Appendix 9.2

Fish Fauna Characterisation Surveys

TURNPENNY HORSFIELD ASSOCIATES

Fisheries Engineering & Aquatic Consultants

Swansea Tidal Lagoon

Fish Fauna Characterisation Surveys

February 2013 survey – 1st Quarter

Prepared for: Tidal Lagoon Swansea Bay Ltd.

Document No. 580R0201

Date: 7th March 2012

Survey vessel – Severn Guardian

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Swansea Tidal Lagoon Fish Fauna Characterisation Surveys

February 2013 – 1st Quarter

Report Reference: 580R0201	Revision date: *7th March 2013*
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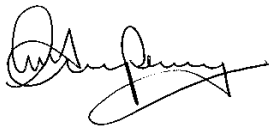
Approver's signature: 	Date: *7th March 2013*

Swansea Tidal Lagoon Fish Fauna Characterisation Surveys

Contents

1 Introduction

1.1 Background to the Project

1.1.0.1 Tidal Lagoon Swansea Bay Ltd propose to develop a tidal lagoon for the purpose of generating energy in Swansea Bay, Wales. The tidal lagoon would be situated between the dredged channels of the Rivers Tawe and Neath, and when fully operational could serve to provide energy for more than 100,000 homes (Tidal Lagoon Swansea Bay Ltd, 2012).

1.1.0.2 The Planning Act 2008 (c. 29) introduced special provisions for the consenting process surrounding the development of energy generating infrastructure with a capacity greater than 100 megawatts (MW). Such developments are termed as Nationally Significant Infrastructure Projects (NSIP) and require a Development Consent Order (DCO) to be submitted to the Planning Inspectorate (PINS). The proposed tidal lagoon at Swansea Bay will have a nominal rated power of 240MW, and as such, falls under this regime.

1.1.0.3 As part of the legislative framework for EIA (Environmental Impact Assessment), as set out in the European Directive 85/337/EEC (as amended), and transposed into UK legislation through the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009, the project will require an EIA to be undertaken. To accompany the DCO and fulfil requirements found within EIA legislation, an Environmental Statement (ES) will be produced.

1.1.0.4 The principal remit of the ES is to describe the likely significant effects of the development on the environment and its receptors and any possible mitigation measures which might be undertaken to decrease such effects.

1.1.0.5 As part of the ES process, Turnpenny Horsfield Associates Ltd (THA) has been commissioned to assess the potential impacts of the project on the fish community of Swansea Bay and adjacent waters.

1.1.0.6 To supplement evidence from a detailed desk-based review, a programme of quarterly fish fauna surveys has been designed to characterise fish populations within the Bay to inform decision-making associated with the project.

1.1.0.7 This report details one of a series of fish fauna characterisation surveys being carried out by THA. The surveys adopt multiple biomonitoring techniques consistent with Water Framework Directive (WFD) monitoring standards and JNCC best practice techniques to monitor biota within marine environments[1].

[1] Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp, ISBN 1 85716 550 0

1.2 Aims and Objectives

1.2.0.1 The aim of this report is to provide an up-to-date characterisation of the seasonal fish community within the defined study area. The study area has been defined as the potential near-field and far-field zone of influence around the Swansea Tidal Lagoon though a high level coastal process model (Tidal Lagoon Swansea Bay Ltd., 2012).

2 Methods

2.1 Study Area

2.1.0.1 Swansea Bay (NGR SS 630910) is approximately 12 km wide with an area of 50 km^2. The seabed of the Bay is largely composed of mud, sand and fine gravel, with some rock outcrops and cobbles occurring on the western edge of the embayment, towards Mumbles Head (Davies, 1998).

2.2 Intertidal Seine and Riley Push-Netting

2.2.0.1 Six sites were sampled as part of the intertidal sampling program between the 20th and 22nd of February 2013. The locations of these sites are shown in Table 1 and mapped in Appendix 1. Sampling was undertaken at low water (LW) ± 2 hours and conducted on suitable shores with a slight slope and fine substrates. Two techniques were utilised at each site, these are detailed below.

Table 1 Intertidal sites sampled during the surveys

Site Code	Site Name	Co-ordinates
I1	Caswell Bay	51:34.13312N 4:1.94620W
I2	Blackpill	51:36.27098N 3:58.87818W
I3	Abertawe	51:36.77037N 3:56.14407W
I4	Port Talbot West	51:35.86105N 3:49.59318W
I5	Langland Bay	51:34.01782N 4:0.84153W
I6	Crymlyn Burrows	51:36.96590N 3:52.44125W

2.2.0.2 A 43 m long (4 m deep) seine net with 14 mm wings and a 6.5 mm centre knotless mesh was deployed from an inflatable vessel. The methods adopted followed JNCC procedural guidelines (Davies *et al.*, 2001).

2.2.0.3 A rope attached to one end of the seine was held onshore by an operative, whilst the net of the seine was loaded onto the vessel. The vessel was then rowed out perpendicularly from the shoreline, once the extent of the rope connecting the seine to the shore was fully paid out the vessel made a 90 ° turn and proceeded parallel to the shore, slowly paying out the remainder of the net. Once fully deployed, the rope attached to the other end was brought ashore and the net ends were brought together and the net was pulled in. Floats on the net were kept outside of the lead line thus preventing accidental the loss of fish from the net.

2.2.0.4 Riley push-netting was undertaken using a 1.5 m wide push-net with a 6.5 mm mesh trouser legs lined with 1 mm fry mesh (Plate 1). A tickler chain was mounted on the net to increase its efficacy. Transects measuring 100 m were marked out on the shore, the net was lifted and placed in knee-depth water by two operatives. A single member of staff then proceeded to push the net for the measured distance.

2.2.0.5 Where sea conditions allowed safe working, two replicates were carried out for each of the techniques.

2.2.0.6 All fish captured were removed and separated from macroinvertebrates and debris. Fish were identified to species level, recorded and measured to the nearest millimetre (total length L_t), whilst macroinvertebrates were recorded and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

Plate 1. Riley net design and technique utilised during sampling

2.3 Subtidal Otter and Beam Trawls

2.3.0.1 The subtidal survey comprised of 12 trawls at six sites, conducted between the 24th and 25th of February 2013. The start and end position of the trawl transects for each of the techniques used are given in Table 2 and Table 3, whilst transects are mapped in Appendix 1. The start of the transect was considered to be when the gear reached the seabed and the end when hauling commenced, all co-ordinates and depths were taken using the vessel's on board instruments. Though sites for subtidal sampling were given individual codes for purposes of method identification, they were slightly offset replicates of the same sites.

Table 2. Subtidal otter trawl sites sampled during the survey

Site Code	Otter Trawls	
	Start	End
O1	51:33.56000N 3:51.65000W	51:32.55000N 3:50.33333W
O2	51:35.51000N 3:52.01667W	51:34.83000N 3:50.10000W
O3	51:35.41000N 3:55.58333W	51:34.78000N 3:53.10000W
O4	51:34.20000N 3:58.06667W	51:35.54000N 3:58.00000W
O5	51:34.48000N 3:55.31667W	51:34.69000N 3:53.28333W
O6	51:34.61000N 3:58.05000W	51:35.70000N 3:56.70000W

Table 3. Subtidal beam trawl sites sampled during the survey

Site Code	Beam Trawls	
	Start	End
B1	51:32.95000N 3:50.50000W	51:33.43000N 3:51.21667W
B2	51:34.85000N 3:49.98333W	51:35.28000N 3:51.15000W
B3	51:35.06000N 3:54.11667W	51:35.48000N 3:55.51667W
B4	51:34.41000N 3:58.05000W	51:35.18000N 3:58.08333W
B5	51:34.68000N 3:53.55000W	51:34.61000N 3:54.68333W
B6	51:34.61000N 3:58.01667W	51:35.22000N 3:57.21667W

2.3.0.2 Trawling was undertaken from the Briggs Marine Ltd. vessel Severn Guardian, an 18.3 m catamaran which is regularly used by the Environment Agency to conduct WFD fisheries surveys. Two nets were used during the survey, specifications for these are given in Table 4.

Table 4. Respective net sizes for both otter and beam trawls utilised in the surveys

Characteristic	Otter Trawl sizes (cm)	Beam Trawl sizes (cm)
Head line length/Width of Beam Trawl	965	236
Ground rope length	905	414
Mouth height	275	90
Wing mesh	8	8
Cod end mesh	1	1

2.3.0.3 Otter trawls (Plate 2) were conducted using a standard otter board setup trawled for approximately 30 minutes at three knots. One trawl was conducted at each site. On completion of the trawl the net was winched aboard the vessel and the catch emptied into holding bins filled with sea water. Fish were removed and separated from macroinvertebrates and debris. Fish were identified to species level, recorded and measured to the nearest millimetre (total length L_t), whilst macroinvertebrates were recorded and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

2.3.0.4 Epibenthic beam trawls (Plate 3) transects were conducted for approximately 15 minutes at three knots. Similarly to the otter trawls, a winch was utilised to bring the net onto the deck of the vessel on completion of the fishing operation. Fish were then immediately placed into holding bins filled with sea water. All fish captured were identified and measured to the nearest millimetre. After processing all fish were returned to the water. Macroinvertebrates were identified to the lowest practicable taxonomic level and their presence was noted.

Plate 2. Otter trawl ready to be lowered into the water

Plate 3. Standard design beam trawl ready to be lowered into the water

2.4 Water Quality and Hydrographic Data

2.4.0.1 Temperature and salinity were recorded using a hand held conductivity meter (470 Portable Conductivity Meter; www.jenway.com), whilst dissolved oxygen (DO) was recorded using a portable oxygen probe (Hach Orbisphere 3655 O_2; www.hach). A single measurement was taken at each site sampled. Instruments were regularly calibrated using standard solutions.

2.5 Analysis

2.5.0.1 The frequency of occurrence of fish across the study area was used to calculate the relative abundance of each taxon. Relative abundance in this work is defined as the percentage of total catch comprised by the given species, which can be calculated using the following formula:

$$\%Ai = \frac{\sum C_i}{\sum S_t} \times 100,$$

2.5.0.2 where: $\%Ai$ is relative abundance, C_i is the sample content composed by the species across surveys/sites and S_t is the total content of all surveys/sites in the entire sampling period.

2.5.0.3 Despite trawls being conducted for a standardised time period (30 and 15 minutes for Otter and Beam respectively), the length of each trawl transect varied owing to differences in the seabed, tidal current and the presence of obstructions (e.g. pot lines). As a result the length of each individual trawl track as recorded using GPS co-ordinates was utilised to calculate the number of specimen for each species sampled per 100 m trawled (catch per unit effort (CPUE)).

3 Results

3.1.0.1 A total of 31 fish species and 22 macroinvertebrate species were recorded in the subtidal and intertidal surveys, raw data for these are presented in Appendix 2 and Appendix 3. Sand gobies were the most abundant fish species (19.2 %), followed by whiting (16.9 %), pout (16.3%) hooknose (8.5 %) and dab (7.8 %). Figure 1 gives the relative abundance of all fish species caught across all of the intertidal and subtidal sites.

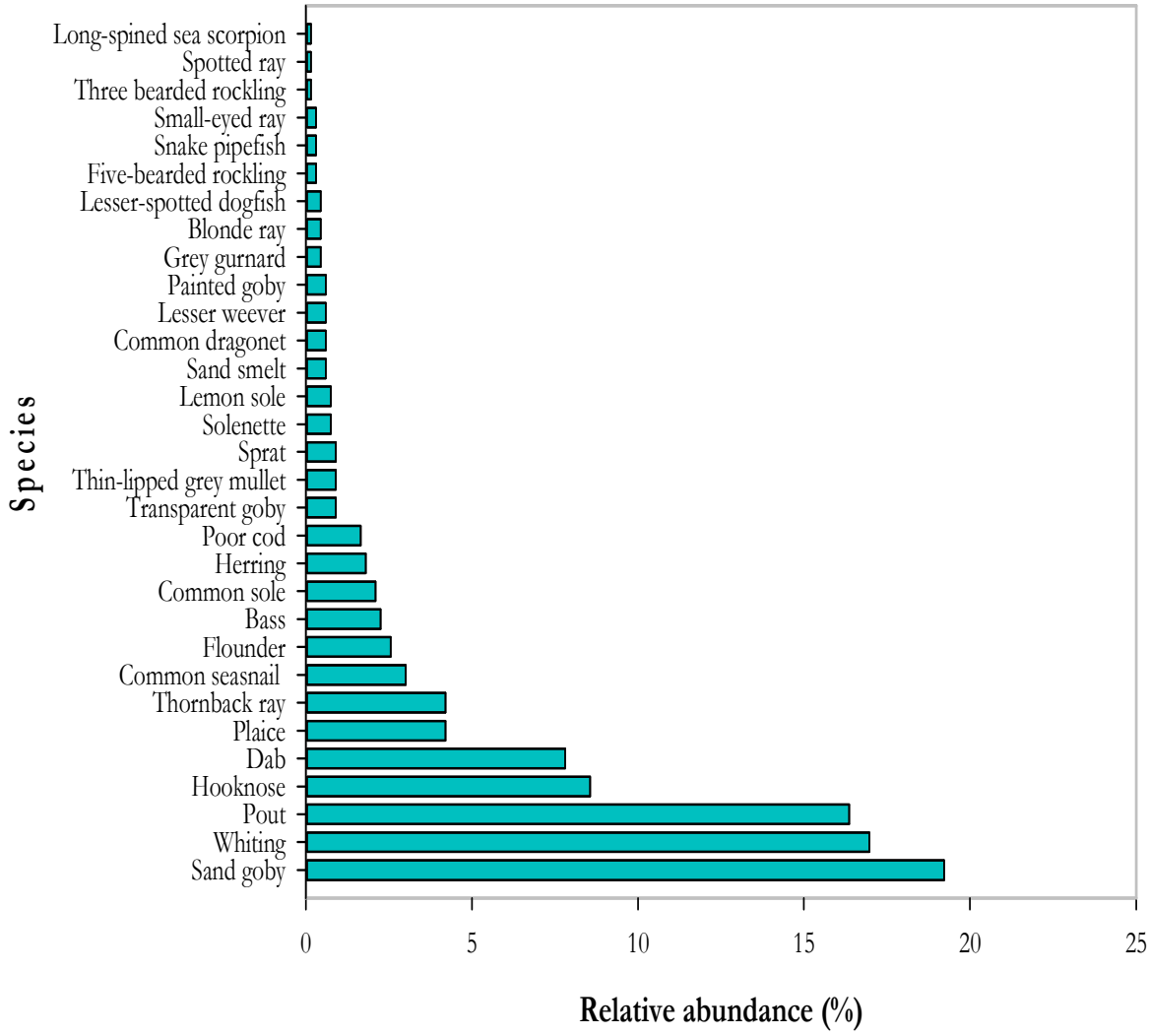


Figure 1. Relative abundance of fish species across all sites sampled

3.1.0.2 Brittle stars were the most abundant macroinvertebrate species recorded during the surveys, followed by common seastar, sea mouse, *Crangon* spp. and *Palaemon* spp.

3.2 Intertidal Seine and Riley Push-Netting

3.2.0.1 Intertidal sampling yielded significantly less specimens than subtidal work. A total of 14 fish were caught belonging to four species. Figure 4 shows the relative abundance of all species caught during the intertidal sampling program, whilst Appendix 1 gives the raw number of fish captured. Although Riley push-nettings were conducted at Sites I5 and I6, no seines were carried out due to adverse weather conditions which made netting unsafe.

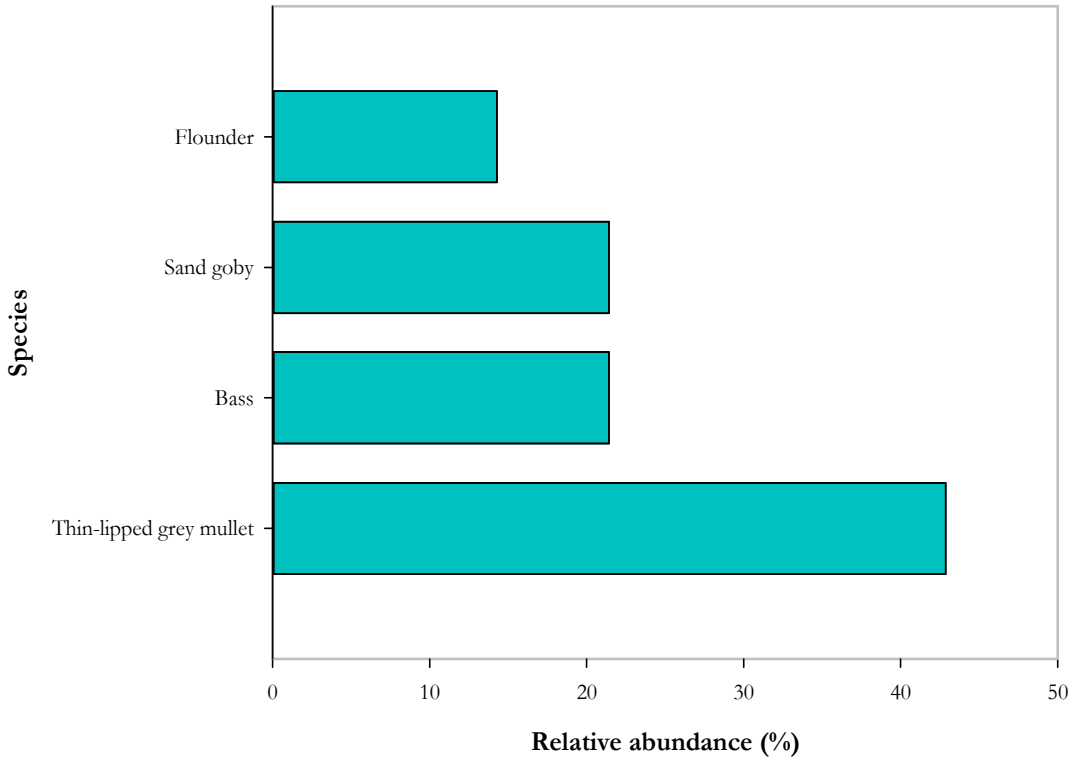


Figure 2. Relative abundance of fish species across intertidal sites sampled

3.2.0.2 All fish were captured at site I2. A single goby was caught using the Riley net, whilst the rest of the fish were captured within a single seine.

3.3 Subtidal Otter and Beam Trawl

3.3.0.1 A total of 652 fish belonging to 30 species were caught during otter and beam trawl surveys, 562 (86.2 %) of which were caught during otter trawling and 90 (13.8 %) using beam trawling. Figure 3 gives the relative abundance of all species across all of the subtidal sites. Only one fish species which was represented in intertidal surveys was not caught during subtidal sampling (Thin-lipped grey mullet).

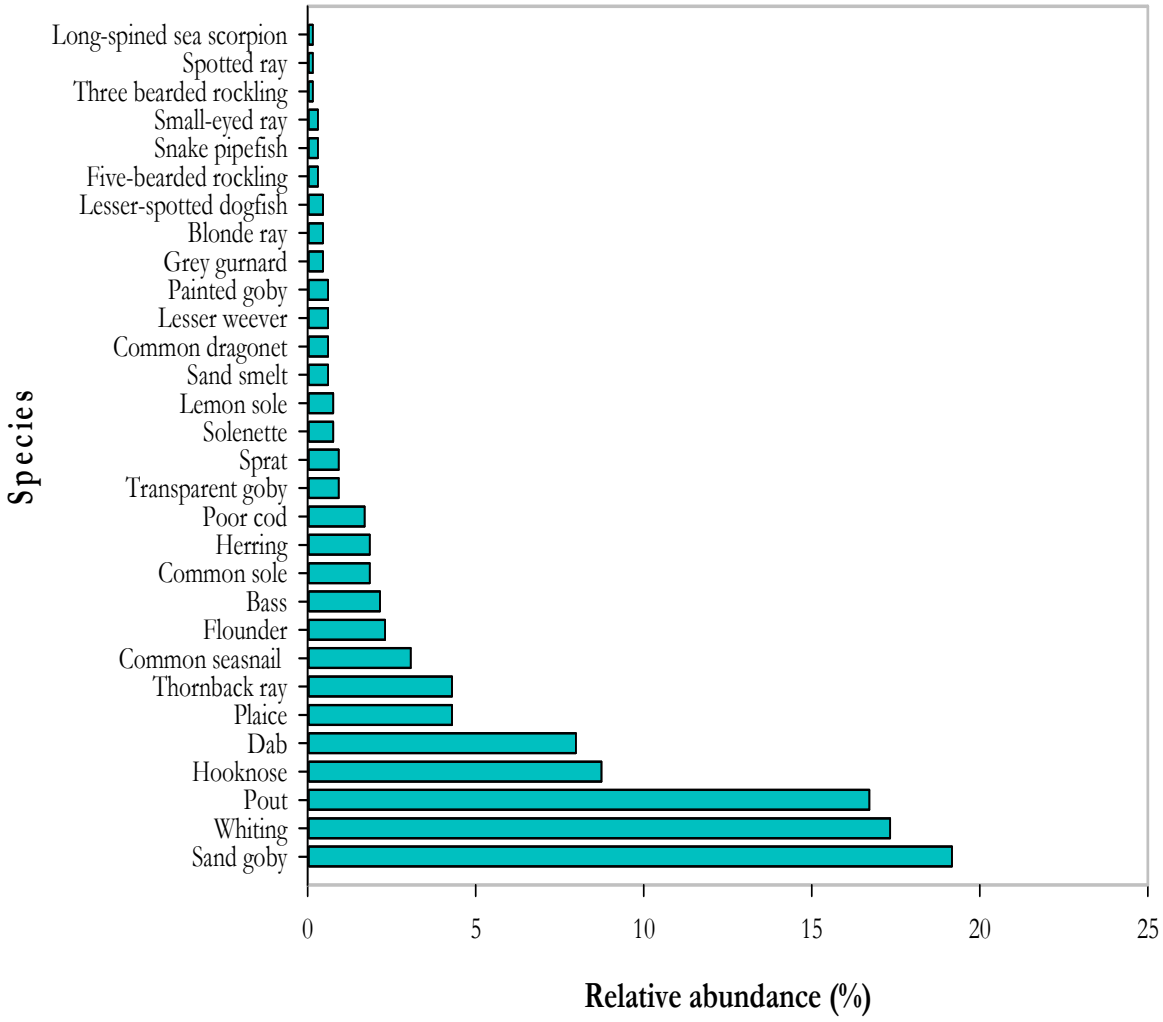


Figure 3. Relative abundance of fish species across subtidal sites sampled

3.3.0.2 Catch per unit effort was typically higher in otter trawls than in beam trawls (Figure 4), site three was the only clear exception with 1.13 and 2.35 CPUE (fish per 100 m trawled) respectively. The primary species contributing to a higher CPUE for site three was dab, 24 were caught using the beam trawl whilst only three were captured in the otter trawl.

