MILFORD HAVEN WATERWAY
ENVIRONMENTAL SURVEILLANCE GROUP

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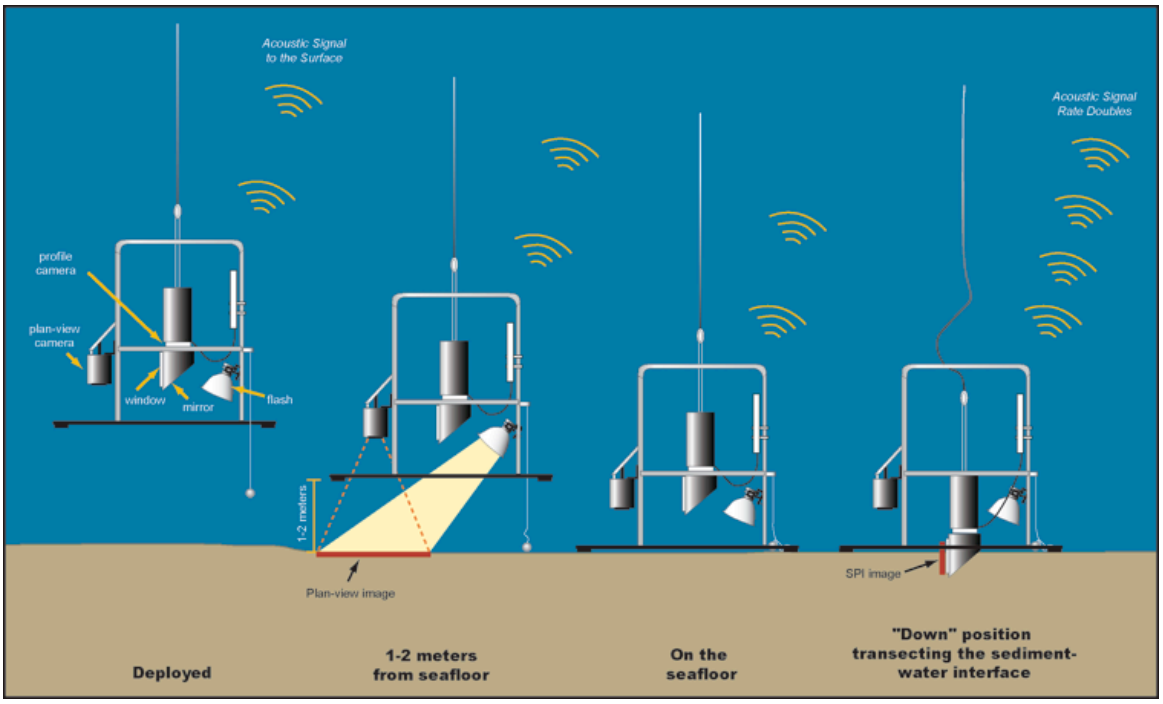

Business Report 2012

MILFORD HAVEN WATERWAY ENVIRONMENTAL SURVEILLANCE GROUP

BUSINESS REPORT 2012

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Milford Haven Waterway Environmental Surveillance Group
Report 2012
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MILFORD HAVEN WATERWAY ENVIRONMENTAL SURVEILLANCE GROUP

Dragon LNG

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South Hook LNG Ltd

Valero Energy Ltd

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[1] NRW replaced Countryside Council for Wales (CCW) and Environment Agency Wales (EAW) with effect from 1 April 2013

COVER IMAGES

Front cover: diagram illustrating Sediment Profile Imaging operation (© Germano & Associates); see page 6

Back cover

Top: example of Sediment Profile Imaging survey output showing sediment facies distribution.

Upper row L to R: SPI image showing eelgrass (Zostera marina); Plan View image at same location; three examples of very fine to fine sand overlying silt/clay near the South Hook jetty; off Wear Point; Creswell River.

Lower left: coverage of 2012 CASI survey (shown in red; © Environment Agency Wales); see page 14

Bottom left: example of CASI survey (© Environment Agency Wales)

Lower right: Asterina phylactica with metamorphosing juveniles (© Robin Crump); see page 15

Bottom right: The two British species of *Asterina* (© Sue Scott).

Milford Haven Waterway Environmental Surveillance Group

Report 2012

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CHAIRMAN'S FOREWORD

In compliance with the Climate Change Act 2008 the government laid the Climate Change Risk Assessment (CCRA) report before Parliament in January 2012. The report considered risks based on impact and evidential confidence and compared over 100 such risks eg flooding.

The government then produced a National Adaptation Programme (NAP) which initially reported by setting out the objectives, policies and proposals to address the principle risks set out in the CCRA.

The NAP sets out a vision for a "climate ready country" as "A society which makes timely, far sighted and well informed decisions to address the threats and opportunities posed by a changing climate."

It is therefore with great pleasure that I introduce the latest annual report into the work of the Group as continuing to make a small contribution towards that vision.

The work of the Group is very straightforward. To gather data about the environmental status of the Milford Haven Waterway with its deep water providing access for leisure users and to some of the largest vessels afloat making it the third largest port and energy capital of the UK. It also supports a particularly diverse estuarine habitat leading to it being incorporated into the Pembrokeshire Marine SAC and having numerous SSSI designations along the foreshore.

This mix of use and needs makes it vitally important that decisions concerning future developments are based on the best evidence available.

The success of the Group is down to the commitment by Members, from industry and public sector, who give their time to ensure that the work programme is both tested and robust. Delivery of the programme is very much down to the Group's Project Officer, Blaise Bullimore, whose commitment is much appreciated.

The future holds challenges, not least in ensuring that the ambitious work programme can be properly funded and this will require more attention in the next couple of years. However, membership has grown over the last few years which are both healthy and a good indicator as to the value of the Group's work.

Captain Mark Andrews

Milford Haven Port Authority

Chairman

RHAGAIR Y CADEIRYDD

Yn Ionawr 2012, yn unol â Deddf Newid Hinsawdd 2008, gosododd y llywodraeth adroddiad gerbron y Senedd ar yr Asesiad Risg Newid Hinsawdd (ARNH). Roedd yr adroddiad hwnnw'n ystyried y risgiau o safbwynt effaith a hyder tystiolaethol, ac yn cymharu dros 100 o risgiau perthnasol, megis llifogydd.

Aeth y llywodraeth ati wedyn i baratoi Rhaglen Ymaddasu Genedlaethol (RhYG), ac yn adroddiad cyntaf y Rhaglen honno pennwyd amcanion, polisïau a chynigion ar gyfer ymateb i'r prif risgiau a nodwyd yn yr ARNH.

Y weledigaeth a amlinellir yn y RhYG yw "gwlad hinsawdd-barod", sef "cymdeithas sy'n gwneud penderfyniadau pell-weledol a gwybodus, i fynd i'r afael â'r bygythiadau a'r cyfleoedd a ysgogir gan y newid yn yr hinsawdd".

Pleser i mi, felly, yw cyflwyno'r adroddiad blynyddol diweddaraf ar waith y Grŵp, sy'n parhau i wneud cyfraniad bychan tuag at wireddu'r weledigaeth honno.

Nod syml ac uniongyrchol sydd i waith y Grŵp, sef casglu data am statws amgylcheddol Dyfrffordd Aberdaugleddau, sydd â'i dyfroedd dwfn yn denu defnyddwyr hamdden yn ogystal â rhai o longau mwyaf y byd. Y porthladd hwn, o ganlyniad, yw'r trydydd o ran ei faint, a'r prif borthladd ynni yn y Deyrnas Unedig. Yn ogystal, mae'r ddyfrffordd yn cynnal amrywiaeth hynod o gynefinoedd aberol, a arweiniodd at ei chynnwys yn ACA Sir Benfro Forol, ac at nifer o ddynodiadau SoDdGA ar hyd y blaendraeth.

Oherwydd y gymysgedd hon o weithgareddau ac anghenion, mae'n hollbwysig seilio'r penderfyniadau datblygu yn y dyfodol ar y dystiolaeth orau sydd ar gael.

Mae llwyddiant y Grŵp i'w briodoli i ymroddiad yr Aelodau, o fyd diwydiant ac o'r sector cyhoeddus, sy'n cyfrannu o'u hamser i sicrhau bod y rhaglen waith yn gadarn ac wedi ei phrofi'n drylwyr. Mae cyflenwi'r rhaglen honno'n dibynnu'n helaeth ar Swyddog Prosiect y Grŵp, Blaise Bullimore, y gwerthfawrogir ei gyfraniad yn fawr iawn.

