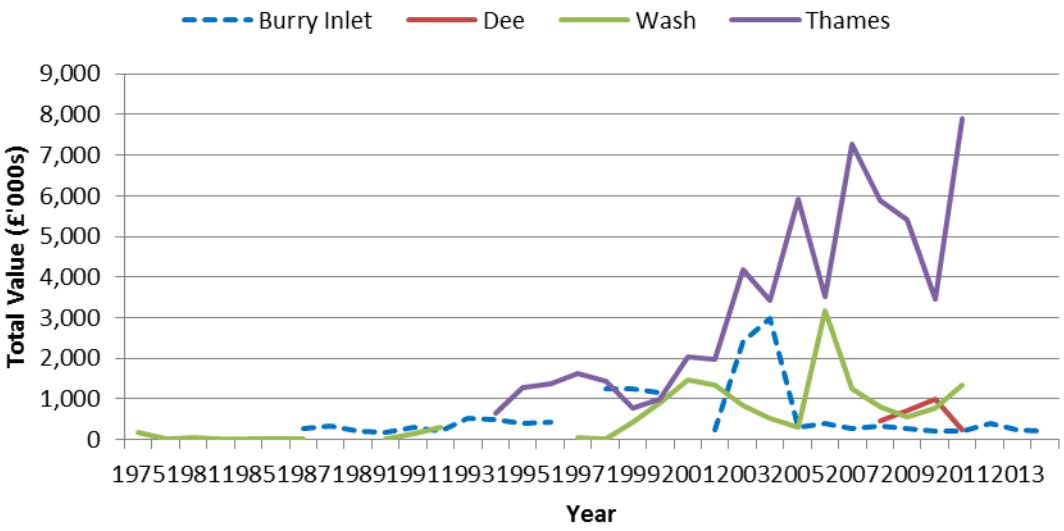

Figure 13: Nominal annual first sale values of recorded landings from the Burry Inlet, Dee, Wash and Thames cockle fisheries 1975-2014

(Sources: SWSFC Annual Fisheries Statistics 1975-2011, interview data, 2012-2013, WG-FMU 2014. N.B. All data uncorrected for inflation)

Figure 14 also shows how prices for BI cockle remained as high or higher than the Wash and the Thames over most of the 1980's and 1990's, rising steadily from £100t to £340/t. Prices fell briefly to around £150/kg from 2000 to 2002 before spiking at £880/kg in 2003 and 2004 (both poorer production years on the Wash and Thames fisheries). Persistently low recorded prices for BI cockle thereafter corresponded with the removal of MLS restrictions in 2006 and the predominance of under-sized single year class cockle.

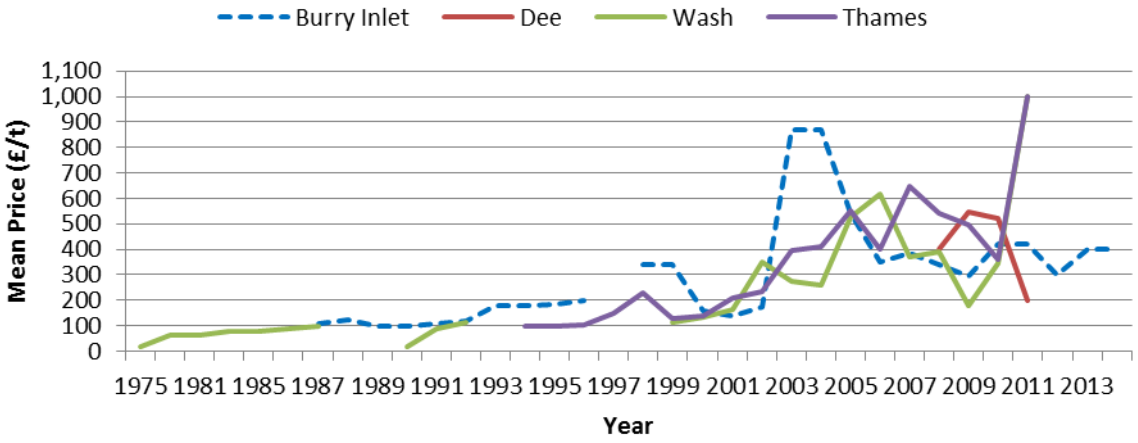

Figure 14: Nominal mean annual first sale cockle prices of recorded landings from the Burry Inlet, Dee, Wash and Thames fisheries 1975-2014

(Sources: SWSFC Annual Fisheries Statistics 1975-2011, interview data, 2012-13, WG-FMU 2014. N.B. All data uncorrected for inflation)

5.5.2 Real value and price trends

Whilst 'nominal' first-sale value and prices for Burry Inlet cockle landings from 1987 to 2014 are plotted in Figure 12 and Figure 14, Table 8 and Figure 15 show adjusted 'real' prices and total values at 2014 monetary value. Adjustments are based on two separate measures of inflation; the Retail Price Index (RPI) and the more conservative Consumer Price Index (CPI).

Table 8: Burry Inlet annual cockle landings, nominal and RPI/CPI adjusted real first-sale value, mean price data 1987-2014

Year	Annual Output (t)	Nominal First Sales Value (£)	RPI Adjusted Value (£)*	CPI Adjusted Value (£)*	Nominal Mean FS Price £/t	RPI Adjusted FS Price (£/t)*	CPI Adjusted FS Price (£/t)*
1987	2,320	£256,100	£644,096	£468,114	£110	£278	£202
1988	2,646	£328,500	£787,533	£582,962	£124	£298	£220
1989	1,989	£195,800	£435,464	£330,509	£98	£219	£166
1990	1,763	£172,300	£350,023	£271,835	£98	£199	£154
1991	2,615	£288,100	£552,916	£422,734	£110	£211	£162
1992	1,827	£212,000	£392,236	£298,409	£116	£215	£163
1993	2,867	£508,700	£926,661	£698,371	£177	£323	£244
1994	2,756	£497,400	£884,201	£669,215	£180	£321	£243
1995	2,181	£405,666	£697,329	£531,813	£186	£320	£244
1996	2,124	£424,800	£712,766	£543,532	£200	£336	£256
1997	3,200	No data	No data	No data	No data	No data	No data
1998	3,672	£1,249,881	£1,966,214	£1,546,637	£340	£535	£421
1999	3,672	£1,249,881	£1,936,141	£1,525,976	£340	£527	£416
2000	7,164	£1,162,290	£1,749,272	£1,408,286	£162	£244	£197
2001	2,538	£355,320	£525,232	£425,287	£140	£207	£168
2002	1,379	£240,750	£350,138	£284,432	£175	£254	£206
2003	2,771	£2,415,455	£3,413,369	£2,814,731	£872	£1,232	£1,016
2004	3,419	£2,979,340	£4,089,112	£3,428,116	£871	£1,196	£1,003
2005	545	£296,450	£395,663	£334,192	£544	£726	£613
2006	1,077	£376,770	£487,304	£471,239	£350	£452	£438
2007	697	£269,644	£334,451	£329,522	£387	£480	£473
2008	960	£325,680	£388,442	£384,133	£339	£405	£400
2009	884	£262,467	£314,732	£303,010	£297	£356	£343
2010	508	£213,360	£244,539	£238,464	£420	£481	£469
2011	508	£213,360	£232,457	£228,237	£420	£458	£449
2012	1,257	£377,100	£398,123	£392,276	£300	£317	£312
2013	573	£229,200	£234,818	£232,563	£400	£410	£406
2014	672	£268,000	£268,000	£268,000	£400	£400	£400

(Sources SWSFC 2014 Annual Fisheries Statistics 1975-2011, interview data, 2012-2013, WG-MFU 2014. * Real values and prices. N.B. All data adjusted to 2014 prices using RPI and CPI inflation indices (ONS 2014))

Adjusted results reaffirm how the real value of landings reached historic lows between 2005 and 2014; the RPI and CPI corrected annual first-sales values averaged over 2005-2014 were respectively only 50.8% and 64.8% of the same values averaged over the 10 years from 1987-1996 (BRP1) and 21% and 25.5% of value averaged over 1998-2001 (BRP2). After marked falls from historic 2003/4 highs (RPI adjusted price exceeding £1,200/t in 2003) real prices continued a slow decline from 2005 to 2014 with RPI and CPI adjusted prices ranging from £726/t - £317/t and £613/t - £312/t respectively over these nine years. Despite this trend real prices averaged over 2005-2014 still remained above the average for the two pre-mortality baseline reference periods. RPI adjusted prices were respectively 165% and 103% higher than BRP1 and BRP2 averages, whilst CPI adjusted prices were 210% and 125% higher. These findings point to an important conclusion; based on historic performance comparisons, reduced yields have had a greater contributory effect on value-reduction than falling prices during the mortality era.

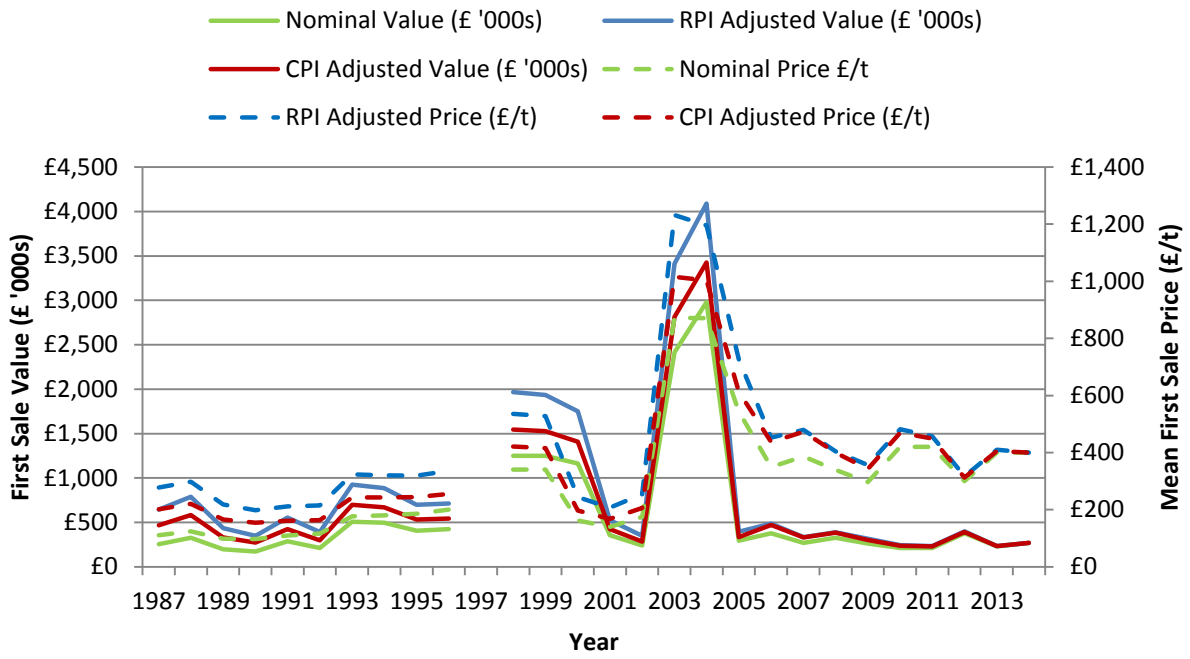

Figure 15: Real annual total value and mean price at first sale for recorded Burry Inlet cockle landings 1987-2014

(Sources: SWSFC 1987-2011 and interview data. N.B. All data adjusted to 2014 prices using RPI and CPI inflation estimates, ONS 2014)

Three-Rivers first landing value: No official value or price information was available for the Three Rivers fishery however primary processors interviewed on the BI (who together purchased almost all the production) estimated a total first sale value of £7.5 million in the exceptional 2005 year when a harvest of around 8,200t of cockle was recorded (Figure 9). This corresponds with a mean first-sales price of £915, comparable with exceptionally high prices paid on the Burry Inlet over the two previous years (Section 5.5.1).

Processor Returns: The same trends are reflected in data supplied by one major primary-processing company operational in the UK. The annual value (RPI adjusted) of whole cockle purchases sourced from the Burry Inlet between 2002-2007 averaged £580,626 (SD £423,332). From 2008-2014 the same average declined to only £118,813 (SD £137,122). Although highly erratic, the Three Rivers contributed the highest value in any single year; £3,122,833 in 2005, compared to the maximum value of £1,302,441 from the Burry Inlet in 2003.

Despite trend similarities, counter-intuitive differences are apparent in the absolute values of the two sets of value data[22] i.e. in many years total Burry inlet processor values are similar to or higher than the 'official' published figures for the whole fishery (by SWSFC etc.). With processor supply volumes averaging only 38% of total reported landings between 2002 to 2014, the main reason for this discrepancy appears to lie with differences in average annual landing prices reported by the two sources; 'official' landing prices were 33.8% lower than the processor prices averaged over the 13 year period.

One explanation may be that the variance reflects real price differentials associated with competition between buyers for limited supplies. However, this alone is unlikely to explain size of the margin and no supporting evidence was found for such margins during interviews with industry stakeholders. Another explanation may lie in the way averages were calculated, i.e. the official data appears to be based on actual reported cash value whilst the processor may have reported simple averages of prices i.e. averages of the price paid for each batch rather than weighted averages that also account for cockle quantity.

5.6 MARGIN ANALYSIS

5.6.1 Gatherer Margins

At 2014 landing quota (330kg including a 10% NRW 'overweight' allowance) and average first sales price (£400/t) gatherers can earn a legal maximum of £132/day. One BI gatherer estimated totally daily costs at around £43 (£20 for diesel, £20 for vehicle depreciation and a daily share of the £648 annual licence fee assuming an average of 4 days worked per week over 12 months). Thus the corresponding maximum daily profit (for 4-5 hours of activity) before tax is £86. This compares unfavourably with an estimated maximum daily profit of £282 for the larger sized cockle available on the Dee Estuary, reportedly averaging £1,015/t at first sale in 2014 (based on an annual licence fee of £1,300[23], an average of 5 days worked per week over 6months, and the same daily quota and vehicle cost assumptions as above).

5.6.2 Processor Margins

5.6.2.1 Primary processors

Primary processor gross margins from 2006 to 2011/14 for raw material originating from BI, Thames and Wash fisheries and sales for secondary pickle processing were estimated using the data and assumptions presented in Table 9 (insufficient data was available on production costs and subsidies etc. to calculate net

[22] Value data from processors has not been presented due to confidentiality considerations.

[23] The Dee licence fee from 2008-2012 was £992, rising to £1300 in 2013??

margins). Results indicate cockle from the Thames produce the highest and most consistent gross margins (mean 100%, SD 21%) consistent with its assured supply of larger cockle over recent years (Section 5.2). The Wash and Burry Inlet both had a comparable performance with mean gross-margins of 82% and 84%, though the performance of the Wash Cockle was more erratic (SD 35%) compared to the BI (SD 21%). However, it should be remembered that much of the cockle cooked in Penclawdd/ Crofty during this period was likely to have originated from the Dee Fishery.

Table 9 calculations also assume no value recovery from processing by-products i.e. shucked shells which were observed being stock-piled behind one the processing factories (Plate 21). Cockle shell has previously been use for a range of uses e.g. as a poultry feed ingredient, as a building aggregate and as a decorative garden mulch and drainage material (one the processors visited used the shell as a road/ track surfacing material on their site).

Table 9: Gross margin analysis for cooked cockle meat sold for secondary processing (using annual mean prices)

Cockle Source	Year	First Sale Mean £/t[1]	Cooked Meat Mean £/t[2]	Mean Meat Yield %[3]	Primary Processor Gross Margin %	Mean Gross Margin & (StDev)
Burry Inlet	2006	£350	£5,229	10	66.9	83.6% (20.9%)
	2007	£387	£4,612	10	83.9	
	2008	£339	£4,293	10	79.0	
	2009	£297	£3,984	10	74.5	
	2010	£420	£3,177	10	132.2	
	2011	£420	£6,806	10	61.7	
	2012	£300	£4,209	10	71.3	
	2013	£400	£4,291	10	93.2	
	2014	£400	£4,480	10	89.3	
Thames	2006	£400	£4,535	10	88.2	100.0 (8.1%)
	2007	£650	£5,776	12	93.8	
	2008	£540	£4,188	12	107.5	
	2009	£498	£3,821	12	108.7	
	2010	£361	£3,072	12	98.0	
	2011	£1,000	£8,003	12	104.1	
	2012		£5,026			
	2013		£5,992			
	2014		£7,331			
Wash	2006	£618	£4,776	12	107.9	81.5 (35%)
	2007	£372	£5,850	12	53.1	
	2008	£390		12		
	2009	£181	£3,263	12	46.1	
	2010	£345	£3,926	12	73.2	
	2011	£1,000	£6,554	12	127.2	

[1] Source: CEFAS 2014 Annual Fisheries Statistics 1975-2011, Interview Data, 2012-2013, WG-MFU 2014
[2] Source: Industry data (See Fig 16)
[3] Mean current annual cockle meat yield estimates from primary and secondary processor interviews.

5.6.2.2 Secondary processors

Secondary processors: No information was sourced on raw material prices paid by cockle canning-factories, or on wholesale prices paid by retailers for processed goods. However, at the time of writing the average price for the most common 155g pickled cockle jars by four supermarket chains was £1.45, equivalent to £0.94/100g. With a 46% cockle meat content this is in turn equivalent to a retail value of £20,370/t of pickled cockle and a gross margin of 344% (based on 2014 prices) to be shared between processor, retailers and any intermediaries having covered bottling and other production costs.

Plate 21: Cockle processing by-product (cockle shells) stockpiled at Penclawdd Shellfish Processing Co factory

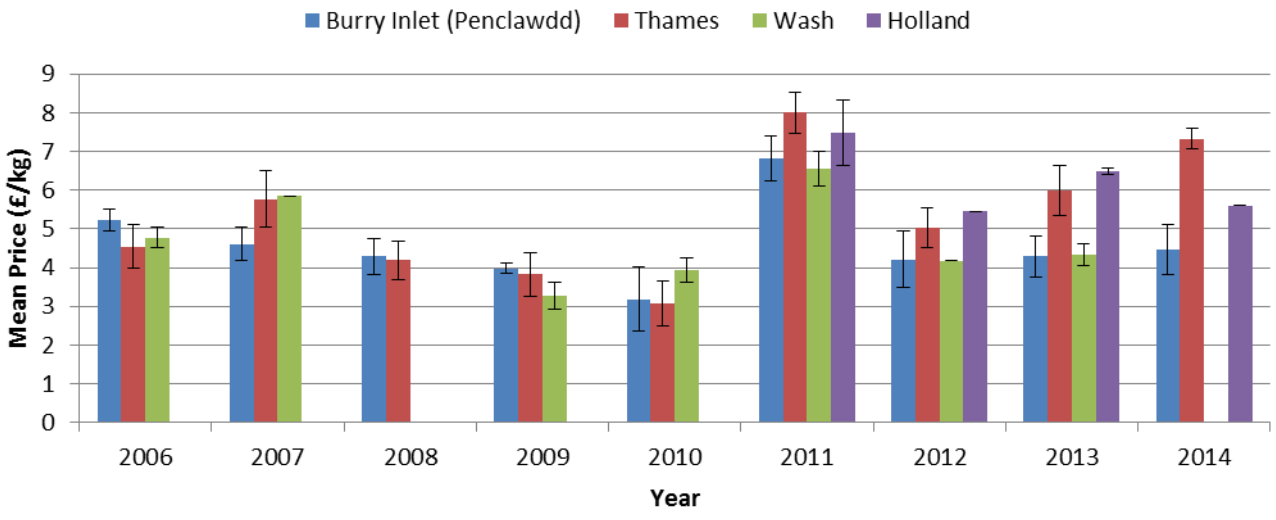

Figure 16: Annual mean purchase price (and standard deviation) of cooked cockles 2006-2014

(Source: Industry data 2006 - 2014)

6 ESTIMATION OF ECONOMIC LOSS

6.1 INTRODUCTION

In this section, baseline and mortality era data presented in Section 5 are used to estimate first-sales (i.e. at landing) economic losses. Next social equity outcomes are evaluated based on analysis of licence holding trends and associated production effort.