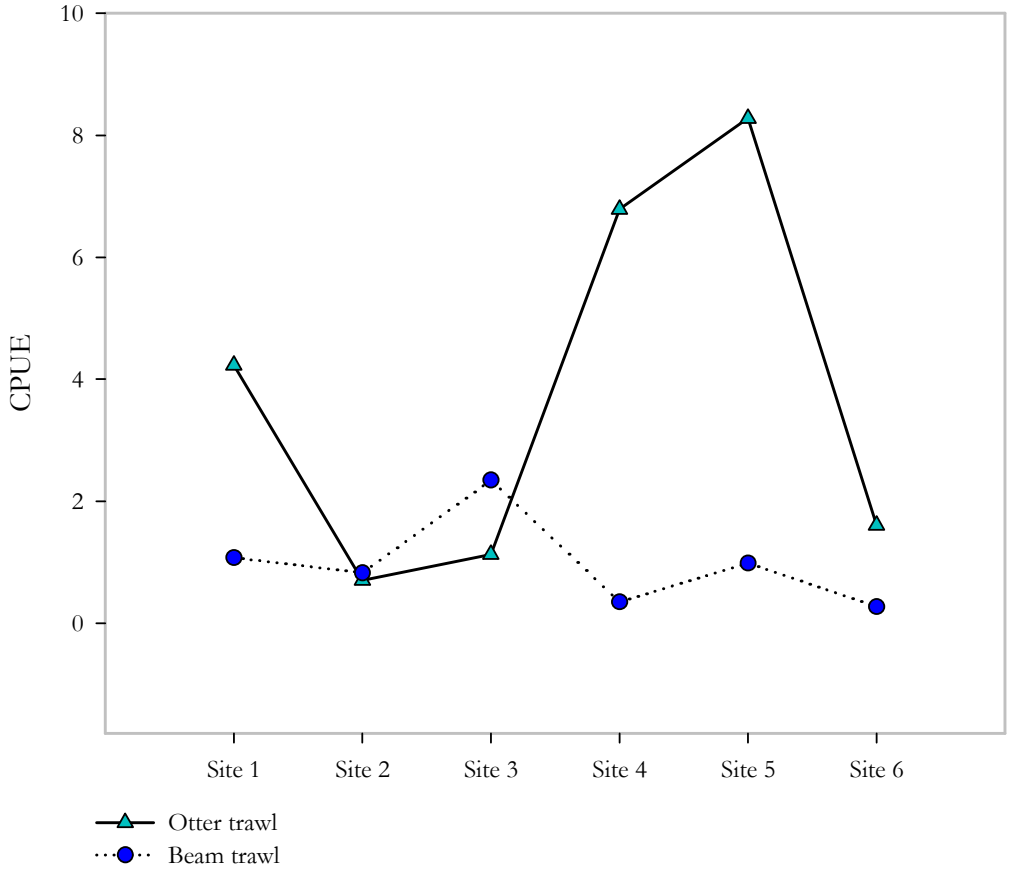


Figure 4. Total number of fish specimens expressed as CPUE (fish per 100 m trawled) recorded in subtidal sampling in February 2013

3.4 Length frequency distributions

3.4.0.1 Several fish species of commercial importance were sampled in relatively high abundance during the subtidal surveys, these included whiting, dab, plaice, thorn-back ray and bass. Figure 5 (A to E) below provides a number of summary histograms for the length frequencies of these fish.

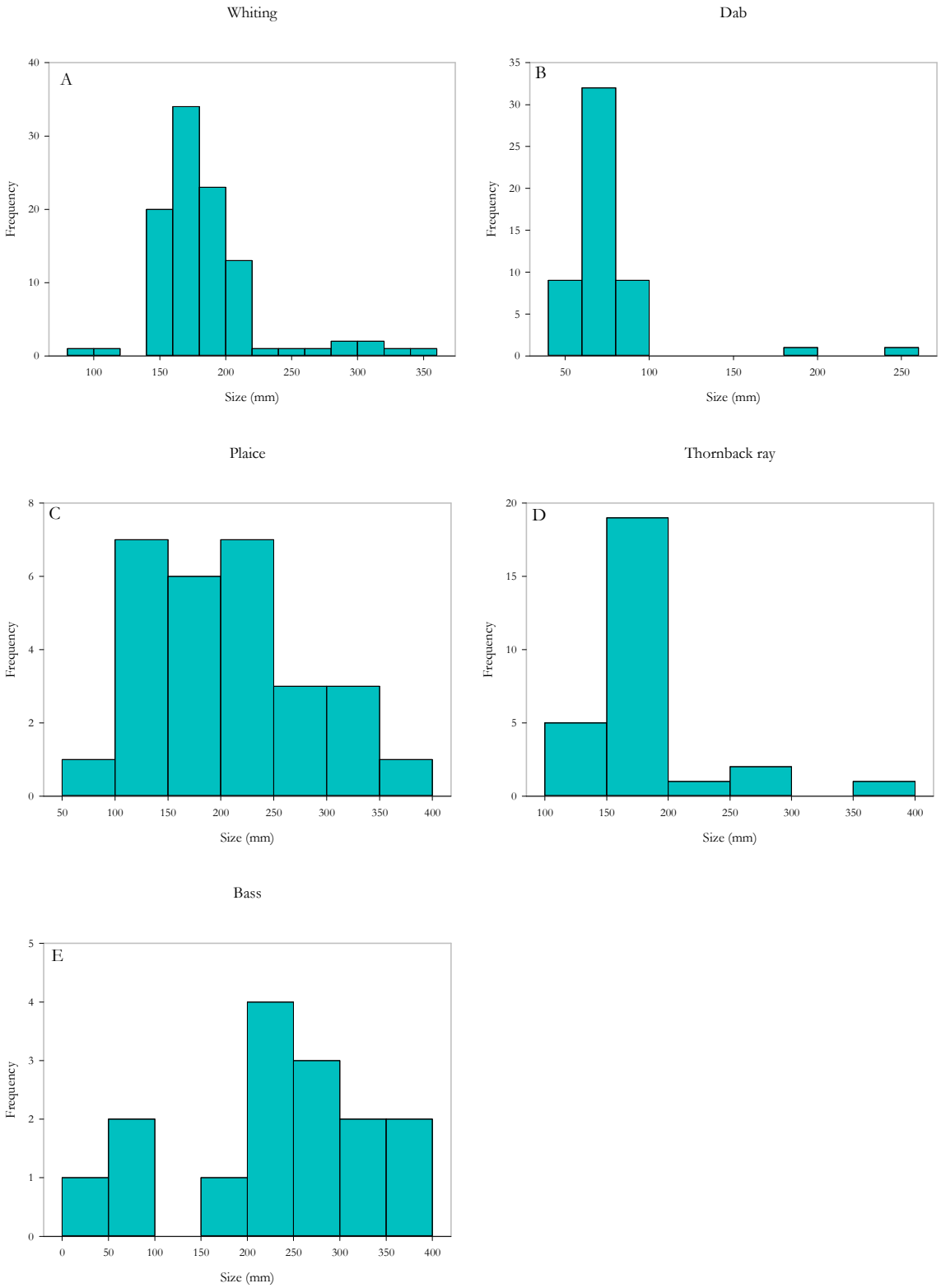


Figure 5. Length frequency distribution histograms for a number commercially important species captured during the surveys (A-E).

4 Discussion

4.1.0.1 The presence of numerous juvenile flatfish and rays confirms that the area provides a good nursery habitat for many of these fish, as identified the Fisheries Baseline report. The fish community recorded within the Bay was broadly in accordance with findings of the desk-based study, through additional species and lifestage are likely to be recorded as the seasonal coverage is expanded.

4.1.0.2 Catches of juvenile fish in the intertidal zone are typically minimal in the winter months, as fish move into deeper water to avoid potentially lethal or sub-optimal low temperatures as the autumn progresses, then returning in spring-early summer to take advantage of solar warming of the shallows (Wither *et al.*, 2012). Cold temperatures in inshore waters (temperature mean ± S. D. = 5.2 ± 1.49℃ (Appendix 4) meant that few fish were captured during the intertidal sampling. Similar work carried out at in February 2013 in other Welsh coastal waters had congruous results, with no fish caught at all (Colclough, S., pers. comm., 2013).

4.2 References

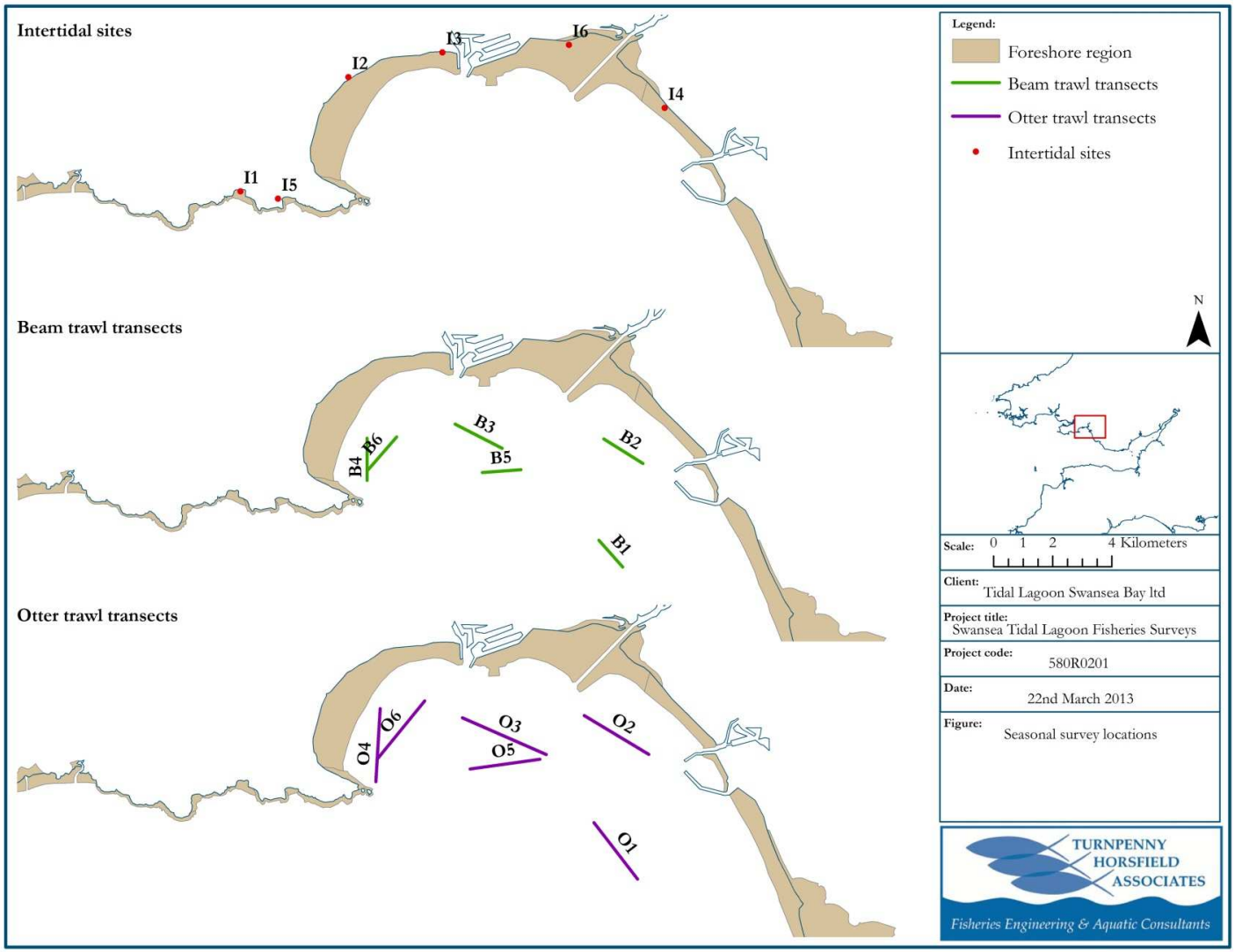
Davies, J., 1998. Bristol Channel and approaches (Cape Cornwall to Cwm-yr-Eglwys, Newport Bay)(MNCR Sector 9). In K. Hiscock, ed. Marine Nature Conservation Review. Peterborough: Joint Nature Conservation Committee, pp. 225–295.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp.

Tidal Lagoon Swansea Bay Ltd. 2012. Proposed Tidal Lagoon Development in Swansea Bay, South Wales Environmental Impact Assessment Scoping Report October 2012. Cheltenham: Tidal Lagoon Swansea Bay Ltd.

Wither, A., Bamber, R., Colclough, S., Dyer, Elliott, M., K. Holmes, P., Jenner, H., Taylor, C.,Turnpenny, A., 2012. Setting new thermal standards for transitional and coastal (TraC) waters. *Marine Pollution Bulletin* 64 (2012) 1564–1579.

Appendix 1. Locations sampled during the surveys.



Appendix 2. Fish presence and abundance recorded during surveys.

Scientific Name	Common Name	Subtidal												Intertidal	
		Otter Trawls						Beam Trawls						Seine	Riley
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6	I2	I2
Agonus cataphractus	Hooknose	1		2	19	16	1			17	1				
Aphia minuta	Transparent goby	1				4						1			
Atherina presbyter	Sand smelt						4								
Buglossidium luteum	Solenette	1	1			1		1		1					
Callionymus lyra	Common dragonet					3	1								
Ciliata mustela	Five-bearded rockling				2										
Clupea harengus	Herring				1		11								
Dicentrarchus labrax	Bass				8	1	2						1	3	
Echiichthys vipera	Lesser weever				1				3						
Entelurus aequoreus	Snake pipefish	2													
Eutrigla gurnardus	Grey gurnard	1										1	1		
Gaidropsarus vulgaris	Three bearded rockling	1													
Limanda limanda	Dab			2	10	12			3	24		1			
Liparis liparis	Common seasnail				4	14	1					1			

Liza ramada	Thin-lipped gray mullet													6	
Merlangius merlangus	Whiting	17	1	19	2	62	2	7	2			1			
Microstomus kitt	Lemon sole					3	2								
Platichthys flesus	Flounder	3			11	1								2	
Pleuronectes platessa	Plaice	6	2		15		2		1		1		1		
Pomatoschistus minutus	Sand goby	41	1	1	58	5	9	4			2	3	1		
Pomatoschistus pictus	Painted goby					1			3						
Pomatoschistus spp.	Goby spp.													2	1
Raja brachyura	Blonde ray					3									
Raja clavata	Thornback ray	3	10	3	1	3	4					4			
Raja microocellata	Small-eyed ray						1					1			
Raja montagui	Spotted ray					1									
Scyliorhinus canicula	Lesser-spotted dogfish	1				2									
Solea solea	Common sole	4			9						1				
Sprattus sprattus	Sprat	1		5											
Taurulus bubalis	Long-spined sea scorpion				1										
Trisopterus luscus	Pout	18	3	3	20	62	1	1	1						
Trisopterus minutus	Poor cod	1			7	3									

Appendix 3. Invertebrates presence and abundance recorded during surveys.

Scientific Name	Common Name	Subtidal												Intertidal
		Otter Trawls						Beam Trawls						Riley
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6	I2
Achelia echinata	Sea spider			1-10										
Anemonia viridis	Snakelocks anemone			1-10		1-10	1-10							
Aphrodita aculeata	Sea mouse	10-100		1-10		10-100								
Ascidiella aspersa	Sea squirt			1-10										
Asterias rubens	Common starfish	10-100	10-100		1-10	1-10	10-100							
Buccinum undatum	Common whelk		1-10	1-10		10-100	1-10			1-10				
Calliostoma zizyphinum	Painted top shell						1-10							
Cancer pagurus	Brown crab					1-10								
Carcinus maenas	Common shore crab	1-10												
Cerastoderme edule	Common cockle													1-10
Chlamys varia	Variegated scallop			1-10										

Corystes cassivelaunus	Masked crab	1-10												
Crangon spp.	Shrimp	1-10	1-10	1-10		1-10	10-100	1-10		1-10	1-10	1-10		1-10
Crepidula fornicata	Slipper limpet			1-10										
Crossaster papposus	Common sunstar						1-10							
Liocarcinus depurator	Harbour crab		1-10		1-10	1-10		1-10			1-10			
Macropodia spp.	Spider crab			1-10										
Mytilus edulis	Common mussel			1-10			1-10							
Necora puber	Velvet swimming crab			1-10										
Ophiura ophiura	Brittle star	100-1000	1-10	1-10			1-10							
Pagurus bernhardus	Common hermit crab	1-10		1-10		1-10				1-10	1-10	1-10		
Palaemon spp.	Prawn	1-10		10-100			1-10	1-10		1-10				
Psammechinus miliaris	Green sea urchin					1-10								

Appendix 4. Dissolved oxygen, temperature, salinity and depth at all sites sampled.

Site	Dissolved oxygen (ppm)	Temperature (C°)	Salinity (ppt)	Depth
O1	5.7	5.6	34.4	12.2
O2	4.7	6.2	36	6.1
O3	6.27	5.5	34.4	5.5
O4	5.2	5.6	34.5	9.1
O5	6.23	6.9	36	9.6
O6	4.25	5.34	35	2
B1	4.7	6.2	36	13.2
B2	5.48	6	35.5	8.3
B3	5.8	6.1	35.9	11.8
B4	4.8	6	35.2	9.1
B5	4.6	5.7	35.7	12.8
B6	5.49	5.9	36	8.7
I1	5.93	7.6	32.6	n/a
I2	5.5	5.8	33.8	n/a
I3	6.1	5.4	35.5	n/a
I4	5.32	4.6	35.3	n/a
I5	7.26	4.3	34.8	n/a
I6	9.06	3.5	30.4	n/a

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Fisheries Engineering & Aquatic Consultants

Swansea Tidal Lagoon

Fish Fauna Characterisation Surveys

May 2013 survey – 2nd Quarter

Prepared for: Tidal Lagoon Swansea Bay Ltd.

Document No. 580R0401

Date: 27th June 2013

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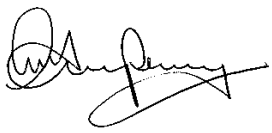
Position: *Director*

Approver's signature:



Date: *27th June 2013*

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1.1.0.4 The principal remit of the ES is to describe the likely significant effects of the development on the environment and its receptors and any possible mitigation measures which might be undertaken to decrease such effects.

1.1.0.5 As part of the ES process, Turnpenny Horsfield Associates Ltd (THA) has been commissioned to assess the potential impacts of the project on the fish community of Swansea Bay and adjacent waters.

1.1.0.6 To supplement evidence from a detailed desk-based review, a programme of quarterly fish fauna surveys has been designed to characterise fish populations within the Bay to inform decision-making associated with the project.

1.1.0.7 This report details one of a series of fish fauna characterisation surveys being carried out by THA. The surveys adopt multiple biomonitoring techniques consistent with Water Framework Directive (WFD) monitoring standards and JNCC best practice techniques to monitor biota within marine environments[1].

[1] Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp, ISBN 1 85716 550 0

1.2 Aims and Objectives

1.2.0.1 The aim of this report is to provide an up-to-date characterisation of the seasonal fish community within the defined study area. The study area has been defined as the potential near-field and far-field zone of influence around the Swansea Tidal Lagoon though a high level coastal process model (Tidal Lagoon Swansea Bay Ltd., 2012). Limitations in the survey methodology have been identified in the Environmental Statement.

2 Methods

2.1 Study Area

2.1.0.1 Swansea Bay (NGR SS 630910) is approximately 12 km wide with an area of 50 km^2. The seabed of the Bay is largely composed of mud, sand and fine gravel, with some rock outcrops and cobbles occurring on the western edge of the embayment, towards Mumbles Head (Davies, 1998).

2.2 Intertidal Seine and Riley Push-Netting

2.2.0.1 Six sites were sampled as part of the intertidal sampling program between the 22th of May and 12 of June 2013. The locations of these sites are shown in Table 1 and mapped in Appendix 1. Sampling was undertaken at low water (LW) ± 4 hours and conducted on suitable shores with a slight slope and firm substrates. Two techniques were utilised at each site, these are detailed below.