Nid y lleiaf o'r heriau a wynebwn yn ystod y flwyddyn neu ddwy nesaf fydd sicrhau cyllid digonol ar gyfer ein rhaglen waith uchelgeisiol. Mae nifer ein haelodau, fodd bynnag, wedi cynyddu dros y blynyddoedd diwethaf, sy'n dynodi bod y Grŵp mewn cyflwr iach, a'r gwaith a gyflawnir ganddo yn cael ei werthfawrogi.

Y Capten Mark Andrews

Awdurdod Porthladd Aberdaugleddau

Cadeirydd

1. INTRODUCTION

This is the thirteenth business report of the Milford Haven Waterway Environmental Surveillance Group (formerly the Milford Haven Waterway Environmental Monitoring Steering Group). It covers the period January to December 2012.

The Milford Haven Waterway Environmental Monitoring Steering Group was established in 1992 following a highly successful one-day conference to examine the issue of oil pollution in Milford Haven. The Group immediately commissioned and published a review of the then current environmental knowledge of the Milford Haven Waterway, which included a description of the nature and extent of monitoring being undertaken on the Waterway at that time. The review made recommendation as to prioritised work plans for the future, covering obvious gaps and omissions in existing monitoring, and this formed the basis of projects contracted by the Group in the following years.

The Group subsequently let a series of contracts to collect data across the full suite of marine habitats within the Haven and, in collaboration with the Environment Agency, carried out systematic water quality surveillance for several years. Studies are resourced by Group members contributing either directly in monetary terms or in kind, and by undertaking or supporting survey and surveillance projects carried out by Group members directly. The value of the Group's data became very clear during the assessment of the environmental impacts of the 1996 Sea Empress oil spill and subsequently in informing environmental assessments of developments.

During the early 2000s, the need to strengthen and increase the formality of the Group's constitution became increasingly important. The development and agreement of a formal Memorandum of Agreement that met the needs and business concerns of all members of the Group took a considerable time. Following ratification and adoption of the MoA by all the Group's members, financial management of the Group transferred from Pembrokeshire County Council to Milford Haven Port Authority.

During the same period, the surveillance and monitoring obligations on several public bodies arising from, in particular, European directives developed and become clearer; for example the monitoring requirements of the Habitats & Species and the Water Framework Directives. Whilst the Group welcomes the use of data it collects to inform such monitoring, it does not wish to duplicate the efforts of public bodies, or be seen to be undertaking their duties. Rather it wishes to fill the gaps between such work, focus on tasks of the widest common interest to its members, and to synthesise and summarise the information available on the environmental health of the waterway.

Although the outputs are primarily for the benefit of the Group members, reports are lodged with public, academic, government and local school libraries, with the Group's business reports also being circulated to local elected representatives of Welsh, UK and European government.

2. GROUP ACTIVITY 2012

2.1 INTRODUCTION

Following two years of preparation and postponements, the Group's major 2012 project was a Sediment Profile Imaging survey carried out by Germano & Associates, Seattle USA. The SPI technique was developed by Joe Germano, while at Yale University, as a rapid and cost-effective sediment seabed characterisation method.

The large (2 x 1.5 x 1.5 metre), heavy (480 kg – almost half a ton) SPI camera system arrived in 14 custom flight cases and was assembled on the quay at Neyland Marina prior to being loaded onto the Environment Agency survey vessel Coastal Guardian, chartered by the Group for the project.

Whilst most marine survey work benefits from calm sea and light winds, benign weather conditions are particularly welcome when deploying heavy and expensive equipment, and late spring had been specifically chosen in hope of good weather. Although Joe Germano and his colleague Ray Valente arrived in rain and a stiff breeze, luckily the weather calmed on the first day of survey and remained good until the final day when the wind increased and we returned to British-weather-as-usual.

The Group expresses its thanks to Dale Sailing Co for providing storage and work-space free of charge; to the crew of Coastal Guardian for their enthusiasm, technical support and friendship to the visiting survey team; and to the Countryside Council for Wales Skomer Marine Nature Reserve team for providing diving support at extremely short notice to successfully relocate and recover the SPI camera after the winch-wire parted, dropping the camera in 24 metres of water off the South Hook jetty.

The meticulous survey report and appendices contain a wealth of data and interpreted maps that will undoubtedly be of enormous value in informing environmental assessments and the management of developments and operations in the Waterway for many years to come.

The Group commenced a forensic investigation into the source of hydrocarbons in Waterway sediments in 2011. The laboratory work was not completed until 2012 and a summary of the data and initial interpretation report from Fugro-ERT is included on page 9. A further report examining the data using more detailed and specialised forensic evaluation and interpretation is scheduled for delivery in 2013.

Wetland bird surveillance continued as in previous years and synopses from the Wetland Birds Surveys (WeBS) and Pembrokeshire Coast National Park Authority shelduck surveys are included.

Members of the Group continued to undertake statutory and license condition monitoring. A brief update of monitoring by RWEnPower is included on page 14 and a brief description of an aerial survey of intertidal opportunistic macro-algae carried out by the Environment Agency Wales (EAW) on page 15.

This report also includes guest contributions from Dr Robin Crump and John Archer-Thomson describing personal research projects undertaken from the Field Study Council Centres at Orielton and Dale Fort respectively. These clearly demonstrate the considerable value of repeated, straightforward, recording and measurement over long periods of time. They show that in addition to providing clear signals of acute impacts, such long-term studies are also able to detect more complex, subtle and unexpected long-term changes with both

natural and anthropogenic causes. Both these personal research interests revealed unforeseen, interesting and perhaps surprising biological changes; in so doing they beg the question whether further insights into the response of Milford Haven's marine wildlife to, or recovery from, chronic or legacy perturbations would have been or might yet be detected had further similar detailed and enduring studies been carried out.

Lastly, the Group celebrated its 20th anniversary in October in the company of senior representatives of its member organisations and former colleagues involved in the Group's establishment in 1991-92. Following a welcome by Mark Andrews, guests and members were given gave a presentation by Blaise Bullimore on the background to and history of the Group and a summary of its achievements over the previous 20 years, and contractors Annie Haycock (Pembrokeshire Wetland Birds Survey coordinator) and Dr Bill Langston (Marine Biological Association UK, Plymouth) gave brief accounts of the varying fates of the Haven's wetland birds and the results of comprehensive contaminant bioaccumulation surveys in 2008 and 2010-11.

2.2 SEDIMENT-PROFILE IMAGING SURVEY OF MILFORD HAVEN WATERWAY, WALES, UK - MAY 2012

Germano & Associates Inc.

Executive Summary

Germano & Associates Inc. (G&A) performed a Sediment-Profile and Plan-View Imaging (SPI/PV or SPI) survey in Milford Haven Waterway in May 2012. The SPI system, pioneered in the United States but used widely throughout Europe and Asia, is combined with a downward looking seafloor camera to capture images of a cross-section and surface view of the seafloor (*front cover image*). The system rapidly collected images from both shallow and deeper areas of the estuary resulting in the most comprehensive assessment of the distribution of Milford Haven Waterway sediments and benthic habitat composition to date.

Detailed maps of sedimentary habitats in the Milford Haven Waterway were compiled for the Milford Haven Waterway Environmental Surveillance Group (MHWESG) from the comprehensive dataset. The results included grain-size information, biological characteristics, and evidence of sediment transport conditions and effects of biological activity.

In order to map the complex mosaic of sediment types, descriptions commonly employed by field sedimentary geologists were used to integrate the information from the images. The scientists that produced the study compared their results to a descriptive study of the intertidal areas of Sandy Haven Pill conducted in the 1970s. They adapted the original approach to include the shallow and deep-water areas of the entire Milford Haven Waterway. This interpretative framework classified each of 559 stations within a 'facies' that included information on the location within the estuary and inferred sedimentary and biological processes. Sediment facies are generally used to describe the sum of characteristics of sediment units at a small (cm-m) scale. This framework groups the stations into classes with similar sediment transport conditions used to describe landscape-scale habitats and can be used to direct future monitoring activities within the Milford Haven Waterway.