6.2 LOSS ESTIMATIONS; CONSTRAINTS AND ISSUES

Acute mortalities episodes were first observed on the Burry Inlet in 2002 and three years later on the Three Rivers estuary (Section 3.4.2). The mortalities have resulted in the loss of the older, more valuable 2 and 3 year-class cockle, formally the economic backbone of the fishery. High compensatory production of fast growing single year class cockle sustained outputs to some degree but not value due to low market demand for the under-sized cockle now routinely produced. Although acute mortality episodes have become less common, chronic losses continue to maintain this population bias. From 2005 a long-standing minimum landing size (MSL) limit of 19mm (square diameter) on the BI was relaxed, since which most harvest today ranges from as small as 8mm (i.e. spat) to 18mm. Consequently the real (RPI adjusted) mean first-sale value of BI cockle has steadily declined from over £1,000/t at the start of the mortality-era to only £400/t in recent years (Section 5.5.2). By contrast larger cockle from Wales' other main commercial cockle fishery, the Dee Estuary have regularly attained prices well over £1,000t/year since it too was placed under regulating order in 2008 limiting access to 50 licensed gatherers.

Lack of data on post-harvest intermediate expenditure (e.g. wages, energy, rents, sales costs etc. and factory co-product expenditure allocation) precluded loss estimation based on forgone real Gross Value Added (GVA) across the Welsh cockle value chain. Analysis was instead limited to estimation of first-sale value losses for whole cockle using a range of baseline output and price scenarios (described below). Other gathered evidence clearly showed the burden of mortality losses fell most heavily on the gatherers. Vertically integrated processers (see below) were able to source most of their raw materials from other Welsh, English and even European cockle fisheries with additional transport costs accounting for most of their losses. Conversely most gatherers access to other cockle fisheries, and therefore options to remain in the sector, are much more restricted.

From 2002-2007 one of the two vertically integrated companies sourced only 6.7% (560t/year, SD 289t) of its mean annual cockle supply for primary processing by its UK operations from the BI, declining to 4% (261t/year SD 298t) between 2008-2014 (only 32t in 2014). Erratic contributions also came from the Three Rivers: Section 5.3). Low continental demand for small cockle of the type now mainly produced by the BI means the UK market for bottled, pickled cockle is an important remaining option. Thus the contribution of BI cockle to the single local (and UK's only) pickling plant; 'Parsons Pickles' accounted from 17-47% of the factory's total annual supply from 2005-2014.

Lack of baseline cockle value data precluded first-sales loss estimates for the TR. A further complication lay with the fact that both the TR and BI enjoyed combinations of abnormally high landings and market prices close or shortly prior to the onset of mortalities. In 2005 some 8,200t of cockle worth approximately £7.5m (processor estimates) was landed from the TI, whilst in 2000 over 7,164t was landed from the BI, tonnages not witnessed since 1968 (Section 5.2). Output from the BI then remained close to the pre-mortality decadal baseline average for most of the next four years despite the onset of mortalities. Although extreme, the exceptional 2000 and 2005 harvests still fall into a longer-term pattern of high inter-annual variability observed in many cockle fisheries, though the BI was formally one of the most consistent since its regulation. This and other data deficiency issues increase the scope for partial claims by different interest groups. The multi-scenario approach to loss estimation described below was adopted in response.

6.3 ESTIMATION OF FIRST SALES ECONOMIC LOSSES

Three scenarios based on different pricing approaches were used to estimate first sale losses directly incurred by BI gatherers due to lost production during the 'mortality era'. The following methodological steps were applied in each case, after which the three scenarios are described:

Outlier years: Two years, 2003 and 2004, were excluded as 'outliers' from the 2002-2014 'mortality era' as reported catches of older/ larger cohorts of cockle and landings values and prices remained atypically high compared to the following years (Figure 15). In other words in all scenarios losses are estimated over 11 rather than 13 years with significant economic losses really beginning in 2005.

Baseline Reference Periods (BRP): In each of the three scenarios the analysis was repeated using three 'baseline reference periods' (BRP): BRP1 = 1987-1996, BRP2 = 1998-2001 and BRP3 1987-2001 (Table 12). This subdivision was based on two distinct value trends; lower average value during BRP1 and higher average value during BRP2 (Section 5.5.2). SWSFC annual value data was only available from 1987 onwards.

Loss calculation: In each of the resulting BRP cases, all pre and post mortality value-data were adjusted to 2014 prices using RPI and CPI inflation indices. Average nominal and real (RPI/CPI price adjusted) total first-sale values of annual landings were then calculated over each reference period. These baseline period results were finally subtracted from values adjusted in the same way for each of the 11 mortality-era years and the outcomes for each fishery were summed.

Price Scenario 1 (S1): Used published Burry inlet annual cockle value-data from 1987 to 2014[24] to calculate the mean annual value for each BRP and as the source for mortality-era annual values.

[24] Sources: SWSFC Annual Fisheries Statistics for the Burry Inlet 1987-2011 (no data available for 1997: see Table 8), key informant data for 2012-13 and WG-FMU data for 2014.

Table 10: Nominal and real (RPI/CPI adjusted) price at first sale for the BI for three baseline reference periods between 1987 and 2001

£/t	1987-1996	1998-2001	1987-2001
Nominal	£140	£272	£205
CPI Adjusted	£170	£302	£232
RPI Adjusted	£246	£378	£300

(Source: SWSFC Annual Fisheries Statistics for the Burry Inlet 1987-2011)

Price Scenario 2 (S2): The scenario 1 approach does not properly account for the fact that over the last 15-20 years growing European demand has driven up real prices for cockle (Figure 14), especially larger grades. The second approach therefore re-values the same historic pre-mortality output of the BI fishery from 1987-2001 (i.e. BRP3 only), this time using RPI and CPI adjusted mean annual landing prices from the Dee Estuary from 2008-2013 (i.e. the period managed under regulating order). This yielded average prices of £533/t (nominal), £555/t (CPI adjusted) and £562/t (RPI adjusted) over the 5 year period (Table 11).

Price scenario 3 (S3): Triangulation of the published Dee Estuary price data used in Scenario 2 against processer-supplied data revealed a 49% difference in mean annual first-sale prices over the same reference period giving £1,093/t (nominal), £1,195/t (CPI adjusted) and £1,219/t (RPI adjusted (Table 11). Consequently the Scenario 2 analysis was re-run using the processor supplied (higher-price) data.

In addition to the explanations given in S2 and S3 above, a further reason why Dee Estuary prices were used in S1 and S2 is because it provided the closest approximation of what production conditions may have been like on the BI in the absence of mortalities (i.e. acting as a positive control). Whilst the Dee is a significantly larger area than the BI[25], from 2008 access to it was restricted to 50 licensed hand-gatherers when the Dee became the second regulated cockle fishery in Wales. However, a wide divergence in 'official' government-agency and processor estimates of Dee first-sale values resulted in the analysis being run twice with both sets of data (i.e. S2 and S3).

Table 11: Comparison of SWSFC[1] and primary processor[2] nominal and real (RPI/CPI adjusted) mean price at first sale for Dee Estuary 2008-2014[26]

£/t (SD)	SWSFC	Processor
Nominal	£533 (£295)	£1,093 (£425)
RPI Adjusted	£594 (£293)	£1,219 (£442)
CPI Adjusted	£583 (£290)	£1,195 (£434)

[1] Published SWSFC 2008-2011 and interview Data, 2013

[2] Industry data 2008-2014

[25] The Dee Estuary SPA designation states it is 14,292 hectares in size compared to 6,628 hectares for the Burry Inlet.

[26] Price estimations are complicated by the (probable) lack of size-class weighted averaging by all data providers. A government official familiar with historic pricing observed: a 'lowest ever' price (since 2008) on the Dee of £0.60/kg for small, £1/kg for medium, £1.40 for large and £1.80 for extra-large cockle. Although value at first point of sale varies considerably, these ratios are broadly indicative of the situation in most recent years.

Results (Table 12) show loss estimates ranging from £544,722 (£49,520/year: BRP1 and S1 nominal prices) to £22,471,905 (£2,042,900/year: BRP2 and S2 RPI adjusted published Dee Prices) to £46,104,140 (£4,191,285/year: BRP2 and S3 RPI adjusted processor supplied Dee prices). The lower of these estimates is heavily biased by the cumulative effect of inflation on nominal (unadjusted) long-term landing values and thus can be discounted (along with other nominal price estimates). The two higher estimates are both based on a series of above average output reference years (BRP2) with exceptionally high output averaging 4,262t over the 4 years. These values can therefore be considered as the worst case situations and difference between them is entirely due to the divergence in official and processer Dee cockle prices estimates.

BRP 3 would seem to provide a more objective basis for assessment compared to BRP1 or BRP2, as it is based on a 15 year historic output average. This results in loss estimates at an intermediate level of £13,499,999 (£1,227,273/year: BRP3 and S2 RPI adjusted published Dee prices) and £27,697,067 (£2,517,915/year: BRP3 and S3 RPI adjusted processor Dee prices).

Table 12: Estimates of first sale economic losses for Burry Inlet cockle fishery 2002-2014 (with 2003/04 excluded as outliers) relative to three defined baseline periods

Price Scenario	Baseline Reference Period (BRP)	BRP Years	Estimated First Sale Economic Losses [4]		
			Nominal Prices	Real Price CPI Adjusted	Real Price RPI adjusted
S1: SWSFC BI first-sales annual values [1]	BRP1	1987-1996	-£544,722	-£1,832,376	-£3,372,083
	BRP2	1998-2001	-£7,974,192	-£10,025,144	-£13,336,894
	BRP3	1987-2001	-£2,667,427	-£4,173,167	-£6,219,172
S2: SWSFC Dee Estuary mean first sales price 2008-2013 [2]	BRP1	1987-1996	-£8,713,340	-£9,517,352	-£9,707,906
	BRP2	1998-2001	-£20,169,681	-£22,030,811	-£22,471,905
	BRP3	1987-2001	-£12,116,938	-£13,235,012	-£13,499,999
S3: Processor Dee Estuary mean first sales price 2008-2013 [3]	BRP1	1987-1996	-£17,857,664	-£19,529,217	-£19,917,076
	BRP2	1998-2001	-£41,337,004	-£45,206,322	-£46,104,140
	BRP3	1987-2001	-£24,833,210	-£27,157,703	-£27,697,067

[1] Value estimates based on published historic values of BI landings (Source SWSFC)

[2] Value estimates calculated using BI tonnage (SWSFC) & mean first-sales prices from the Dee Estuary 2008-2013 (SWSFC)

[3] Value estimates calculated using BI tonnage (SWSFC) & mean first-sales prices from the Dee Estuary 2008-2014 (Industry data)

Table 13: Estimates of first sale economic losses for Burry Inlet cockle fishery 2002-2014 (with 2003/04 excluded as outliers) relative to three defined baseline periods with a 17% increase to account for under-reporting issues

Price Scenario	Baseline Reference Period (BRP)	BRP Years	Estimated First Sale Economic Losses [4]		
			Nominal Prices	Real Price CPI Adjusted	Real Price RPI adjusted
S1: SWSFC BI first-sales annual values [1]	BRP1	1987-1996	-£637,324	-£2,143,879	-£3,945,337
	BRP2	1998-2001	-£9,329,805	-£11,729,419	-£15,604,167
	BRP3	1987-2001	-£3,120,890	-£4,882,605	-£7,276,431
S2: SWSFC Dee Estuary mean first sales price 2008-2013 [2]	BRP1	1987-1996	-£10,194,608	-£11,135,302	-£11,358,250
	BRP2	1998-2001	-£23,598,526	-£25,776,049	-£26,292,128
	BRP3	1987-2001	-£14,176,817	-£15,484,964	-£15,794,999
S3: Processor Dee Estuary mean first sales price 2008-2013 [3]	BRP1	1987-1996	-£20,893,467	-£22,849,184	-£23,302,979
	BRP2	1998-2001	-£48,364,294	-£52,891,397	-£53,941,844
	BRP3	1987-2001	-£29,054,855	-£31,774,513	-£32,405,569

These results can be compared with interim BI loss estimates over the period 2003 - 2007 as reported by the Molluscan Working Group of the South West Wales Sea Fisheries Committee (SWSFC, 2007) ranging from £6.46m (£1.29m/year) to £14.27m (£2.85m/year), depending on assumptions used (Appendix 8). On an annualised basis, these estimates are comparable to the two worst case scenarios in our analysis described above. However the following differences in approach should be noted;

- The first SWSFC approach calculates loss using pre-mortality 'long-term' production averages; for the BI giving an average of 3500t/year from 1997-1999 as a baseline for comparison. As these were three historically above average production years (Table 8) this will tend to overestimate losses compared to use of longer term averages (i.e. BRP3 above).
- Using a second approach, the SWSFC estimated losses for both the TR and the BI based on 'stock expectation' calculated as the difference between annual recorded production outcomes and periodic juvenile stock assessments with 'grow-on' estimates. This risks over-estimation due to the r-selection shift problem described in Section 3.4.4. Using this method, at £2.85m/year the SWSC loss estimate for the BI (2003-2007) is more than double their £1.29m/year estimate using a 1997-1999 baseline production average as described above. TR losses are estimated at £2.13m/year (2005-2007) using the stock expectation approach only.
- Lack of retail/ consumer price index correction in the SWSFC method will underestimate losses, though given the relatively short time interval of 5 years this is likely to be less significant than the aforementioned over-estimation factors.
- The SWSFC approach also bases loss estimates on the cost of larger more valuable forgone 2yr cockle comparable to use of Dee price data in the current study (though price data provenance is unclear).

Industry estimates tend to be much higher still; a 2012 newspaper article (Misstear 2012b) stated 'around £70m worth of cockles have been lost in the past decade in south Wales'. Presumably the figure refers also to both the BI and Three-Rivers fisheries - but again assumptions are not clear. During the current field work a gatherer observed that "in 2002 a gatherer could earn up to £60,000 per year whereas in 2013 this figure was

closer to £9,000 per year. It may be that such estimates are based on best and worse-case scenarios. Actual turnover and profit data provided by BI gatherers more accurately reflects the high natural background variability in fishery output with mean profits ranging from only £2,000 to £18,500 over five seasons between 2009 and 2014 (Figure 17).

Gatherers also tended to quote prices for larger cockle grades when comparing other fisheries with the BI. In contrast, prices quoted in Table 8 are likely to be weighted means being calculated from total tonnage and first-landing value. At reported 2002 prices (£175t, Table 8) £60,000 would correspond to an improbable individual gatherer harvest of 340t per year; and may more realistically refer to the exceptional 2003 year when with prices at a record £872/t (SWSFC data), £60,000 would correspond to an annual total of 69t (still very respectable, averaging 287kg/day over 240 working days). Historic under-reporting of landings may also contribute to the difference. Based on observations in Section 4.7 (market failures) applying an under-reporting multiplier of 1.17 increase our intermediate BRP3 upper loss estimates to £15,794,999 (S2, RPI adjusted) and £32,405,569(S3, RPI adjusted) and worst-case BRP2 upper loss estimates to £26,292,128 (S2, RPI adjusted) and £53,941,844(S3, RPI adjusted).

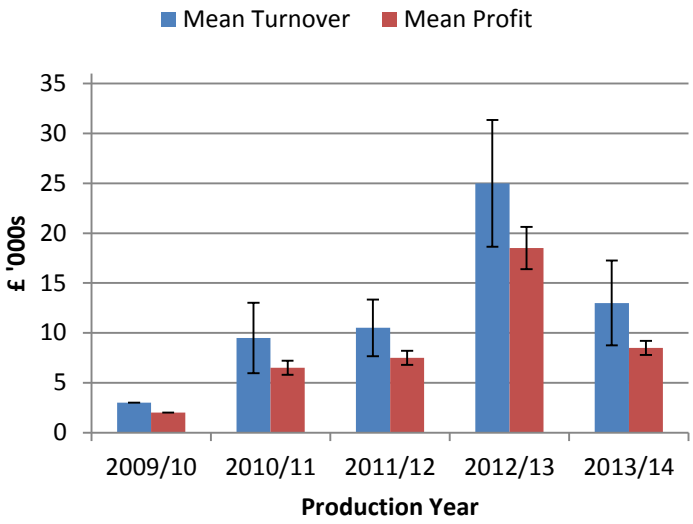

Figure 17: Mean turnover and profit of BI gatherers 2009-2014 with standard deviation bars

(Source: formal accounts submitted by gatherers)

6.4 LICENCE-HOLDING AND EFFORT TRENDS

In 2003 the number of licensed-gatherers submitting returns each month averaged 35 (SD 6.4) on the northern foreshore and 15 per month (SD 9.2) on the southern foreshore. Thereafter to the present time, average monthly numbers have never exceeded 16 and 12 respectively in any year. Numbers fell as low as 2 (north shore) and 1 (south-shore) in 2009 (Figure 18).