Table 1 Intertidal sites sampled during the surveys

Site Code	Site Name	Co-ordinates
I1	Caswell Bay	51:34.13312N 4:1.94620W
I2	Blackpill	51:36.27098N 3:58.87818W
I3	Abertawe	51:36.77037N 3:56.14407W
I4	Port Talbot West	51:35.86105N 3:49.59318W
I5	Langland Bay	51:34.01782N 4:0.84153W
I6	Crymlyn Burrows	51:36.96590N 3:52.44125W

2.2.0.2 A 43 m long (4 m deep) seine net with 14 mm wings and a 6.5 mm centre knotless mesh was deployed from a rigid mono-hull vessel. The methods adopted followed JNCC procedural guidelines (Davies *et al.*, 2001).

2.2.0.3 A rope attached to one end of the seine was held onshore by an operative, whilst the net of the seine was loaded onto the vessel. The vessel was then taken out perpendicularly from the shoreline, once the extent of the rope connecting the seine to the shore was fully paid out the vessel made a 90˚ turn and proceeded parallel to the shore, slowly paying out the remainder of the net. Once fully deployed, the rope attached to the free end of the net was brought ashore and the net hauled bringing together the ends of the net and pursing the seine. Floats on the net were kept outside of the lead line thus preventing accidental the loss of fish from the net.

2.2.0.4 Riley push-netting was undertaken using a 1.5 m wide push-net with a 6.5 mm mesh trouser legs lined with 1 mm fry mesh (Plate 1). A tickler chain was mounted on the net to increase its efficacy. Transects measuring 100 m were marked out on the shore, the net was lifted and placed in knee-depth water by two operatives. A single member of staff then proceeded to push the net for the measured distance.

2.2.0.5 Two replicates for each method were carried out at all sites with exception to Langland Bay (I5), where adverse weather conditions limited the surveys to one seine replicate.

2.2.0.6 All fish captured were removed and separated from macroinvertebrates and debris. Fish were identified to species level, recorded and measured to the nearest millimetre (total length L_t); whilst macroinvertebrates were recorded as log abundance: 1-9; 10-99; 100-999; or 1000+ and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

Plate 1. Riley net design and technique utilised during sampling

2.3 Subtidal Otter and Beam Trawls

2.3.0.1 The subtidal survey comprised of 14 trawls at seven sites, conducted between the 20th and 21st of May 2013. The start and end position of the trawl transects for each of the techniques used are given in Table 2 and Table 3, whilst transects are mapped in Appendix 1. The start of the transect was considered to be when the gear reached the seabed and the end when hauling commenced, all co-ordinates and depths were taken using the vessel's on board instruments. Each transect was surveyed with both the otter and beam trawl gear. Though sites for subtidal sampling were given individual codes for purposes of method identification, they were slightly offset replicates of the same sites.

Table 2. Subtidal otter trawl sites sampled during the survey

Site Code	Otter Trawls	
	Start	End
O1	51:32.398N 3:50.529W	51:33.544N 3:51.127W
O2	51:35.051N 3:50.047W	51:35.594N 3:51.756W
O3	51:35.712N 3:53.136W	51:34.888N 3:54.541W
O4	51:35.002N 3:57.049W	51:34.431N 3:57.404W
O5	51:34.430N 3:55.457W	51:34.748N 3:54.292W
O6	51:35.189N 3:57.215W	51:35.747N 3:56.292W
O7	51:34.382N 3:52.414W	51:33.530N 3:53.691W

Table 3. Subtidal beam trawl sites sampled during the survey

Site Code	Beam Trawls	
	Start	End
B1	51:33.228N 3:50.723W	51:33.008N 3:49.668W
B2	51:35.092N 3:50.259W	51:35.627 N 3:52.120W
B3	51:35.645 N 3:53.860W	51:35.511N 3:52.822W
B4	51:34.419N 3:57.966W	51:34.997N 3:57.566W
B5	51:34.561N 3:55.356W	51:34.853N 3:54.314W
B6	51:35.708N 3:56.655W	51:34.983N 3:57.869W
B7	51:33.870N 3:52.918W	51:33.624N 3:53.753W

2.3.0.2 Trawling was undertaken from the MFV Heather D (Barry Thomas Mumbles), a 12.1 m mono-hull trawler vessel. The specifications for the two nets deployed during the subtidal surveys, are given in Table 4.

Table 4. Respective net sizes for both otter and beam trawls utilised in the surveys

Characteristic	Otter Trawl sizes (cm)	Beam Trawl sizes (cm)*
Head line length/ Width of Beam Trawl	1500	150
Ground rope length	1620	330
Mouth height	360	45
Wing mesh	10	8
Cod end mesh	1	1

*(Shoe width = 10 cm and Bridles = 300 cm)

2.3.0.3 Otter trawls (Plate 2) were conducted using a standard otter board setup trawled for approximately 30 minutes at an average tow speed of 2.1 knots. One trawl was conducted at each site. On completion of the trawl the net was winched aboard the vessel and the catch emptied into holding bins filled with sea water. Fish were removed and separated from macroinvertebrates and debris. Fish were identified to species level, recorded and measured to the nearest millimetre (total length L_t), whilst macroinvertebrates were recorded and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

2.3.0.4 Epibenthic beam trawls (Plate 3) transects were conducted for approximately 30 minutes at an average speed of two knots. As for the otter trawls, a winch was utilised to recover the net onto the deck of the vessel on completion of the fishing operation. Fish were then emptied from the net into holding bins filled with sea water. All fish captured were identified and measured to the nearest millimetre. After processing all fish were returned to the water. Macroinvertebrates were identified to the lowest practicable taxonomic level and their presence was noted.

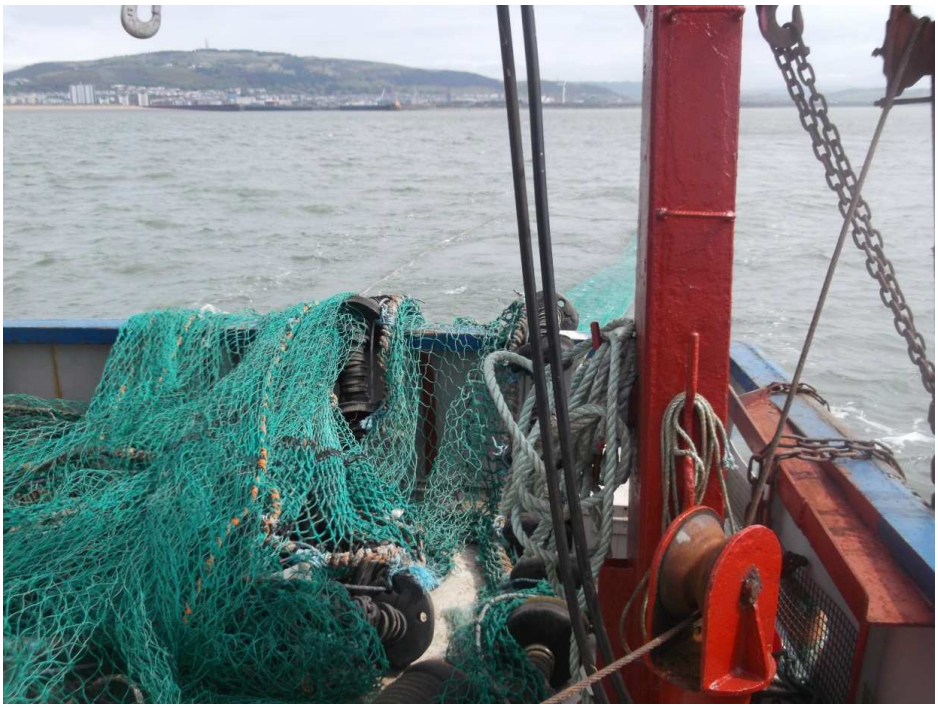


Plate 2. Otter trawl ready to be lowered into the water

Plate 3. Standard design beam trawl used in the surveys

2.4 Water Quality and Hydrographic Data

2.4.0.1 Temperature and salinity were recorded using a hand held conductivity meter (470 Portable Conductivity Meter; www.jenway.com), whilst dissolved oxygen (DO) was recorded using a portable oxygen probe (Hach Orbisphere 3655 O_2; www.hach). A single measurement was taken at each site sampled. The conductivity meter was calibrated at the startof each survey period using a 5000 µS/cm standard solution; whilst the oxygen probe was air calibrated. Analysis

2.4.0.2 The frequency of occurrence of fish across the study area was used to calculate the relative abundance of each taxon. Relative abundance in this report is defined as the percentage of total catch comprised by a given species, which can be calculated using the following formula:

$$\%Ai = \frac{\sum C_i}{\sum S_t} \times 100,$$

2.4.0.3 where: $\%Ai$ is relative abundance, C_i is the sample content composed by the species across surveys/sites and S_t is the total content of all surveys/sites in the entire sampling period.

2.4.0.4 Despite trawls being conducted for a standardised time period (30 minutes for Otter and Beam respectively), the length of each trawl transect varied owing to differences in the seabed, tidal current and the presence of obstructions (e.g. pot lines). As a result the length of each individual trawl track as recorded using GPS co-ordinates was utilised to calculate the number of specimen for each species sampled per 100 m trawled (catch per unit effort (CPUE)).

3 Results

3.1.0.1 A total of 34 fish species and 20 macroinvertebrate species were recorded in the subtidal and intertidal surveys, raw data for these are presented in Appendix 2 and Appendix 4. Bass were the most abundant fish species (24.5 %), followed by herring (21.9 %), sand eel (16.3%) sand smelt (8.5 %) and plaice (7.8 %). Figure 1 gives the relative abundance of all fish species caught across both the intertidal and subtidal sites.

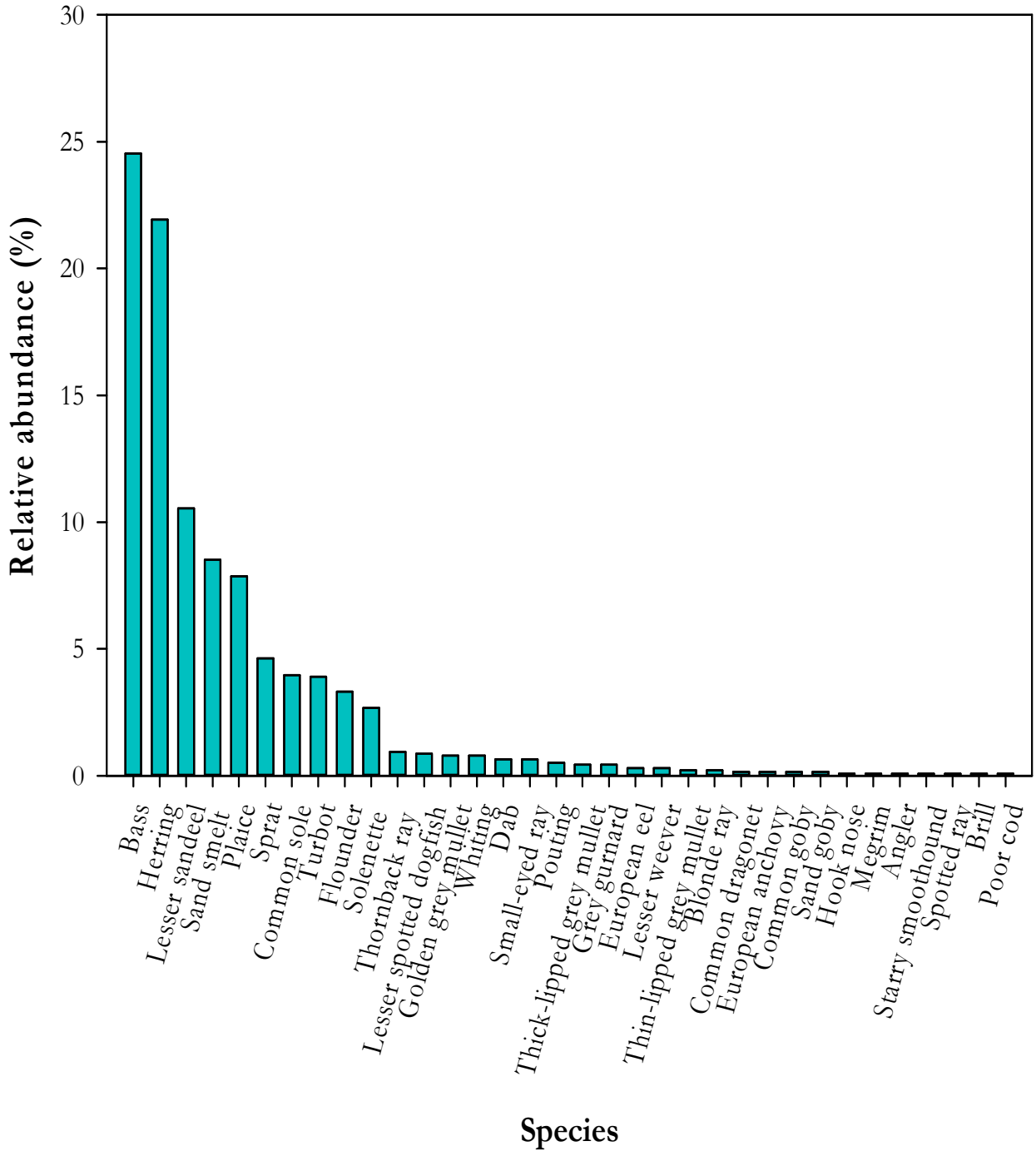


Figure 1. Relative abundance of fish species across all sites sampled

3.2 Intertidal Seine and Riley Push-Netting

3.2.0.1 A total of 1159 fish belonging to 19 species were caught during intertidal surveys. Figure 4 shows the relative abundance of all species caught during the intertidal sampling program, whilst Appendix 1 gives the raw number of fish captured. The most abundant species during intertidal sampling was bass (29.3 %), followed by herring (26.2 %), lesser sandeel (12.5 %), sand smelt (10.1 %) and sprat (5.4 %).

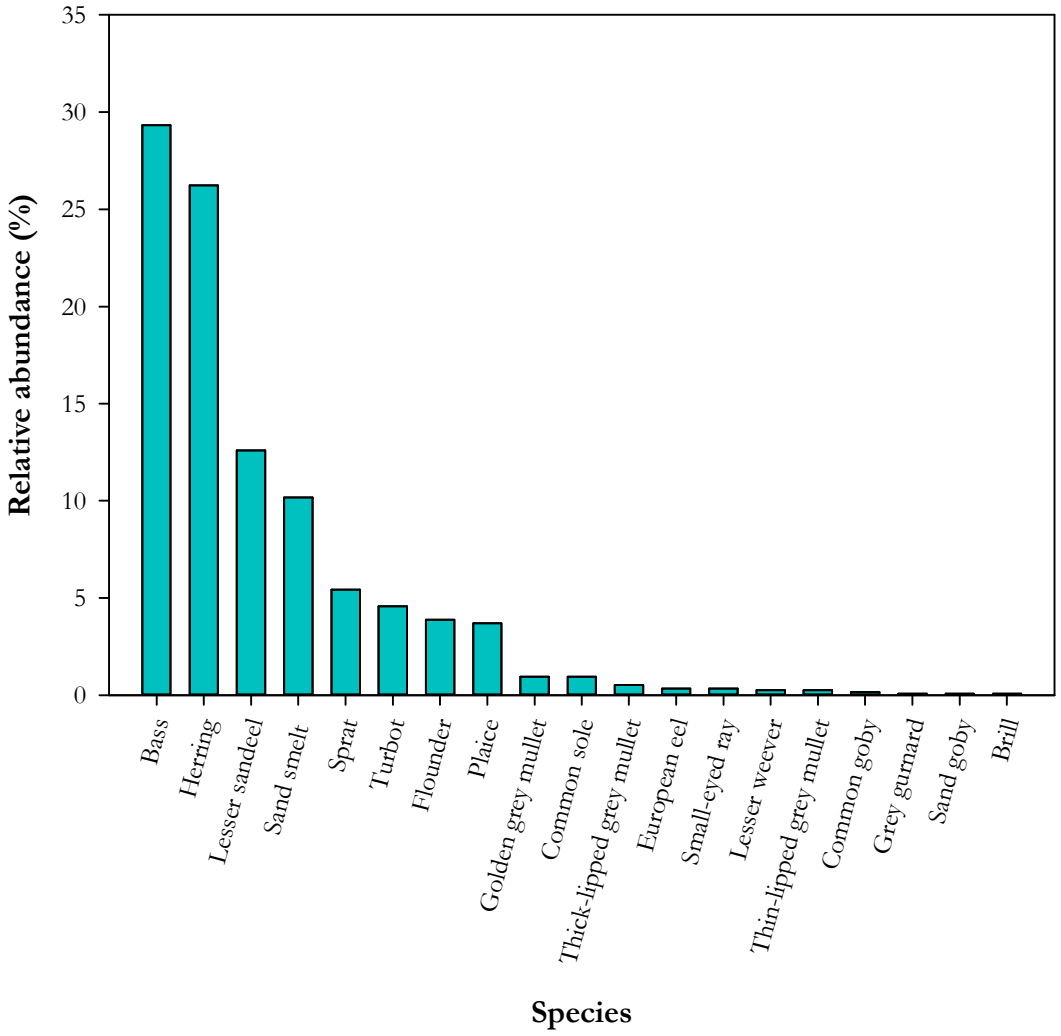


Figure 2. Relative abundance of fish species across intertidal sites sampled

3.3 Subtidal Otter and Beam Trawl

3.3.0.1 A total of 227 fish belonging to 24 species were caught during beam and otter trawl surveys, 168 (74.0 %) of which were caught during otter trawling and 59 (25.9 %) using otter trawling. Figure 3 gives the relative abundance of all species across all of the subtidal sites.

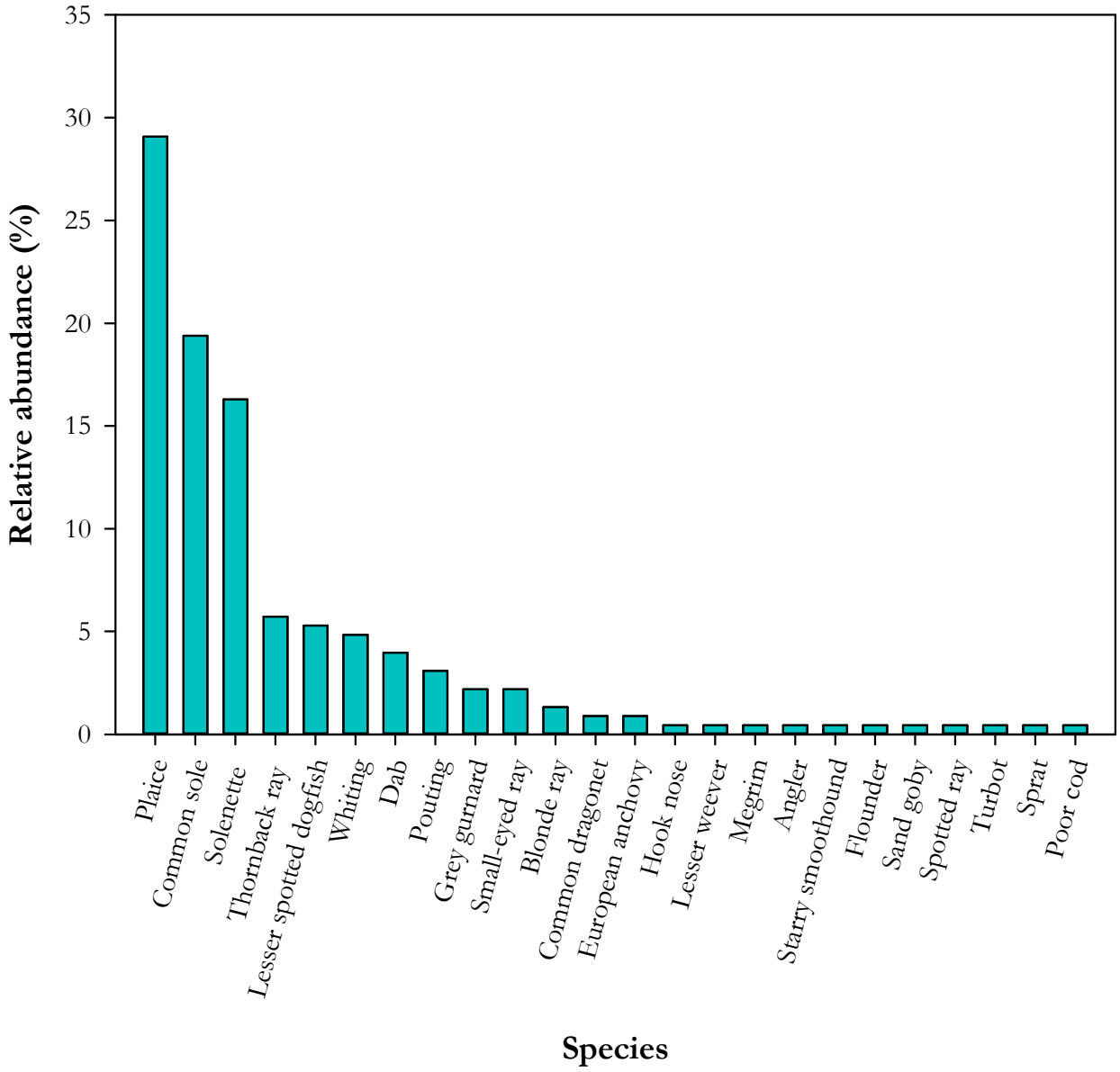


Figure 3. Relative abundance of fish species across subtidal sites sampled

3.3.0.2 Catch per unit effort was typically higher in beam trawls than in otter trawls (Figure 4), site seven was the only exception with 0.28 and 0.32 CPUE (fish per 100 m trawled) respectively.