Because sediment facies can be projected over larger areas than individual samples (due to assumptions based on physiography, or landforms) they represent a model of the distribution of sediments in an estuary. This model can be tested over time and space through comparison with additional samples or older sample results. This approach provides a means to evaluate stability or change in the physical and biological conditions of the estuarine system. Indeed, initial comparison with past results shows remarkable stability over time for the Milford Haven Waterway.

One of the most useful end products of this study is a novel computer display of the images associated with each station. This 'popup' map allows a user to examine the images collected from each station by rolling the cursor over the station; the images 'popup' next to the map and are replaced by images from the next station selected. The maps will allow scientists and managers of the Waterway to target monitoring efforts in the future saving effort and resources for the areas at greatest risk.

We recommend that MHWESG utilize the results of the SPI and PV survey for planning purposes:

- Prioritize sediment and benthic sampling within habitats and sediment facies most at risk from localized disturbance and contamination.

- Focus future sampling density to reflect the variation and transition between sediment facies and broad grain size groupings. Fewer samples can be located in relatively homogeneous areas such as Pembroke River whereas more samples should be taken in areas with heterogeneity such as Dale Roads, Pwllcrochan Flats or Angle Shelf.
- Utilize the Appendix E with 'popup' images of SPI and PV superimposed on switchable layers (bathymetry, facies) to investigate sediment conditions in specific areas of interest. Close study of the raw data using the guidance in interpretation provided by this study is preferable to accepting models or maps of grain size estimation.

2.3 INVESTIGATION INTO THE SOURCE OF HYDROCARBONS PRESENT IN SEDIMENT SAMPLES FROM MILFORD HAVEN WATERWAY

Fugro ERT

Report summary

Prior to, and following, the Sea Empress spill in 1996 the Milford Haven Waterway has experienced a regular input of hydrocarbons of petrogenic and non-petrogenic origin as a busy commercial harbour. In the 1960s and 1970s Esso, BP, Regent Amoco and Gulf opened refineries and terminals to handle and process crude oil at sites in and around Milford Haven. The Esso refinery was decommissioned in 1983 and is now the site of ExxonMobil's South Hook LNG terminal. In addition to an extensive petrochemical industry, the area has a long history in the mining and exporting of coal, a significant source of polycyclic aromatic hydrocarbons (PAHs).

In December 2012 ERT (Scotland) Limited (now Fugro ERT a division of Fugro GeoConsulting) was contracted to analyse sediments and a range of reference oils for the purpose of establishing, if possible, the differing sources of contemporary hydrocarbons in the Milford Haven Waterway.

Marine and estuarine sediments contain hydrocarbons derived from many sources which themselves enter the environment via three general processes, biosynthesis (marine and land organisms biosynthesise hydrocarbons), geochemical processes (submarine, coastal and land oil-seeps) and anthropogenic sources (from accidental or intentional discharge of fossil fuel) . The latter obviously includes hydrocarbon exploration, production and its associated shipping; these and other sources of contaminants are assessed in various OSPAR reports.

Biosynthesised hydrocarbons are ubiquitous in the marine environment. Long-chain n-alkanes are widely distributed in the plant kingdom as components of the cuticular waxes which are common to the surfaces of leaf, stem, flower and pollen and their presence in sediments is indicative of an input through run-off from adjacent land masses. This is a common feature of many marine sediments, particularly inshore marine sediments.

Anthropogenic hydrocarbon inputs enter the marine environment from a number of sources, typically identified in on-going estimation categories as: marine transportation, offshore oil production, coastal oil refineries, accidental shipping losses, industrial and municipal waste (which includes sewage and dredged spoils) with a significant contribution to the global budget entering via urban and river run-off, atmospheric deposition (i.e. from combustion sources; PAHs) and natural seepages.

Sediment samples were analysed by gas chromatography-flame ionisation detection and gas chromatography-mass spectrometry. Sediment and reference sample data were analysed by "fingerprinting" and comparison of diagnostic PAH and biomarker ratios.

In order to place the sediment hydrocarbon data in context, the data was reviewed with regard to cited background Celtic Sea levels and previously recorded data sets.

The gas chromatographic profiles obtained for the sediment samples around Milford Haven exhibited a 'background' of predominately weathered petroleum hydrocarbons and biogenic n-alkanes, with some recent low-level petroleum hydrocarbon inputs. The profiles were typical of those frequently observed in offshore and coastal marine sediments, particularly around industrialised estuaries.

The concentration of hydrocarbon material and specifically PAHs was significantly higher in the sediment samples than typically found in background offshore marine sediments or undeveloped estuaries and bays. Although exceeding background concentrations, both THC and PAH levels were lower than their previously highest recorded values for the area.

The source of the hydrocarbons in the sediments analysed could not be ascribed to any particular input. This is primarily due to the compositional modification that hydrocarbons undergo in the environment from the point of release until deposition in the sediments. In addition to the changes that the hydrocarbons undergo in transit from the point of release they appear in general, to be dominated by petroleum hydrocarbons with characteristics similar to those produced in the Middle East region.

2.4 REVIEW OF THE STATUS OF WETLAND BIRDS IN THE MILFORD HAVEN WATERWAY AND DAUGLEDDAU ESTUARY

A Haycock, Pembrokeshire WeBS Coordinator

Executive summary

The Milford Haven Waterway - Daugleddau Estuary system ("the estuary system") is an important wintering ground for waders and wildfowl because of its sheltered location and open mudflats.

The estuary system is of international importance by virtue of hosting an average of over 20,000 waterbirds each winter. It is of national importance for its populations of wintering wigeon, teal and greenshank, and for migrating curlew. Other species have reached nationally important levels here in past winters, but either numbers have declined, or the threshold for national importance has been raised, and they no longer reach that threshold. The estuary system holds some 13.5% of the Welsh waterbirds (on WeBS sites) in midwinter, and just under 1% of the UK waterbirds on WeBS sites.

- Almost all the **shelduck** in Pembrokeshire in winter are found on the estuary system. Numbers of wintering shelduck have fallen, both here and across the UK
- **Wigeon** numbers have increased dramatically since 2003, particularly on Pembroke River. They move on, either to other parts of the estuary system or out of the estuary system altogether, as soon as the food supply is exhausted in mid-winter.
- **Teal** numbers have fluctuated over the past decade, but are just over the threshold for national importance. The cause is thought to be the recent run of mild winters and an increase in the protected areas on mainland Europe allowing larger numbers of birds to remain further north and east.
- Mid-winter peak counts of **curlew** have decreased both on the estuary system and in Carmarthen Bay, although the UK trend shows an increase. However, data indicate that the estuary system is now an important migratory stopover for curlew.
- **Redshank** numbers dropped by half in the early 1990s, but have been reasonably stable since then. The cause is almost certainly that warmer winters mean fewer birds using the west coast estuaries.
- **Greenshank** numbers have increased following a period of low counts in the 1990s. The estuary system is one of the top ten wintering sites for this species in in the UK, and almost half of the birds wintering in Wales are found here.
- **Little egret** numbers have increased rapidly between 1995 and 2005, then leveled out. The cold winters of 2010 and 2011 reduced their numbers considerably.
- · **Little grebe** numbers have declined, despite an increase in the Pembrokeshire, breeding population. The trend for both Wales and the whole of the UK is for increasing numbers in winter. It may be that the birds are staying on smaller freshwater sites in the county (if these are no longer prone to winter freezing) and just not wintering on the estuary system.
- The **Canada goose** population rose considerably in the 1990s, in line with the trends for the Welsh and the UK populations. Birds are most often found between Llangwm and Boulston, though they also feed away from the estuary. There is no evidence yet that they

are affecting the numbers or distribution of other bird species, however, they may have an effect on the flora through trampling and eutrophication.

- **Greylag geese** have rarely been recorded on the estuary, but there is increasing evidence of them breeding locally, and they may or may not be a future cause for concern.
- **Grey herons** breed at two main sites on the Cleddau system, totaling 20-30 nests each year. However, counts are sporadic and no conclusions can be drawn about the breeding population.