The lower effort on the south shore evident in all the following analysis (Figure 18, Figure 19 and Figure 20) may in part reflect longer term cyclical shifts in cockle productivity (Section 3.2).[27]

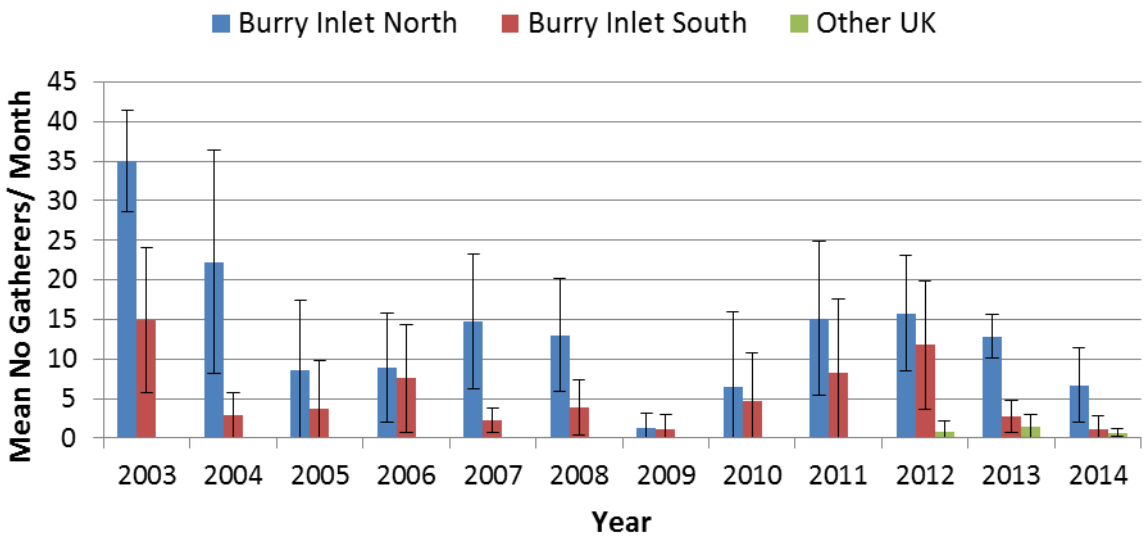

Figure 18: Mean monthly number of licensed gatherers active on northern and southern Burry Inlet and other UK cockle beds 2003-2014 (with standard deviations).

(Data sources: WG/SWSFC returns 2003-10, NRW returns 2010-14. N.B: 2003 and 2014 data each cover 9 months only)

The annual number of licences withheld due to none-payment of fees and other factors over this period showed a corresponding increase (Figure 19). Over the three seasons from 2003 to 2006 only one of 55 gatherers holding licences immediately prior to the first 2002-03 mortality episode was withheld (in the 2003-04 season), the number then rose sharply, with 9 of 55 licences withheld in 2006-07 and 12 in each of the next two seasons i.e. 22% of the pre-mortality total[28]. Licence numbers continued to decline before stabilising at 34-37 licences issued over the five seasons from 2010-11.

Two gatherers failed to renew their licences for the current 2014-15 season one of them retiring at the age of 86, whilst a third elderly licence holder passed-away shortly before the October field-visit. This reduced numbers to a new low of 34 licences i.e. 62-67% of the pre-mortality total and around half (51-55%) of the peak number of 67 licenses issued in any season between 1965 and 2002. Although the waiting list for licences remains large, numbers have also declined from 133 persons in 2000 and 155 in 2005 (SWSFC 2005) to only 89 in 2014 (WGFU 2014). The waiting list is currently closed for new applications and those already on it must

[27] It should be noted this is an assumption. In addition NRW are aware that there is thought to be some level of non-compliance with submission of catch returns from some Burry Inlet licence holders – a situation which NRW are trying to address.

[28] From 2012 NRW dealt with inherited problems with licence fee arrears by abolishing an informal option to make quarterly payments. Henceforth, the fee of £684 (fixed since NRW became responsible for the fishery) must be submitted as a single advance annual payment.

re-apply each year. Only one new licence was granted in 2014, to a male (37yrs) waiting list member from Laugharne on the Three Rivers Estuary, raising the total number back to 35.

Consistent with the current state of the fishery, it has been the policy of NRW (formerly EAW) to maintain licences at the 'current rate' i.e. at 36 licences over the duration of their current 5 year management plan (Section 3.4.3), which is the same number of licences inherited when EAW took on responsibility for management of the fishery in 2010 (EAW then became NRW in 2012).

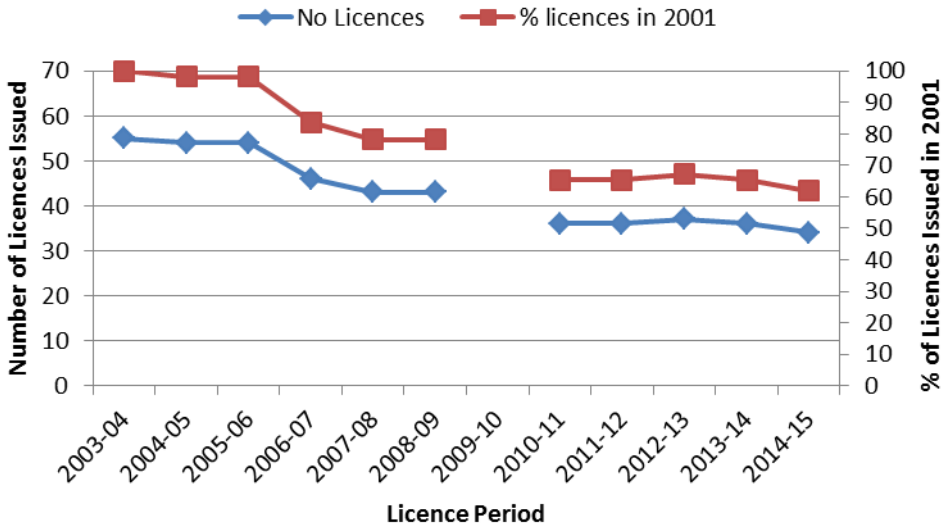

Figure 19: Number of Burry Inlet cockle licenses issued 2003-2015.

(Source SWSFC and NRW data; no data for 2009/10)

One active gatherer interviewed estimated only around 10 of 34 current licence-holders (their estimate) regularly gathered to their daily quota 'working any weather – whatever it takes'. Others were more periodically active whilst an unspecified number were effectively inactive but continue to pay their annual licence fee 'in the hope of one day gaining compensation for loss of income'. This compares with the upper estimate of 22 active gatherers out 41 licence holders in 2008 (Hough and Holt 2009).

Monthly Effort: The Burry inlet is nominally open all year compared to only 6 months for the Dee estuary[29] ('Other UK' in Figure 20). In practice, the Burry Inlet recorded 8-10 months of activity in 6 of the 12 years from 2003 to 2014, 11-12 months during 4 years and only 5 months in 2009. With an average of only 1-2 gathers active per month (Figure 18), 2009 was also the worst employment year during the mortality era, possibly on record. In the current season, only 7 months of activity were recorded up to October2014; with gatherers anticipating all activity would cease in November.

[29] A consequence of the historic development of regulating orders on the two fisheries, rather than more site-specific management requirements (WG-FMU Pers. Com).

Fishing effort also remained consistently higher on the northern than southern Burry Inlet cockle beds over nearly all years from 2003 to 2014 (Figure 18 and Figure 20). In 8 of 12 years the north-shore provided 1-3 additional months of activity compared to the southern-shore, with the difference being even more marked in terms of the mean number of active gathers per month (Figure 18). It is probable that the 'other UK' activity shown Figure 22 reflects the acquisition Dee licences by a small number of BI licence holders from 2012.

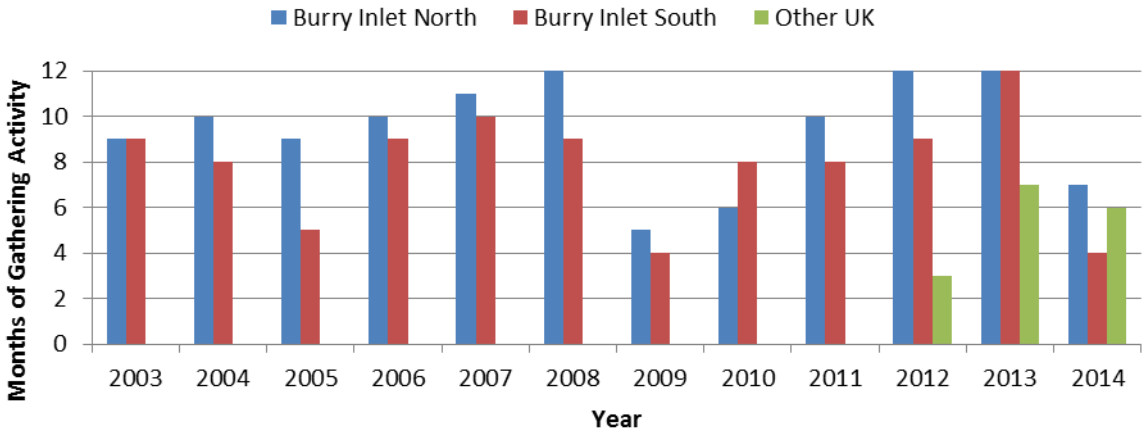

Figure 20: Number of annual months with recorded gathering activity by BI licensees on northern and southern Burry Inlet and 'other' UK cockle beds 2003-2014.

(Sources: WG/SWSFC returns 2003-10, NRW returns 2010-14. –N.B: 2003 and 2014 data each cover 9 months only)

During the second October field-visit (16-20/Oct/14) a total of only 5 licence holders were observed to be active over the three early morning working tides available (i.e. excluding Sunday). The visit occurred during a period of short neap tides, which reduced the daily gathering time on a single tide to only around 2hrs around low water. All these gatherers were working the north-shore (Rudder Gutter: Figure 2) accessed from Llanelli North Pier. Only two of these gathers were active on all the working tides.

Figure 21 shows the results of a the same (triangulation) analysis using processor supplied data, this time for the Burry Inlet, Three Rivers and Dee fisheries. Broadly similar trends are observed for the Burry Inlet, with levels in Figure 21 being lower or equal to the aggregate collection data in Figure 20 as would expected. Results again show reflect the growing contribution of the Dee estuary with 5-6 months of purchases recorded in every year the fishery has been under regulating order from 2008-2013[30]. Sporadic purchasing was recorded on the Three Rivers in 5 of 13 years. The three best years 2005, 2010 and 2011 had 4-6 month of activity. Only in one year, 2009 was no cockle was sourced from the Burry Inlet.

[30] Years recording 7months of activity include split-months i.e. when the season started and ended in the middle of month. 2014 data only extends to August.

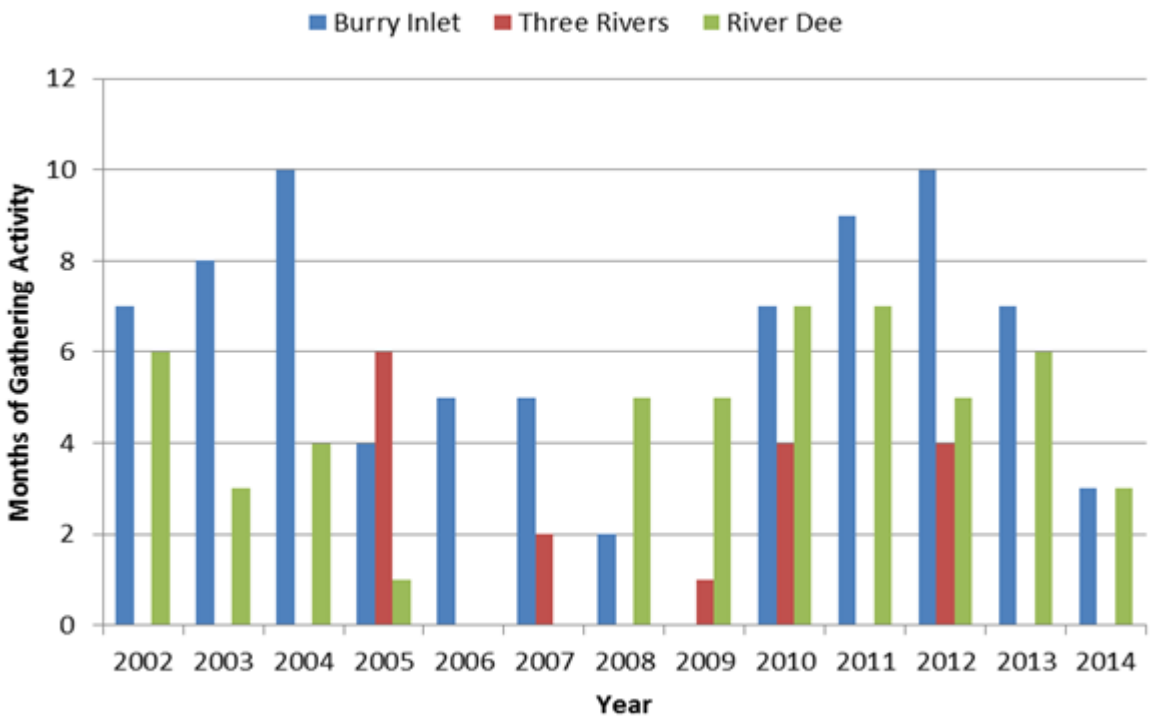

Figure 21: Number of annual months with cockle purchases recorded by one UK primary processor sourced from the three main Welsh cockle fisheries, 2002 to August 2014.

6.4.1 Quota and Yield

Quotas were reported to average around 250-300 kilos/ person/ day in a good to average year. After a series of poor years, yields in 2012 proved exceptionally good following a cool spring and wet June, ideal conditions for survival of the 2013 cockle-year class. Although though larger year classes were still absent, mortalities of the year-1 class remained low in 2012 (prematurely prompting some to think the mortality crisis was abating). This resulted in progressive TAC revisions from 600t at the start of the season, to 1,000t and finally 1500t at the end of September 2012[31].

In 2013 and 2014 the total allowable catch (TAC) was set at 1500t, an increase from only 300-400t in 2011-12. Based on winter 2013 spat-fall assessments, in 2014 the daily quota opened at a generous 800kg per licence-holder but was quickly revised downward before any gathering had occurred to 250kg and later back 350kg, after severe storms in February and March 2014. This resulted in some three quarters of an estimated 18,000t stock of harvestable cockles being lost.

Figure 22 shows how mean individual monthly landings decreased from a high of 4.3t (north-shore: SD 0.9t) and 3.2t (south-shore: SD 1.1t) in 2003 to as low as 1.2t (SD 0.9t) and 0.9t (SD 0.8t) respectively in 2011. The figure also shows product from the Dee (Other UK) starting to supply local processors.

[31] With consent of the Countryside Commission for Wales (CCW) responsible for the welfare of wild bird stocks.

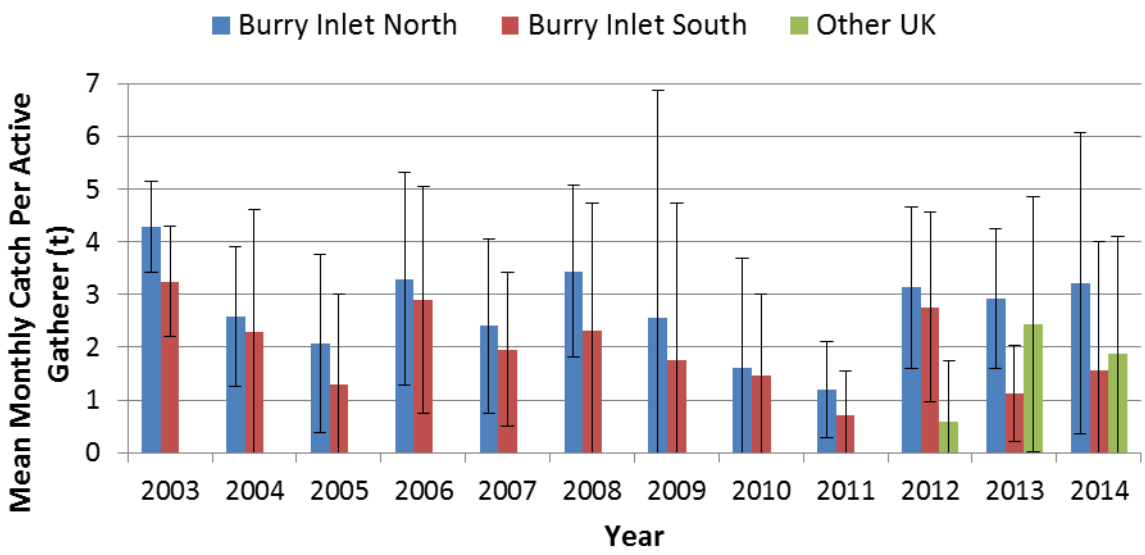

Figure 22: Mean monthly catch per active gatherer on northern and southern Burry Inlet and other UK cockle fisheries 2003-2014 (with SD).

(Sources: WG/SWSFC returns 2003-10, NRW returns 2010-14, N.B: 2003 and 2014 data each cover 9 months only)

Figure 23 shows normalised estimates of monthly harvest variability (as coefficient of variation or 'CoVar') between gatherers over the same 12 year period. Catches were most uniform in 2003 the best production year, with CoVar of 20-32%, followed by three discrete peaks (max 169%) and troughs (min 45%) coinciding with poorer production years. Although variability was marginally higher on the south than the north-shore in all but one year, overall trends were broadly similar on both shores. This probably reflects the mobility of gatherers, with most licence holders from the north and south shores tending to focus on the most productive beds at any given time. Consistent with the observations regarding given effort presented above, high landing variability was observed between gatherers in 2014, with CoVar ranging from 89% to 156% on the northern and southern shores respectively. These values correspond with standard deviations of 2.7t (north) and 2.4t (south) in 2014 compared to only 0.86 to 1.1t in 2003. The findings are consistent with the effort-differentials observed between active gathers during the October 2014 field visit (Section 4.3)

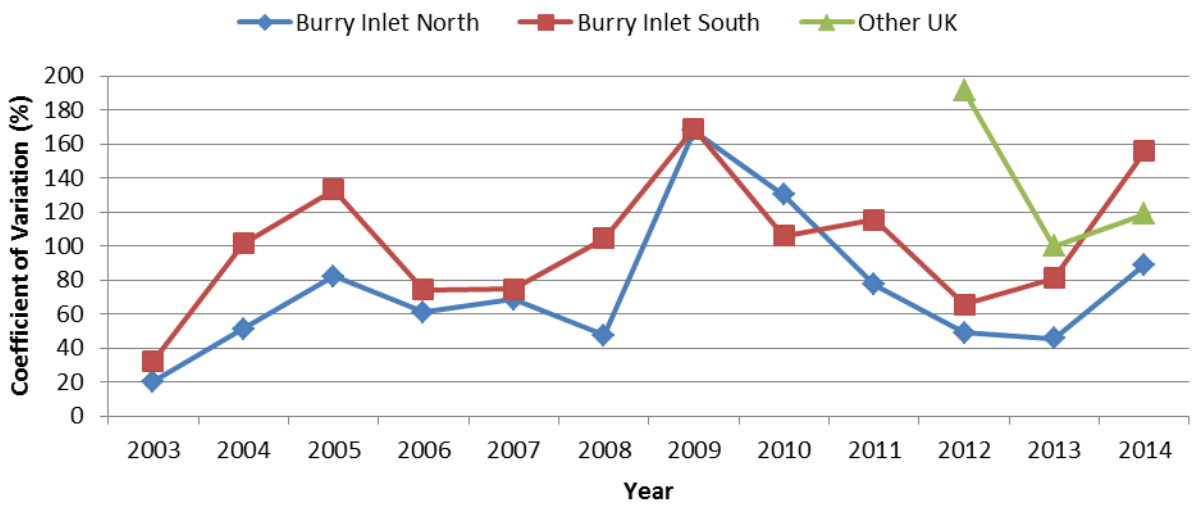

Figure 23: Monthly coefficient of variation for individual licensee catches from Burry Inlet and other UK cockle fisheries 2003-2014.