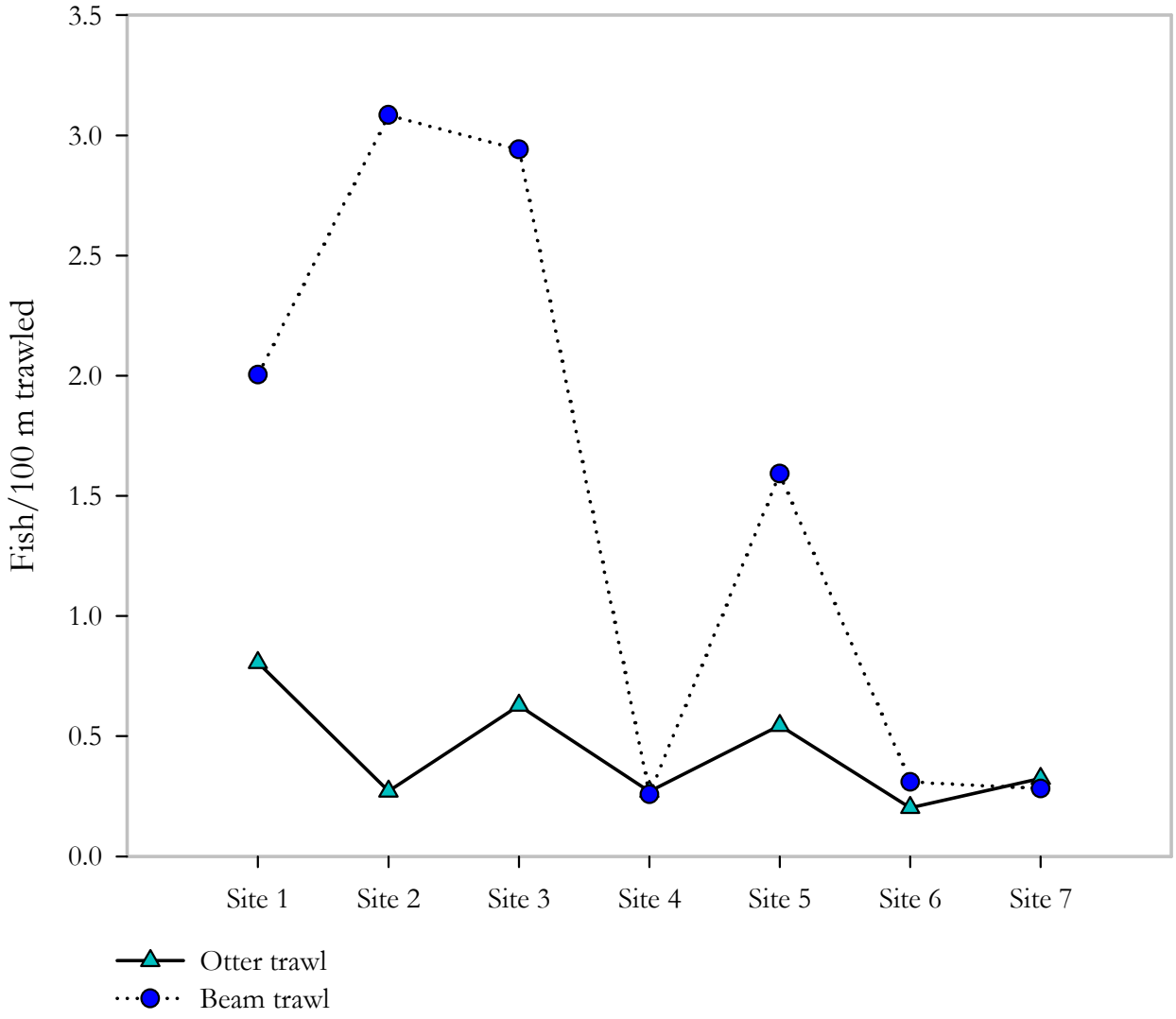


Figure 4. Total number of fish specimens expressed as CPUE recorded in subtidal sampling in May 2013

3.4 Length frequency distributions

3.4.0.1 Several fish species of commercial importance were sampled in relatively high abundance during the surveys. These included herring, bass, plaice, turbot and sole. Figure 5 (A to E) below provides a number of summary histograms for the length frequencies of these fish.

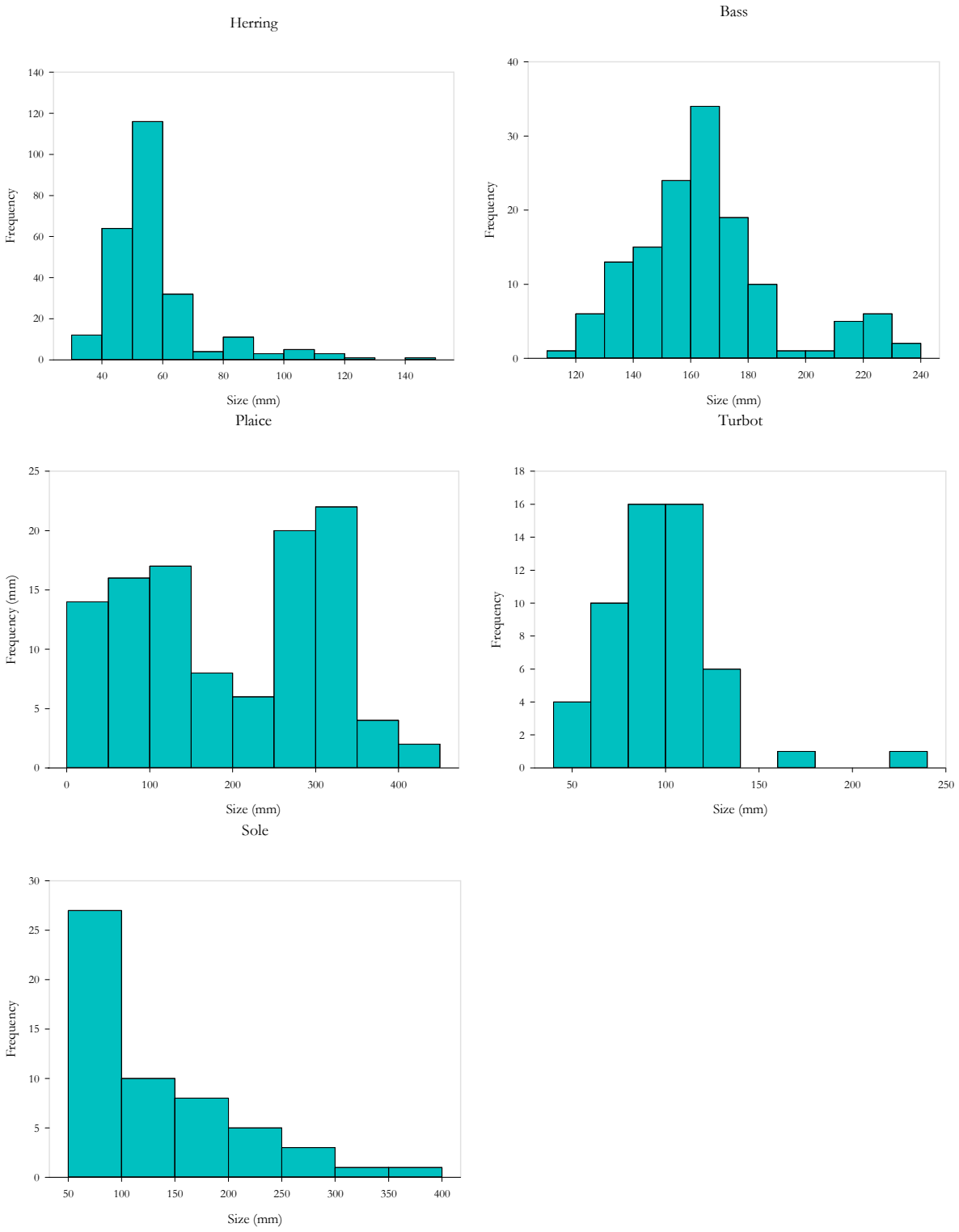


Figure 5. Length frequency distribution histograms for a number commercially important species captured during the surveys (A-E).

3.5 Invertebrates

3.5.0.1 A total of 20 species of macroinvertebrate were recorded during the survey; this included molluscs, crustaceans and echinoderms. Brittle stars were the most abundant species found during the spring surveys; this was consistent with earlier winter surveys, whilst common hermit crab were the species present across most sites (n = 9).

3.5.0.2 Appendix 4 gives a full breakdown of results.

4 Discussion

4.1.0.1 Warm temperatures in inshore waters (temperature mean ± S. D. = 12.8 ± 1.34 ℃ (Appendix 5) meant that intertidal sampling during spring yielded a greater number of fish when compared to winter surveys. Abundance was dominated by juveniles of several species (e.g. bass, turbot and herring), whilst the adult population was typically composed of sand smelt, lesser sandeel and mullet.

4.1.0.2 A relatively high density of flatfish were recorded during the survey belonging to a number of species including turbot, plaice, and sole. Juvenile flatfish were most numerous in shallow (< 5 m) intertidal areas, with turbot and plaice the most abundant species. Adult specimens of flat fish were predominantly caught at sub-tidal sampling stations with plaice and sole most abundant.

4.1.0.3 Protected and shallow inshore marine areas are known to be utilised by flatfish as nursery areas. Black pill (I2), Abertawe (I3), Port Talbot West (I4), Caswell Bay (I1) and Langland Bay (I5) provide ideal conditions for juveniles of these species, offering shallow sloping, sandy areas, with good availability of prey such as mysids and amphipods.

4.1.0.4 Bass (mean ± S.D. = 164.6 ± 24.6) were caught solely during intertidal surveys. Highest densities were present in the vicinity of the Neath estuary at Crymlyn Burrows (I6), these were primarily multi-year juveniles (1+ and 2+).

4.1.0.5 Sandeel were most abundant at the western most site (I1), their presence is important as they are considered a keystone species. Herring juveniles were abundant at several sites across the bay, these are most likely the result of a spring spawning population which is known to visit the bay early in the year.

4.1.0.6 Subtidal surveys were dominated by catches of plaice and sole, with elasmobranch fish such as rays also frequent.

4.1.0.7 The species captured during the surveys are in line with the overall assemblage to be expected in the Bristol Channel (Potts and Swaby, 1993).

5 References

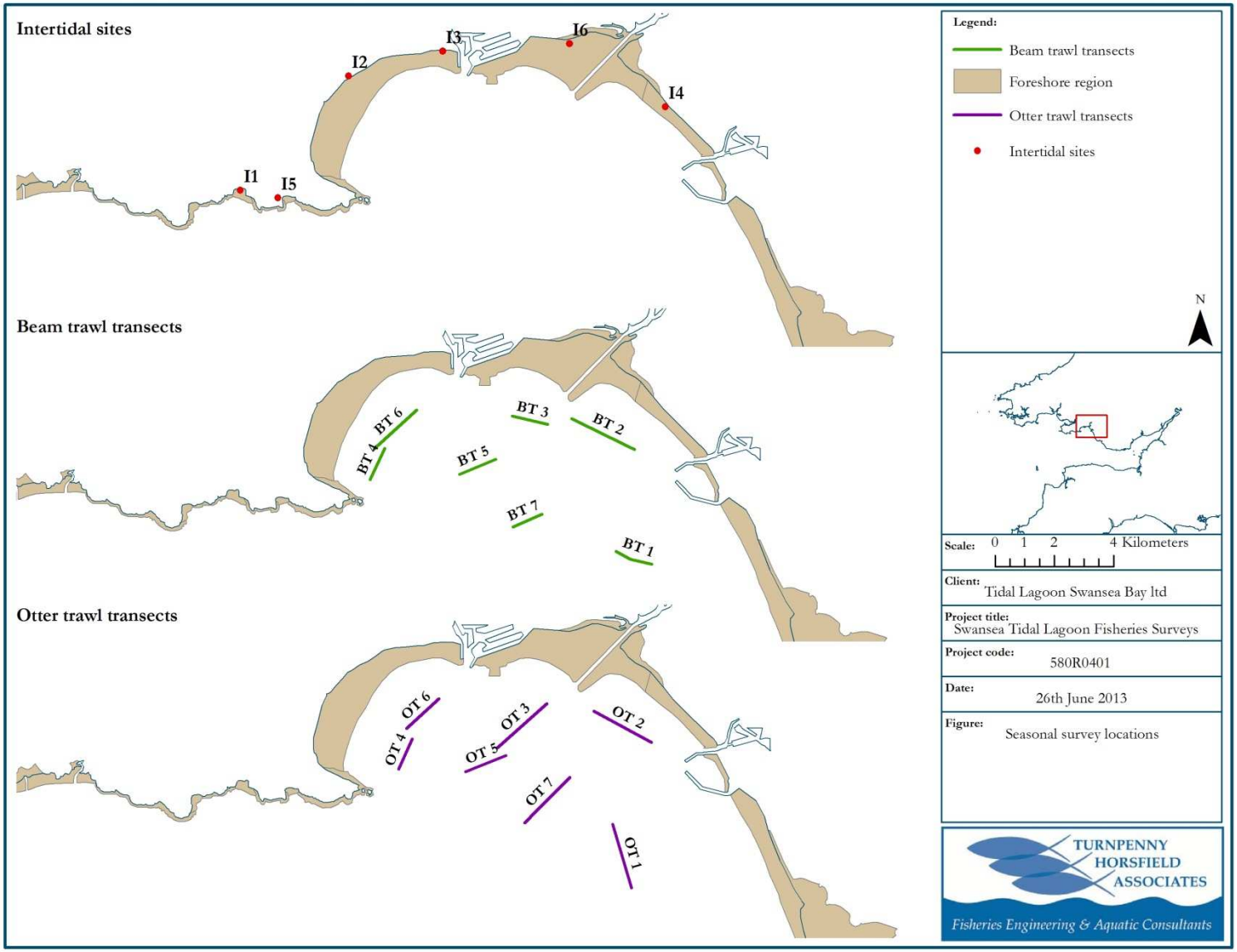
Davies, J., 1998. Bristol Channel and approaches (Cape Cornwall to Cwm-yr-Eglwys, Newport Bay)(MNCR Sector 9). In K. Hiscock, ed. Marine Nature Conservation Review. Peterborough: Joint Nature Conservation Committee, pp. 225–295.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp.

Potts, G. W. & Swaby, S. E., 1993. Marine and Estuarine Fishes of Wales: the development of the British Marine Fishes Database and monitoring programme for Wales. CCW Science Report 49.

Tidal Lagoon Swansea Bay Ltd. 2012. Proposed Tidal Lagoon Development in Swansea Bay, South Wales Environmental Impact Assessment Scoping Report October 2012. Cheltenham: Tidal Lagoon Swansea Bay Ltd.

Appendix 1. Locations sampled during the surveys.



Appendix 2. Fish presence and abundance recorded during subtidal surveys

Scientific Name	Common Name	Otter Trawl sites							Beam Trawls sites						
		O1	O2	O3	O4	O5	O6	O7	B1	B2	B3	B4	B5	B6	B7
Agonus cataphractus	Hook nose												1		
Buglossidium luteum	Solenette	1								27	7			1	1
Callionymus lyra	Common dragonet												2		
Echiichthys vipera	Lesser weever													1	
Engraulis encrasicolus	European anchovy									2					
Eutriglia gurnardus	Grey gurnard									1	4				
Lepidorhombus whiffiagonis	Megrim												1		
Limanda limanda	Dab	1	2			1		2	1		1		1		
Lophius piscatorius	Angler										1				
Merlangius merlangus	Whiting								3	8					
Mustelus asterias	Starry smoothound	1													
Platichthys flesus	Flounder									1					
Pleuronectes platessa	Plaice	6	3	11	2	7	2	1	5	10	8	2	7	1	1
Pomatoschistus minutus	Sand goby										1				
Raja brachyura	Blonde ray			2						1					

Scientific Name	Common Name	Otter Trawl sites							Beam Trawls sites						
		O1	O2	O3	O4	O5	O6	O7	B1	B2	B3	B4	B5	B6	B7
Raja clavata	Thornback ray	1	1		1			2	1	2	3	1			1
Raja microocellata	Smalleyed ray	2					1	1						1	
Raja montagui	Spotted ray							1							
Scophthalmus maximus	Turbot													1	
Scyliorhinus canicula	Lesser spotted dogfish									4	2		6		
Solea solea	Common sole	5							13	16	8		1	1	
Sprattus sprattus	Sprat									1					
Trisopterus luscus	Pouting	1		1					2		1		2		
Trisopterus minutus	Poor cod								1						

Appendix 3. Fish presence and abundance recoded during intertidal surveys

Scientific Name	Common Name	Seine						Riley					
		S1	S2	S3	S4	S5	S6	R1	R2	R3	R4	R5	R6
Ammodytes tobianus	Lesser sandeel	131		14		1							
Anguilla anguilla	European eel		2				2						
Atherina presbyter	Sand smelt	25	13	5	1	30	44						
Chelon labrosus	Thick-lipped grey mullet		1				5						
Clupea harengus	Herring	1	173	18	58		31			3			20
Dicentrarchus labrax	Bass		18		9		313						
Echiichthys vipera	Lesser weever	1				2							
Eutriglia gurnardus	Grey gurnard	1											
Liza aurata	Golden grey mullet		3		1		7						
Liza ramada	Thin-lipped grey mullet				1		2						
Platichthys flesus	Flounder	1	4	16	1	21	2						
Pleuronectes platessa	Plaice	2	21	10	5	2	2			1			
Pomatoschistus microps	Common goby												2
Pomatoschistus minutus	Sand goby						1						
Raja microocellata	Small-eyed ray		4										

Scientific Name	Common Name	Seine						Riley					
		S1	S2	S3	S4	S5	S6	R1	R2	R3	R4	R5	R6
Scophthalmus maximus	Turbot	7		12	24	10							
Scophthalmus rhombus	Brill	1											
Solea solea	Sole	1	10										
Sprattus sprattus	Sprat		2	1	58		2						

Appendix 4. Invertebrates presence and abundance recorded during surveys.

Scientific Name	Common Name	Otter Trawl sites							Beam Trawls sites						
		O1	O2	O3	O4	O5	O6	O7	B1	B2	B3	B4	B5	B6	B7
Achelia echinata	Sea spider												1-10		
Alloteuthis subulata	European common squid								1-10	1-10	1-10			1-10	1-10
Anemonia viridis	Snakelocks anemone									1-10	1-10	1-10		1-10	1-10
Aphrodita aculeata	Sea mouse								1-10	1-10	1-10				
Asterias rubens	Common starfish	1-10	1-10	1-10					1-100				1-10	1-10	1-10
Buccinum undatum	Common whelk								1-10		1-10				
Cancer pagurus	Brown crab	1-10													
Cerastoderme edule	Common cockle									1-10					
Corystes cassivelaunus	Masked crab		1-10	1-10					1-10		1-10				
Crangon spp.	Shrimp	1-10	1-10						1-10	1-100	1-10		1-10		
Crossaster papposus	Common sunstar					1-10									1-10
Homarus gammarus	Lobster					1-10									
Macropodia spp.	Spider crab				1-10										1-10
Nucella lapillus	Dog whelk									1-10			1-10		
Ophiura ophiura	Brittle star	1-10	1-10						1-1000	1-100	1-10			1-10	1-10

Scientific Name	Common Name	Otter Trawl sites							Beam Trawls sites						
		O1	O2	O3	O4	O5	O6	O7	B1	B2	B3	B4	B5	B6	B7
Pagurus bernhardus	Common hermit crab	1-10	1-10						1-10	1-10	1-10	1-10	1-10	1-10	1-10
Palaemon spp.	Prawn								1-10	1-10			1-10		1-10
Psammechinus miliaris	Green sea urchin														1-10
Sepia officinalis	Common cuttlefish			1-10			1-10								
Sepiola atlantica	Little cuttlefish								1-10	1-10					

Appendix 5. Dissolved oxygen, temperature, salinity and depth at all sites sampled.

Site	Dissolved oxygen (ppm)	Temperature (C°)	Salinity (ppt)	Depth
O1	7.0	12.1	33.5	16.6
O2	6.2	12.6	32.2	12.2
O3	5.3	11.8	31.7	11.2
O4	5.9	12.3	32.3	5.1
O5	5.7	12.0	32.4	13.2
O6	5.7	13.1	31.7	3.2
O7	5.6	11.8	32.4	15.3
B1	8.5	11.7	33.6	12.8
B2	3.9	11.9	32.2	9.5
B3	6.9	12.6	31.8	9.0
B4	6.7	12.7	31.9	8.7
B5	8.0	11.5	32.3	13.7
B6	4.4	11.3	32.5	6.5
B7	7.6	12.6	32.6	18.0
I1	3.8	15.1	33.7	n/a
I2	4.6	15.6	33.3	n/a
I3	7.1	12.2	31.8	n/a
I4	6.3	13.5	32.1	n/a
I5	4.6	15.9	33.2	n/a
I6	5.7	13.9	31.6	n/a

TURNPENNY HORSFIELD ASSOCIATES

Fisheries Engineering & Aquatic Consultants

Swansea Tidal Lagoon

Fish Fauna Characterisation Surveys

July 2013 survey – 3rd Quarter

Prepared for: Tidal Lagoon Swansea Bay Ltd.