Most of the changes in bird populations are reflected in other sites, either in Wales or in the UK as a whole. Some of the observed changes in numbers using the estuary system in winter may reflect the run of mild winters between 1995 and 2009 (which may or may not suggest long-term climate change), so birds do not have to travel so far south and/or west to escape harsh winter weather. Data suggest that large numbers of birds are more likely to visit the estuary system during periods of extreme weather, but during normal weather would prefer the conditions (including a better food supply) on the east coast.

Winter distribution may also be affected by the increase in protected areas on the European mainland, which have resulted in birds, *eg* teal, that are susceptible to hunting pressure, to remain in those areas.

The data collected during the annual shelduck surveys in July and early August since 1992 have demonstrated the importance of the estuary system as a migration stopover for several species, notably curlew.

The Cleddau estuary system is clearly of national importance for wintering and migrating wetland birds, and it is vital that the full range of their requirements (*eg* undisturbed good quality feeding habitat and high tide roosts) continue to be met here.

Why do we need to keep counting?

In winter 2012-13 the wigeon arrived in September as usual, but left early, with the peak count some 3000 less than in recent winters. This may be a one-off event; it may be caused by events away from the estuary; there may have been some disturbance that kept the birds away, or it may indicate some change in the food supply in Pembroke River.

Annual monitoring will pick up trends in the numbers of birds at local and national levels, and flag up changes that may require further consideration or investigation (eg environmental or water quality) in the estuary system.

Long-running datasets are very rare, but are extremely valuable in picking up both long-term and short-term changes. It is therefore important to continue with annual surveillance of wetland birds within the estuary system, both as part of the UK dataset and in terms of SSSI monitoring.

2.5 ANNUAL SUMMER SHELDUCK SURVEY 2011

J E Hodges, PCNPA Ecologist

Executive summary

The Daugleddau Estuary and Milford Haven Waterway hold nationally important numbers of shelducks during the winter months. In addition there is a small summer population which had been the subject of annual summer boat surveys carried out between 1991 and 2011. The summer boat surveys were repeated in 2012 as part of a coordinated programme of environmental surveillance in the estuary system. The aims, objectives and methods used, together with the data obtained are described in this report.

The results indicate that in terms of the numbers of broods of ducklings seen on the water, 2012 was the poorest year for breeding shelducks in the estuary since the current sequence of annual surveys began in 1991. Predation is thought to have been a major factor affecting the number and size of broods recorded in 2012. Disturbance may also have been a contributory factor, although there is little hard evidence on which any assessment of the importance of this as a factor affecting the population can be based. Adverse weather conditions in the spring and summer of 2012 are thought to have been a significant factor affecting the

population: the prolonged periods of torrential rain and huge quantities of surface water may have resulted in some nests being flooded out. A further factor to consider is that since the mid-1990 s there has been a steady decline in the numbers of shelduck over wintering in the UK which has been reflected at local levels probably in response to the recent run of mild winters across northern Europe. The decline in the over wintering population has led to fewer birds remaining within the estuary system to breed.

Data collected for other wetland birds once again underlined the importance of the estuary system during the autumn migration period, especially for species such as curlew and green and redshank.

The report concludes with a recommendation for the continuation of the annual surveillance of summer shelduck populations in the estuary system as part of the Milford Haven Waterway Environmental Surveillance Group’s annual work programme.

2.6 PEMBROKE POWER STATION BASELINE AQUATIC SURVEYS

RWE Pembroke Power Station has undertaken aquatic ecology and marine water quality surveys in the proximity of the power station since 2006. Surveys between 2006 and 2011 were aimed at establishing a baseline understanding of the marine environment in that area.

During 2012 these surveys were continued with the emphasis moving towards developing an understanding of any changes to the marine environment in that area resulting from both natural and anthropogenic influences.

The survey programme consists of studies of marine water quality, temperature, bathymetry, fisheries, plankton, intertidal ecology, subtidal benthic ecology, subtidal epifauna ecology and eelgrass. More detail on the methodology of these surveys has been published in previous MHWESG business reports. A suite of reports detailing results from this programme of monitoring is anticipated to be completed during 2013.

2.7 MILFORD HAVEN CASI SURVEY 2012

Richard West, Environment Agency Wales

The Milford Haven Waterway was surveyed by the Environment Agency Geomatics Team using a Compact Airborne Spectographic Imager (CASI) on 12 September 2012. The CASI is a passive sensor attached to a low flying aircraft that generates imagery by detecting visible and near infrared electromagnetic energy reflected from the Earth's surface. CASI imagery produces a more accurate aerial image of survey areas than conventional red-green-blue photography, with a higher level of detail than is achievable using visual interpretation of aerial photographs (Hambidge, C and Brown, K. EA Geomatics Group, 2011).

The extent of the 2012 CASI survey is shown in the map shown on the back cover. Accurate survey data can only be obtained for areas of clear sky below the aircraft flight path and conditions at the time of the survey resulted in some data loss due to cloud cover, particularly in Sandy Haven, Castle Pill and the entire area of Milford Haven north of Lawrenny. Ground truth data was collected by the Environment Agency Wales Analysis and Reporting Team between 17-25 September 2012. An example of the survey outputs is also on shown the back cover.

2.8 ASTERINA SPECIES IN SOUTHWEST WALES

Dr Robin Crump, Emeritus Director of Studies, Orielton Field Centre.

This article was originally published in the newsletter of the Porcupine Marine Natural History Society.

When I first came to work at Orielton Field Centre in 1970 I had recently finished a Ph.D in New Zealand on a large asterinid sea star *Patiriella regularis*. I was keen to continue to research cushion stars in the field and decided to have a look at *Asterina gibbosa* (Pennant) which is not uncommon on the lower shore throughout Wales. I was told by my boss Eric Cowell that there was a large population (thousands, he said) at West Angle Bay. I enlisted the help of a friend, Dr. Roland Emson of Kings College, London and together we spent the next seven years working on this large population of *A. gibbosa* in the mid shore rock pools at West Angle.

Our joint research showed that *A. gibbosa* is a medium size (up to 40mm diameter arm tip to arm tip) cushion star, which is male for the first two years, becomes hermaphrodite with ripe eggs and sperm in the third year and female in the fourth at about 20mm in diameter. It lays heavy yolked benthic eggs in patches of up to a thousand in each egg mass on the underside of stones. These eggs normally metamorphose in 3-4 weeks in June producing mobile sea stars approximately 0.75 mm in diameter. The eggs are subject to severe predation by a variety of annelid worms, prawns and small crabs. The cushion stars are usually found on the underside of stones during the day but may come out to feed on the tops at night. Small numbers are found scavenging on dead crabs and other carrion but the principal method of feeding is to evert the stomach lobes over a film of bacteria, diatoms and detritus on the surface of the rock (Crump and Emson 1978).

Asterina gibbosa ranges in colour from green to khaki to bright orange. During the course of our studies we kept finding a small brown variety of *A. gibbosa* with a distinctive colour pattern of bright orange brown sub star on a dark green ground (i*mage rear cover*). This colour form never grew larger than 15mm and further research showed that these animals were regularly found sitting over the egg mass for three weeks in June. Eventually newly metamorphosed juveniles crawled out from under the mother (*image rear cover*) and dispersed. It appeared that most of the two year olds failed to survive another winter. After much discussion and even heated argument we were forced to describe the small brown form as a new species *Asterina phylactica* (Emson & Crump 1979).

There are very few morphological differences other than colour and a pair of small spines under the chin but *A. gibbosa* and *A. phylactica* have significantly different life strategies. In addition to the fact that *A. phylactica* broods the eggs and developing juveniles, whereas *A. gibbosa* does not, *A. phylactica* matures earlier, laying eggs first when only one year old (5mm diameter) against four years and 20mm in *A. gibbosa*. *A. phylactica* has a much shorter life span (2-3 years) where as *A. gibbosa* may live to seven years or more (Crump & Emson 1983). Further studies using gel electrophoresis and DNA analysis have confirmed the specific status of *A. phylactica* (Bullimore & Crump 1982).

On the evening of February 1996 the rock pools at West Angle Bay were inundated with oil from the Sea Empress oil tanker. Over the next few days the pools were repeatedly oiled and a specialist team was called in to attempt to remove as much of the oil as possible in order to save the sea stars at the type locality of *A. phylactica*. At that time the species was thought to

be very rare with only six known localities in Britain (*eg* Langerstone point in Devon). A thorough search revealed only one or two *A. phylactica* although adult *A. gibbosa* were common.