(Sources: WG/SWSFC returns 2003-10, NRW returns 2010-14, N.B: 2003 and 2014 data each cover 9 months only)

6.5 LIVELIHOODS AND ALTERNATIVE EMPLOYMENT

Current licence holders are roughly equally divided between the North and South shores i.e. 17 from Carmarthenshire CC (47%) and 19 from Swansea City & CC (53%) with waiting list shares respectively at 60% and 35% for the same areas (5% from other regional councils). Licence holder ages range from 38-73 whilst waiting list ages range from 18-66 supporting our finding that the waiting list system excludes younger entrants. Results indicate low current female participation and future interest i.e. of 36 current licence holders 5 (14%) are female whilst only 3 (3.4%) on the waiting list of 88 persons are female.

Of the gatherers currently licensed under the BI regulating order, 12 belonged to five long-established families (1-3 licences per family) with multi-generational involvement in the fishery. Members of two of these families also manage the two remaining primary processing factories (Section 4.4). Very few new licences have been issued since 2002 as natural wastage has allowed numbers to be reduced by 30% with the current NRW 5 year management plan envisaging maintaining numbers at 36. Thus negligible opportunity exists for those on the waiting list, which has also been closed to new applications. Furthermore many gatherers are likely to hold their licences well into retirement age or until they die hence the existing licensed gatherers therefore constitute an aging workforce.

Whereas until relatively recently many licensed gathers gained full-time employment in the sector i.e. through a combination of harvesting, cottage-processing, with the possible exception of the processing factory managers today most others must also secure other full or part-me salaried work in unrelated sectors (cited occupations included taxi-driving, joinery, and a bailiff whilst one had their own business).

More positively the same consolidation has created a significant number of full-time salaried positions in the processing sector, in fact with 34 reported positions almost exactly the same as the number of gatherers. Whereas the primary processing also relies on a large number of seasonal part-time workers, most of the full-time jobs (25) are in the secondary processing i.e. Parsons Pickles. However it should be remembered that more than two-thirds of the raw materials for this factory are routinely sourced from other cockle fisheries and around 40% of the income generated by the factory comes from production of other foods. Unfortunately no interviews were conducted with the staff of these factories though it is certain that more women are employed (in administration and production) than in the gathering sector.

Whereas the gatherers have proved very adept at using the media to convey their grievances and individual misfortunes (two older male gatherers without alternative income have lost their homes in recent years), as employees there seems to have been very little comparable public space or opportunity for processing factory workers to voice their opinions regarding the future of the fishery.

A small number (three) of Burry Inlet gatherers managed to gain licences on the Dee by demonstrating their involvement in the fishery prior to its regulation in 2008, whilst other 'Burry Inlet/ Three Rivers' residents are also on the waiting list. This has caused some division and antagonism amongst both Burry inlet and Dee estuary licence holders. Some of the Burry Inlet gatherers who had participated on the Dee but lacked necessary documentation required to prove this felt disenfranchised, while those from the Dee area felt access should be prioritised for local residents. Consequently the latter group were reported to be content to keep daily quota low as a disincentive to other southerners on the waiting list who have cover the additional expense and inconvenience of relocating to north Wales during the Dee season. At £1,500 per year the annual licence cost for the Dee is also almost triple the cost for the Burry Inlet (£684 for 2014/15).

Over and above any economic loss, even during our short association with some of the more active gatherers, it was readily apparent that there remains a strong cultural attachment and sense of identity associated with life-long participation in this iconic fishery in its stunning setting. One respondent spoke strongly of his dissatisfaction with his second, part-time occupation compared to cockling; thus there is also a non-financial quality of life aspect that must also be considered in any assessment of the mortality impact.

6.6 IMPACT ON THE LOCAL ECONOMY

Llanelli, on the north shore of the Burry Inlet, includes the seventh largest urban area in Wales, having a population of 78,300 in 2008. With 333 people per km^2 the county is more densely populated than Wales as a whole. Over recent decades the Llanelli labour market has fared in a similar way to much of the rest of the UK with a decline in manufacturing, a growth of service-based industries, an ageing population (some 22% of the population were above retirement age in 2010; Dolmen 2010) and high levels of migration.

With progressive closure of coal mines, steel and tin factories the area's traditional employment base resulted in sustained economic decline and rising unemployment from the late 1970s[32]. Local government initiated a regeneration programme in 2001 centred on five major developments in Llanelli town centre. These included new retail parks, residential and recreational developments. To promote tourism, the waterfront and its 800ha of contaminated industrial wasteland became a key focus of the regeneration effort. This investment started to redress chronic unemployment problems; employment levels began to steadily rise with many young people entering the job market finding work in retail, hospitality and care work sectors

However regional trends mask pockets of more persistent underachievement. In 2008 the Welsh Index of Multiple Deprivation which ranks areas of Wales in terms of deprivation found that 12% of areas in Llanelli fall in the 10% of most deprived areas in Wales and overall the majority of its areas were more deprived than the Wales average (Dolmen 2010).

Despite the economic crisis, by February 2012 Llanelli county ranked 19th of 22 Welsh Authorities in terms of its employment levels (based on numbers of Job Seeker Allowance (JSA) claimants). However almost half of a total of 1096 claimants in Llanelli remained concentrated in the two central waterfront wards of Glanymor and Tyisha. Youth and gender imbalances also remained persistent. Males constituted 70% of Carmarthenshire's total of 3457 JSA claimants at the same point in time (Llanelli Star 2012).

Table 14: Employment trends in Llanelli, Carmarthenshire and the UK

	Unemployed (18 to 59 or 64yrs)[1 2]	Working Age Employed[2]	Unemployed (16 to 64yrs) [2]				
	Feb 2010		Jan 2012	Feb 2013		May 2014	Jul 2014
Carmarthenshire							2.4%
Llanelli County	4.7%	69%	6.7%	6.2%	M 6.8%		
					F 5.6%		
Wales	4.6%	71%	9.3%	8.4%	M 8.9%		
					F 7.8%		
Great Britain			10.3%			6.8%	

[1] Eligible for job seekers allowance (JSA)
[2] 16-64 for men and 16-59 for women - changed to 16-64 for both sexes from Aug 2010

(Sources: Storch 2014, Llanelli Star 2014, Llanelli Star 2012, Dolmen 2010)

In 2014 Llanelli recorded 10 consecutive months with falling numbers of JSA claimants (Llanelli Star 2014) with the Carmarthenshire total falling to just 2.4% of the working-age population in July (1,747 claimants) of which almost equal numbers were male and female and around 40% classified as youth (18-24yrs). However national improvements more generally (with 73% of working age population in employment) saw

[32] A small number of manufacturing companies survive including Dyfed Steels, the Tata Steel Trostre Tinplate Works and The Technium Performance Engineering Centre.

Carmarthenshire's employment ranking fall to 17th of the 22 Welsh Authorities by September 2012 (i.e. the sixth lowest authority in Wales for Jobseekers Allowance claims).

However, despite the positive employment statistics it must remembered that relative GDP and earnings have remained exceptionally low (Drinkwater 2012). In February 2010 average gross weekly earnings for those working in Llanelli was around £468 whilst the equivalent figure for Wales was £470 (Dolmen 2010). Furthermore many of the employed (especially the young) are on temporary contracts cross-subsidised under the Department for Work and Pensions (DWP) Work Experience Programme Youth Contract. The area also has a high public sector dependency which may be threatened by future cuts to the sector.

7 SUMMARY

7.1 OVERVIEW OF KEY FINDINGS

The main aim of this report was to estimate the economic impact of cockle mortality on the south Wales cockle industry, related businesses and wider Welsh economy. Data collected from semi-structured interviews of industry stakeholders and regulators, direct observation, secondary literature, production and price data (provided by gatherers, processors and government agencies) were used to characterise value-chains, historic livelihood, regulatory and production trends and to quantify losses based on first sales values.

First-sale value loss calculations were based on three baseline reference periods for BI output: BRP1 1987 to 1996 (lower historic value), BRP2 1998 to 2001 (higher historic value) and BRP3 1987 to 2001 (long term average) and three price scenarios: S1 – BI 'official' (government agency) annual production values 1987 to 2014, S2 'official' Dee Estuary average price 2008 to 2013 and S3 processor Dee Estuary average price 2008 to 2014. For each combination of BRP and Scenario calculations were also repeated using nominal, RPI and CPI corrected prices.

Worst-case results (Table 12) came from the combination of S3, BRP2 and RPI adjusted 'processor' Dee prices amount to £46,104,140 over 11 years or £4,191,285 per year. The same analysis using 'official' Dee price data gave a cumulative loss of £22,471,905 or £2,042,900 per year. Arguably BRP3 based on a 15 year historic output average provides a more objective reference period. Combined with the other price/value scenarios cited above, this gave intermediate loss levels ranging from £13,499,999 or £1,227,273 per year (BRP3, S2 and RPI prices) to £27,697,067or £2,517,915per year (BRP3, S3 and RPI prices). Repeated again this time with an under-reporting correction of 17% (Section 4.7) the two ranges described above rise to £26,292,128 and £53,941,844 (worst-case) and £15,794,999 to £32,405,569 (intermediate case). On an annualised basis, the worst case scenario results compare with Burry Inlet estimates of £6.46m (£1.29m/year) to £14.27m (£2.85m/year) from 2003 to 2007 reported by the SWSFC Molluscan Working Group (SWSFC, 2007) . Industry estimates tend to be much higher still; a 2012 newspaper article cited gathers claims of £70m losses 'in South Wales' since 2002 (no assumptions were given). One gatherer indicated earnings of around £60,000 in 2002 had fallen to £9,000 per year, probably reflecting best and worst case scenarios.

The wide variation in economic losses as estimated in this document and reported or claimed from other publications and sources underlines how difficult it is to attribute different degrees of validity or robustness to estimates. However taking into consideration all the data and information gathered during the course of this work it is not unreasonable to state the following:

- BRP 3 would seem to provide the more objective basis for the assessment period as it is on a 15 year historic output average (even though it means data from two atypically high production years are included).
- Price scenarios S2 & S3 use recent Dee rather than historic BI prices (S1), which seems most reasonable as this is how a regulated fishery without mortalities could have been expected to be perform during

recent years over the BI mortality period. How to choose between S2 (SWSFC Dee prices) and S3 (Processor Dee prices) is more problematical as both appear to be based on un-weighted price averages. However as the processor average is based on fewer price points, and is actual first hand data, it seems reasonable to go with that in the final instance.

This would suggest that the author's most robust estimation of first-sale economic losses is £32,405,569 or £2,945,961/year over an 11 year period (BRP3, S3, RPI prices and 17% under reporting correction). However, the overall impact to the Welsh economy could have expected to have been much greater if a GVA analysis had been completed.[33]

Any assessment of economic impact must also consider the influence of wider market and economic changes over the mortality-era. Most significant has been the internationalisation of the cockle trade over the last two decades in order to meet growing demand for whole and (mainly) processed product in continental Europe. This proved impetus for rapid industry consolidation. Today two horizontally and vertically integrated companies; Hollands Lenger Seafood's and Spain's DANI Foods control production, primary (cooking) and secondary processing (canning and pickling) and distribution across most of the UK cockle sector (designation of the north and south BI cockle as Class B and C for E. coli risk means most product is cooked to avoid additional depuration requirements). Two key factors have driven consolidation at production and processing levels. Increased capital requirements following introduction of UK 'Torry' processing rules (Section 5.4) linked to new EU food safety laws in 1986 rapidly excluded many of the traditional cottage cooking businesses who's cooking practices often prioritised commercial above public-health goals. On the Burry Inlet this lead to the acquisition and concentration of processing by the same companies; Lenger and DANI both own modern primary processing plants on the south shore (Penclawdd/Crofty). Lenger also acquired a controlling interest in pickling plant on the north shore (Burry Port). This investment supported around 35 full time factory and administrative jobs (more than half in secondary processing) roughly equivalent to number of gathering licences currently issued. Canning, the dominant form of secondary processing is co-located with primary processing plants located near larger cockle fisheries (e.g. DANI's Boston plant on the Wash) or in the case of Lenger in Holland.

Secondly, although the BI (and TR) was a relatively small fishery compared to the Wash and Thames estuaries, its consistently high productivity elevated its contribution to UK production relative to its size (Section 5.2). This began to change following the mechanisation of the Thames and Wash fisheries. Hand-gathering gave way to suction-dredging from boats from the late 1960's dramatically increasing productivity. Both the Thames and Wash fisheries were regulated in the early 1990's further limiting access to small numbers of licensed vessels. Fourteen such vessels now work the Thames, by now far the most productive cockle fishery in the UK (Section

[33] A recent study carried out in 2014 by Maritek on the economic impact of farmed shellfish to the Jersey economy found that the total GVA figure was more than 190% that of the first sale value. Considering that Jersey is a small and relatively closed economy and given that the majority of the farmed shellfish produced there are exported, it is highly likely that the equivalent relationship between first sale value and total GVA figures for the economic impact of the cockle mortalities would be at least the same, if not greater, with respect to the Welsh economy.

5.2). Each vessel is reliably capable of landing over 8t per day (Section 3.2), more than twice the landings of a BI hand-gatherer in a good month. Lenger and DANI have since acquired most of these vessels and their licences. It is evident that only prescription of mechanisation prevents comparable production consolidation of the BI and other fisheries where gathering remains limited to hand gathering.

Industrial Inertia: Today the south Wales cockle sector provides an example of industrial inertia, arising both as a consequence of the above externally driven changes and mortality losses. This describes a situation in which an industry prefers to operate in its historic location despite loss of many of the factors that originally attracted it. Reasons for persistence of processing activities around the BI include (i) linkages between primary and secondary processing and other production activities (tinned laverbread, pickled mussels and vegetables contribute at least 40% of the pickling factory revenue, whilst the primary processors also produce small amounts of fresh laverbread) (ii) local skills associated with cockle production (iv) significant investment in factory modernisation by Lenger and Dani (with regional development agency support) prior to the onset of mortalities and (v) less tangibly, the historic tradition and cultural attachment to the cockle sector in south Wales. Notwithstanding this inertia, there is evidence of progressive decline of primary processing. DANI has essentially mothballed it cooking plant in Penclawdd and its manager (and original owner) is exploring other diversification options including production of nori-style dry-seaweed snacks building on laverbread traditions. Other respondents in the processing sector also expressed exasperation and fatigue in what they felt was a continued effort to support gatherers by purchasing under-sized cockle.

The number of licensed gatherers currently fixed at 36 by NRW decreased from a peak of 67 prior to the mortality. The waiting list for licences (now closed for new applications) has also declined from 155 in 2005 to 89 in 2014. The waiting list system also elevates the mean age of gathers is high, most are between 40-60 years of age, some above retirement age. Our analysis points to declining gathering effort, less than one third of licensees regularly gather close to their quota limits and all gatherers augment gathering income with other part or full-time employment (Section 6.5). Some gatherers continue renewing their licences (costing £648 per year) in the hope of one day receiving compensation from the Welsh Government for loss of earnings. Although investigations into mortality causes have been unable to determine the relative influence of a range of putative causes (doubt even remains regarding causes and effects), one group of gatherers are pursuing a claim based on alleged infringement of EU environmental and public health legislation linked to sewage spills and their correlation with mortality episodes.

7.2 FUTURE SCENARIOS AND RECOMMNEDATIONS ON MANAGEMENT OF THE FISHERY

Any management recommendation is complicated by ongoing uncertainty regarding mortality cause and its future incidence on the BI and TR. Available BI records going back to 1931 (Section 5.2) reveal several 3-4yr lean production year series in the past. However none have endured anywhere near as long the current episodes on the BI and TR, nor have any atypical mortality episodes observed on other UK fisheries (Section 3.4.3). The problem has parallels with the emergence of other multi-factorial mortality syndromes affecting other species e.g. the early mortality syndrome (EMS; aka Acute hepatopancreatic necrosis disease) epizootic affecting farmed shrimp stocks around the world and colony collapse disorder (CCD) resulting from abrupt

mortality of worker bees from honey bee colonies. Hopes that the cockle mortality problem was abating following a good BI production year in 2012 now seem premature, although the acute mass mortalities of the early 2000's do seem to have been replaced by more chronic trends. In the worst-case scenario the fisheries may have passed an ecological threshold (or 'tipping-point') and the ecosystem may no longer be able to return to its previous state. If the change is reversible, the return path from altered to original state may also hold considerable uncertainty.

Without progressive improvement and left entirely to market forces, it is difficult to envisage long-term sustainability of the BI primary-processing plants as economically viable elements of vertically integrated companies taking a much more global supply outlook. This may lead to a revival of smaller owner-operated cooking plants. As in the past these would be likely serve the local market, now much more limited. Assuming quality criteria could be met these operations might also continue to supply raw material for local secondary processing i.e. by Parson's Pickles. This company appears to have a firmer economic footing than the primary processors due to its more diversified product range and lower transport costs for higher-value, lower volume externally sourced raw materials. Following the running down of production at the DANI 'Selwyn's Penclawdd Seafood' plant in Crofty, one such small-scale, family-run entity has already attracted a small number of local gatherers. It is unlikely that there will be demand for the small BI cockle from external primary processors sited close to other important commercial cockle fisheries, therefore in the short-term Selwyn's withdrawal from primary processing may create a near-monopoly situation with potential to create further downward pressure on first-sale price and value.

The loss situation has also effectively frozen the BI licence charge at pre-mortality levels. This fee provides a modest but direct contribution to NRW (grantee for the BI regulating order to 2025) regulatory costs including salary for a full-time cockle officer, stock assessment and monitoring, enforcement and stakeholder consultation costs. Currently NRW can earn up to £24,624 per year from BI licence returns assuming successful receipt of £648 per year for 36 licences, just over a third of the total of £68,900[34] payable by the 53 licensees on the Dee Estuary. Even factoring in additional tax revenue generated along the value-chain for BI cockle, it is highly probable that at current production levels, management of the fishery under Regulating Order entails significant state cross-subsidy.

This also raises the question of whether or not the Three Rivers cockle fishery should be brought under regulating order (RO). Historic records (Section 5.2) point to marked production improvement after the Dee fishery was brought under regulating order in 2008, both in terms of its overall economic output and the production consistency necessary to provision sustainable livelihoods. The Three Rivers permit-based management system which brings sporadic benefits to many casual entrants arguably serves more of a social than a stock management or economic-optimisation function i.e. in mitigating conflicts between multiple resource users likely to prevail under lighter-touch or open-access regulation. If an RO was introduced under

[34] 53 full licensees each paying £1300 per licence per year

the prevailing mortality conditions, then a limited number of licensed gathers would also have to be permitted to take a proportion of their quota as 'undersized' cockle as on the BI to ensure sufficient consistency of output. Assuming mortality levels decreased, consistent and increased output from a regulated TR could also provide critical mass along with the BI to retain significant primary processing investment.