Document No. 580R0501

Date: 28th August 2013

Survey vessel – Heather D

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Swansea Tidal Lagoon Fish Fauna Characterisation Surveys

July 2013 – 3rd Quarter

Report Reference: 580R0501

Revision date: *28th August 2013*

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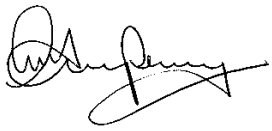
Position: *Aquatic Ecologist*

Approved by: *Dr Andy Turnpenny*

Position: *Director*

Approver's signature:



Date: *28th August 2013*

Swansea Tidal Lagoon Fish Fauna Characterisation Surveys

Contents

1 Introduction

1.1 Background to the Project

1.1.0.1 Tidal Lagoon Swansea Bay Ltd propose to develop a tidal lagoon for the purpose of generating energy in Swansea Bay, Wales. The tidal lagoon would be situated between the dredged channels of the Rivers Tawe and Neath, and when fully operational could serve to provide energy for more than 100,000 homes (Tidal Lagoon Swansea Bay Ltd, 2012).

1.1.0.2 The Planning Act 2008 (c.29) introduced special provisions for the consenting process surrounding the development of energy generating infrastructure with a capacity greater than 100 megawatts (MW). Such developments are termed as Nationally Significant Infrastructure Projects (NSIP) and require a Development Consent Order (DCO) to be submitted to the Planning Inspectorate (PINS). The proposed tidal lagoon at Swansea Bay will have a nominal rated power of 240MW, and as such, falls under this regime.

1.1.0.3 As part of the legislative framework for EIA (Environmental Impact Assessment), as set out in the European Directive 85/337/EEC (as amended), and transposed into UK legislation through the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009, the project will require an EIA to be undertaken. To accompany the DCO and fulfil requirements found within EIA legislation, an Environmental Statement (ES) will be produced.

1.1.0.4 The principal remit of the ES is to describe the likely significant effects of the development on the environment and its receptors and any possible mitigation measures which might be undertaken to decrease such effects.

1.1.0.5 As part of the ES process, Turnpenny Horsfield Associates Ltd (THA) has been commissioned to assess the potential impacts of the project on the fish community of Swansea Bay and adjacent waters.

1.1.0.6 To supplement evidence from a detailed desk-based review, a programme of quarterly fish fauna surveys has been designed to characterise fish populations within the Bay to inform decision-making associated with the project.

1.1.0.7 This report details one of a series of fish fauna characterisation surveys being carried out by THA. The surveys adopt multiple biomonitoring techniques consistent with Water Framework Directive (WFD) monitoring standards and JNCC best practice techniques to monitor biota within marine environments[1].

[1] Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp, ISBN 1 85716 550 0

1.2 Aims and Objectives

1.2.0.1 The aim of this report is to provide an up-to-date characterisation of the seasonal fish community within the defined study area. The study area has been defined as the potential near-field and far-field zone of influence around the Swansea Tidal Lagoon though a high level coastal process model (Tidal Lagoon Swansea Bay Ltd., 2012). Limitations in the survey methodology have been identified in the Environmental Statement.

2 Methods

2.1 Study Area

2.1.0.1 Swansea Bay (NGR SS 630910) is approximately 12 km wide with an area of 50 km^2. The seabed of the Bay is largely composed of mud, sand and fine gravel, with some rock outcrops and cobbles occurring on the western edge of the embayment, towards Mumbles Head (Davies, 1998).

2.2 Intertidal Seine and Riley Push-Netting

2.2.0.1 Six sites were sampled as part of the intertidal sampling program between the 22nd of July and 23rd of July 2013. The locations of these sites are shown in Table 1 and mapped in Appendix 1. Sampling was conducted on suitable shores with a slight slope and firm substrates. Two techniques were utilised at each site, these are detailed below.

Table 1 Intertidal sites sampled during the surveys

Site Code	Site Name	Co-ordinates
I1	Caswell Bay	51:34.13312N 4:1.94620W
I2	Blackpill	51:36.27098N 3:58.87818W
I3	Abertawe	51:36.77037N 3:56.14407W
I4	Port Talbot West	51:35.86105N 3:49.59318W
I5	Pwlldu Bay	51:33.88237N 4:3.48465W
I6	Crymlyn Burrows	51:36.96590N 3:52.44125W

2.2.0.2 A 43 m long (4 m deep) seine net with 14 mm wings and a 6.5 mm centre knotless mesh was deployed from a rigid mono-hull vessel. The methods adopted followed JNCC procedural guidelines (Davies *et al.*, 2001).

2.2.0.3 A rope attached to one end of the seine was held onshore by an operative, whilst the net of the seine was loaded onto the vessel. The vessel was then taken out perpendicularly from the shoreline, once the extent of the rope connecting the seine to the shore was fully paid out the vessel made a 90˚ turn and proceeded parallel to the shore, slowly paying out the remainder of the net. Once fully deployed, the rope attached to the free end of the net was brought ashore and the net hauled bringing together the ends of the net and pursing the seine. Floats on the net were kept outside of the lead line thus preventing accidental the loss of fish from the net.

2.2.0.4 Riley push-netting was undertaken using a 1.5 m wide push-net with a 6.5 mm mesh trouser legs lined with 1 mm fry mesh (Plate 1). A tickler chain was mounted on the net to increase its efficacy. Transects measuring 100 m were marked out on the shore, the net was lifted and placed in knee-depth water by two operatives. A single member of staff then proceeded to push the net for the measured distance.

2.2.0.5 Two replicates for each method were carried out at all sites.

2.2.0.6 All fish captured were removed and separated from macroinvertebrates and debris. With exception to juvenile specimens of *Pomatoschistus* spp., fish were identified to species level, and recorded and measured to the nearest millimetre (total length L_t); whilst macroinvertebrates were recorded as log abundance: 1-9; 10-99; 100-999; or 1000+ and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

Plate 1. Riley net design and technique utilised during sampling

2.3 Subtidal Otter and Beam Trawls

2.3.0.1 The subtidal survey comprised of 12 trawls at six sites, conducted between the 24th and 25th of July 2013. The start and end position of the trawl transects for each of the techniques used are given in Table 2 and Table 3, whilst transects are mapped in Appendix 1. The start of the transect was considered to be when the gear reached the seabed and the end when hauling commenced, all co-ordinates and depths were taken using the vessel's on board instruments. Each site was surveyed with both the otter and beam trawl gear along parallel transects.

Table 2. Subtidal otter trawl sites sampled during the survey

Site Code	Otter Trawls	
	Start	End
O1	51:33.422N 3:51.026W	51:32.841N 3:50.386W
O2	51:35.000N 3:50.175W	51:35.385N 3:51.236W
O3	51:35.572N 3:53.165W	51:35.862N 3:53.468W
O4	51:34.428N 3:58.012W	51:35.329N 3:57.157W
O5	51:34.030N 3:52.763W	51:33.710N 3:53.607W
O6	51:35.351N 3:57.084W	51:36.114N 3:56.214W

Table 3. Subtidal beam trawl sites sampled during the survey

Site Code	Beam Trawls	
	Start	End
B1	51:33.243N 3:50.753W	51:32.625N 3:50.010W
B2	51:35.451N 3:51.266W	51:35.027N 3:49.858W
B3	51:36.013N 3:53.529W	51:35.053N 3:52.674W
B4	51:34.717N 3:57.735W	51:35.466N 3:57.585W
B5	51:34.428N 3:55.469W	51:35.019N 3:53.971W
B6	51:35.414N 3:57.074W	51:35.892N 3:56.304W

2.3.0.2 Trawling was undertaken from the MFV Heather D (Barry Thomas Mumbles), a 12.1 m mono-hull trawler vessel. The specifications for the two nets deployed during the subtidal surveys are given in Table 4.

Table 4. Respective net sizes for both otter and beam trawls utilised in the surveys

Characteristic	Otter Trawl sizes (cm)	Beam Trawl sizes (cm)*
Head line length/Width of Beam Trawl	1500	150
Ground rope length	1620	330
Mouth height	360	45
Wing mesh	10	8
Cod end mesh	1	1

*(Shoe width = 10 cm and Bridles = 300 cm)

2.3.0.3 Otter trawls (Plate 2) were conducted using a standard otter board setup trawled for approximately 30 minutes at an average tow speed of 2.1 knots. One trawl was conducted at each site. On completion of the trawl the net was winched aboard the vessel and the catch emptied into holding bins filled with sea water. Fish were removed and separated from macroinvertebrates and debris. Fish were identified to species level (with exception of juvenile *Pomatoschistus* spp. and *belone* spp.), recorded and measured to the nearest millimetre (total length L_t), whilst macroinvertebrates were recorded and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

2.3.0.4 Epibenthic beam trawls (Plate 3) transects were conducted for approximately 30 minutes at an average speed of 2 knots. As for the otter trawls, a winch was utilised to recover the net onto the deck of the vessel on completion of the fishing operation. Fish were then emptied from the net into holding bins filled with sea water. All fish captured were identified and measured to the nearest millimetre. After processing all fish were returned to the water. Macroinvertebrates were identified to the lowest practicable taxonomic level and their presence was noted.

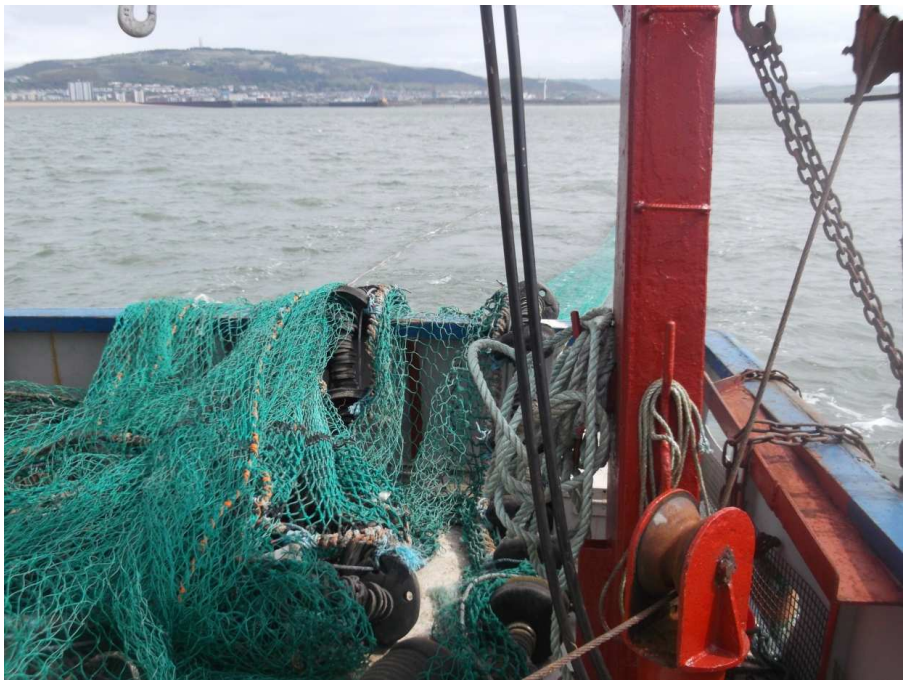


Plate 2. Otter trawl ready to be lowered into the water

Plate 3. Standard design beam trawl used in the surveys (1.5m)

2.4 Water Quality and Hydrographic Data

2.4.0.1 Temperature and salinity were recorded using a hand held conductivity meter (470 Portable Conductivity Meter; www.jenway.com), whilst dissolved oxygen (DO) was recorded using a portable oxygen probe (Hach Orbisphere 3655 O_2; www.hach). A single measurement was taken at each site sampled. The conductivity meter was calibrated at the start of each survey period using a 5000 µS/cm standard solution; whilst the oxygen probe was air calibrated.

2.5 Analysis

2.5.0.1 The frequency of occurrence of fish across the study area was used to calculate the relative abundance of each taxon. Relative abundance in this report is defined as the percentage of total catch comprised by a given species, which can be calculated using the following formula:

$$\%Ai = \frac{\sum C_i}{\sum S_t} \times 100,$$

2.5.0.2 where: $\%Ai$ is relative abundance, C_i is the sample content composed by the species across surveys/sites and S_t is the total content of all surveys/sites in the entire sampling period.

2.5.0.3 Despite trawls being conducted for a standardised time period (30 minutes for Otter and Beam respectively), the length of each trawl transect varied owing to differences in the seabed, tidal current and the presence of obstructions (e.g. pot lines). As a result the length of each individual trawl track as recorded using GPS co-ordinates was utilised to calculate the number of specimen for each species sampled per 100 m trawled (catch per unit effort (CPUE)).

3 Results

3.1.0.1 A total of 39 fish species and 21 macroinvertebrate species were recorded in the subtidal and intertidal surveys, raw data for these are presented in Appendix 2 and Appendix 4. Sprat were the most abundant fish (58.4 %), followed by herring (13.6 %), *Pomatoschistus* spp. (6.5%) grey gurnard (3.9 %) and plaice (3.1 %). Figure 1 gives the relative abundance for all fish species with an abundance >0.1.

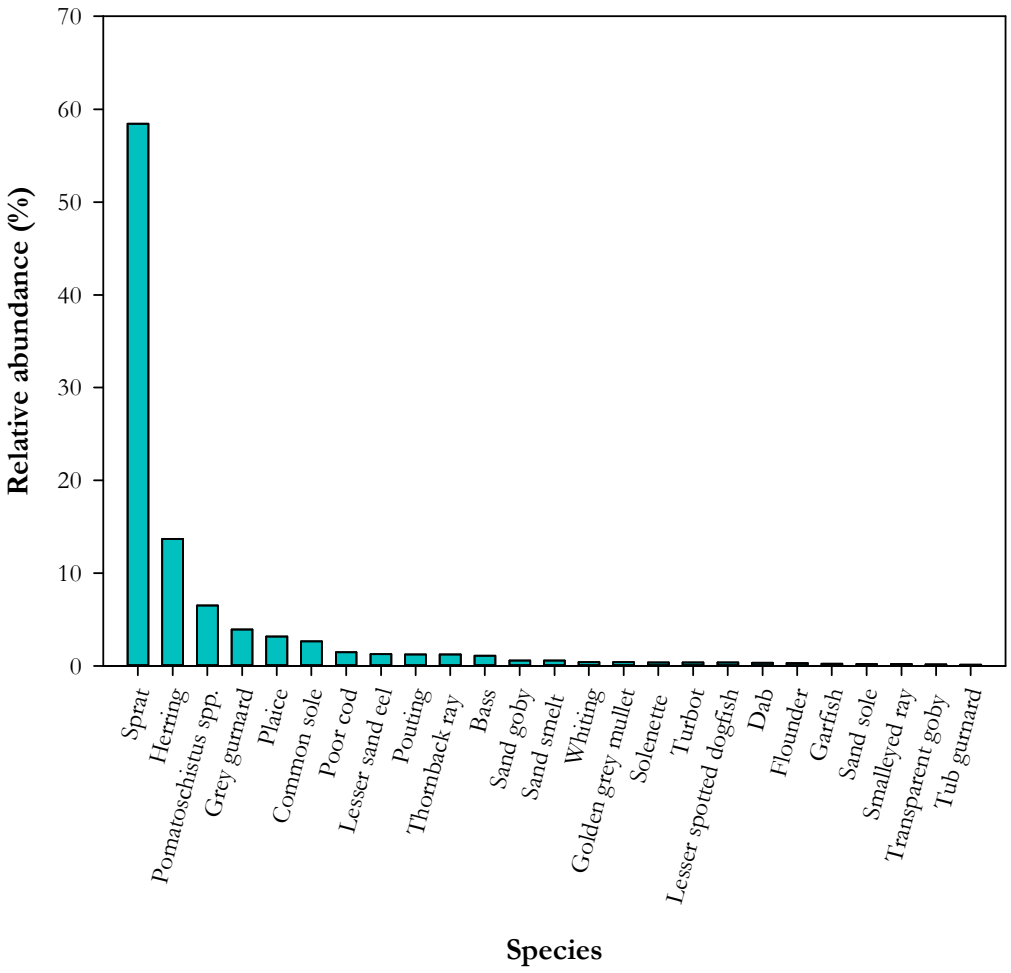


Figure 1. Fish species with abundances > 0.1 caught across all surveys

3.2 Intertidal Seine and Riley Push-Netting

3.2.0.1 A total of 7151 fish belonging to 24 species were caught during intertidal surveys. Fish with abundances >0.1 are shown in Figure 4, whilst Appendix 1 gives the raw number of all fish captured. Similarly to subtidal sampling, sprat (65.4 %) were the most numerous species caught in intertidal surveys, followed by herring (17.2 %), juvenile gobies (12.5 %), plaice (2.1 %) and lesser sand eel (1.6 %).

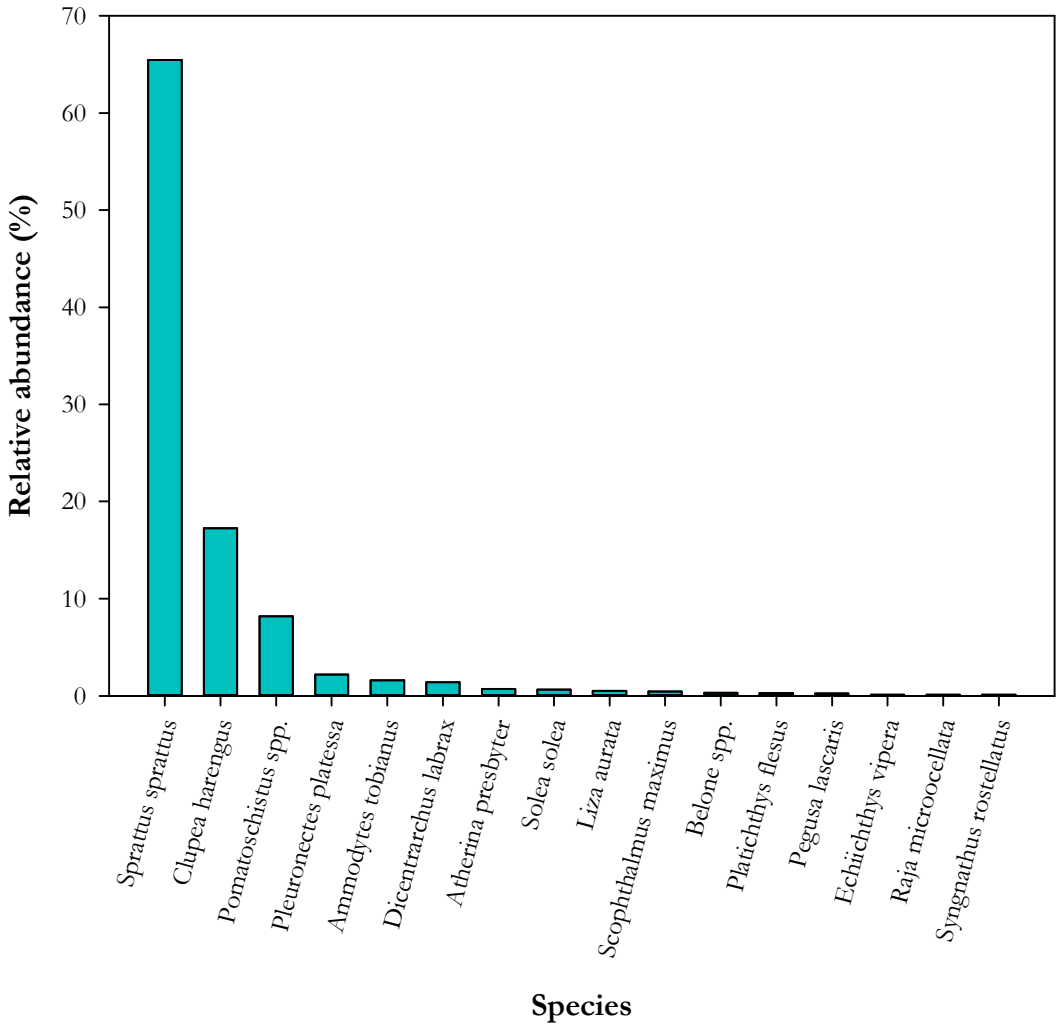


Figure 2. Fish species with abundances > 0.1 caught across the intertidal sites

3.3 Subtidal Otter and Beam Trawl

3.3.0.1 A total of 1857 fish belonging to 26 species were caught during beam and otter trawl surveys, 1601 (86.2 %) of which were caught during otter trawling and 256 (13.7 %) using beam trawling. Figure 3 gives the relative abundance of all species across all of the subtidal sites.