A further extensive search of the pools in June 1996 showed that the majority of the 250 *A. phylactica* present before the spill had been wiped out, with only 10 remaining. By contrast the adult *A. gibbosa* (15mm+) had not only survived but were laying eggs under rocks that still showed signs of oil. We feared that *A. phylactica* would become extinct at the type locality and asked permission to introduce animals from Devon to replenish the stock but this was refused.

In June 1997 I found 5 out of 10 *A. phylactica* individually brooding egg masses several metres apart and decided to see if the species was capable of self-fertilisation. Accordingly I bought one brooding animal on its rock, into the lab at Orielton and within three weeks the egg mass had metamorphosed successfully. After two weeks of feeding the juveniles on the algae growing on the glass of the aquarium, I was able to return the adult and 50 juveniles to the pools at West Angle.

Nonetheless prospects for the survival of *A. phylactica* at West Angle looked bleak. The absence of almost all the predators on eggs due to the oil spill meant that the vast majority of the eggs of *A. gibbosa* had survived to metamorphosis and a population explosion of the species ensued. By October 1997 there were huge numbers of tiny white (3-4 mm diameter) juvenile *A. gibbosa* found throughout the pools. By June 1998 (fig. 8) the population had risen to 655 animals as against only 21 *A. phylactica*.

Despite this intense competition for food and space *A. phylactica* continued to hold its own and began the fight back. By June 2000 *A. phylactica* numbers had risen to 107 with 80 animals in the 1+ category and only 222 *A. gibbosa* were found (fig.8). The numbers of *A. gibbosa* remained much the same over the next four years but by June 2004 there had been an excellent recruitment of *A. phylactica* with over 600 found in the survey. While both species had good and bad years over the next 8 years the numbers of *A. phylactica* greatly exceeded those of *A. gibbosa* and by June 2012 numbers of *A. gibbosa* had shrunk to just over 100 individuals while 1345 *A. phylactica* were measured (Fig. 1). It is probable that all the animals are descended from the 10 survivors of the spill which represents a very limited gene pool. Nevertheless one can say that *A. phylactica* has more than recovered and now appears to be out competing *A. gibbosa* to a considerable degree.

It was always difficult to understand how two such similar sympatric species could live under the same stones in the same midshore pools, exploiting exactly the same microphagous feeding habit without competing with each other for food and space. Prior to the oil spill for 20 years the ratio of the numbers of the 2 species was of the order 5:1 in favour of *A. gibbosa*. Now the situation is reversed with a better than 10:1 ratio in favour of *A. phylactica*.

It would appear that *A. phylactica* is now out competing *A. gibbosa* in this midshore rock pool habitat. It is possible that this competition may include a rather unusual form of conflict. *A. gibbosa* has been observed to cover, eat and digest individually brooding *A. phylactica*. By the same token *A. phylactica* is attracted to the egg masses of *A. gibbosa* and has been observed to prey on them. It may be that at the present time the huge numbers of *A. phylactica* are pushing *A. gibbosa* to extinction in the pools by predating the egg masses. Prior to the oil spill egg masses of *A. gibbosa* were common in June occurring on every large

stone. In 2012 only two intact egg masses were found. By contrast there were close to a hundred groups of 5 or more brooding *A. phylactica* sitting over egg masses at that time. I know of no other example of two invertebrate species competing by eating each other or their eggs, though it may happen in birds.

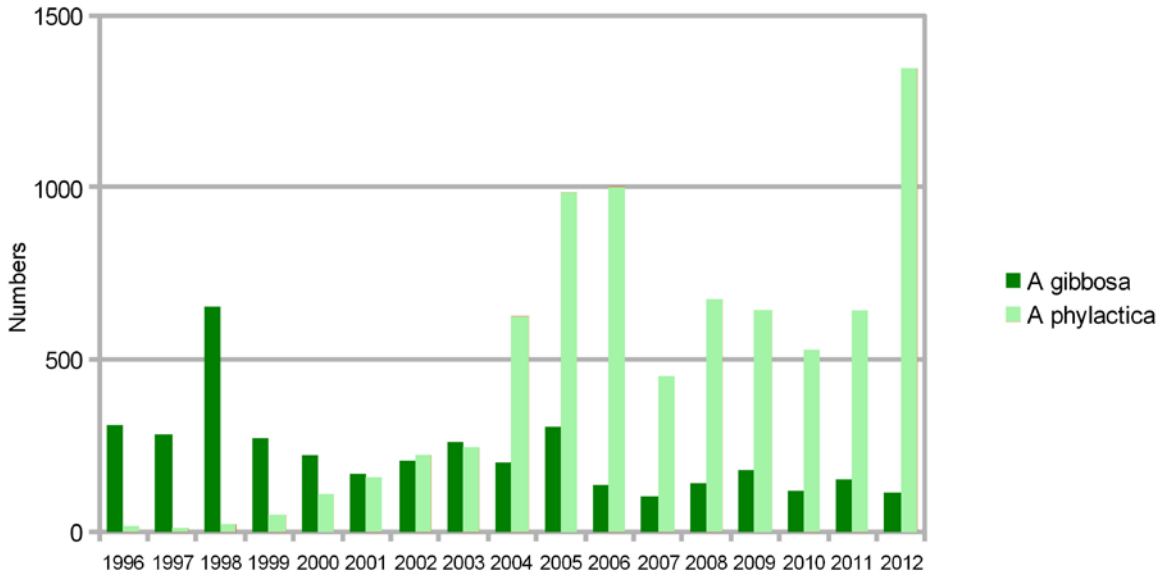

Figure 1 Total numbers of *Asterina gibbosa* and *A. phylactica* in June, 1996-2012

Interestingly single species populations of *Asterina gibbosa* and *Asterina phylactica* are the norm. *A. gibbosa* is normally found on the lower shore under stones exposed at low tide. On the left hand side of West Angle Bay there are a large number of shallow midshore pools with a large population of *A. gibbosa* and not a single *A. phylactica* has been found there. Conversely the large systems of rock pools at Carrigathorna, Eire, Langerstone Point, Devon and the Worms Head, near Swansea support pure populations of *A. phylactica* with no *Asterina gibbosa* present. Indications are that *A. phylactica* is a Mediterranean species close to its northernmost limit in Wales. It may be that the higher temperatures in the rock pools in summer, as a result of climate change, may be contributing to the success of the species in Wales.

References

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2.9 THE CONTINUING STORY OF THE LIMPETS OF FRENCHMAN'S STEPS.

John Archer-Thomson, Former Deputy Warden, Dale Fort Field Centre

This article is based on a paper presented to the Problems of Small Estuaries Symposium, Unviersty Swansea, 9 – 11 March 2013

Dale Fort has been one of the Field Studies Council's (FSC) residential Field Centres an for over sixty years; its speciality is marine and coastal ecology. I first joined the teaching staff in September 1982. At that time one regular student investigation looked at the population dynamics of common limpets on a moderately sheltered rocky shore close to the Centre kn own as "Frenchman's Steps".

We investigated the vertical range of the limpets (how high and low they could live on the shore), their size range and how this might vary with height and also how their numbers (abundance) varied up and down the shore. Immersion time in seawater decreases significantly with increasing height up a shore; consequentially shores exhibit a pronounced environmental gradient from top to bottom. Salty but essentially terrestrial conditions exist at the top of the shore; marine conditions prevail at the base. As a result rocky shores are fascinating places in which to conduct ecological investigations.

The method for data collection is simple. Groups of students are spaced at regular intervals along a tape measure at the known starting height above chart datum near the base of the shore, the tape is horizontal i.e. parallel to the water's edge. Each group has a 50x50cm quadrat (sample area) in which they measure the longest diameter of all the limpets they can find, recording the measurements in 5mm size classes. Groups then move up the shore to the next height (75cm above) and repeat the process, continuing upwards at regular height intervals until they run out of limpets to measure. In formal sampling terms this is an interrupted belt transect at 75cm vertical height intervals, with up to ten replicates at each height. Results are then standardised so that they are comparable despite being collected by different numbers of groups/replicates.