The co-location of the BI and TR could to some extent minimise additional regulatory costs assuming responsibility for the RO was also transferred to NRW. However the geography of the TR with its much longer coastline per unit area of cockle bed compared to the BI (with only six defined access points for gatherers) would also present a much greater enforcement challenge along with additional associated costs. This could be addressed to some extent by inclusion of a closed season as is applied on the Dee Estuary. A similar standardised cost-saving transition should also be considered for the BI fishery. Most effort is already concentrated between May to October with gatherers being more dependent on other income-sources during winter months. Similarly, processors have already diversified supply options and both primary and secondary businesses are increasingly freezing raw materials to even-out supply shortages. Formal closed seasons may also bring environmental benefits i.e. allowing stock recovery and minimisation of disturbance to wild bird populations.

Given the many uncertainties in the first instance a limited 'RO feasibility trial' could be conducted on one of the more productive and observable TR cockle beds. Such change would obviously require extensive consultation; however there is evidence of local support; an interest group; the Three Rivers Estuary Action Group (TREAG) recently lobbied for an RO (APPENDIX 5).

Consistent with an ecosystem management approach, regulation of both fisheries also entails environmental as well as social and economic objectives, further complicating any cost-benefit analysis. Such assessments, which would require application of contingent valuation methods to monetize social and environmental value of these functions to different interest groups is beyond the scope of this report. It is clear however that on-going improvement in the management of sewage treatment and effluent disposal should continue to take high priority. Not to do so risks incurring sizeable financial penalties for breach of EU environmental and public health directives. Improved management may also contribute to upgrading of the *E. coli* classification of the BI and TR cockle fisheries thus supporting direct-marketing of high-value whole-live cockle by gathers (elevated *E. coli* concentrations have also been linked to spring-tide inundation of Llanrhidian salt-marsh sheep grazing on the south BI shore). Gatherers have correlated more serious sewage spill events with acute mortality episodes though whether, and to what extent sewage effluents are contributing to on-going chronic mortalities is highly contentious. It should be noted that improved sewage management may also reduce nutrient inputs that were likely to have contributed to the pre-mortality productivity of the cockle fishery.

Exactly what resources the Welsh Government choose to devote to the fishery in future will also be shaped by political factors, including trade-offs between on-going public expenditure cutting and the iconic and cultural value of these historic cockle fisheries to south Wales.

Llanelli, the most populous area adjacent to the BI and TR fisheries, has transitioned from heavy industry to a largely service economy over the last four decades. Although recent regeneration programmes have contributed to high employment, youth unemployment remains relatively high, many jobs are based on temporary contracts and wage levels generally low (Section 6.6). Despite the need for more substantive youth employment options, the current BI licence waiting list system prevents any chance of access to younger would-be participants. Even with an aging workforce, at the current replacement rate it would take decades for those at the bottom of the 89-strong list to gain a licence. The current system can also create resentment and division as those on the list feel they are losing rightful entitlement when quotas are increased in good years, whilst gatherers feel this is pay off for lean years.

We therefore recommend that the waiting list continue to be closed to new entrants with a view to finally closing it entirely. A replacement lottery-based system would also see applications weighted against socially desirable criteria. This could incorporate a mentoring system whereby existing licensees are incentivised to support younger new entrants. Under current provisions waiting list applicants are granted temporary fishing rights when cockle stocks are exceptionally high; the TR temporary permit-system could be applied under such conditions ensuring some equity of benefit to the wider community.

These observations point to persistent knowledge gaps regarding mortality causes and effects. In light of this it is recommended that NRW and local business could look to form/be part of a consortium, with industry and academic collaboration taking integrated approach to the shellfish mortality causes, environmental, social and economic impacts; for example under the EU Horizon 2020 program.

Currently the BI (and Dee) cockle fisheries are MSC certified i.e. under an independent, third-party audited sustainability benchmark. NRW bears the burden of future audit costs currently totalling £3,000 to £5,000 per year (WGFU 2014, Appendix 5). However as a commodity business to consumer label the primary role of the certification is to support market penetration through increased sales (and ideally product premium) particularly in the retail sector. An additional charge is imposed by the MSC to use the label on packaging or for promotion. No evidence was found of any retail product ever having borne this label, bringing the rational for on-going certification into question. We therefore recommend a full cost-benefit review for continuing the MSC certification of the BI fishery[35], including an appraisal of whether there are opportunities, perhaps through increased support for marketing, for certification to provide more tangible benefits to the gatherers and other stakeholders in the supply chain. In addition to identifying future marketing potential, other possible benefits of certification to consider include; i) the contribution of useful (and cost effective) additional information with regard to stock assessment and defined management outcomes from MSC audits, and ii) improved credibility and reputation of regional public-sector environmental management efforts from independent third party auditing.

[35] NRW have since informed us that a review is already underway and that unless external funding can be sourced it is likely that NRW funding of MSC certification for both the BI and Dee cockle fisheries will be discontinued.

Finally normalised economic comparisons between sites and years are complicated by lack of size-specific harvest and price data. Assuming costs are not prohibitive, it is recommended that further effort be made to gather such data which could also be of value to stock assessments. As gatherers are paid 'on-grade' it may be that such information is most readily collectable from primary processors responsible for grading.

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APPENDIX 2: GEOGRAPHY OF THE BURRY INLET AND THREE RIVERS

THE BURRY INLET (BI)

The Burry Inlet also known as the Loughor Estuary is located to the east of Carmarthen Bay, between Llanelli town and Swansea city (Figure 26). Its more urbanised northern-shore centred on Llanelli is part of south Carmarthenshire coast. The northern Gower Peninsula with the largest continuous area of saltmarsh in Wales (inundated only by spring tides) forms its southern coast (Plates 22 and 23). East to west it extends over 20km inland from Pontarddulais to Burry Port/ Whiteford point, is 5km at its widest point near Llanelli and covers an area of around 6,628ha (45km^2) most of which is inter-tidal. The estuarine complex has sandy inter-tidal sediments interspersed with more muddy sediments in more sheltered areas, a macro-tidal range exceeding 8m and is almost fully exposed at low-tide. These conditions providing ideal conditions for cockle-harvesting in what has traditionally been the largest such fishery in Wales.

Figure 24: The Burry Inlet and Three Rivers Estuaries
(Map Source: Google Maps 2014)

The Burry Inlet has a catchment of about 470ha. The Loughor is its largest river with a sub- catchment of 262 km^2. Its major tributaries include the Dulais, Morlais, Lliw and Llan; the last two converge near the town of Loughor in the south west below the tidal limit. Originating in the Black mountains the Loughor and its tributaries are more surface than ground-water fed and thus flows are highly responsive to rainfall conditions (EA 2007).

The estuary takes its more recognised name from the small Burry River which enters the estuary on the southern Gower coast close its mouth[36]. The narrow '*Upper Estuary*' extends from tidal limit at Pontarddulais to Loughor Bridge, whilst most cockling activity takes place in two progressively widening downstream sections; the '*Loughor Estuary*' extending from Loughor Bridge to an axis between Morfa and Salthouse Point, finally the main '*Bury Inlet*' extends to the seaward limit between Burry Port and Whitford point. We distinguish the entire estuarine complex as the Burry Estuary, from the Burry Inlet (BI) which incorporates over 80% of the entire estuary area and most of its cockle-beds (Figure 27).

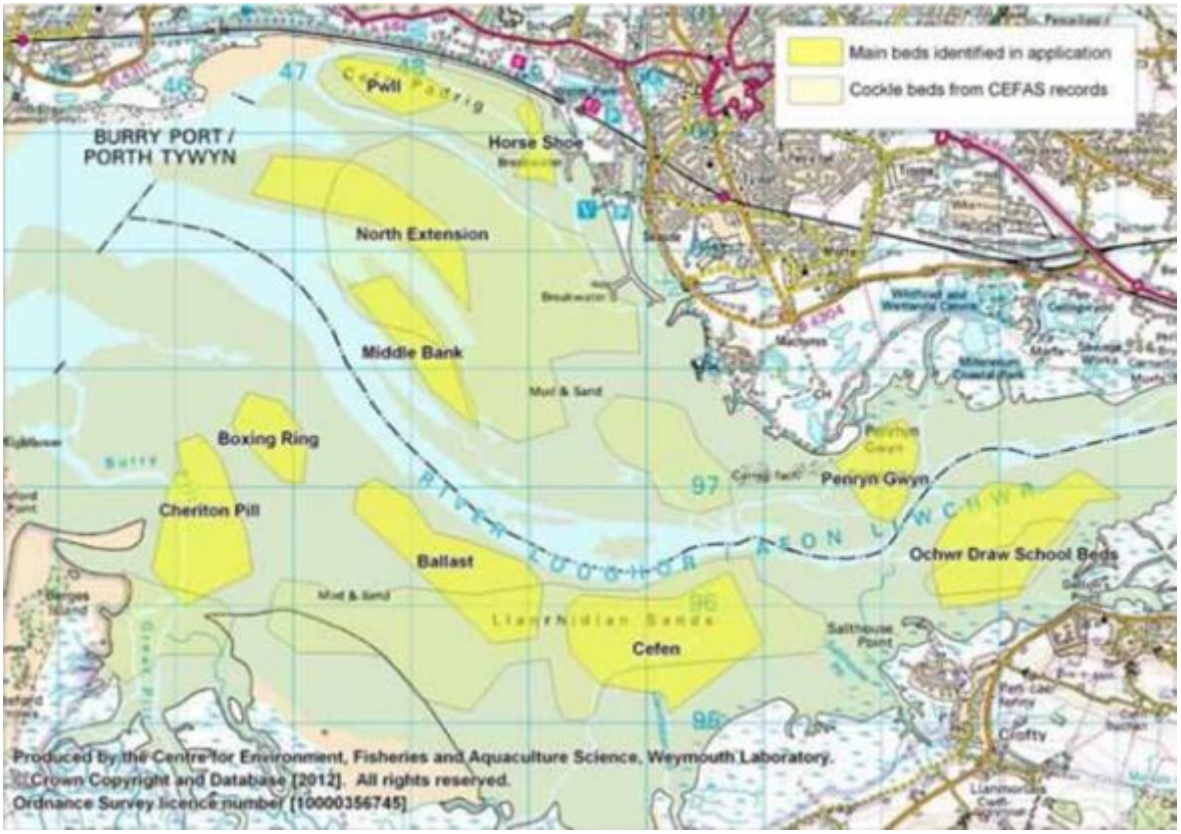


Figure 25: Principal commercial cockle beds in the Burry Inlet

Note: 2008 beds in light green and 2012 beds in yellow (Source: CEFAS 2012)

[36] http://en.wikipedia.org/wiki/River_Loughor

Plate 22: Llanhridian Salt Marsh vista

Plate 23: Llanhridian Salt Marsh entrance

THE THREE RIVERS (TR):

A second, smaller and unlike the Burry Inlet still an un-regulated cockle fishery (Appendix 5) is located some 10km NE of the Burry Inlet in the confluent 'Three-Rivers' estuaries of the Gwendraeth, Tywi and Taf Rivers (Figure 26). The principle beds named after adjacent settlements are Ferryside, Llansteffan and Laugharne St Ishmaels (Figure 28). Historically, these beds have tended of temporary and unstable nature in marked contrast to the relatively stable beds of Burry Inlet. The highly episodic nature of formal permit-based cockle gathering activity also results occasional windfalls for large numbers of entrants rather sustainable livelihoods for the few.

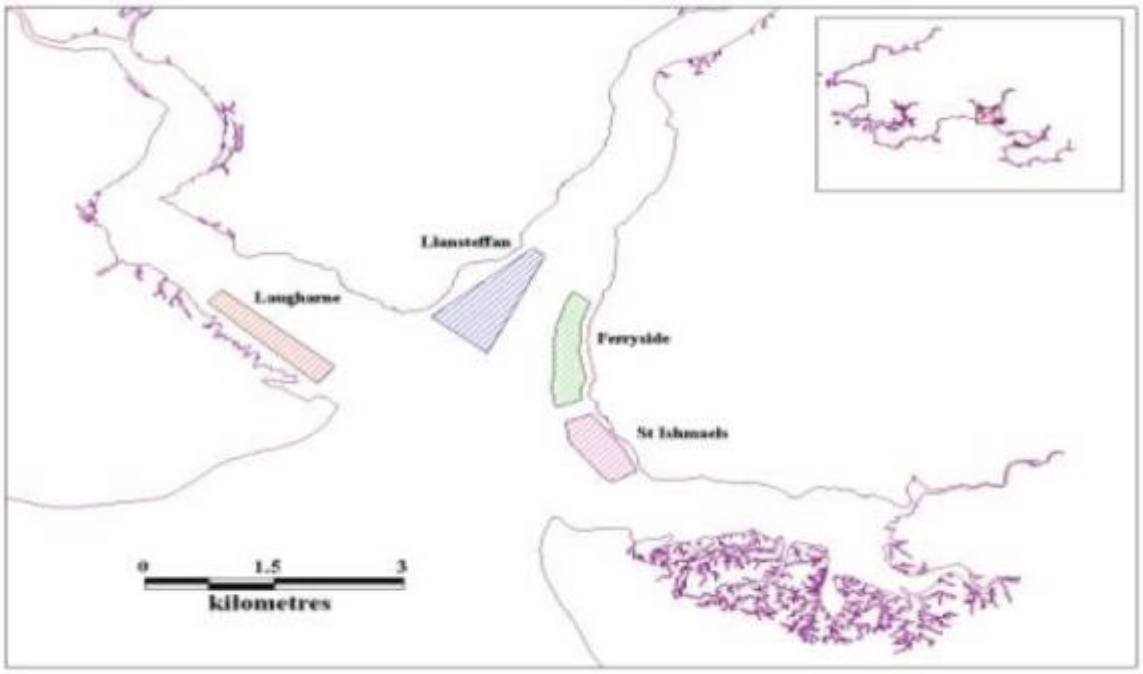


Figure 26: Cockle beds in the Three-Rivers Estuary
(Source SWSFC 2005)

APPENDIX 3: ENVIRONMENTAL DESIGNATIONS AND POLLUTION

ENVIRONMENTAL DESIGNATIONS

Environmental considerations are key factors in the management of the BI and TR fisheries both of which are highly protected under national and EU statutes. The BI estuary, including the cockle beds is an important habitat for migratory birds and is designated as a Site of Special Scientific Interest (SSSI) and an EU Special Protection Area (SPA) under the EC Birds Directive. It is a candidate Special Area of Conservation (cSAC) under the EC Habitats Directive and a Ramsar Site under the Ramsar International Convention on Wetlands. The estuary will be included in the European Natura 2000 network as an SPA and SAC site. Surrounding the site are the Pembrey Coast SSSI, Llandimore Marsh SSSI and Whiteford Burrows National Nature Reserve (NNR).

The Three Rivers estuary lies within the Carmarthen Bay and Estuaries Special Area of Conservation (SAC: EC Habitats Directive (92/43/EEC) and also includes areas designated as Sites of Special Scientific Interest (SSSI: Wildlife and Countryside Act 1981).

LAND USE AND POLLUTION

Whilst land-use along the southern-shore remains predominantly agricultural, the north-shore of the estuary was the site of heavy industry (steel, copper and tin and coal mining) during the 19th and 20th centuries resulting in heavy land and water contamination from multiple sources. Following the closure of Llanelli Dock in 1952 industrial manufacturing declined rapidly with reclaimed and remediated water front sites being replaced by housing and service industries (tourism and leisure). Today only Trostre Corus tinplating works (which retains discharge consents), remains as a reminder of the areas industrial past.

More recent water quality concerns have been associated with the performance of sewage treatments systems servicing growing populations to the north and west of the estuary. Prior to 1997 Llanelli was serviced by four wastewater treatment works (WWTW) offering only primary treatment (screening and settlement). Treated sewage and sludge was then discharged to the Burry Inlet at four outfalls between Burry Port (Plate 25) and Bynea. In response to three EU-directives (i.e. The Urban Waste Waters Treatment Directive (UWWTD), The Bathing waters Directive (BWD) and the Shellfish Waters Directive (SWD), Dwr Cymru Welsh Water (DCWW) commissioned a new treatment works at Llanelli in 1997 with primary, secondary (activated sludge and denitrification) and tertiary (UV disinfection) treatment capability. The four former treatment works were converted to pumping stations to send effluent from the previously separate catchments to the new plant discharging fully treated effluent to the north-shore. Progressive improvements (variously secondary treatment efficiency upgrading, denitrification, phosphate removal and UV treatment) have also been made to Gowerton, Llannant and Garnswllt WWTW servicing three other sewage catchments draining into the estuary. In addition to continuous discharges of treated sewage from these plants, more serious intermittent untreated discharges are associated with their operation as combined sewage overflow systems (CSO) – i.e. they designed to treat combined sewage and surface water flows whilst preventing flooding through discharge of excess water during wet weather and storm events (via short residence storm tanks) directly to the estuary.

Despite DCWW investment of over £50million in progressive improvements since 1995 (and long-term plans to separate surface-water), the ongoing frequency of overflows from the Llanelli and Gowerton systems in particular have given rise to much public concern. In 2005 'catastrophic failures' (including a burst distribution pipe) contributed to 111 overflow events from the Llanelli works. In 2007 a similar number was reported from the Llanelli works, 118 from one of the Llanelli pumping station and 115 from the Gowerton works (EA 2009). Overflow events have been associated, as yet circumstantially with cockle mortalities and claims for loss of earnings compensation by licensed cockle-gatherers.

Plate 24: Ferryside secondary sewage treatment works, Three-Rivers Estuary

Plate 25: Combined sewage outfall (CSO) at Burry Port, Burry Inlet

(Source: consultant October 2014)

APPENDIX 4: MECHANISATION AND INTENSIFICATION TRENDS

Attempts to intensify harvesting through use of dredging vessels using hydraulic suction at high tide as practiced in the larger Thames (with around 70 square miles of beds), Wash and Dutch fisheries, or tractor dredging (Dutch fisheries) have been resisted in the Burry Inlet and other Welsh Cockle fisheries including the Three Rivers and Dee. These methods are highly efficient in terms of labour productivity and have thus contributed to industry consolidation of cockle-sector around the Thames and Wash. Today commercial access to both these fisheries is limited to a small number of highly productive dredge-vessels licensed under regulating orders. Fourteen such vessels work the Thames, the most productive UK cockle fishery (Section 5.2) each capable of landing over 8t per day. The boats and their licences have been acquired by two foreign owned vertically integrated production, processing and export companies, one dominating production on the Thames and the other the Wash Fishery (Appendix 7).

Despite its commercial efficiency, dredge fishing is less selective and can incur higher mortality and wastage rates compared to hand-gathering methods. A mortality rate of 10% per pass associated with the suction sieving process is considered good, whilst greater cumulative losses result from multiple passes over a bed where zonal management is poorly coordinated. Tractor dredging is used in NW England and has been experimented with on the Burry Inlet (SWFSC 2005). The tractor-dredge, which employs a shallow towed-blade and a drum sieve (sieved product falls between wheels), can be operated more systematically than a boat dredge. This efficiency makes the practice economically viable even at cockle densities as low as 1/m2 compared to at least 10-20/m2 for hand dredging.[37] However this very efficiency and potential for compaction of the sub-stratum has resulted in the method being banned in most fisheries including the BI and Three Rivers. The higher mortality levels associated with both techniques also represents a greater economic and environmental challenge for smaller fisheries such as the Burry Inlet (with only around 4 square miles of cockle beds).