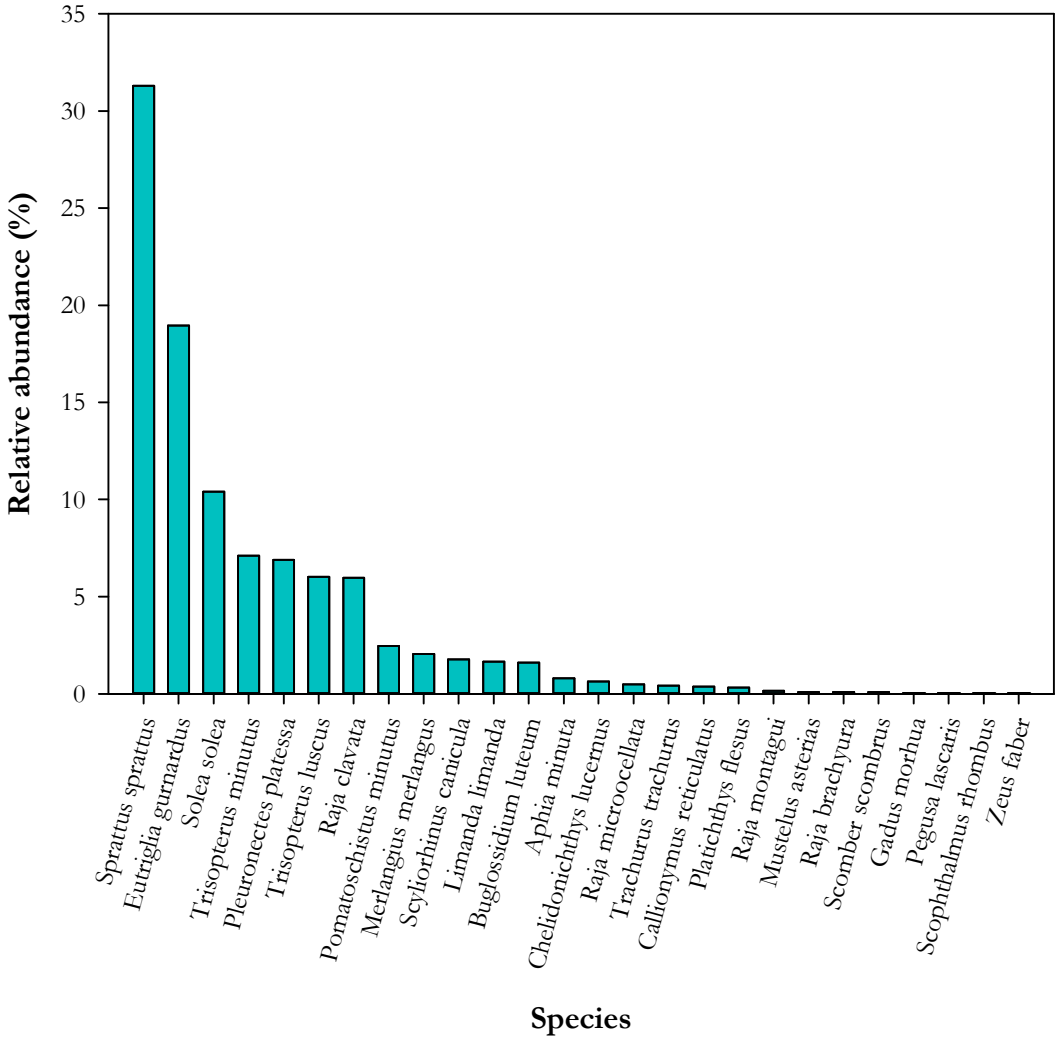


Figure 3. Relative abundance of fish species across subtidal sites sampled

3.3.0.2 Catch per unit effort was consistently higher in otter trawls than in beam trawls (Figure 4), in several occasions this was as a result of pelagic species such as sprat.

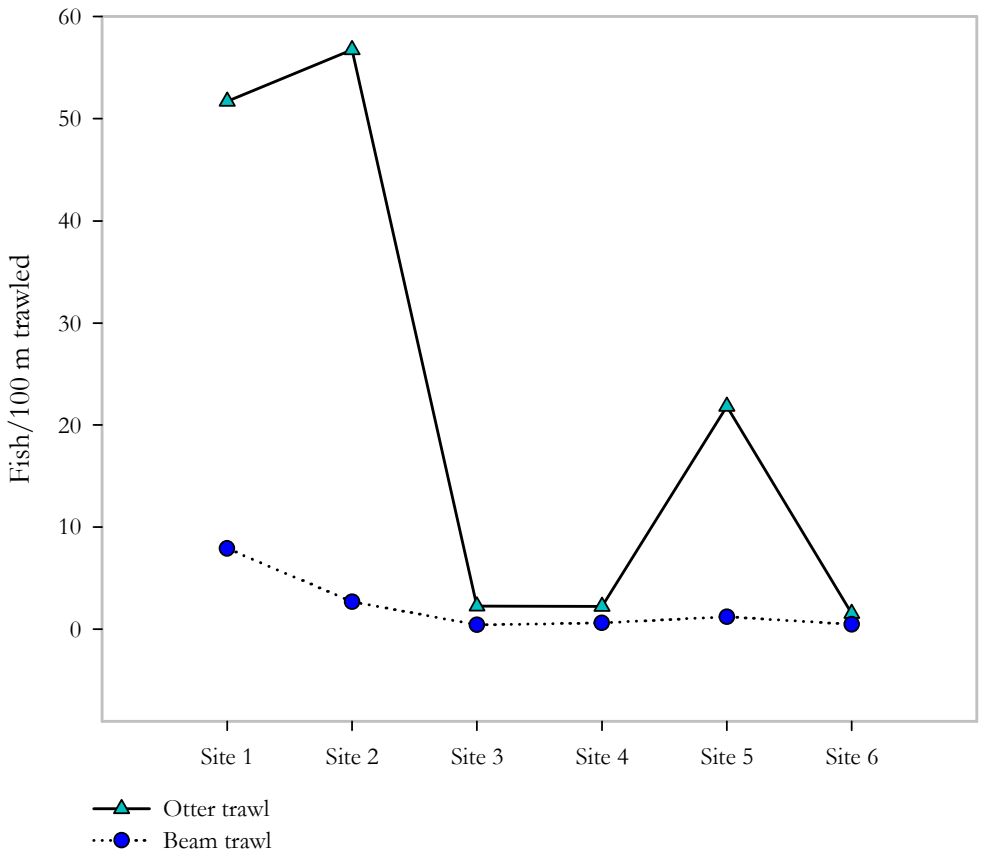


Figure 4. Total number of fish specimens expressed as fish per 100m trawled recorded in subtidal sampling in July 2013

3.4 Length frequency distributions

3.4.0.1 Several fish species of commercial importance were sampled in relatively high abundance during the surveys. These included herring, plaice, sole, thornback ray and bass. Figure 5 (A to E) below provides a number of summary histograms for the length frequencies of these fish. Note that the figures represent fish captured both during intertidal and subtidal sampling.

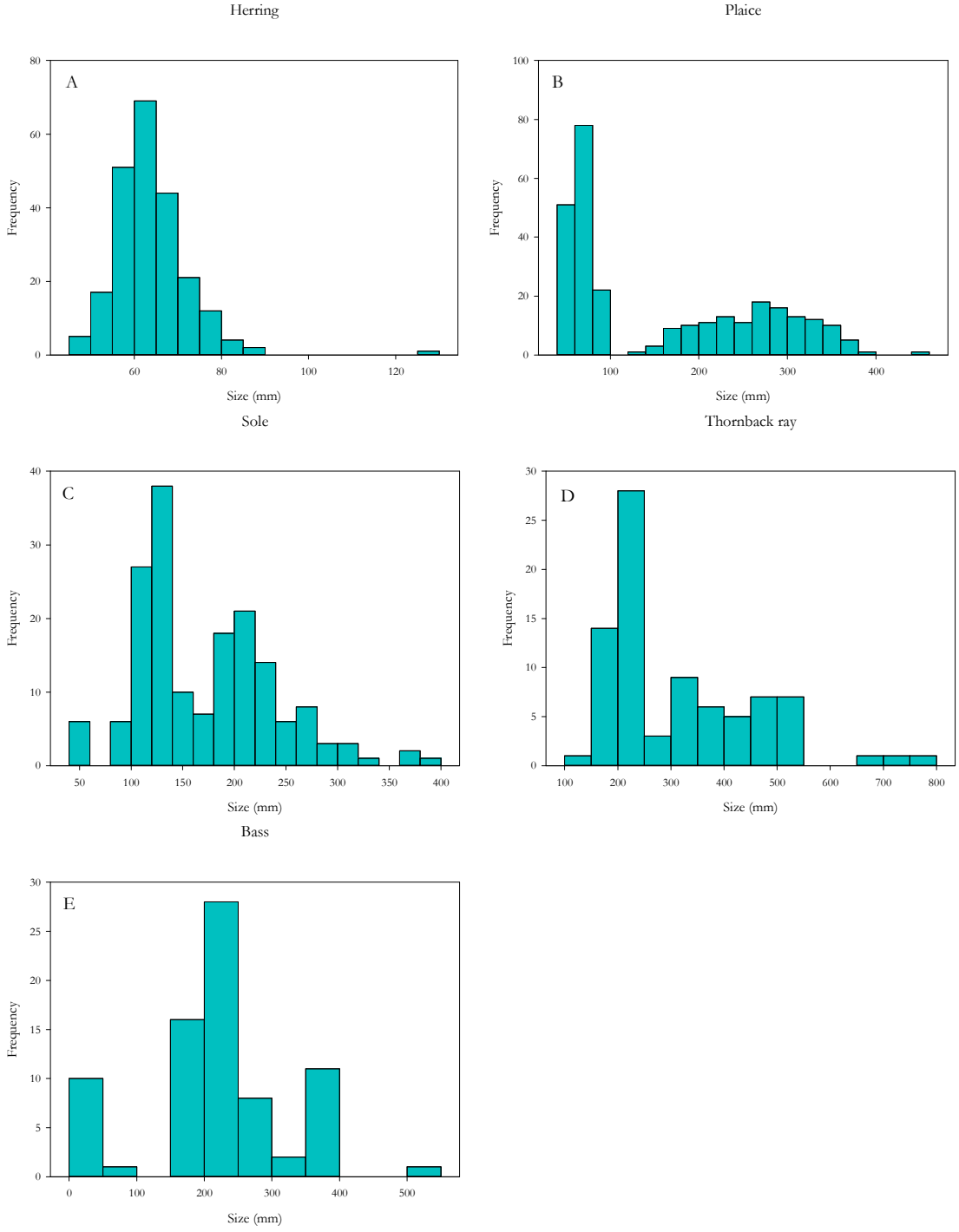


Figure 5. Length frequency distribution histograms for a number of commercially important species captured during the surveys (A-E).

3.5 Invertebrates

3.5.0.1 A total of 21 species of macroinvertebrates were recorded during the survey; this included molluscs, crustaceans and echinoderms and cephalopods. Moon jellyfish were the most abundant species found during the spring surveys. Appendix 4 gives a full breakdown of results.

4 Discussion

4.1.0.1 The summer surveys yielded the greatest numbers of fish since the start of the survey season. This is to be expected as spring and summer spawners tend to inflate the numbers of fish during summer sampling. Abundance was dominated by pelagic fish including sprat and herring.

4.1.0.2 Similar to the spring surveys, bass (mean ± S.D. = 221.7 ± 104.1) were only captured during intertidal work. The size of bass was consistently larger at sites west of Mumbles Head (mean ± S.D. = 380.1 ± 43.4 (I5)) than towards Port Talbot (mean ± S.D. = 221.7 ± 30.5 (I6)). A bimodal size distribution was also clear in plaice (Figure 5), as larger fish were captured in deeper water using subtidal sampling techniques (mean ± S.D. = 268.7 ± 63.6) whilst smaller juveniles were principally caught in shallower intertidal waters (mean ± S.D. = 71.7 ± 27.1).

4.1.0.3 A species belonging to the *Belone* family of fishes was sampled at one of the intertidal sites (I3), although accurate identification of this species in the field was not possible. It was noted that the species did not belong to *Belone belone*, however morphometric characteristics indicated it could possibly belong to the less common *Belone svetovidovi*.

4.1.0.4 Owing to restrictions in the dispensation for the surveys, no fish could be taken from the sites sampled. This meant that both juvenile gobies and garfish could not be identified to species level.

4.1.0.5 Intertidal site 5, which in previous surveys was Langland Bay, was replaced with Pwlldu Bay owing to sampling difficulties primarily associated with the presence of underwater obstructions. The latter is recognised as having a similar morphology, and is within 3.2 km of Langland Bay.

5 References

Davies, J., 1998. Bristol Channel and approaches (Cape Cornwall to Cwm-yr-Eglwys, Newport Bay)(MNCR Sector 9). In K. Hiscock, ed. Marine Nature Conservation Review. Peterborough: Joint Nature Conservation Committee, pp. 225–295.

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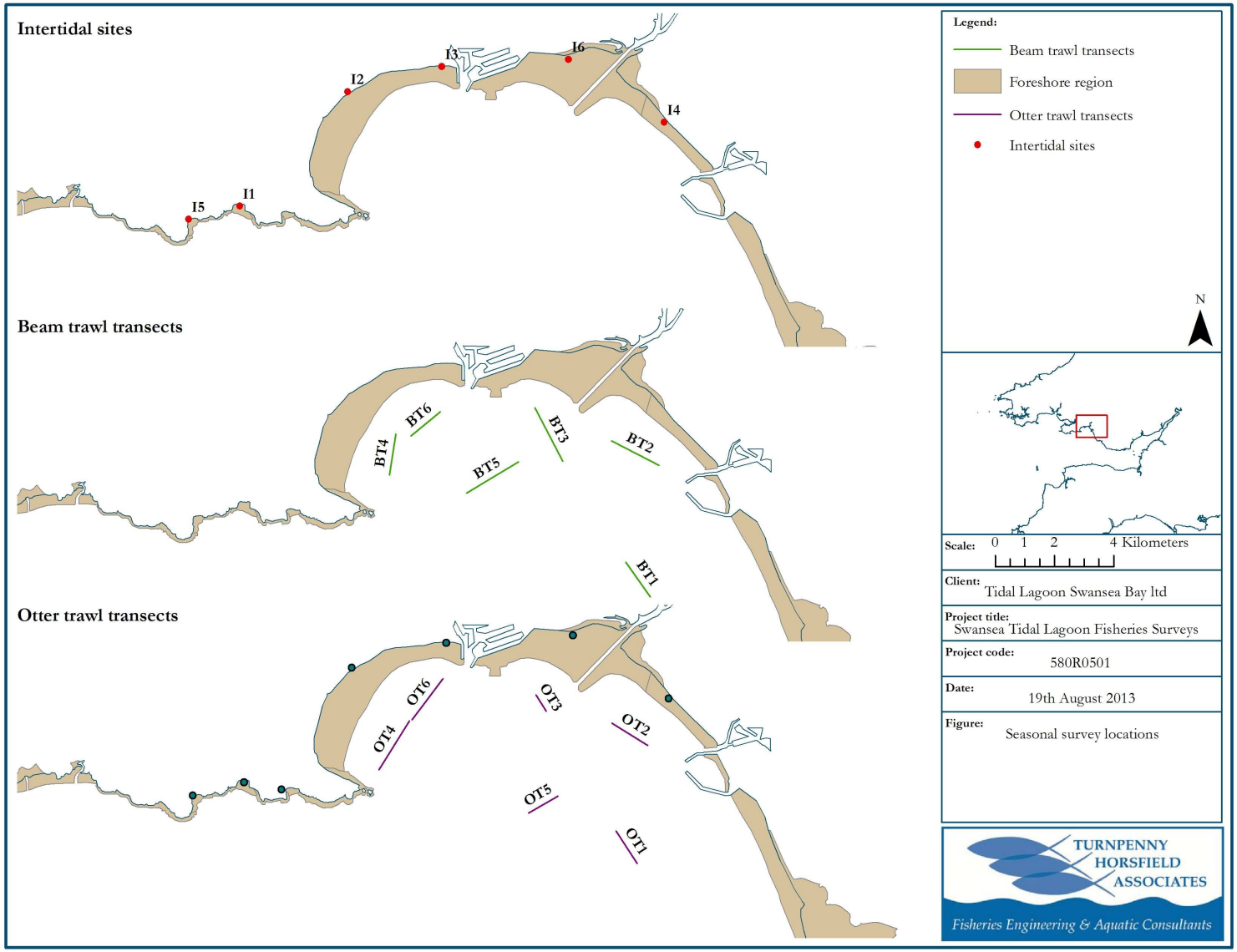
Appendix 1. Locations sampled during the surveys.



Appendix 2. Fish presence and abundance recorded during subtidal surveys

Scientific Name	Common Name	Otter Trawl sites						Beam Trawls sites					
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Aphia minuta	Transparent goby	5	9						1				
Buglossidium luteum	Solenette	1	21	1		1			6				
Callionymus reticulatus	Reticulated dragonet						1					6	
Chelidonichthys lucernus	Tub gurnard	1	6	4								1	
Eutriglia gurnardus	Grey gurnard	211	17		1	1	1	95	16	1	6	1	2
Gadus morhua	Atlantic cod								1				
Limanda limanda	Dab	13	5		4	1		5	1	1	1		
Merlangius merlangus	Whiting	19						19					
Mustelus asterias	Starry smoothound			1		1							
Pegusa lascaris	Sand sole												1
Platichthys flesus	Flounder		1	1	1	2	1						
Pleuronectes platessa	Plaice	16	39	11	10	17	21	5	3		2	3	1
Pomatoschistus minutus	Sand goby	27	16					1		2			
Raja brachyura	Blonde ray					2							
Raja clavata	Thornback ray	19	78	4	4	2	2		2				

Scientific Name	Common Name	Otter Trawl sites						Beam Trawls sites					
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Raja microocellata	Smalleyed ray		1	1	3	2			1		1		
Raja montagui	Spotted ray	3											
Scomber scombrus	Atlantic mackerel			1			1						
Scophthalmus rhombus	Brill												1
Scyliorhinus canicula	Lesser spotted dogfish	3	4	5	2	12				1		6	
Solea solea	Common sole	19	119	3	4	14	2	16	14	1	1		
Sprattus sprattus	Sprat	535	45						1				
Trachurus trachurus	Scad	7	1										
Trisopterus luscus	Pouting	17	1			66	1	17	9				1
Trisopterus minutus	Poor cod	1				128		3					
Zeus faber	John dory		1										

Appendix 3. Fish presence and abundance recoded during intertidal surveys

Scientific Name	Common Name	Seine						Riley					
		S1	S2	S3	S4	S5	S6	R1	R2	R3	R4	R5	R6
Ammodytes tobianus		38	1	38	21	1	16						
Atherina presbyter		49		3									
Belone spp.				23									
Buglossidium luteum				3			1		1				
Chelon labrosus				1			2						
Clupea harengus			76	371	784		1						
Dicentrarchus labrax		1	1		2	12	78		6	1			
Echiichthys vipera				2			7						
Eutriglia gurnardus					3								
Hyperoplus lanceolatus						1							
Liparis liparis							1						
Liza aurata		27		3	1	6							
Pegusa lascaris		2			8		1	2	2	1			
Platichthys flesus		1	3	13	3	1							
Pleuronectes platessa		6	9	54	64	4	19		5	1			

Scientific Name	Common Name	Seine						Riley					
		S1	S2	S3	S4	S5	S6	R1	R2	R3	R4	R5	R6
Pomatoschistus spp.									585	1			
Pomatoschistus microps			1		1								
Pomatoschistus minutus					5					1	1		
Raja brachyura					1								
Raja microocellata					5						3		
Scophthalmus maximus		4		8	19	1				1			
Solea solea				3	41		2				1		
Sprattus sprattus			628	4035	13		6						
Syngnathus rostellatus			7								1		

Appendix 4. Invertebrates presence and abundance recorded during surveys.

Scientific Name	Common Name	Otter Trawl sites						Beam Trawls sites					
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Achelia echinata	Sea spider							1-10					
Alloteuthis subulata	European common squid	10-100	10-100	1-10	1-10		1-10	1-10	1-10				
Anemonia viridis	Snakelocks anemone		10-100		1-10		1-10						
Aphrodita aculeata	Sea mouse	1-10						1-10				1-10	
Asterias rubens	Common starfish	1-10	1-10					10-100		1-10	1-10	1-10	1-10
Astropecten irregularis	Sand starfish								1-10				
Aurelia aurita	Moon jellyfish	100-1000	100-1000	100-1000	10-100		1-10	10-100	1-10	1-10			1-10
Buccinum undatum	Common whelk		1-10										
Crangon spp.	Shrimp	10-100	10-100					1-10				1-10	1-10
Littorina littorea	Common periwinkle								1-10				
Maja squinado	European spider crab						1-10						
Nucella lapillus	Dog whelk							10-100	1-10		1-10	1-100	1-10

Scientific Name	Common Name	Otter Trawl sites						Beam Trawls sites					
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Ophiura ophiura	Brittle star	1-10	10-100		1-10			100-1000	1-10	1-10		1-10	
Pagurus bernhardus	Common hermit crab				1-10			10-100		1-10	1-10		
Pagurus cuanensis	Hairy hermit crab												
Palaemon spp.	Prawn						1-10					1-10	
Pleurobranchia spp.	Sea Gooseberries	1-10											
Pleurobranchus membranaceus	Sea snail										1-10		
Psammechinus miliaris	Green sea urchin							1-10				1-10	
Rhizostoma octopus	Dustbin lid jellyfish							1-10	1-10				
Sepiola atlantica	Little cuttlefish										1-10		1-10

Appendix 5. Dissolved oxygen, temperature, salinity and depth at all sites sampled.

Site	Dissolved oxygen (ppm)	Temperature (C°)	Salinity (ppt)	Depth
O1	6.4	20.5	26.5	13.1
O2	6.3	23.2	26.5	5.0
O3	6.5	21.3	26.7	5.5
O4	8.0	20.2	26.4	6.8
O5	8.4	20.8	26.5	12.2
O6	8.0	20.0	26.3	8.1
B1	6.1	20.2	26.2	12.0
B2	5.3	20.5	26.4	8.6
B3	8.3	20.7	26.5	7.0
B4	6.4	21.4	26.8	2.4
B5	5.0	20.9	26.5	7.8
B6	6.8	21.7	26.9	7.0
I1	6.7	19.8	25.3	n/a
I2	5.3	20.5	26.8	n/a
I3	6.6	24.8	26.9	n/a
I4	6.1	22.7	27.9	n/a
I5	5.8	18.4	26.1	n/a
I6	6.4	22.3	26.9	n/a

TURNPENNY HORSFIELD ASSOCIATES

Fisheries Engineering & Aquatic Consultants

Swansea Tidal Lagoon

Fish Fauna Characterisation Surveys

November 2013 survey – 4th Quarter

Prepared for: Tidal Lagoon Swansea Bay Ltd.