Typical sets of results for the total number of limpets at each height are shown in Table 1 and Figure 1. Numbers are lower at the top of the shore because of abiotic factors such as dehydration and temperature stress; numbers are lower at the bottom of the shore because although conditions are much better for marine organisms there are other biotic issues such as competition for space (with other species better suited to this part of the shore) and possibly increased risk of predation from oystercatchers, for example, which often stroll along the base of the shore at low water, chipping limpets off the rocks. On this particular shore the substrate becomes less suitable at the base of the rocks as there are more pebbles and less solid rock for limpets to attach to. Optimum conditions, between these two extremes, are found in roughly the middle of the shore so this is where limpet numbers peak.

Figure 2 shows two sets of results for the size measurements before and after the 1996 Sea Empress oil spill. Typically most limpets are to be found in the 10-14.99mm size class. To analyse this data we make an assumption that limpet shell length varies with age, the largest being the oldest (not too bad an assumption for any one shore but definitely not safe if comparing limpets on different shores; growth rate in limpets is indeterminate - no fixed maximum - and very sensitive to food supply). There are fewer big (old) limpets because they die (disease, predation etc.). There appear to be fewer small (young) limpets as they are much more difficult to see because of their diminutive size and they tend to live in damp

Example of raw limpet data, 7 groups standardised to 10.

30/04/1998	No. of Groups			7				
	Vertical height above chart datum / m							
Size class / mm	2.25	3	3.75	4.5	5.25	6	6.75	TOTALS
< 4.99	7	36	61	29	4	0	0	137
5.0--9.99	26	118	116	52	17	6	0	335
10.0--14.99	24	100	136	103	43	4	0	410
15.0--19.99	12	90	104	91	39	9	0	345
20.0--24.99	12	69	50	89	53	12	0	285
25.0--29.99	2	25	17	21	32	22	0	119
30.0--34.99	9	8	5	6	17	10	0	55
35.0--39.99	3	1	0	0	5	7	0	16
40.0--44.99	5	2						7
45.0--49.99	1							1
50.0--54.99								
55.0--59.99								
60.0--64.99								
65.0--69.99								
TOTALS	101	449	489	391	210	70	0	1710
	Vertical height above chart datum / m							
Size class / mm	2.25	3	3.75	4.5	5.25	6	6.75	TOTALS
< 4.99	10	51	87	41	6	0		195
5.0--9.99	37	169	166	74	24	9		479
10.0--14.99	34	143	194	147	61	6		585
15.0--19.99	17	129	149	130	56	13		494
20.0--24.99	17	99	71	127	76	17		407
25.0--29.99	3	36	24	30	46	31		170
30.0--34.99	13	11	7	9	24	14		78
35.0--39.99	4	1			7	10		22
40.0--44.99	7	3						10
45.0--49.99	1							1
50.0--54.99								
55.0--59.99								
60.0--64.99								
65.0--69.99								
TOTALS	143	642	698	558	300	100	0	2441

Table 1. Raw data set for seven groups standardised to ten for comparison.

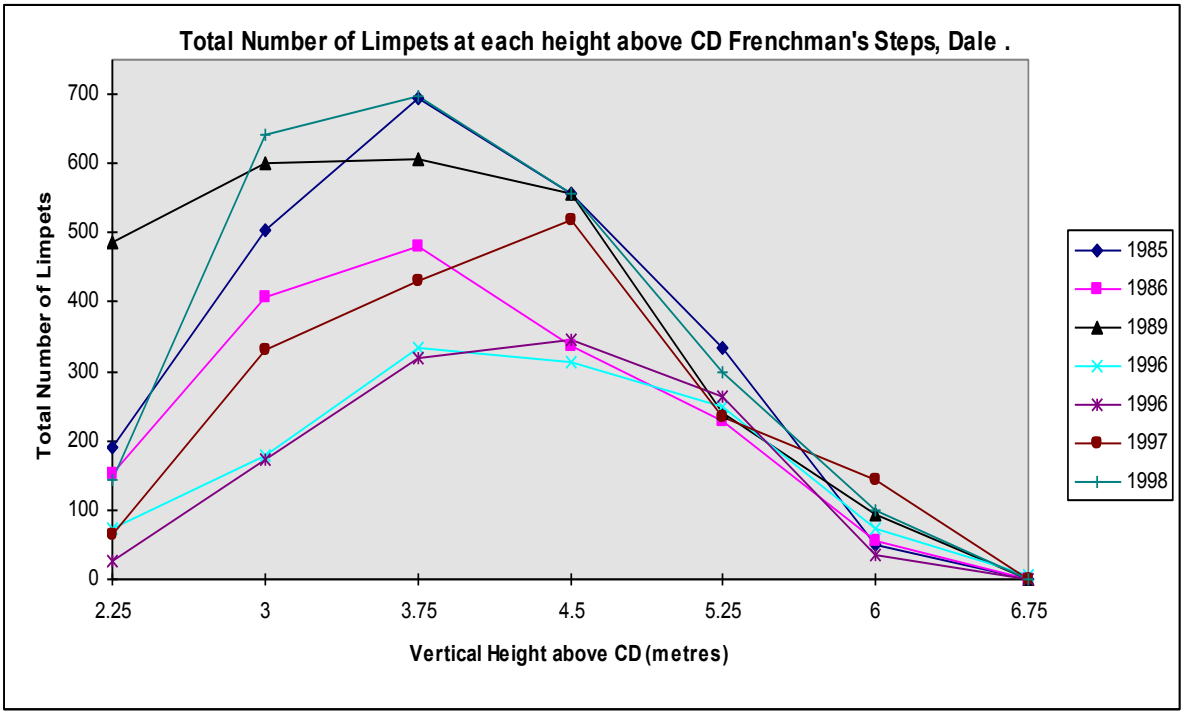

Figure 1. Total numbers of limpets at each shore height 1985 - 1998.

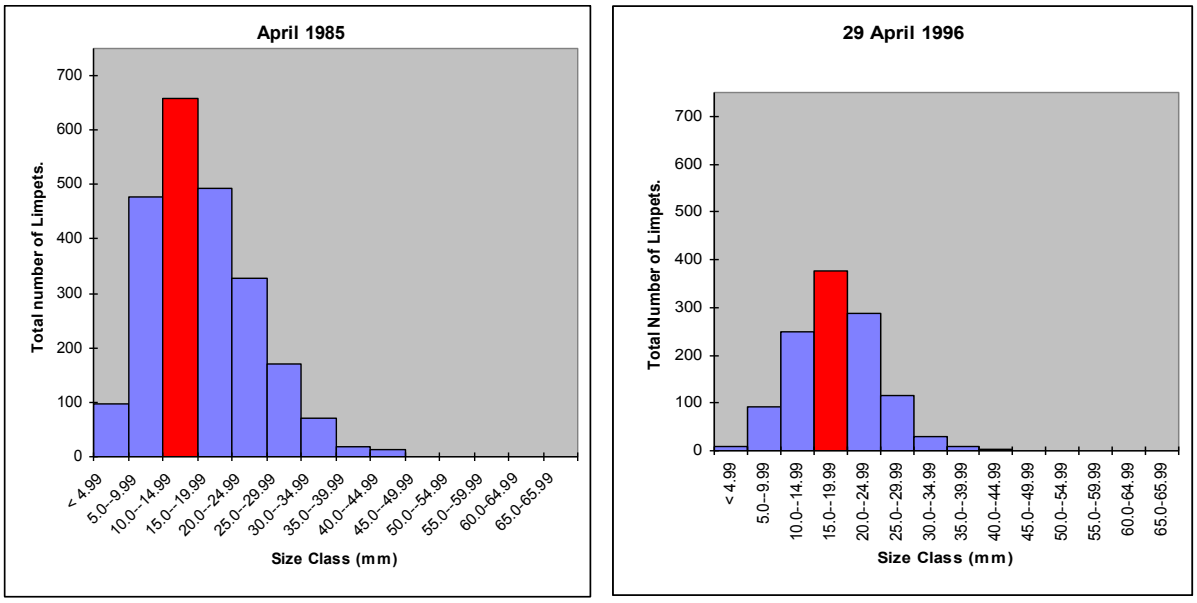

Figure 2. Number of limpets in each size class for a typical (left) and polluted (right) dataset. Note shift in modal class to the right for April 1996.

microhabitats such as crevices where they would be difficult to spot. Small (young) limpets grow quickly and move into larger size classes relatively rapidly.