A simple piece of equipment known as a 'jumbo' a flat board with handles used tamp and liquefy sand to bring cockles to the surface is still permitted in the Dee, though use of the traditional 'Llanelli hand-dredge' (Appendix 4) was discontinued on the Burry Inlet in 1969 as a consequence of damage caused to young cockles when operated on dry-sand. The dredge consisted of a toothed 'dis-lodger' blade positioned ahead of mesh riddle box; operating by dragging with side-to-side movements, (Plate 26).

[37] One gatherer interviewed suggested a minimum of 300-400 cockles/m2 was need to make a good profit at prevailing price of £400/t for Burry Inlet cockle in 2014.

Plate 26: Male-cockle gatherer operating a hand dredge on the Burry Inlet in the 1960's

(Source: Franklin 1972)

In the BI, TR and Dee use of four-wheel drive vehicles and boats are permitted to access beds and for collection of bagged cockle from the sands (foreshore) and larger catches may be transferred to tractors closer to the shore (backshore).

APPENDIX 5: GOVERNANCE

As natural fisheries both the Burry Inlet (BI) hand the Three Rivers (TR) are public-goods with common property characteristic that prescribe management options. Common property can be divided into common pool (CPR) and open access resources (OAR: Ostrom 1990, 1993). CPR have attributes that lend themselves to more local community management in terms of size, informal social access norms/ rules and linked ability to prevent free-riding and guarantee economic (or social) returns to individual effort. Conversely combinations of increasing resource size/ area, erratic rewards to individual effort and lack of informal norms open OARs to all entrants with greater risk of resource depletion. Whilst both the BI and TR have some historical CPR attributes (e.g. such as the ability of riparian family-based group to defend rights to particular beds) they are both essentially OARs necessitating varying degrees of co-management support from external government agencies to regulate exploitation of their fisheries in a sustainable manner.

STATUTORY GOVERNANCE

Sea Fisheries Committees were first established over 100years ago to regulate inshore fisheries. Funded by local authorities they are responsible for policing their own local by-laws as well as national and latterly EU regulations. The South Wales Sea Fisheries Committee (SWSFC) often referred to as 'The Cockle Committee' (despite its range of responsibilities) was one of 12 such regional regulatory committees in Britain and was the local management authority for the Burry Inlet up to 1 April 2010 at which point its functions and those of the NWSFC were transferred to the Welsh Government. In 2012 NRW took over as grantee of the Burry Inlet Regulating Order (Appendix 5).

The Welsh Government, Marine and Fisheries Division (WG-MFD) has retained responsibility for all none-regulated shellfish fisheries including the Three Rivers.

- **Regulating orders**

The Burry Inlet Regulating Order: In 1965 The SWSFC was granted the Burry Inlet Cockle Fishery Regulating Order by the Welsh Government under the Seafish Industry Act 1868. This licensing scheme was designed to regulate the quantity of cockles taken by limiting the number of gatherers within the area limits shown in Figure 29 and to make gathering a more economically sustainable form of employment for this restricted number of operators. Rules were more fully codified in an amended national statute; Section 1 of the Sea Fisheries (Shellfish) Act 1967. In addition under local by-laws, the SWSFC also had power to set daily quotas, cockle size-limits, fishing zones, times, methods and manage conflicts with other resource-users.

The grantees costs for management, enforcement and fishery improvement are (partially) covered by an annual licence fee payable by the licensees. The fee has remained relatively static during the mortality era, rising from £648 in 2005 to £684 in 2014/15.

Landings must be collected in sacks bearing licence number tags (Plate 27) and details of all catches recorded in a registration book (Plate 28) or 'movement document' that also functions as part of a traceability system. For each landing one of a set of 5 carbon sheets is collected by district health inspectors, one by NRW, one is retained by the primary processor purchasing the consignment and one is retained by the gatherers.

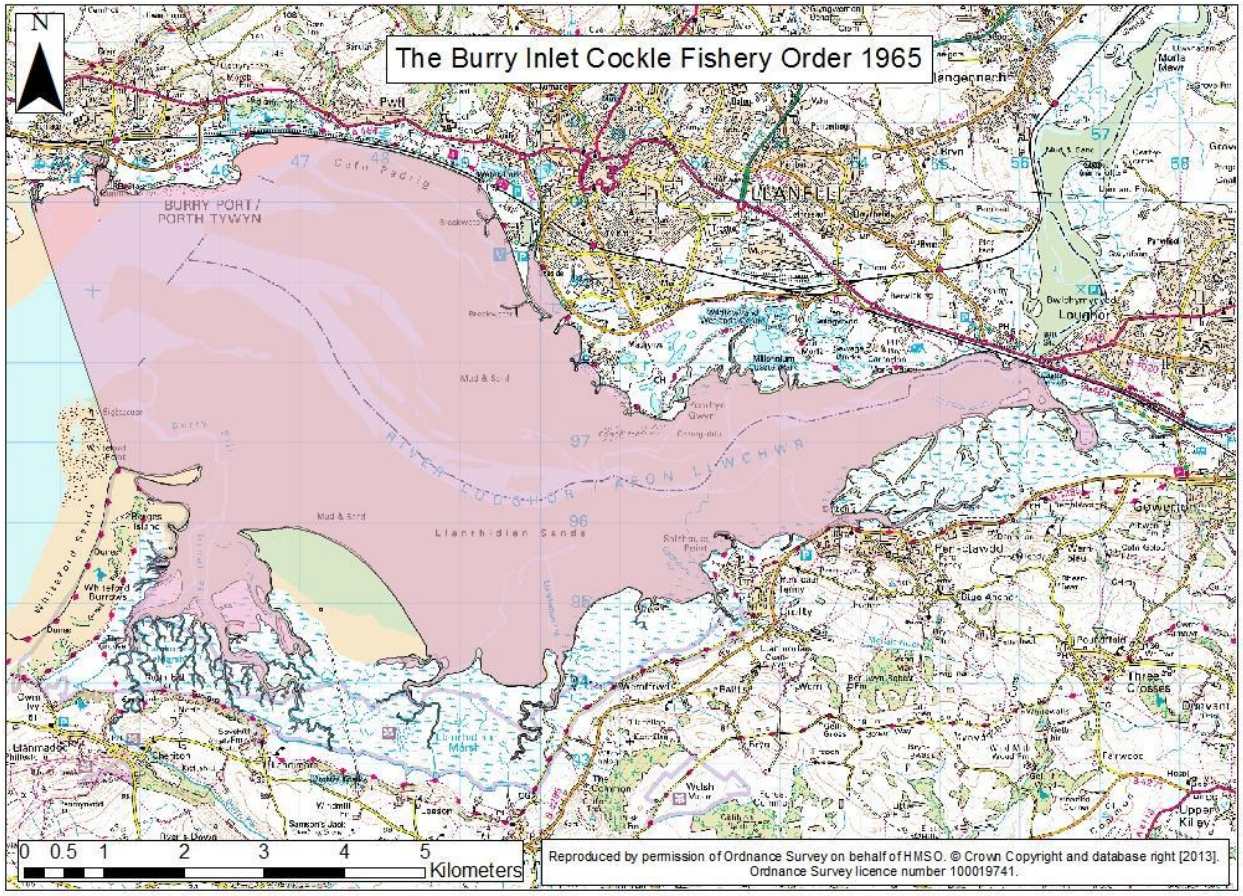


Figure 27: Map showing area covered by the Burry Inlet Cockle Order (4,247 Ha below MHWS) (Source NRW 2013b)

Commencing in January 1966, a total of 50 licences were issued to those who could demonstrate a track record in industry. The number has since fluctuated between 35 and 67 (Section 6.4) and the current NRW 5 year management plan (2013-2017: NRW 2013b) aims to fix the number at 36. Licences are provisional for the first 36months becoming 'confirmed' as permanent thereafter. Depending on the status of stocks, temporary revocable licenses may also be issued, usually in summer, to would-be gatherers on waiting list. The number on the waiting list stood at 133 in 2000. Non-licensed collection of up to 8kg of cockles per day for personal use is also allowed in designated areas out with the commercial beds. The Burry Inlet Order was originally granted for 50 years i.e. becoming due for renewal in 2015. However, with effect from 1 April 2013, Natural Resources Wales (NRW) assumed responsibility for the Order and regulation of the fishery until 15 June 2025.

Plate 27: Gatherer licence number tags on harvest bags

Plate 28: Bivalve catch registration document

(Source Consultant Oct 2014)

Other Regulating Orders: Wales only other cockle regulating order was established in 2008 on the Dee Estuary fishery, this time for a period of 20 years. Following the 2009 demise of the 'fishery committee' system (i.e. the SWFSC and NWFSC38), the Welsh Environment Agency, formerly the National Rivers Authority (NRA) was named as the grantee in 2010 based on its historic management role for this cross-border resource. At the same time, the Welsh Government (Marine and Fisheries Division) became responsible for management of the Burry Inlet. However as it could not credibly be both the grant-giver and grantee, from 2012 the Environment Agency, subsequently rebranded as the Natural Resources Wales (NRW), became grantee for bother regulated fisheries i.e. the Burry Inlet as well as the Dee.

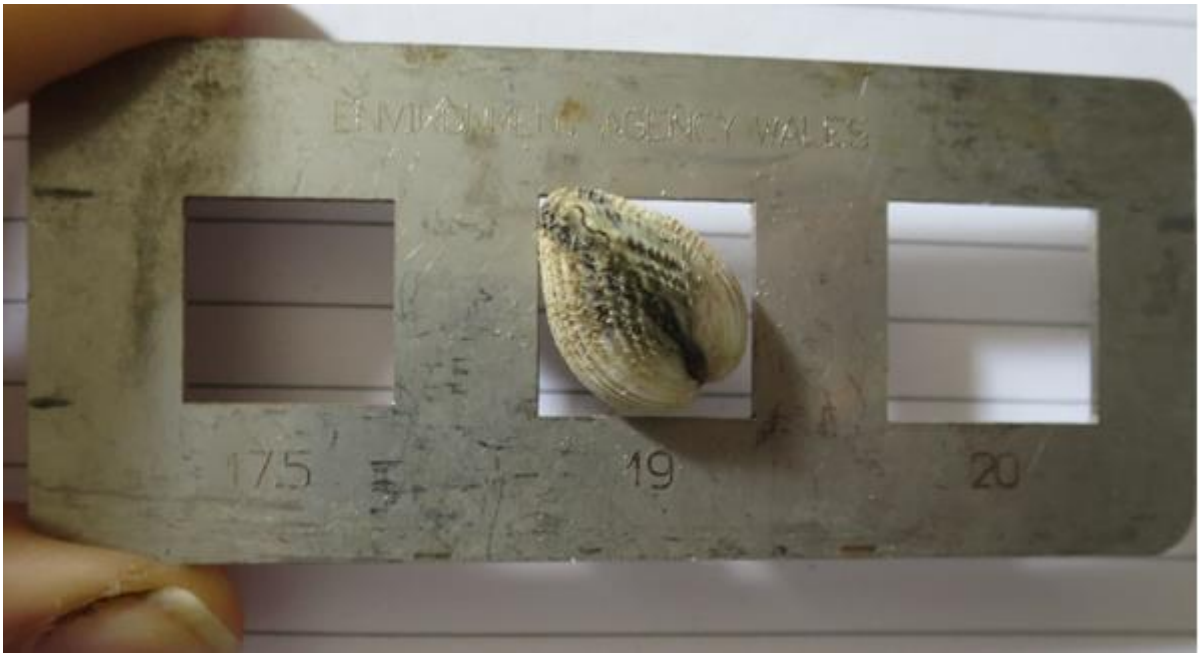
Although both the Burry Inlet and Dee have similar numbers of (around 50) licensees under their regulating order, they differ in terms of their opening (the Dee for 6 months from June to Nov and the BI for 12months) and Minimum Legal Size (in normal years); 19mm and 21mm square[39] respectively (Plate 29) due to different local by-laws[40]. It was the opinion of one key informant these differences were more a consequence of their governance histories than any fundamental difference between resource conditions.

[38] The by-laws implemented by the SWSFC & NWSFC Byelaws were 'conserved' by the Marine and Coastal Access Act 2009 (MACAA 2009) www.legislation.gov.uk/ukpga/2009/23/contents

[39] In the UK, for statutory purposes shell-on cockle size is measured as 'square' width, being the minimum square aperture on a standard gauge (Plate 29) that the shell can pass through. This contrasts with practice in continental Europe where the longest-cross-sectional shell diameter is typically referenced (Section 5.4).

[40] The minimum size limit has been removed entirely from the Bury Inlet since shortly after the onset of mass mortalities.

Plate 29: Environment Agency (now NRW) cockle size gauge



(Photo Consultant, courtesy of Rob Griffiths)

The Wash and Thames cockle fisheries in England were granted regulating orders in 1992 and 1994 respectively. They are currently under management of two regional Inshore Fisheries and Conservation Authorities (IFCAs) successors of the fisheries committees as grantees in England.

- **None Regulated Fisheries**

The WG-MFD (and NRW) control annual landings of fisheries under their jurisdiction through local by-laws 'inherited' from the SWFSC. These include the ability to set daily quotas and zonal open or closed season fishery days/ seasons linked to stock assessments rules. Fisheries are closed when the total allowable catch (TAC) is filled based on on-going monitoring of landings and cockle sizes by fishery officers.

The Three Rivers: In the past periodic 'windfall' harvests on the Three Rivers attracted gathers from far and wide resulting in 'cockle wars' between rival local and immigrant cockle gangs in 1993 (similar in nature to those underlying the Morecambe bay disaster in 2004). To deter a recurrence and to increase accountability through enhanced collection of tax revenues on landings a permit system was introduced in 1998. Permits are available to all free of charge on presentation of formal identification, a National Insurance number and a photograph and this also the basis for recording catch return from named individuals using the return form shown in Figure 30. Conflicts with local landowners have also been addressed through re-enforcement of their rights to restrict vehicular access across their lands. To relieve congestion fishing is also rotated between beds and days including Sundays (e.g. Laugharne is open at weekends when there is no firing on and adjacent MoD range). Never-the-less there remains tremendous pressure placed on the regulator to open the fishery as soon as stocks appear adequate. 'D-day' for the last major fishery in 2010 attracted over 2000 participants – events equally dreaded by many locals due to the history of past disputes.

WELSH GOVERNMENT INSHORE FIHSERIES UNIT - COCKLE CATCH RETURN FORM FOR THE THREE RIVERS – 2012/2013

Name: _____ **Address:** _____

Date of Birth _____ **NI Number:** _____ **Signature:** _____

MONTH:				MONTH:				MONTH:				MONTH			
Day	Taf	Twyi	Gwendraeth	Day	Taf	Twyi	Gwendraeth	Day	Taf	Twyi	Gwendraeth	Day	Taf	Twyi	Gwendraeth
1				1				1				1			
2				2				2				2			
3				3				3				3			
4				4				4				4			
5				5				5				5			
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29				29				29				29			
30				30				30				30			
31				31				31				31			

PLEASE NOTE: Condition B(iii) of Byelaw 47 – Full and true catch returns (including NIL returns) must be sent to the **Inshore Enforcement Team – South:** Llys y Ddraig, Penllergaer Business Park, Penllergaer, Swansea, SA4 9NX .Tel: 0300 790 4457 by **30th April of each year**. Failure to do so may mean that a permit will not be issued in future years) It may be advisable to send completed catch return forms by Recorded Delivery.

Taf – Laugharne/Llanybri / Tywi - Llansteffan/Ferryside / Gwendraeth – Cefn Sidan

Figure 28: Three Rivers cockle return form 2012/13

- **Regulated v permit-based management**

Table 14 compares the tools available to managers under these two systems on the Burry Inlet and Three Rivers Fisheries.

There are clear trade-offs between the two systems. Year-round co-management of the Burry Inlet imposes considerably more effort and cost (beyond the licence revenue and so ultimately on the public purse), but before the mortality era at least, the system provided a reliable source of livelihood to a limited number of licensed fishers. Rules are more enforceable; on the Burry Inlet, rules are enforced by license suspension or loss after three infringements and gatherers were themselves observed policing the beds against possible poaching.

The permit system may be more equitable but yields erratic windfalls, so many feet on the beds may increase mortality, fishers remain far less accountable and there is greater potential for conflicts between local communities and outsiders. Arguably this form of regulation serves as much as a form of social management/ crowd control as a stock management function - a questionable role for fisheries managers. A local body, the Three Rivers Estuary Action Group (TREAG) is lobbying the Welsh Government to grant a regulating order on the three rivers estuary (Misstear 2012a).

Table 15: Comparison pf management tools for Burry Inlet and Three Rivers

Management Measure	Burry Inlet - NRW	Three Rivers - WG (MFD)
Access	Restricted to 50-60 local licensees under regulating order Occasional access to 200 on a waiting list when stocks are good	Open access under a temporary permit system (>2000 issued in 2010)
Closed/ open seasons	12months per year – no night or Sunday fishing (and one tide per day)	Linked to stock assessment Staggered daily permits to 'ease congestion' and no night fishing
Total allowable quota (TAC)	Typically 250-300 kg/licence/day linked to stock assessment	Determined by duration of temporary permits
Minimum Landing Size (MLS)	19mm square (21mm diameter) to 2005 - MLS suspended thereafter (min size of 14-15mm determined by economic factors)	19mm square (21mm diameter)
Fishing methods	Hand gathering by rake and sieve only (no tamps or hand dredges)	Hand gathering by rake and sieve only (no tamps or hand dredges).
Transport	4-wheel drive & boat (tractors on backshore only) – via registered access points only	Vehicles on inter-tidal sands and backshore only with permission of land-owners
Enforcement	Random monitoring of takes at access points & processing plants via registration system by NRW enforcement officers	Random monitoring of takes by MFD officers

- **Stock Assessment**

From 1892 onwards the SWSFC commissioned CEFAS[41] to conduct stock assessment surveys on the BI in November of each year, and from 1996 an additional spring survey in May of each year to assess over-wintering mortalities. The surveys were based on counting and size-classing of cockles along random transects taken on both sides of the Loughor Estuary along with growth and mortality assessments using historic data. Results were then used to portion sustainable catch limits to each the licensees. Allocation was then based on a

[41] The Centre for Environment, Fisheries and Aquaculture Science; formally the Ministry of Agriculture Fisheries and Food (MAFF).

'rule of thirds'; each year permitting a total allowable catch (TAC) of one third of the estimated biomass of adult standing stock, leaving one third for the bird populations (including large numbers of dependent oyster-catchers) and the remaining third as broodstock. The system therefore predates similar input (gear) and output (quota) management approaches that form the central plank of the EU common fisheries policy.