Document No. 580R0901

Date: 8th January 2014

Survey vessel – Heather D

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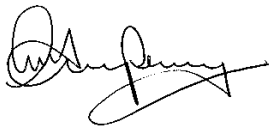
Swansea Tidal Lagoon Fish Fauna Characterisation Surveys

November 2013 – 4th Quarter

Report Reference: 580R0901	Revision date: *8th January 2014*
Prepared by: *Davide Thambithurai*	Position: *Aquatic Ecologist*
Approved by: *Dr Andy Turnpenny*	Position: *Director*
Approver's signature:	Date:



Swansea Tidal Lagoon Fish Fauna Characterisation Surveys

Contents

1 Introduction

1.1 Background to the Project

1.1.0.1 Tidal Lagoon Swansea Bay Ltd propose to develop a tidal lagoon for the purpose of generating energy in Swansea Bay, Wales. The tidal lagoon would be situated between the dredged channels of the Rivers Tawe and Neath, and when fully operational could serve to provide energy for more than 100,000 homes (Tidal Lagoon Swansea Bay Ltd, 2012).

1.1.0.2 The Planning Act 2008 (c.29) introduced special provisions for the consenting process surrounding the development of energy generating infrastructure with a capacity greater than 100 megawatts (MW). Such developments are termed as Nationally Significant Infrastructure Projects (NSIP) and require a Development Consent Order (DCO) to be submitted to the Planning Inspectorate (PINS). The proposed tidal lagoon at Swansea Bay will have a nominal rated power of 240MW, and as such, falls under this regime.

1.1.0.3 As part of the legislative framework for EIA (Environmental Impact Assessment), as set out in the European Directive 85/337/EEC (as amended), and transposed into UK legislation through the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009, the project will require an EIA to be undertaken. To accompany the DCO and fulfil requirements found within EIA legislation, an Environmental Statement (ES) will be produced.

1.1.0.4 The principal remit of the ES is to describe the likely significant effects of the development on the environment and its receptors and any possible mitigation measures which might be undertaken to decrease such effects.

1.1.0.5 As part of the ES process, Turnpenny Horsfield Associates Ltd (THA) has been commissioned to assess the potential impacts of the project on the fish community of Swansea Bay and adjacent waters.

1.1.0.6 To supplement evidence from a detailed desk-based review, a programme of quarterly fish fauna surveys has been designed to characterise fish populations within the Bay to inform decision-making associated with the project.

1.1.0.7 This report details one of a series of fish fauna characterisation surveys being carried out by THA. The surveys adopt multiple biomonitoring techniques consistent with Water Framework Directive (WFD) monitoring standards and JNCC best practice techniques to monitor biota within marine environments[1].

[1] Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp, ISBN 1 85716 550 0

1.2 Aims and Objectives

1.2.0.1 The aim of this report is to provide an up-to-date characterisation of the seasonal fish community within the defined study area. The study area has been defined as the potential near-field and far-field zone of influence around the Swansea Tidal Lagoon though a high level coastal process model (Tidal Lagoon Swansea Bay Ltd., 2012). Limitations in the survey methodology have been identified in the Environmental Statement.

2 Methods

2.1 Study Area

2.1.0.1 Swansea Bay (NGR SS 630910) is approximately 12 km wide with an area of 50 km^2. The seabed of the Bay is largely composed of mud, sand and fine gravel, with some rock outcrops and cobbles occurring on the western edge of the embayment, towards Mumbles Head (Davies, 1998).

2.2 Intertidal Seine and Riley Push-Netting

2.2.0.1 Six sites were sampled as part of the intertidal sampling program between the 27th and 28th of November 2013. The locations of these sites are shown in Table 1 and mapped in Appendix 1. Sampling was conducted on suitable shores with a slight slope and firm substrates. Two techniques were utilised at each site, these are detailed below.

Table 1 Intertidal sites sampled during the surveys

Site Code	Site Name	Co-ordinates
I1	Caswell Bay	51:34.13312N 4:1.94620W
I2	Blackpill	51:36.27098N 3:58.87818W
I3	Abertawe	51:36.77037N 3:56.14407W
I4	Port Talbot West	51:35.86105N 3:49.59318W
I5	Pwlldu Bay	51:33.88237N 4:3.48465W
I6	Crymlyn Burrows	51:36.96590N 3:52.44125W

2.2.0.2 A 43 m long (4 m deep) seine net with 14 mm wings and a 6.5 mm centre knotless mesh was deployed from a rigid mono-hull vessel. The methods adopted followed JNCC procedural guidelines (Davies *et al.*, 2001).

2.2.0.3 A rope attached to one end of the seine was held onshore by an operative, whilst the net of the seine was loaded onto the vessel. The vessel was then taken out perpendicularly from the shoreline, once the extent of the rope connecting the seine to the shore was fully paid out the vessel made a 90˚ turn and proceeded parallel to the shore, slowly paying out the remainder of the net. Once fully deployed, the rope attached to the free end of the net was brought ashore and the net hauled bringing together the ends of the net and pursing the seine. Floats on the net were kept outside of the lead line thus preventing accidental the loss of fish from the net.

2.2.0.4 Riley push-netting was undertaken using a 1.5 m wide push-net with a 6.5 mm mesh trouser legs lined with 1 mm fry mesh (Plate 1). A tickler chain was mounted on the net to increase its efficacy. Transects measuring 100 m were marked out on the shore, the net was lifted and placed in knee-depth water by two operatives. A single member of staff then proceeded to push the net for the measured distance.

2.2.0.5 Two replicates for each method were carried out at all sites.

2.2.0.6 All fish captured were removed and separated from macroinvertebrates and debris. With exception to juvenile specimens of *Pomatoschistus* spp., fish were identified to species level, and recorded and measured to the nearest millimetre (total length L_t); whilst macroinvertebrates were recorded as log abundance: 1-9; 10-99; 100-999; or 1000+ and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

Plate 1. Riley net design and technique utilised during sampling

2.3 Subtidal Otter and Beam Trawls

2.3.0.1 The subtidal survey comprised of 12 trawls at six sites, conducted between the 25th and 26th of November 2013. The start and end position of the trawl transects for each of the techniques used are given in Table 2 and Table 3, whilst transects are mapped in Appendix 1. The start of the transect was considered to be when the gear reached the seabed and the end when hauling commenced, all co-ordinates and depths were taken using the vessel's on board instruments. Each site was surveyed with both the otter and beam trawl gear along parallel transects.

Table 2. Subtidal otter trawl sites sampled during the survey

Site Code	Otter Trawls	
	Start	End
O1	51 32.671N 3 50.237W	51 33.393N 3 50.879W
O2	51 34.938N 3 49.586W	51 35.297N 3 50.895W
O3	51 36.083N 3 53.720W	51 35.803N 3 53.223W
O4	51 34.387N 3 57.891W	51 34.767N 3 57.645W
O5	51 34.554N 3 55.141W	51 34.304N 3 55.797W
O6	51 35.256N 3 56.982W	51 35.626N 3 56.590W

Table 3. Subtidal beam trawl sites sampled during the survey

Site Code	Beam Trawls	
	Start	End
B1	51 53.023N 3 50.34W	51 33.522N 3 51.072W
B2	51 34.978N 3 50.021W	51 35.329N 3 51.173W
B3	51 35.972N 3 53.178W	51 35.323N 3 52.952W
B4	51 34.552N 3 58.077W	51 34.815N 3 57.462W
B5	51 34.563N 3 54.947W	51 34.206N 3 55.984W
B6	51 35.118N 3 57.035W	51 35.671N 3 56.362W

2.3.0.2 Trawling was undertaken from the MFV Heather D (Barry Thomas Mumbles), a 12.1 m mono-hull trawler vessel. The specifications for the two nets deployed during the subtidal surveys are given in Table 4.

Table 4. Respective net sizes for both otter and beam trawls utilised in the surveys

Characteristic	Otter Trawl sizes (cm)	Beam Trawl sizes (cm)*
Head line length/ Width of Beam Trawl	1500	150
Ground rope length	1620	330
Mouth height	360	45
Wing mesh	10	8
Cod end mesh	1	1

*(Shoe width = 10 cm and Bridles = 300 cm)

2.3.0.3 Otter trawls (Plate 2) were conducted using a standard otter board setup trawled for approximately 15 minutes at sites 3, 5 and 6 and 30 minutes at sites 1, 2 and 4. The average speed of tow was 1.4 knots. One trawl was conducted at each site. On completion of the trawl the net was winched aboard the vessel and the catch emptied into holding bins filled with sea water. Fish were removed and separated from macroinvertebrates and debris. Fish were identified to species level (with exception of juvenile *Pomatoschistus* spp. and *belone* spp.), recorded and measured to the nearest millimetre (total length L_t), whilst macroinvertebrates were recorded and identified to the lowest practical taxonomic level. After processing, all fish and macroinvertebrates were returned to the water.

2.3.0.4 Epibenthic beam trawls (Plate 3) transects were conducted for approximately 30 minutes at an average speed of 1.4 knots. As for the otter trawls, a winch was utilised to recover the net onto the deck of the vessel on completion of the fishing operation. Fish were then emptied from the net into holding bins filled with sea water. All fish captured were identified and measured to the nearest millimetre. After processing all fish were returned to the water. Macroinvertebrates were identified to the lowest practicable taxonomic level and their presence was noted.

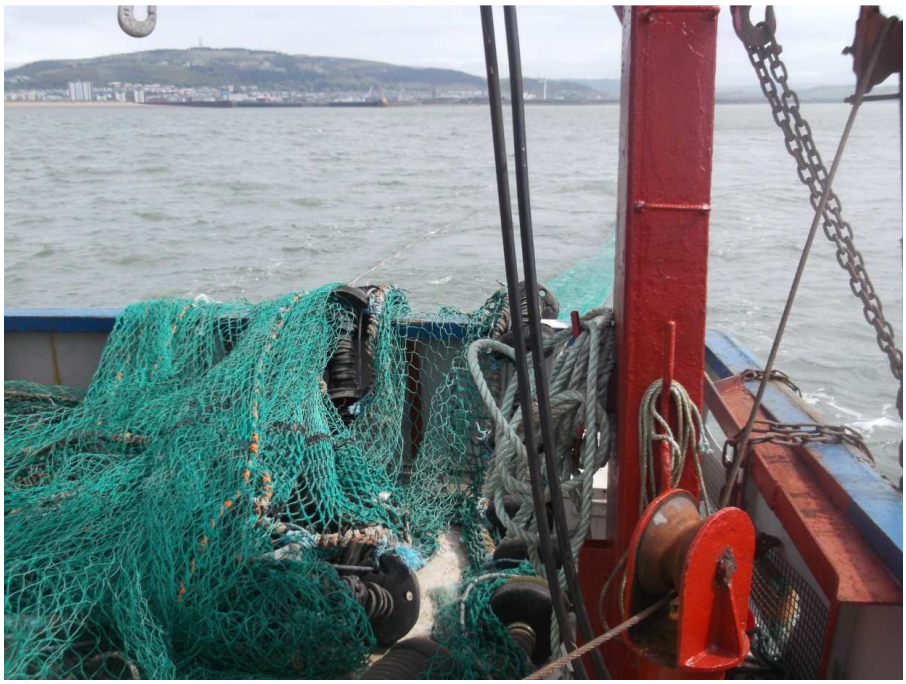


Plate 2. Otter trawl ready to be lowered into the water

Plate 3. Standard design beam trawl used in the surveys (1.5m)

2.4 Water Quality and Hydrographic Data

2.4.0.1 Temperature and salinity were recorded using a hand held conductivity meter (470 Portable Conductivity Meter; www.jenway.com), whilst dissolved oxygen (DO) was recorded using a portable oxygen probe (Hach Orbisphere 3655 O_2; www.hach). A single measurement was taken at each site sampled. The conductivity meter was calibrated at the start of each survey period using a 5000 µS/cm standard solution; whilst the oxygen probe was air calibrated.

2.5 Analysis

2.5.0.1 The frequency of occurrence of fish across the study area was used to calculate the relative abundance of each taxon. Relative abundance in this report is defined as the percentage of total catch comprised by a given species, which can be calculated using the following formula:

$$\%Ai = \frac{\sum C_i}{\sum S_t} \times 100,$$

2.5.0.2 where: $\%Ai$ is relative abundance, C_i is the sample content composed by the species across surveys/sites and S_t is the total content of all surveys/sites in the entire sampling period.

2.5.0.3 Despite trawls being conducted for a standardised time period, the length of each trawl transect varied owing to differences in the seabed, tidal current and the presence of obstructions (e.g. pot lines). As a result the length of each individual trawl track as recorded using GPS co-ordinates was utilised to calculate the number of specimen for each species sampled per 100 m trawled (catch per unit effort (CPUE)).

3 Results

3.1.0.1 A total of 39 fish species and x macroinvertebrate species were recorded in the subtidal and intertidal surveys, raw data for these are presented in Appendix 2 and Appendix 4. Sprat were the most abundant fish (58.40 %), followed by herring (13.67 %), *Pomatoschistus* spp. (6.50 %) grey gurnard (3.94 %) and plaice (3.16 %). Figure 1 gives the relative abundance for all fish species with an abundance >0.10.

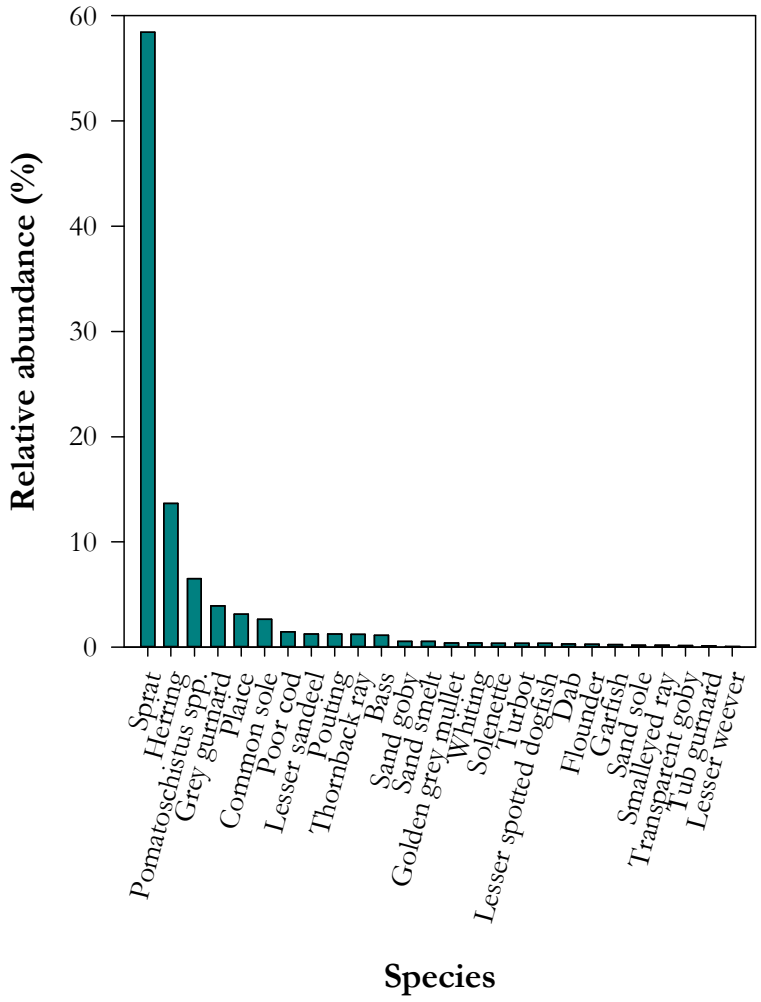


Figure 1. Fish species with abundances > 0.10 caught across all surveys

3.2 Intertidal Seine and Riley Push-Netting

3.2.0.1 A total of 939 fish belonging to 15 species were caught during intertidal surveys. Fish with abundances >0.1 are shown in Figure 2, whilst Appendix 1 gives the raw number of all fish captured. The most numerous species caught with intertidal sampling techniques was sprat (54.42 %). The second most abundant species caught in intertidal surveys were sand smelt (19.49 %) followed by herring (8.73 %), turbot (3.73 %), and lesser sandeel (3.09 %).

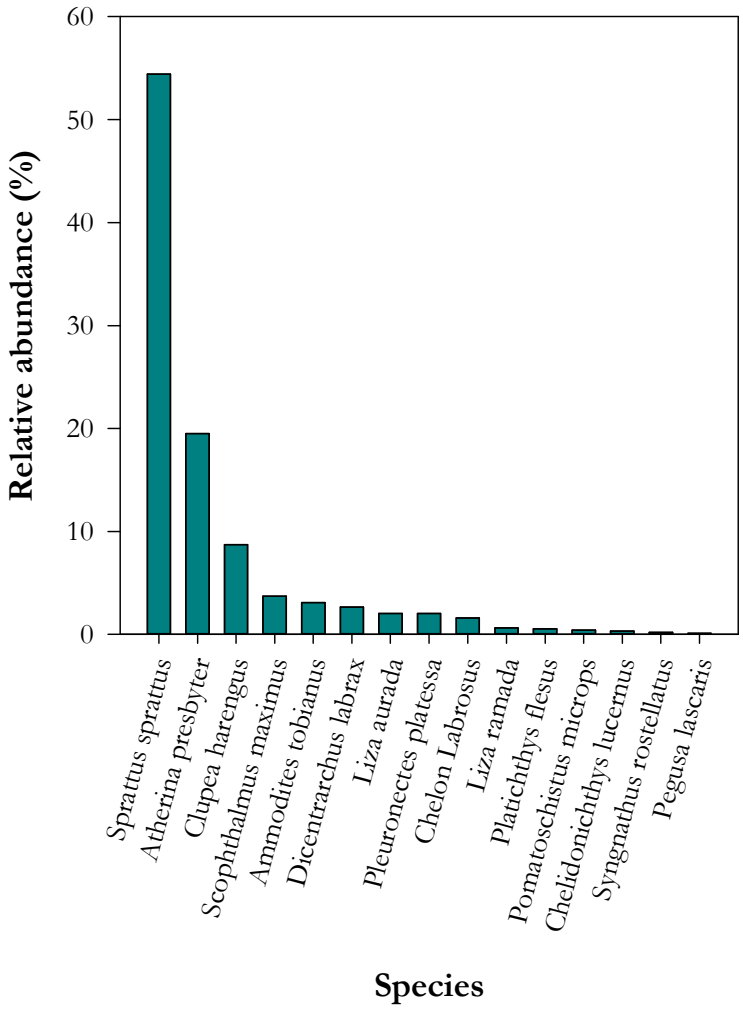


Figure 2. Fish species with abundances > 0.1 caught across the intertidal sites

3.3 Subtidal Otter and Beam Trawl

3.3.0.1 A total of 1837 fish belonging to 28 species were caught during beam and otter trawl surveys, 1260 (68.6 %) of which were caught during otter trawling and 577 (31.4 %) using beam trawling. Figure 3 gives the relative abundance of all species across all of the subtidal sites.

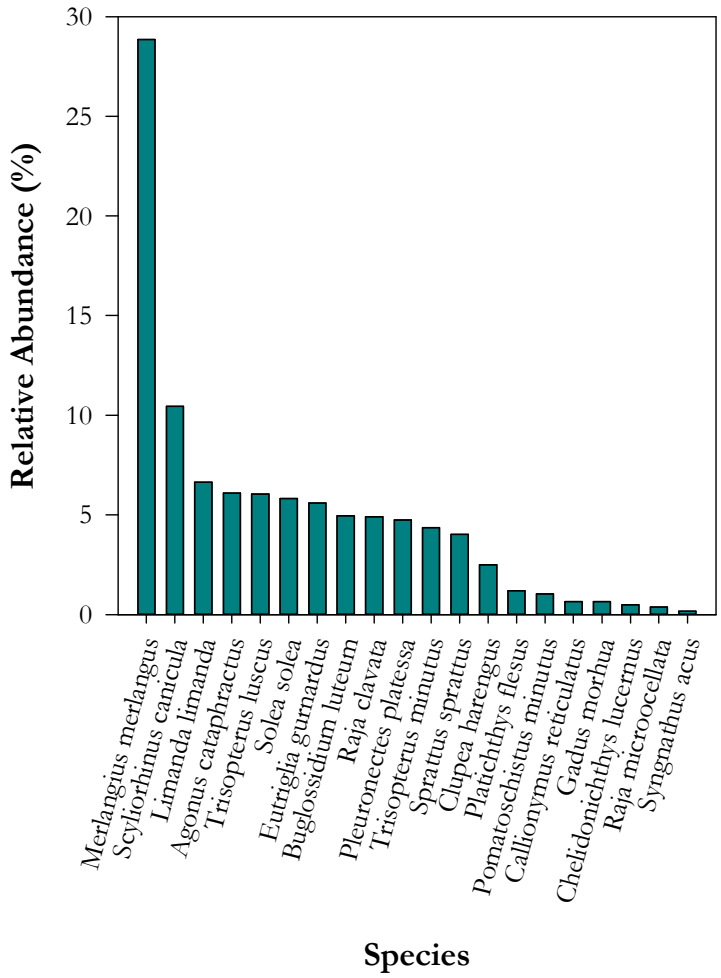


Figure 3. Relative abundance of fish species across subtidal sites sampled

3.3.0.2 The most abundant species caught using subtidal techniques was whiting (28.85 %) followed by lesser spotted dogfish (10.45 %), dab (6.64 %), hook-nose (6.10 %) and pouting (6.04 %).