Limpets also seem to get bigger (on average) with increasing height up the shore (Table 1). Explanations for this vary and indeed the strength (and direction) of the trend varies considerably from shore to shore, it has been a constant in the Frenchman's Steps data though. Most small limpets are to be found on the lower part of the shore because this is where the water is most often and it is from the water that limpet larvae settle when they leave their planktonic phase behind them. Most small limpets survive on the lower part of the shore because their thin shells mean they are prone to desiccation. One theory suggests that as limpets grow they need more space so they migrate up shore to where there is less competition for a place on the rocks. This is reasonable, although some workers disagree that this occurs, but it does seem to conflict with another known aspect of limpet behaviour, that of "homing". Limpets have a place on the rocks they return to after foraging for food (they eat green seaweeds, lichens and the biofilm of microscopic algae and cyanobacteria on the rock surface. They scrape their food off the rocks with a tongue-like structure called a radula). Experiments we have done with student groups show "homing" is over 95% successful. This rather contradicts the idea of limpets migrating up the rocks into free space. A suggestion, which makes sense, is that homing is the norm until the limpet outgrows (or gets ousted from) its home scar, then it migrates up the rocks into more open space where a new home scar is instigated.

Student groups vary in their motivation and competence and hence the quality of their results but I decided to keep the sets of data we had collected without being entirely sure why. In 1996 when the Sea Empress tanker spilled 72,000 tons of Forties Blend light crude oil on the coast of the Pembrokeshire Coast National Park, Frenchman's Steps got its share. Suddenly my (warts and all) student data looked very interesting as a record of what was there before the spill. Mortality rates were in the region of 50% for the shores around Dale Fort. The size data showed a shift in the modal class from the "normal" 10-14.99mm size class to the 15-

19.99mm class (Figure 2). Oil kills limpets and young ones are particularly susceptible (hence the shift in the modal class). Within a year, perhaps surprisingly given the extent of the spill, numbers had recovered to within what might be considered a normal range but the modal size class was still 15-19.99mm. Within two years the modal class had returned to the typical 10-14.99mm class and the population was back (in gross terms) to what might be considered normal. The rate of apparent recovery was surprisingly rapid.

I wasn't entirely happy with the quality of the pre-pollution data though and I wished to know what represented "natural" variation in the population of limpets on Frenchman's Steps. From 1996 onwards, every April, a group of postgraduate students from the University of Leuven, and latterly the teaching staff at Dale Fort, has monitored the population and Figure 3 shows the results up to and including 2013. There are two 1996 data sets to demonstrate that although this is student data, samples taken within a fortnight of each other by two different school groups were remarkably (reassuringly) similar. Since the apparent recovery in 1998 the size class data has resolutely stayed in the 10-14.99mm size class so this seems to be "normal". The number of limpets varied, albeit within what seemed reasonable limits, until 2010 when results exceeded all previous years by so much that I thought my conscientious teaching colleagues had done it too well. When we all collected data in April 2011 the results showed record breaking numbers of limpets on the shore, confirming that the 2010 data was not a blip; 2011 was a very good year for limpets.

As monitoring continued in 2012 and 2013 numbers began to fall back to what I had regarded as "normal" again but there were subtle differences in the sizes of the limpets that were affected. In 2012 the total number of limpets was down but the 10-14.99mm size class seemed unaffected (see figures 4, 5a and 6). By 2013 the total number of limpets was down again but this time the 10-14.99mm size class was affected quite substantially. The data trends in recent years require some explanation and this will require a small digression into the world of tri-butyl tin (TBT) anti-fouling paint and the dogwhelk (*Nucella lapillus*).

When I started work at Dale Fort (1982) it was very difficult to find a dogwhelk on the rocky shores between the Field Centre and Dale village approximately one mile distant. At that time TBT was used as an anti-fouling paint to prevent barnacles, seaweeds and other sessile organisms from settling on the hulls of pleasure and commercial craft. Fouling slows vessels down in the water and inconveniences boat owners in their bid for racing glory or in terms of commercial viability where time is money. TBT was an extremely effective product but it was found to be the most toxic compound ever deliberately released into the environment by human beings: the equivalent of a teaspoon-full in an Olympic-sized swimming pool was enough to be biologically active to the detriment of a wide variety of marine organisms. TBT bio-accumulated as well. In dogwhelks the female grew a non-functional male reproductive organ, which blocked the oviduct and prevented reproductive success. Dogwhelk populations crashed. TBT was banned on pleasure craft in 1987 and on all commercial vessels by 2003. Since then dogwhelk numbers have increased spectacularly on the shores between the Field Centre and the village. Dogwhelks eat barnacles predominantly on the local shores but it is tempting to suggest that barnacle food may have been over exploited by the burgeoning dogwhelk population (hence initially, being at least one of the factors, allowing the impressive limpet increases of 2010 and 2011as barnacles and limpets must compete for space) and the dogwhelks may have turned their attention to young limpets as an alternative

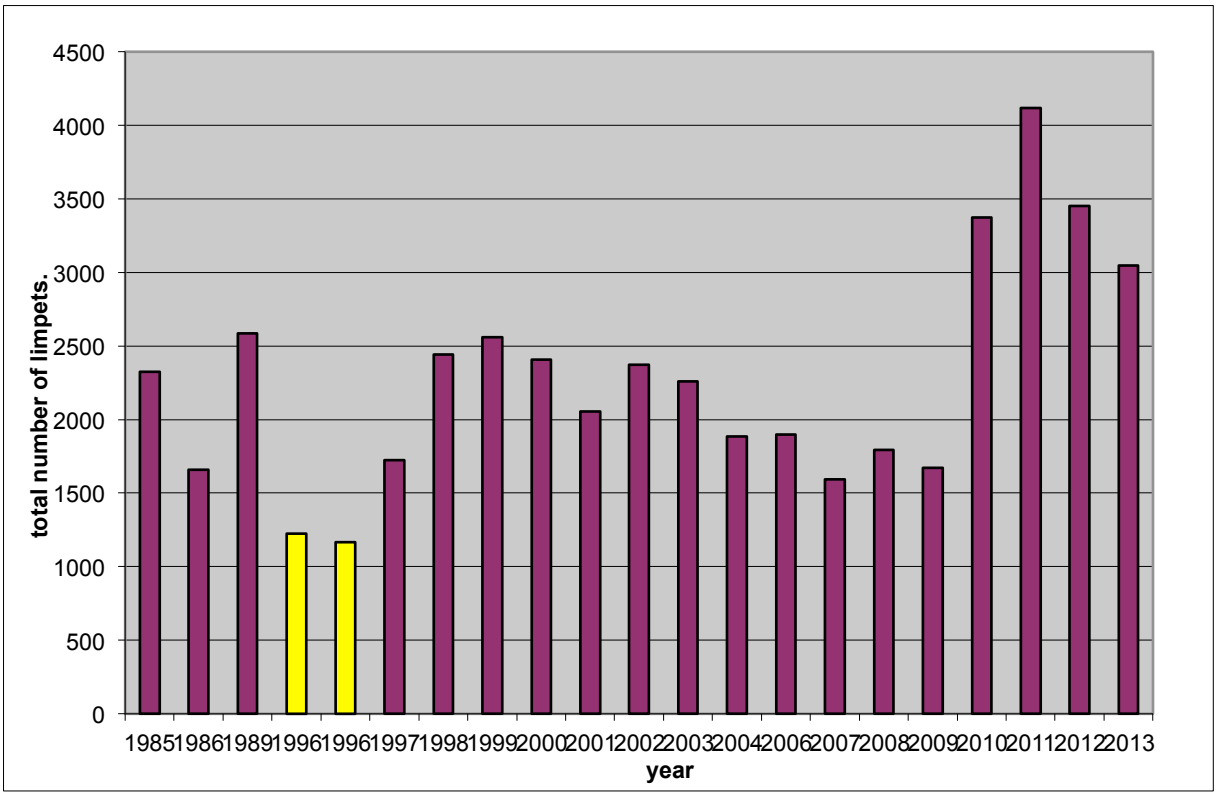

Figure 3. Total number of limpets present on the Frenchman's Steps study site 1985 – 2013.