Today NRW conduct their-own stock assessments using a more robust grid-based sample-frame covering the entire cockle bed area. Allocation by the crude rule-of-thirds (rule of thumb) has also been replaced my more refined predictive stock and bird population and foraging models.

Stocking levels are deemed to be critically low when individual quotas are set at or below 200kg for two or more consecutive months. In average to good pre-mortality years, quota typically ranged from 2,000t to 3,500t per year allocated amongst the different licence holders (subject to a minimum harvest of 100kg per day).

The Welsh Government Inshore Fisheries Unit (WG-IFU) is responsible for annual surveys on the Three Rivers.

- **Management planning:**

In 2008 the Welsh Government initiated consultation on an improved and more harmonised national cockle management regime with further consultation in 2010 eliciting 58 responses. It is anticipated that the outcomes forming part of the new Welsh Fisheries strategy currently being drafted will be in place for 2015 covering. In addition NRW is also developing its own improved management plan for the Burry Inlet.

- **Food Safety Regulation**

Although both the northern and southern shore cockle beds are directly managed by NRW, they are treated as two separate fisheries in accounting terms reflecting separate District administrative boundaries and reporting requirements e.g. with respect to public health oversight. Food safety risk assessment and product traceability are the prime responsibility of environmental health officers of the two local authorities i.e. Swansea and Carmarthenshire on the north and southern shores. Sampling of water and flesh samples are undertaken on a monthly basis and analysed by the Food Standards Agency FSA and CEFAS for *E. coli*, Phytotoxins and chemical contaminants. Based on *E. coli* thresholds beds are classified into one of three groups; A, B or C with increasingly rigorous post-harvest safety-processing requirements (an 85% annual compliance rate is required to maintain a rating in any class).

Counterintuitively perhaps given the greater urban concentration on the north-shore, the beds to the south (Class C) have performed consistently worse than the north-shore (Class B) over recent years (Figure 22). A theory proposed by NRW is that this a result of relatively high levels of sheep grazing activity in the salt marshes of the southern-shore (Thomas: Pers. Com.) – also consistent with detection of elevated E. coli concentrations during spring-tides when the marshes become inundated.

Cockles are also routinely tested for phytotoxins (linked to algal blooms in warmer months) that have been implicated in episodic food-poisoning outbreaks[42]. Commencing in 2001, routine positive testing for Diarrhetic Shellfish Poisoning (DSP) resulted in a sequence of long periodic closures of the Burry Inlet fishery totalling around 20 months over the next two years. This compounded the problems the gatherers already faced with the onset of mass mortalities and restricted ability to sell shellfish while stocks were still plentiful. Frustrations increased when it became apparent some closures may have arisen due to false-positive results. Analytical problems were revealed following differential testing outcomes by CEFAS and the Aberdeen Marine laboratory (Pers. Com. NRW and gatherers).

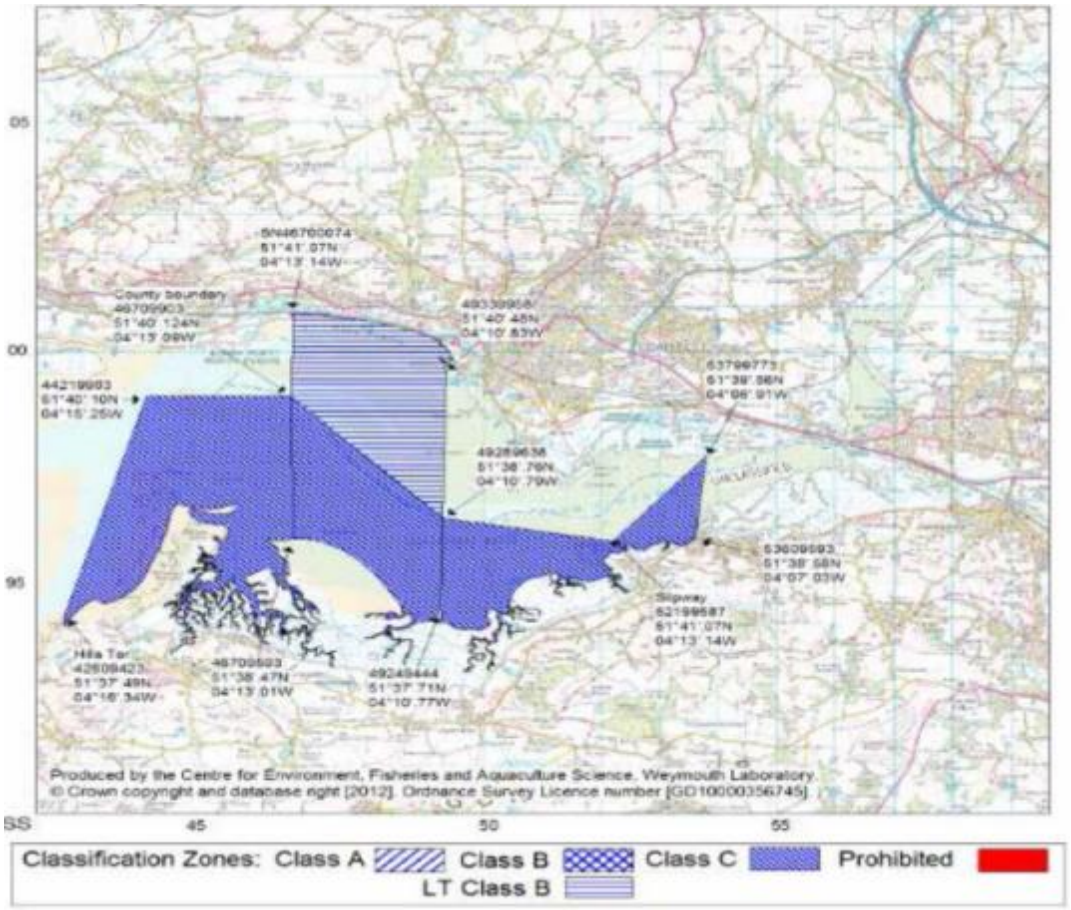

Figure 29: Burry Inlet shellfish classification zones

(Source: Beynon 2014. Notes: Class A – Harvestable for direct human consumption without any processing, Class B - Consumable only after re-laying in a class A area, depuration or heat treatment, Class C – Consumable after relaying for at least 2 months in an approved area, followed by depuration or heat treatment**)**

[42] Diarrhoeic Shellfish Poisoning (DSP) Amnesiac Shellfish Poisoning (ASP) and Paralytic Shellfish Poisoning (PSP)

MARKET BASED GOVERNANCE

Marine Stewardship Council (MSC) Certification: With support from the SWFSC the Burry Inlet Cockle fishery was the first bivalve mollusc fishery to receive MSC certification in April 2001[43] i.e. immediately prior to the first mass mortalities followed by the Dee fishery in July 2012. This conferred both fisheries with an independent, third-part audited sustainability benchmark, with the BI and Dee certified for an estimated production of 3,500t and 657t per year respectively (MSC 2012, 2013)

The Countryside Council for Wales (CCW) and WWF have also twice shared the costs of certifying the Burry Inlet MSC fishery (in April 2001 and February 2007) and after a lapse in certification, NRW has most recently taken on the burden of renewal costs (last in August 2013) with audit costs currently totalling £3,000 per year (WGFU 2014). The Welsh Assembly Government has sought to encourage replication of the model in its Environment Strategy for Wales and it' new Welsh Fisheries Strategy. The industry is also positive about the certification as a mechanism for complying with regulation orders.

However as a business to consumer label arguably the primary role of the certification is to support market penetration through increased sales and ideally product premiums, particularly in the supermarket retail sector. An additional charge is imposed by the MSC to use the label on packaging or for promotion. Unfortunately no evidence was found of any product ever having borne this label, bringing the rational for on-going certification into question.

[43] http://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/north-east-atlantic/copy_of_template-fishery-in-assessment

APPENDIX 6: BURRY INLET TIMELINE AND SOCIAL HISTORY

The timeline in Table 16 charts the development of the Burry Inlet and Three Rivers fisheries over the last 150 years, summarising the key events and the socio-economic evolution of the fishery described elsewhere in the report.

Table 16: Historic timeline of key events in the evolution of the Burry Inlet and Three Rivers fisheries

Date	Event
1862	Cockle fishery marked on Llanrhidian sands on Admiralty Chart
1885	Value of cockles and mussels from BI estimated at £15,000 per year (Davies)
1890	First management organisation Glamorgan Sea Fisheries Committee Established
1911	250 exclusively female gatherers in Penclawdd each collecting 60-150kg per day using donkeys to supplement income. An additional 150 female gatherers reported on the Ferryside and Llansaint on the Three Rivers Estuary (Bullstrode)
1912	GSFC merged with Milford Haven Sea Fisheries committee to form SWSFC
1921	SWSFC impose first MLS of ¾" (18.3mm square) to protect breeding stock – but shellfish for cooking still taken at 5/8" (15.4mm square)
1920's	Horse-drawn carts introduced – harvests up to 500kg/ gatherer/ per day
1953	MLS fixed at 11/16" (17.1mm square)
Mid 1950's	Use of motor vehicles on sands enable increased & indiscriminate daily catches
1957	New by-laws ban vehicles on Llhanridian sands, Sunday and night fishing
1959	MLS revised back to 18.3mm square following first stock survey by MAFF – subsequently fixed at 19mm with the introduction of the regulating order 1965
1963	Massive year-class spat-fall following severe 1962/63 winter
1965	Significant role of oyster catcher predation on second winter cockles identified
1965	SWSFC implement the BI Cockle Regulating Order licensing 50 gatherers in 1966
1967	Regulating Order formalised under the Sea Fisheries (Shellfish) Act 1967
1968	Record BI catch of over 7,000t in a sequence of above average years followed by lean years in the early to mid-1970's
1968/69	Dredge-fishery displaces hand gathering on the Thames Estuary (with Whitefish Authority – now Seafish - technical support).
1974	Main river channel migrates south removing cockle beds from Llanrhidian shore
1980's	Beds re-established; harvests stabilise between 1,700-2,700t over next 2 decades
1986	EU food safety legislation and associated 'Torry' processing rules and recommended cooking system drive progressive consolidation of formally 'cottage-based' processing activity
1987	Ban on 4-wheel drive vehicles removed – as daily quota in place
1989	Sea Empress oil spill on Cleddau Estuary nr. Milford Haven, closes Whitford Sands cockle beds at the mouth of the Burry Inlet
1990's	Increase in prices due to increased access to enlarged European markets and cockle shortages
1991	New European Shellfish Hygiene legislation contributes to processor consolidation

1992	The Wash Fishery Order (WFO) introduced – a hybrid several and regulating order
1994	The Thames Estuary Cockle Fishery Regulating Order introduced covering most of the fishery
2000	Burry Inlet becomes world first mollusc fishery to gain MSC certification (followed by River Dee in 2012)
2001	Burry Inlet 'one in a hundred' years cockle harvest (>7,000t) following heavy spat-falls in 1998 and 1999
2002	First mass cockle mortality observed on the Burry Inlet
2003 – 05	High mortality of settled spat followed by sever mortalities of 1 year classes in 2004 and 2005 – a pattern which has continued to recur with varying severity. Small amounts of ad hoc fishing occur thereafter
2001 – 03	Periodic (DSP) fishery closures following CEFAS detection of biotoxins in cockles[44]
2005	First mass cockle mortality observed on the Three Rivers (July 2005) – but still yields a record catch >8000t
2005	SWFSC reduces cockle size-threshold from 19 to 17.5mm on the Burry Inlet
2006	SWFSC permits fishing of same year cockle spat (13/14mm) first time in history
2006/7	Following the Morecambe Bay disaster, a Gangmaster Licensing Authority is established to protect casual labour in unregulated fisheries & other sectors.
2008	The Dee Estuary with its 5 beds becomes the second regulated cockle-fishery in Wales (gaining MSC certification and Blue Eco-Label status in 2012)
2010	Three Rivers: last formal harvest (>2000t)
2009/10	SWSFC abolished & BI management taken over by WG Inshore Fishery Unit
2012	Three Rivers fishery closed & bathing banned in after shellfish fail *E. coli* test
2012	Three Rivers fisheries closed from June due to low adult stock levels. The closure subsequently extended four times - currently to 1 March 2015
2012	Petition requesting public enquiry into sewage pollution in Carmarthen Bay submitted to Welsh Assembly
2012	NRW becomes grantee for the Burry Inlet Regulating Order (as well Dee fishery)

(Sources: Franklin 1972, CEFAS 2007, Elliot et al 2012 & others specified in text)

[44] Some Thames cockle beds also suffered closures for similar reasons in 2001 http://news.bbc.co.uk/1/hi/uk/1384716.stm

APPENDIX 7: THE BURRY INLET COCKLE PROCESSING VALUE CHAIN

Today all local processing operations serving the BI and TR fisheries are located on BI south shore (3 primary processing plants in Penclawdd) and north shores (secondary processing; one pickling plant in Burry Port where it relocated from Laugharne on the TR in 1995).

PRIMARY PROCESSING

- **Penclawdd Shellfish Processing Co. Ltd (PSP)**

PSP was first established in September 1992 as a cooperative venture with support of the Welsh Development Agency and Swansea City Council, by a group of 11 licenced gatherers belonging to 5 families with long employment-histories in the sector. This established a company of sufficient size to compete with the other surviving major family-business Selwyn's (below). Their state-of the art turn-key factory finally established in Crofty in 1995 had a capacity of10t/hr (Plates 30 and 31).

First PSP then Selwyn's soon began to attract external investment from large European seafood companies competing for supplies. In the case of PSP the interest came from the Dutch based company, Holland Shellfish Group which acquired 20.67% in the company, the largest single stake amongst 13 listed shareholders at the time[45]. This followed earlier acquisitions by the group of other small-family processors around the Burry Inlet in the early 1990's.

Holland Shellfish itself resulted from the merger and acquisition of Lenger Seafoods and other leading Dutch and foreign companies in the early 1990's. The Lenger family from Harlingen with over 80years industry experience had the lead role in the group reflected in the formal changing of the company name to Lenger Seafoods BV in 2008[46]. Today the company is headquartered in Yerseke, Holland. In 1995 the current MD of Parson's Pickles joined the PSP cooperative as a Director, also taking responsibility for UK purchasing for the Holland/Lenger group. The MD had formally been manager of a cockle processing factory on the Wirral also acquired by the same group and his experience also helped secure RDA grant-funding for the start up in 1995. The company received the Welsh Exporter of the Year Award in 1998. Another of the local licenced gathers in the PSP cooperative, belonging to one of the long established gathering families became production manager whilst the other shareholders progressively reduced their holdings; today the company which employs 7 staff[47] can no longer be considered to be a cooperative. The company had registered capital of £218,397.00 on 17 Oct 2013[48].

[45] https://www.check-business.co.uk/business/02750549/penclawdd-shellfish-processing-co-limited

[46] The ascendant company which had also been in fierce competition with the then dominant Severnside group in the 1960's and 70's also purchased the by then dormant company name for £10,000.
http://www.lengerseafoods.nl/site_uk/pdf/Persbericht%20HS-Lenger%20Seafoods%20FR%2001-09-08.pdf

[47] http://www.192.com/atoz/financial/business/02750549/

[48] https://www.companiesintheuk.co.uk/ltd/penclawdd-shellfish-processing-co

Plate 30: Penclawdd Shellfish Processing Co. Ltd site

Plate 31: Penclawdd Shellfish Processing Co. Ltd facility

- **Selwyn's Penclawdd Seafood Ltd (SPS)**

One of the largest traditional family owned processing businesses prior to the mortality era, Selwyn's was one of only two (along with the aforementioned cottage-business) to have survived the 1990's consolidation phase intact. With four generations and over 100 years of gathering and processing experience Selwyn's was established by the current manager's great grand-mother at the start of the 20th Century with her son amongst the first men to enter the business on a full-time basis (Kelsey 2012). Following early success in van-based retailing, in 1950 the company invested in construction of a processing plant in Swansea helping it become formally established as one of the more successful family run businesses on the Burry Inlet[49]. In 1996 under a new generation of family management (the current managers father), the company constructed a new (EU-approved) 460m^2 factory in Crofty (Plates 32-34). The factory which employed full-time and seasonal workers had a cooking capacity of 3.5t of cockles per hour. This allowed the company to expand into wholesale alongside their existing retail business (Section 4.4). Like traditional processors (and the other two contemporary processors), the factory was designed to produce both cockles and laverbread. From around 2000 the company was selling a significant share of its product to one of the leading European shellfish companies, multi-national DANI headquartered in Vilassar, Spain. After two years of negotiation, in 2003 DANI bought a controlling share of Selwyn's investing some £1million pounds with additional regional development agency investment support to further develop and upgrade the factory (inaugurated in 2004). The new plant had a design capacity of 10-12t/hr with an expectation of producing at least 6-7t/day over the main production season. Selwyn's family members continue to manage the operation.

[49] http://www.walesonline.co.uk/business/business-news/picking-cockles-burry-inlet-selling-2025456

Plate 32: Selwyn's Penclawdd Seafoods Ltd

Plate 33: Selwyn's new dried seaweed processing unit

Plate 34: Selwyn Seafood's MD

The acquisition of Selwyn's followed DANI's 2002 investment in its first UK cooking and canning factory in Boston Lincs, by the Wash (prior to which the company shipped locally cooked product back to Spain for canning and then on for sale in France and Spain). This strategy aimed to facilitate DANI's sourcing of raw materials from East and West coasts for canning and export. To secure cockle supply base in an increasingly competitive international market, DANI-UK also became progressively more vertically (as well as horizontally) integrated. The company has acquired 8 of the 14 highly productive dredging licences allocated for the Thames Fishery. Two processing businesses servicing the Wash Fishery, Cardium Shellfish Ltd. in Whitstable and Trevor Lineham Shellfish Ltd. in Boston, were also acquired in 2010 and 2011[50].

Ultimately, the timing of the Selwyn's acquisition right at the start of the mortality episode was less than fortuitous for DANI. Lack of reliable cost-effective local supply meant the factory never operated to capacity and it rapidly took on the role of an auxiliary back-up processing facility for the main Boston Plant. At most the factory employed 5 full-time staff. In recent years the factory has effectively become 'moth-balled'; one source suggested the last cooking took place two years ago and plant parts had since been exchanged for use elsewhere in the companies UK operation. Currently Selwyn's retains just two full-time staff; the purchasing director and an accountant, both servicing the wider DANI UK operation i.e. sourcing for the Boston factory.

The Selwyn family are currently establishing a separate production facility on the same site for production of Japanese/ Korean 'nori' style dried seaweed snacks as a diversification strategy (Plate 20), building on their laverbread traditions (Plate 17).

- **Other primary processing**

The cessation of processing by Selwyn's and poor export market for small cockle may have contributed to the revival of a third traditional family-owned small-scale plant in Crofty, owned and operated by a local family

[50] http://www.dani.es/en/company

(Geoff Tucker and his Son, both licensed gatherers, and Geoff's wife). The business survives by cooking small amounts of the smaller available cockles for a niche local retail market. The factory also uses batch steam cooking methods, resulting in greater processing losses than continuous boiling systems (Section 4.4) but affords greater flexibility in stopping and starting production contingent on raw material supply. In addition to cockle gathered by the owner and his son, the business has also started to take the harvests of three other licence holders.