3.3.0.3 Catch per unit effort was consistently higher in otter trawls than in beam trawls (Figure 4), in several occasions this was as a result of pelagic species such as whiting.

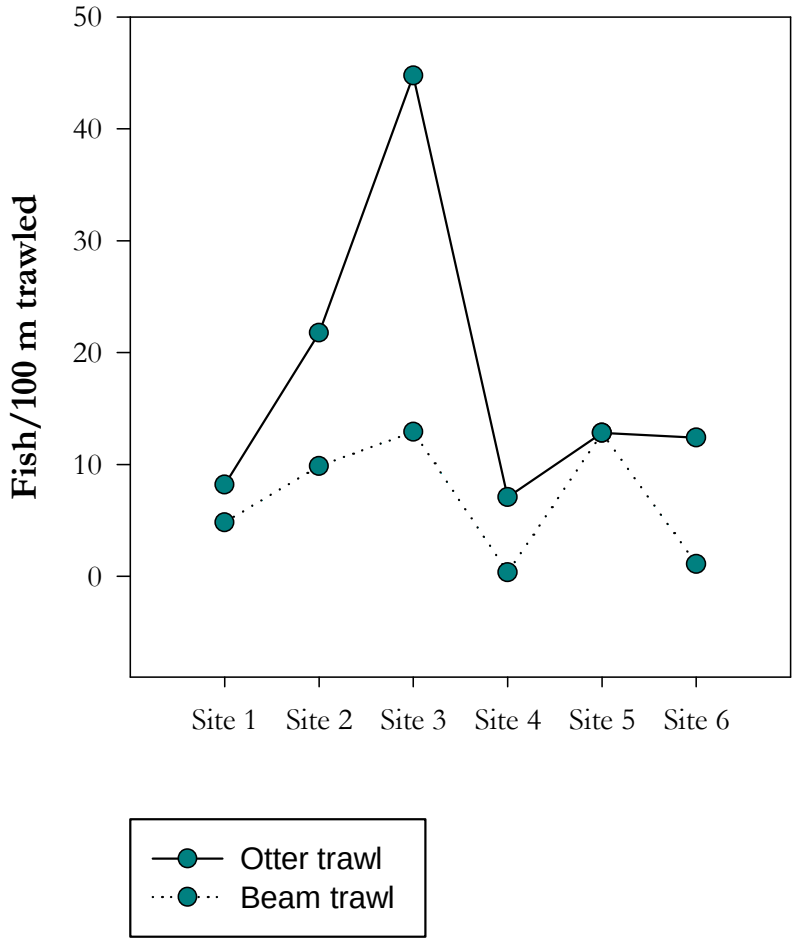


Figure 4. Total number of fish specimens expressed as fish per 100m trawled recorded in subtidal sampling in July 2013

3.4 Length frequency distributions

3.4.0.1 Several fish species of commercial importance were sampled in relatively high abundance during the surveys. These included herring, plaice, sole, thornback ray and bass. Figure 5 (A to E) below provides a number of summary histograms for the length frequencies of these fish. Note that the figures represent fish captured both during intertidal and subtidal sampling.

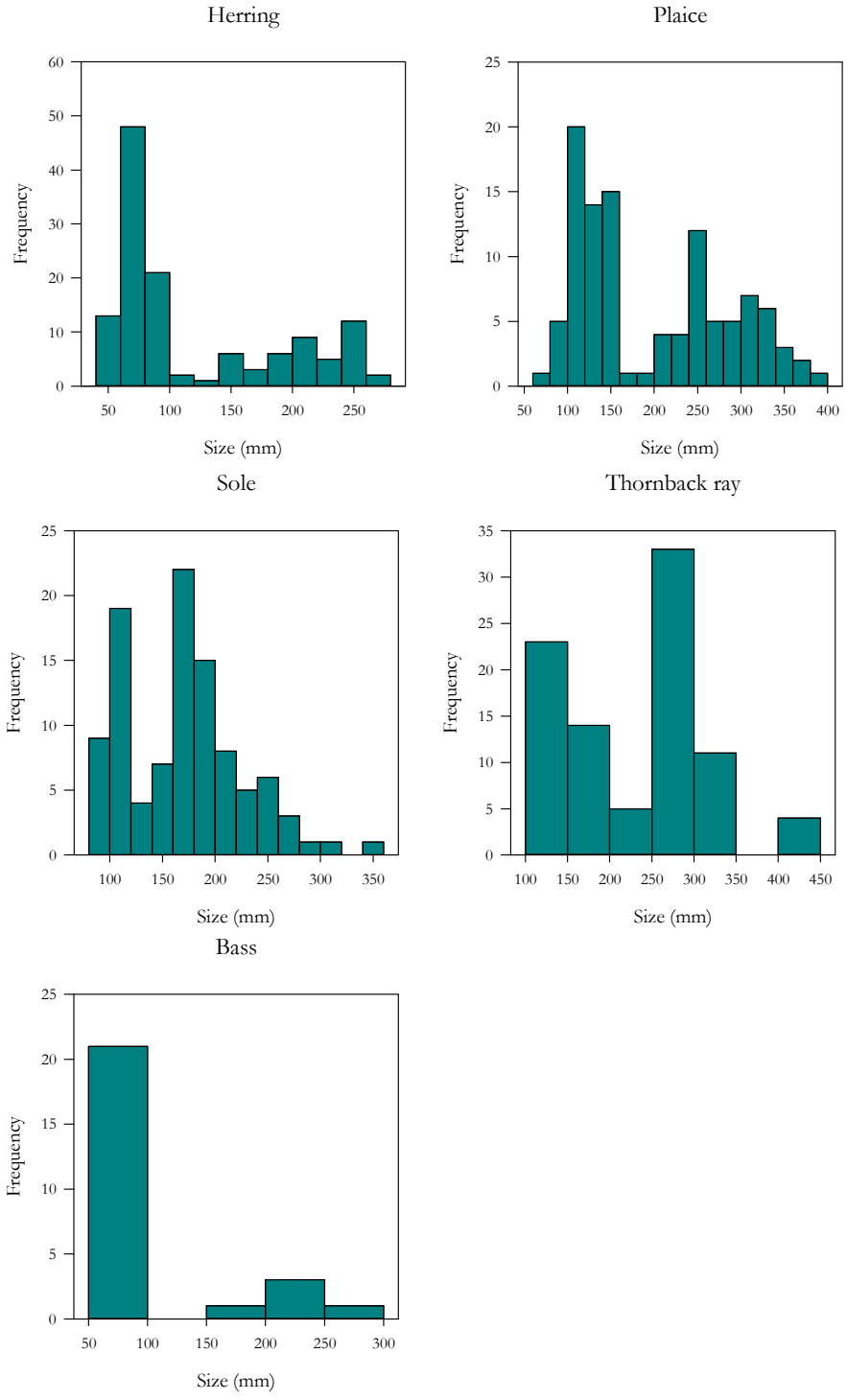


Figure 5. Length frequency distribution histograms for a number of species captured during the surveys (A-E).

3.5 Invertebrates

3.5.0.1 A total of 20 species of macroinvertebrates were recorded during the survey; this included molluscs, crustaceans and echinoderms and cephalopods. Brittle sea star and small white Palourde clams (Manila Clam) were the most abundant species found during the autumn surveys. Appendix 4 gives a full breakdown of results.

4 Discussion

4.1.0.1 The autumn surveys yielded less fish than the summer survey. This is to be expected as spring and summer spawners inflated the numbers of fish during summer sampling and cooler inshore waters force fish into deeper offshore waters. Similar to summer, abundance was dominated by pelagic fish including sprat and herring.

4.1.0.2 The subtidal community was dominated by high numbers of gadoids, namely whiting, pouting and poor cod. Other species that showed an increase in the subtidal areas of the Bay compared with the summer survey included solenette, dab, hooknose and lesser spotted dogfish.

4.1.0.3 The fish population in intertidal areas was dominated by sprat (significantly less than in summer), sand smelt, turbot, golden grey mullet and common goby. The autumnal abundance of common goby is linked with the fact that by autumn specimens are developed enough to allow precise identification in the field. Similarly to the summer surveys all but one bass (mean ± S.D. = 110.6 ± 59.3) were captured during intertidal work.

4.1.0.4 Owing to restrictions in the dispensation for the surveys, no fish could be taken from the sites sampled. This meant that both juvenile gobies and garfish could not be identified to species level if they had not developed enough.

4.1.0.5 As with the summer survey, the intertidal site 5 was replaced with Pwlldu Bay owing to sampling difficulties primarily associated with the presence of underwater obstructions at Langland Bay. The latter is recognised as having a similar morphology, and is within 3.2 km of Langland Bay.

5 References

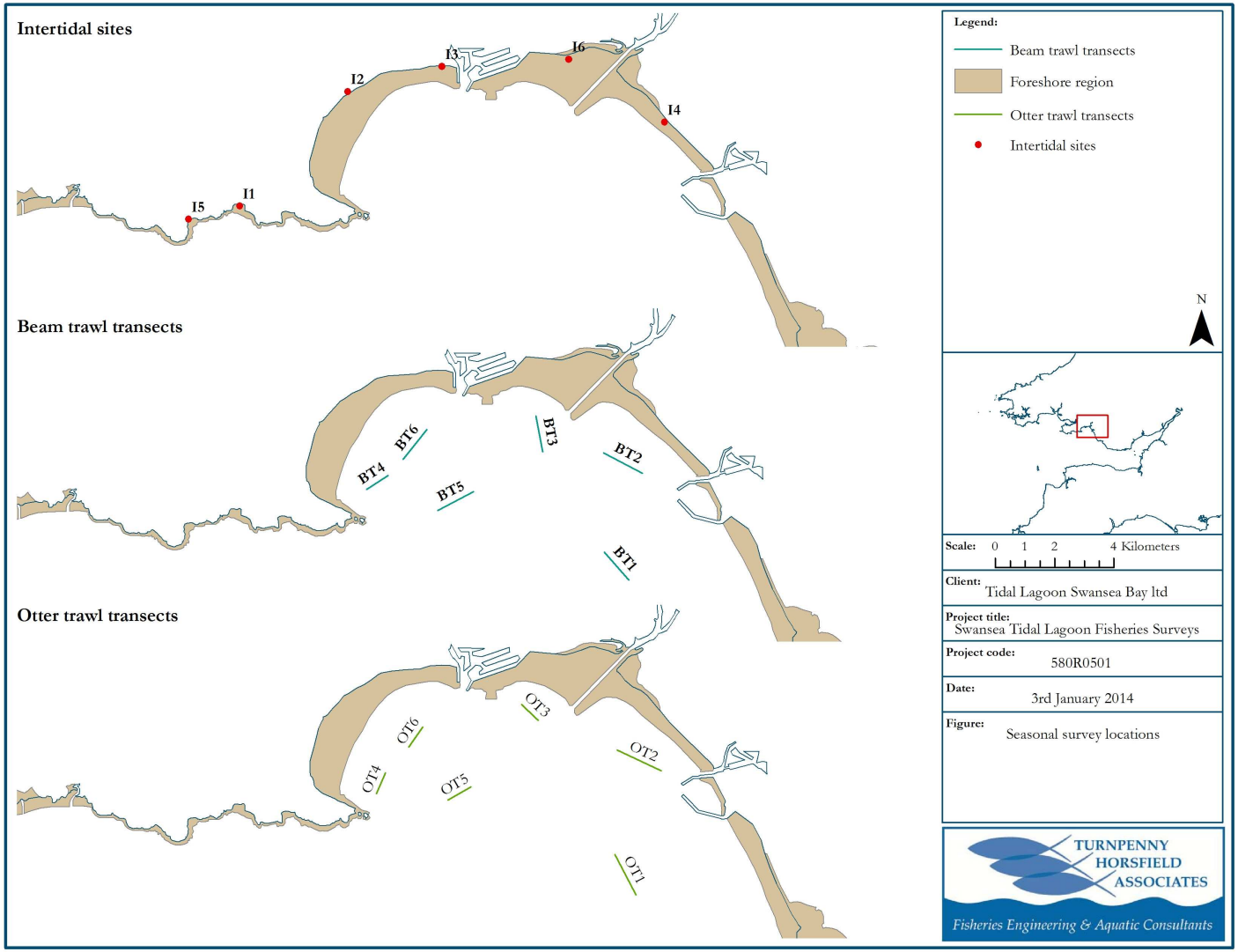
Davies, J., 1998. Bristol Channel and approaches (Cape Cornwall to Cwm-yr-Eglwys, Newport Bay)(MNCR Sector 9). In K. Hiscock, ed. Marine Nature Conservation Review. Peterborough: Joint Nature Conservation Committee, pp. 225–295.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. & Vincent, M., 2001. Marine Monitoring Handbook, 405 pp.

Potts, G. W. & Swaby, S. E., 1993. Marine and Estuarine Fishes of Wales: the development of the British Marine Fishes Database and monitoring programme for Wales. CCW Science Report 49.

Tidal Lagoon Swansea Bay Ltd. 2012. Proposed Tidal Lagoon Development in Swansea Bay, South Wales Environmental Impact Assessment Scoping Report October 2012. Cheltenham: Tidal Lagoon Swansea Bay Ltd.

Appendix 1. Locations sampled during the surveys.



Appendix 2. Fish presence and abundance recorded during subtidal surveys

Scientific Name	Common Name	Otter Trawl sites						Beam Trawls sites					
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Agonus cataphractus	Hook-nose		2	56	1	7				6		39	1
Buglossidium luteum	Solenette	3	11	11				9	35	22			
Callionymus lyra	Common dragonet												1
Callionymus reticulatus	Reticulated dragonet									1		7	
Chelidonichthys lucernus	Tub gurnard		7							1		1	
Ciliate mustela	Fivebeard rockling			1									
Echiichthys vipera	Lesser weaver				1								
Eutriglia gurnardus	Grey gurnard	19	24	19				17	12	9		2	1
Gadus morhua	Atlantic cod		1	1		6		1				3	
Limanda limanda	Dab	21	10	6	2	34	4	13	5	6		19	2
Lophius piscatorius	Angler											1	
Melanogrammus aeglefinus	Haddock					1							
Merlangius merlangus	Whiting	31	85	243	4	6	51	6	27	71	4	5	
Microstomus kitt	Lemon sole											1	
Platichthys flesus	Flounder	1		8	2	2	8			1			

Scientific Name	Common Name	Otter Trawl sites						Beam Trawls sites					
		O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Pleuronectes platessa	Plaice	8	20	26	8	2	15	1	2	2			2
Pomatoschistus minutus	Sand goby			1				5	11	1			
Raja clavata	Thornback ray	4	53	13		3	1	2	7	4		3	
Raja microocellata	Smalleyed ray		1	1			3	2					
Scophthalmus rhombus	Brill						1						
Scyliorhinus canicula	Lesser spotted dogfish	27	56	33	5	27	3	1	6	6		28	
Solea solea	Common sole		37	20		3	1	6	23	16			1
Sprattus sprattus	Sprat	2	14	19	26	1	12						
Syngnathus acus	Greater pipefish					1						1	1
Trisopterus luscus	Pouting	7	19	35		3		8	7	21		10	1
Trisopterus minutus	Poor cod				3	11		4	2	1		58	1

Appendix 3. Fish presence and abundance recoded during intertidal surveys

Scientific Name	Common Name	Seine						Riley					
		S1	S2	S3	S4	S5	S6	R1	R2	R3	R4	R5	R6
Ammodytes tobianus	Lesser sand eel	10			1	16	1						1
Aphia minuta	Transparent goby			2									
Atherina presbyter	Sand smelt	121	4	2	4	33	17						
Chelidonichthys lucernus	Tub gurnard		7	2		2							
Chelon labrosus	Thicklip grey mullet	3		2	2								
Ciliata mustela	Fivebeard rockling			1									
Clupea harengus	Atlantic herring		14	7	7		53						
Dicentrarchus labrax	European seabass		22				3						
Liparis liparis	Common seasnail						2						
Liza aurata	Golden grey mullet		16		1								
Liza ramada	Thinlip mullet		6										
Pegusa lascaris	Sand sole	1											
Platichthys flesus	European flounder	1	2			2							
Pleuronectes platessa	European plaice	1	4	2	2	8	2						
Pomatoschistus microps	Common goby		2										

Scientific Name	Common Name	Seine						Riley					
		S1	S2	S3	S4	S5	S6	R1	R2	R3	R4	R5	R6
Pomatoschistus spp.	Goby spp.								1				1
Scomber scombrus	Atlantic mackerel			1									
Scophthalmus maximus	Turbot	16	1	2	13	2							
Solea solea	Common sole			234									
Sprattus sprattus	Sprat		1	260	3		13						
Syngnathus rostellatus	Lesser pipefish					1				1			

Appendix 4. Invertebrates presence and abundance recorded during surveys.

		Subtidal											
		Otter Trawl sites						Beam Trawl sites					
Scientific Name	Common name	O1	O2	O3	O4	O5	O6	B1	B2	B3	B4	B5	B6
Actinia equina	Beadlet anemone				1 - 10								
Ophiura ophiura	Brittle star							1000 +	100 - 1000	1000 +			
Cancer pagurus	Brown crab			1 - 10								1 - 10	
Cerastoderme edule	Common cockle												
Cetenophora	Comb jelly												
Pagurus bernhardus	Common hermit crab							10 - 100					1 - 10
Asterias rubens	Common starfish	100 - 1000	10 - 100	10 - 100	1 - 10	1 - 10	10 - 100	100 - 1000	1 -10	1 - 10			1 - 10
Buccinum undatum	Common whelk			1 - 10		1 - 10				10 - 100			
Crangon spp	Shrimp		10 - 100		1 - 10		1 - 10	10 - 100	10 - 100	1 - 10	1 - 10	100 - 1000	10 - 100
Nucella lapillus	dog whelk								10 - 100	1 - 10			
Liocarcinus depurator	Harbour crab	1 - 10	1 - 10			1 - 10		10 - 100	10 - 100	1 - 10		1 - 10	1 - 10
palaemon	Prawn	1 - 10		10 - 100				10 - 100	10 - 100			100 - 1000	100 - 1000
Aequipecten opercularis	Queen Scallop											1 - 10	
Aphrodita aculeata	Sea Mouse			1 - 10		1 - 10		100 - 1000		1 - 10		1 - 10	
Achelia echinata	Sea spider										1 - 10		
Psammechinus miliaris	Green sea urchin								10 - 100				
Carcinus maenas	Common shore crab												
Ruditapes philippinarum	Small white palourde (Manila Clam)									1000 +			
Anemonia viridis	Snakelock anemone		1 - 10				1 - 10						
Crossaster papposus	Common sun star										1 - 10		

		Intertidal											
		Seine Sites						Riley Sites					
Scientific Name	Common name	I1	I2	I3	I4	I5	I6	I1	I2	I3	I4	I5	I6
Actinia equina	Beadlet anemone												
Ophiura ophiura	Brittle star												
Cancer pagurus	Brown crab												
Cerastoderme edule	Common cockle		100 - 1000						100 - 1000	1 - 10			
Cetenophora	Comb jelly	1 - 10				10 - 100							
Pagurus bernhardus	Common hermit crab				1 - 10								
Asterias rubens	Common starfish												
Buccinum undatum	Common whelk												
Crangon spp	Shrimp	1 - 10	10 - 100		1 - 10	10 - 100	10 - 100		10 -100	1 - 10	1 - 10	10 - 100	1 - 10
Nucella lapillus	dog whelk												
Liocarcinus depurator	Harbour crab												
palaemon	Prawn												
Aequipecten opercularis	Queen Scallop												
Aphrodita aculeata	Sea Mouse												
Achelia echinata	Sea spider												
Psammechinus miliaris	Green sea urchin												
Carcinus maenas	Common shore crab		1 - 10										
Ruditapes philippinarum	Small white palourde (Manila Clam)												
Anemonia viridis	Snakelock anemone												
Crossaster papposus	Common sun star												

Appendix 5. Dissolved oxygen, temperature, salinity and depth at all sites sampled.

Site	Dissolved oxygen (ppm)	Temperature (C°)	Salinity (ppt)	Depth
O1	10.74	10.1	27.15	15.1
O2	10.56	9.1	26.5	9.8
O3	10.68	9.3	26.15	6.7
O4	10.81	9.1	25.1	6.7
O5	10.6	9.8	26.65	13.1
O6	10.74	9.1	25.45	4.5
B1	10.69	9.8	27.1	16.5
B2	10.61	9.6	26.65	12.5
B3	10.58	9.6	26.25	7.3
B4	10.59	10.1	26.25	6.3
B5	10.64	9.9	25.85	13.6
B6	10.51	9.9	26.15	4.9
I1	10.63	10.4	26.8	n/a
I2	10.71	9.1	25.65	n/a
I3	10.63	9.4	26.05	n/a
I4	11.35	9.3	26.15	n/a
I5	10.42	10.6	26.5	n/a
I6	11.2	9.2	24.55	n/a