One other shellfish processor based in the area, located in Burry Port specialises in depuration of mussels and whelks (but not cockles) for live export, predominantly to Spain.

- **Pontarddulais Cooperative**

Occasionally other merchants set up grading or distribution centres where the cockles are sent either to 'shell on' markets or for processing elsewhere. In the 1990's some of the BI gathers saw an opportunity for sales of live sales of larger cockle (min 24 mm square) via a local intermediary first to France followed by Spain. Prior to the mortality era, Burry Port with its highly productive fishery was one of the few places where such product could be obtained at this time of year; the fastest-growing and largest cockle being selectively harvested from the mouth of the estuary. One of the gatherers reported regularly sending 1 to 1.5t of such cockle per for export via Bristol Docks, product being hand loaded on to waiting transport at an intermediate motorway service station.

In order to supply this lucrative niche market for large live cockle on a firmer footing 17 Burry Inlet licensees started the now defunct 'Pontarddulais Cooperative' in an industrial estate in Pontarddulais 7 miles NW of Llanelli. The cooperative purchased a grader and began selling graded-cockle to a processor and distributor based in Liverpool (Kershaw's Quality Foods Ltd in Southport near Liverpool - now ceased trading). At their peak, the cooperative harvested and processed 22-23t of cockle every 2 days, earning an average of '£70 per bag' (£1,400/t) for larger grade (19mm or greater)[51]. The cooperative finally folded in 2008, six years after the onset mortalities. Once the minimum size rule was relaxed i.e. to 9-10mm riddle size and the average price fell to £400/t) the cooperative were forced to relinquish their industrial unit. Their grader still sits in the yard at Penclawdd Seafoods (Plate 35).

[51] For each 22t of cockle graded, around 0.5t of undersized 'spat' was returned back to the mud-flats.

Plate 35: Former Pontarddulais Cooperative cockle grader at Penclawdd Shellfish Processing Company Ltd

SECONDARY PROCESSING

Parsons Pickles – The only secondary cockle processing facility serving the Burry Inlet began life as the family-owned Leslie A. Parsons & Sons Limited, producing pickled products in its first base in Laugharne, the home of its founder from 1947[52] (the company still uses Laugharne Castle as its logo). The company became incorporated as a Private Limited Company when it moved to its current location in a converted textile mill in Burry port in 1955[53] (Plates 36 and 37). Today the factory employs 25 full-time staff producing pickled cockles, pickled mussels as well as smaller amounts of pickled vegetables (beetroot, onion and cabbage), eggs and laverbread. The factory operates to British Retail Consortium (BRC) Standards[54].

The factory effectively became a sister-company of PSP when was finally acquired by the current owners for around £750,000 in 2005. The company has three registered directors including the MD of Lenger Seafood BV[55]. One of the local Directors of PSP has responsibility of day to day operation of the company. Lenger also provides Parsons with access to diverse range of cockle supply i.e. not just from PSP, but also from its cooking factories serving the Wash (Lynne Shellfish Ltd) and Thames Fisheries (W.H. Osborne Ltd, Thameside Ltd) which it acquired from 1995 onwards.

[52] http://burry-port.cylex-uk.co.uk/company/l-a-parsons---sons--burry-port--ltd-16371846.html
[53] http://www.seafishdirectory.com/directory/2009/leslie-a-parsons-sons-burry-port-ltd/

[54] http://www.parsonspickles.co.uk/about/
[55] http://www.bizstats.co.uk/ltd/leslie-a-parsons-sons-limited-00552115/

Plate 36: Leslie A Parsons & Sons Ltd

Plate 37: Leslie Parsons & Sons Ltd processing facility

APPENDIX 8: COCKLE LANDINGS & POTENTIAL ECONOMIC LOSS ESTIMATIONS AS REPORTED BY THE SWSFC MOLLUSCAN WORKING GROUP (SWSFC, 2007)

Historical fishery landings and potential losses

Cockle Landings 2001 – 2007

Burry Inlet	2007	2006	2005	2004	2003	2002	2001
Actual Landings	ca 455t	1077t	557t	1469t	3400t	2006t	2538t
Value (£)	£180,800	£376,770	£299,400	£936,000	£2.9m	£1.9m	£390,000
Price / tonne*	£400	£350	£537	£637	£853	£947	£153

* These are first sale prices (ie to the gatherer on the beach) and do not reflect processed value which may be x4 – x5 more (on average).

From 2003 to 2006 the demand for large cockles was high and hence prices per tonne were high.

Estimated losses								Totals
Long term 3500t av & av prices for 2yr cockle	**£1.98m**	**£1.21m**	**£1.76m**	**£1.42m**	**£90k**	-	-	**£6.46m**
Based on expectation of stock, & av prices for 2 yr cockle**	**£3.6m**	**£3.9m**	**£3.85m**	**£1.42m**	**£1.5m**	-	-	**£14.27m**

** Crude assessment. It would be possible to model growth & depletion based on historical data making allowances for future density dependant settlement and value of cockles to the resultant size profile.

Three Rivers	2007	2006	2005	
Actual landings	ca410t	Nil	8,200t	
Value	£205,000		£4,600,000	
Estimated Losses	**£2m** (4000t x £500/t)	**£0.5m** (1000t x £500/t)	**£3- 4m** (6000t x £650)	**£5.5-6.5m**

APPENDIX 9: GATHERER SURVEY

General Questionnaire for the Welsh Cockle Industry

Background on consultation

Seafish, Wales have commissioned contractor Maritek to carry out an assignment titled "The economic impact of cockle mortality in the Burry Inlet and Three Rivers cockle fisheries, South Wales, UK". The scope of the work is set out in the Seafish tender document 'Invitations to Tender.

Key outputs of the assignment will include:

- A description of the south Wales cockle industry (gatherers and processors), and its related support and dependent businesses and industries. i.e. gathering/processing support industries, distributors, retailers.
- An estimated, baseline (pre-mortality) economic value of the Burry Inlet and Three Rivers fisheries, based on historic landings, 1st sale values and reasonable assumptions about the potential 'value-added' value of landings.
- An estimate of the economic loss to the local south Wales cockle industry and wider community due to the cockle mortality in the Burry Inlet and Three Rivers fisheries, based on current landings, 1st sale values and reasonable assumptions the potential 'value-added' value of landings.

Consultation with the cockle industry is an integral part of the assignment and will include the following steps:

- Introduction of contractor to the industry at industry meetings on the 15th & 16th August, at which this questionnaire will be issued to producers
- Detailed consultations with individual stakeholders and processors during the week 14th-20th August

Questionnaire

The questionnaire is intended to provide background information on the industry and will help to throw light on the key issues indicated above. When completing the questionnaire, please use continue any answers on additional blank sheets of paper if necessary.

The completed questionnaire should be completed by the 29th August 2014 and returned to Maritek by email (info@maritekworldwide.com)

Participant Information

Full name	
Position in Company	
Company name	
Telephone (landline & mobile)	
Email	
Preferred method of contacting you	

Cockle Gatherer Survey

1a. How many cockle gathering licences do you (and your family) currently hold (if you've held more in the past please state maximum number held and year – in brackets)

1b. What type of licence do you currently have?

A. Provisional (held for first 36 months)

B. Confirmed (permanent)

C. Temporary (on waiting list with occasional seasonal access)

2. What equipment do you use to harvest cockles (please give details)

3. Do you have a vehicle you use for transporting cockle, if so what?

3a. How long have you been in the cockle gathering business? (Please circle)

A. 0-2 years B. 3-5 years C. 6-10 years D. >10 years

3b. From which cockle beds do you harvested in the past and currently

Burry Inlet	Past (specify which years)	Current (please state if actively collecting this year)
Burry Inlet		
3 Rivers		
Dee Estuary		
Other in Wales (please state name)		

4. Do you plan on staying in the cockle gathering industry?

A. YES B. NO (Please circle)

if NO then please state how why?

5. Would you classify your operation as a part-time (P/T) or full-time (F/T) business?

A. P/T B. F/T

5a. If part-time, what proportion of your time is devoted to it

A. <10% B. 10-25% C. 25-50% D. 50-75%

5a. If part-time, what proportion of your household income comes from it?

A. <10% B. 10-25% C. 25-50% D. 50-75%

6. Does anyone normally work with you to help gather cockles?

A. YES B. NO (please circle)

if YES then please state how many?

6a. Full time _____

6b. Part time _____

6c. Unpaid (e.g. family)_____

7. Do you live within ten miles from the Burry Inlet and/or 3 Rivers?

A. YES B. NO

8. Harvest data

8a. Please state the amount gathered per year (in kilos) for each cockle size and from each fishery you fished and the time taken (in weeks) to achieve that total amount together with the average sale price and who was the main customer you sold them to each year

YEAR	Live cockles harvested from the Burry Inlet								Live cockles harvested from elsewhere in Wales (combine data if more than 1 place)Please state where gathered:							
	Small cockles		Med. cockles		Large cockles		No of weeks spent cockling	Sold to (state company name)	Small cockles		Med. cockles		Large cockles		No. of weeks spent cockling	Sold to (state company name)
	Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo			Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo		
2000																
2001																
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2005																
2006																
2007																
2008																
2009																
2010																
2011																
2012																
2013																

Any other comments on information provided above regarding historical cockle harvesting data?

9. What area of beach do you estimate you use/cover when gathering cockles for Burry Inlet and 3 Rivers in recent years and how does that compare to before the mortalities started in 2002

9a. Burry Inlet

9b. 3 Rivers:

10. Any difficulties (conflicts) with other gatherers or resource users?

Other Gatherers: a. YES b. NO

Other beach users: a. YES b. NO

Miscellaneous Information

11. Markets

Can you provide any information relating to consumption of cockles e.g. where sold to consumers, retail sale prices and products in shops (weight, format) or dishes served in restaurants (how are they served – with what other foods, the menu price)

12. Do you have any observations regarding the cockle mass mortalities (when they occur, any contributing factors?)

13. Do you have any Environmental concerns (deteriorating water quality/sedimentation etc.)?

A. Yes B. No

If yes please specify

14. How would you rate the perception of the general public regards the environmental impact of cockle harvesting?

A Environmentally beneficial

B Environmentally neutral

C Environmentally positive

D Other comment _____

Barriers to growth

15. What are the most significant barriers to growth of your business?

Rate each from 1 to 10 (with 10 having a maximum impact), if no impact put 0

15a. Economic

Return on Investment _____

Licence fees _____

Labour cost _____

Sale price _____

Finance – access to loans _____

Access to market _____

15b. Social

Local opposition _____

Conflict with other coastal users _____

Lack of Public understanding of industry _____

15c. Operational

Sourcing Labour _____

Distance to/lack of processing facilities _____

Cockle stocks _____

15d. Environmental

Water quality _____

Storms _____

Reducing growth rate (reaching maximum carrying capacity) _____

15e. Other

Please specify _____

16 What is your view on the overall balance of regulation and operation of the cockle industry and how it might be changed, if at all?

Benefits of the industry to the Welsh economy

17. What wider economic and social benefits do you consider are being created by the cockle industry for Wales?

Other Miscellaneous comments

18. Please add any other comments you feel are important and that we should be aware of in relation to this assignment

Thank you for completing this survey

APPENDIX 10: PROCESSOR SURVEY

Cockle Processors

1a. In which year was the factory built

1b. Was the factory initially built in order just to process cockles or for processing cockles and other foods

☐ Built just for cockles ☐ Built mainly for cockles & some other foods ☐ Built mainly for other foods

2. What was the initial investment cost and initial production capacity when first built?

3. Current cockle processing seasons and capacity

a. What are the peak months of the year for processing cockles
b. What is the maximum daily cockle processing capacity
c. What is the average (daily/weekly) weight of cockles processed during peak season
d. What is the average (daily /weekly) weight of cockles processed during low season

4. Employment

Staff numbers:	Full-time		Part-time		Seasonal		
Staff categories:	Management		Admin		Manual worker		

5A. For each of the cockle products listed in Q4 above, please describe the cockle production processes for each product including; time required, cockle meat yield (i.e. weight losses/discard of waste products during processing), production costs (per Kilo) and selling price (per Kilo)

Cockle Product A: Cockle wastage/weight loss Production cost (per Kilo) Selling Price (per Kilo) Process description:
Cockle Product B: Cockle wastage/weight loss Production cost (per Kilo) Selling Price (per Kilo) Process description:
Cockle Product C: Cockle wastage/weight loss Production cost (per Kilo) Selling Price (per Kilo) Process description

5B Production of other processed foods

[*Note: this is to provide an indication of any move away from a reliance on cockle products*]

If you produce other products from the same factory, please indicate sales of your top 3 other products over the past 10 years

Sales Volume (Table 1) [Note: if you are not able to provide figures for each of the years below, please try to provide for those years highlighted in yellow]

Product	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013

Sales Value (Table 2) [Note: if you are not able to provide figures for each of the years below, please try to provide for those years highlighted in yellow]

Product	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013

6. <u>Sourcing your cockles:</u>

6A. Do you work with particular gatherers

If YES, how many are gatherers working from the Burry Inlet fishery and how has this number changed over the past 10 years [*Note: where possible please state numbers for example: in 2001 25 gatherers from Burry Inlet, 5 from other cockle fisheries in Wales and 2 from outside Wales. In 2012 5 gatherers from Burry Inlet and 12 gatherers from other cockle fisheries in Wales and 6 from outside Wales*]

If NO, please state how you from where source/secure cockle supplies

6B Does cockle quality vary depending on where and when it is harvested if so please explain

6C. Since the onset of the cockle mortalities in the Burry Inlet, has this significantly affected your business and if so how

6D. From where have you sourced cockle to make up for the loss of supplies from the Burry Inlet?

6E. If the Burry Inlet cockle fishery returned to its pre-mortality levels (in terms of quality and size of cockles harvested) would you prioritise it for sourcing cockles or continue with your current approach to sourcing cockles?

6C. Purchases of cockles from sources in Wales and elsewhere. (Table 3)

[Note the purpose of this information is to show how the cockles harvested from the Burry Inlet have got smaller over the years resulting in lower earnings from the fishery (since the mortalities started). Information is needed from another cockle fishery (The Dee Estuary) to show a comparison purposes. The data for cockles harvested elsewhere is further back-up data in case the information for the Dee Estuary is poor or you feel that data from another cockle fishery is better at showing the impact of the decline in the Burry Inlet fishery (if you choose to provide cockle harvest data from elsewhere that would be much appreciated but please state which cockle fishery the data relates to].

[Note: if you are not able to provide figures for each of the years below, please try to provide for those years highlighted in yellow]

YEAR	Live cockles harvested from the Burry Inlet							Live cockles harvested from the Dee Estuary							Live cockles harvested from elsewhere in UK (state where)						
	Small cockles		Med. cockles		Large cockles		Number of suppliers	Small cockles		Med. cockles		Large cockles		Number of suppliers	Small cockles		Med. cockles		Large cockles		Number of suppliers
	Vol. (Kg)	Price	Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo		Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo		Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo	Vol. (Kg)	Price per Kilo	
2000																					
2001																					
2002																					
2003																					
2004																					
2005																					
2006																					
2007																					
2008																					
2009																					
2010																					

2011																					
2012																					
2013																					

7. Sales of processed cockle products:

7A. Primary Processing activities (Table 4)

[Note: if you are not able to provide figures for each of the years below, please try to provide for those years highlighted in yellow]

Price Point	**Live cockles harvested in Wales & sold to food service sector (i.e. restaurants)**		**Live cockles harvested in Wales & sold to retailers (e.g. market stalls, Tesco)**		**Cooked mussel meat (processed in Wales) & sold to retailers**		**Cooked mussel meat (processed in Wales) & sold for further processing (i.e. sold for canning or pickling)**		**Cooked mussel meat (processed in Wales) & sold to the food service sector**		**Cooked mussel meat (processed in Wales) & sold for export to EU customer**		**Cooked mussel meat (processed in the UK) & sold for export to EU customer**	
Year	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)
2000														
2001														
2002														
2003														
2004														
2005														
2006														
2007														
2008														

2009														
2010														
2011														
2012														
2013														

7B. Secondary Processing activities (Table 5)

[Note: if you are not able to provide figures for each of the years below, please try to provide for those years highlighted in yellow]

Price Point	**Value added cockles (i.e. tinned or pickled) processed in Wales & sold to Welsh retailers (e.g. supermarkets, market stalls)**		**Value added cockles (i.e. tinned or pickled) processed in Wales & sold via Internet**		**Value added cockles (i.e. tinned or pickled) processed in Wales & sold to food service sector (i.e. restaurants)**		**Value added cockles (i.e. tinned or pickled) processed in the UK and exported to the EU**		**Value added cockles (i.e. tinned or pickled) sold to**	
Year	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)	Amount (Tonnes)	Price (£/Tonne)
2000										
2001										
2002										
2003										
2004										
2005										
2006										

8. Haulage (freight) costs per tonne

a. Within Wales e.g. North Wales (Dee Estuary) to South Wales (processing plant)

b. Within UK e.g. Wales to processing plant elsewhere in UK or from other cockle fishery in UK to processing plant in Wales

Miscellaneous Information

9. Markets

Can you provide any information relating to consumption of cockles e.g. where sold to consumers, retail sale prices and products in shops (weight, format) or dishes served in restaurants (how are they served – with what other foods, the menu price)

10A. Do you have any observations regarding the Burry Inlet cockle mass mortalities (when they occur, any contributing factors)

10B. Are you aware of any mass cockle mortalities occurring now or in the past elsewhere in the UK or abroad, if so please state details

YES/NO

If YES, details (when, where, possible cause, has it stopped now?)

11. Do you have any Environmental concerns (deteriorating water quality/sedimentation etc.)?

A. Yes B. No

If yes please specify

11. How would you rate the perception of the general public regards the environmental impact of cockle industry?

A Environmentally beneficial

B Environmentally neutral

C Environmentally positive

D Other comment _____

Barriers to growth

12. What are the most significant barriers to growth of your business?

Rate each from 1 to 10 (with 10 having a maximum impact), if no impact put 0

12a. Economic

Return on Investment _____

Licence fees _____

Labour cost _____

Sale price _____

Finance – access to loans _____

Access to market _____

12b. Social

Local opposition _____

Conflict with other coastal users _____

Lack of Public understanding of industry _____

12c. Operational

Sourcing Labour _____

Distance to/lack of processing facilities _____

Cockle stocks _____

12d. Environmental

Water quality _____

Storms _____

Reducing growth rate (reaching maximum carrying capacity) _____

12e. Other

Please specify

_____

13 What is your view on the overall balance of regulation and operation of the cockle industry and how it might be changed, if at all?

Benefits of the industry to the Welsh economy

14. What wider economic and social benefits do you consider are being created by the cockle industry for Wales?

Other Miscellaneous comments

15. Please add any other comments you feel are important and that we should be aware of in relation to this assignment

Thank you for completing this survey