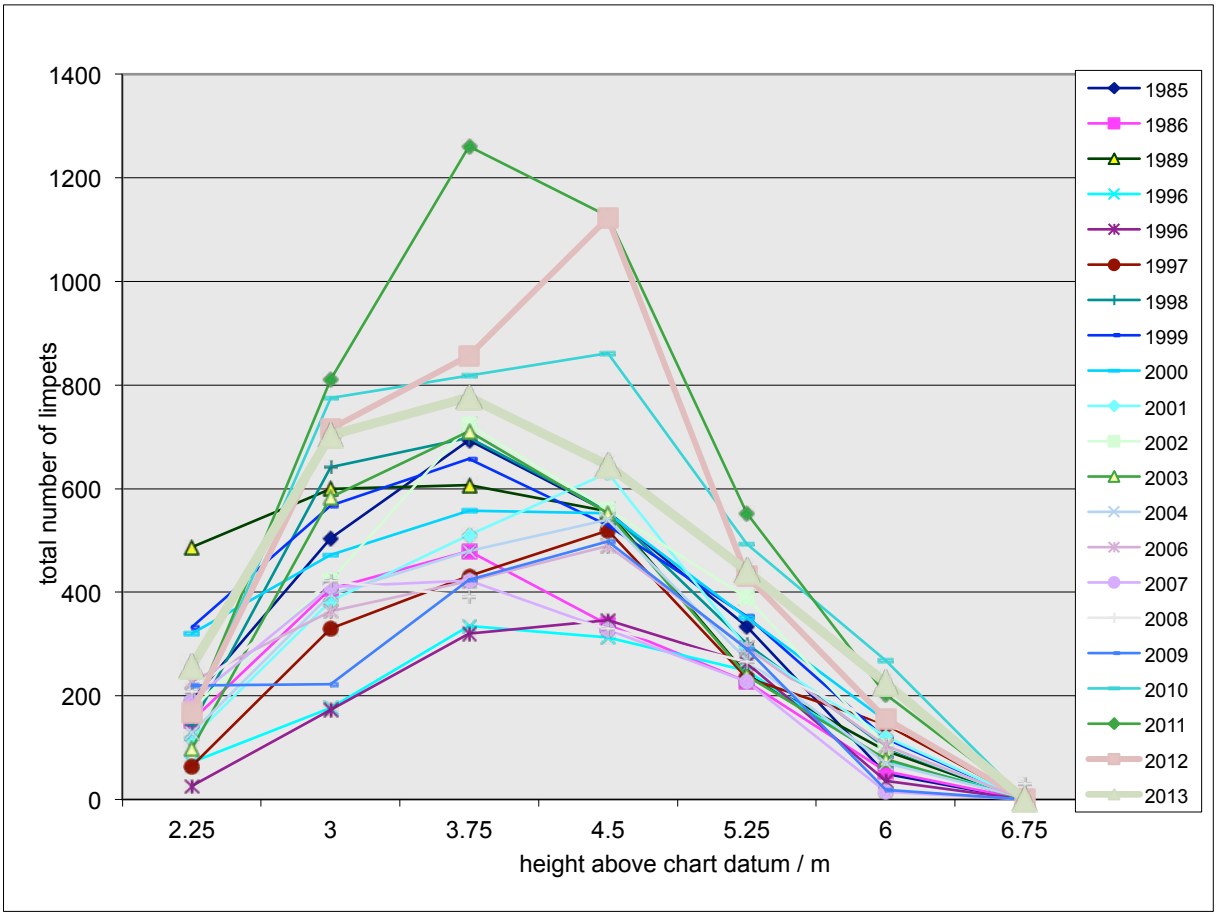

Figure 4. Number of limpets at each shore height**,** Frenchmen's Steps, Dale 1985-2013.

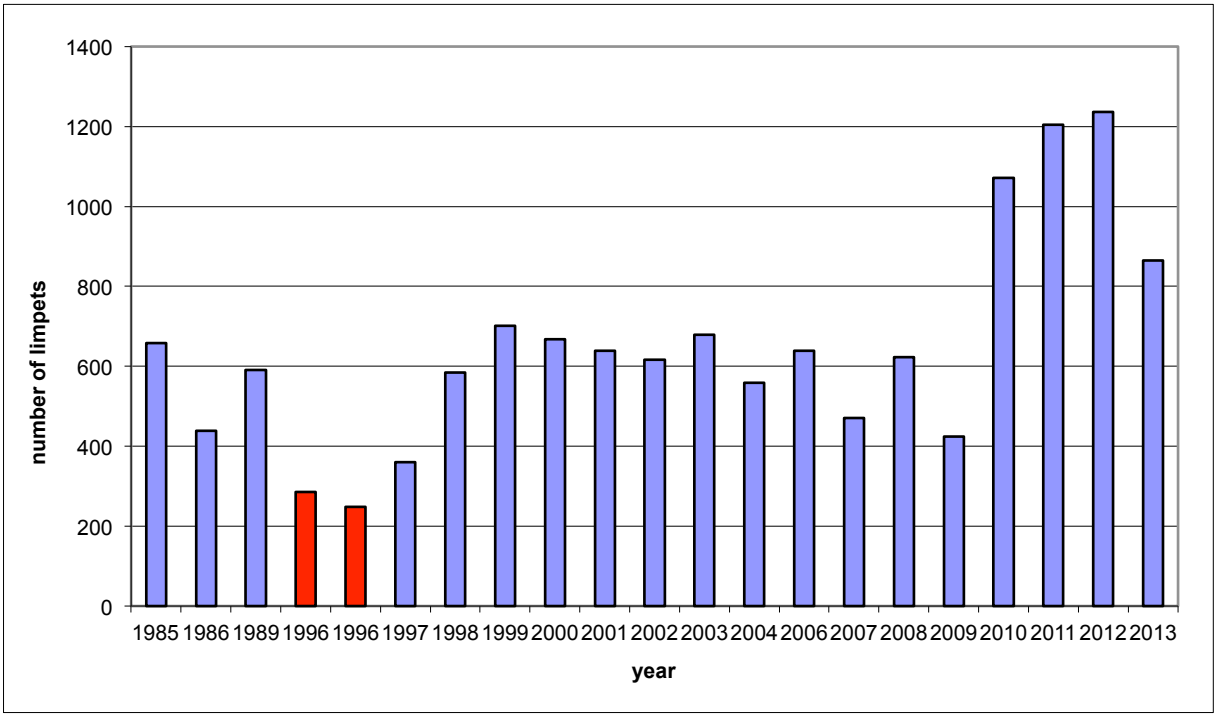

Figure 5. Number of limpets in the 10.00-14.99 mm size class 1985 - 2013.

food source (they select older limpets as their shells are too thick to make this an energetically sensible strategy). I have no empirical evidence for this but it might explain why the decrease in abundance is in 5-9.99mm limpets in particular (Figure 6). The continued drop from 2012 to 2013 seems to suggest that dogwhelks may be targeting 10-14.99mm sized limpets as well (figure 7).

The effect of an "unnaturally" high dogwhelk population seems to be the driver pushing the limpet population back towards "normal" limits again. It is interesting to speculate if the rocky shore community on Frenchman's Steps *has* to revert to the observed status quo (pre- and post pollution) or whether there are other "solutions" to the ecological problem of life on that beach that would display a different set of community characteristics?

Counting and measuring limpets in little blue squares may not be considered cutting edge science but the exercise has tremendous value. Long-term data sets showing variation (or lack of it) in "natural" populations are not that common. It is unwise to speculate on the effects of pollution, climate change and so on if the information about natural fluctuations in populations is not available. Students benefit educationally from seeing how data they have collected fits into a bigger picture and has relevance to the real world in which, unfortunately, oil spills and other environmental exigencies, occur.

Taxonomic note: I have been deliberately vague about the species of limpet we are talking about here. The common limpet (*Patella vulgata*) is likely to make up the bulk of the experimental population but I can't rule out the presence of the china limpet (*P. ulyssiponensis*) more common on the lower shore and in pools, and the black-footed limpet (*P.intermedia*) which seems to favour the lower shore and exposure to wave action. Telling the three species apart is difficult without removing the animal from the rock, which stresses and possibly kills it. This would be totally unacceptable for student groups working on a regular basis in practical terms and ethically best avoided unless scientifically essential.

Frenchman's Steps' site characteristics favour an almost exclusive population of the common limpet hence the need to identify down to species level is unnecessary, especially considering the ethical cost.

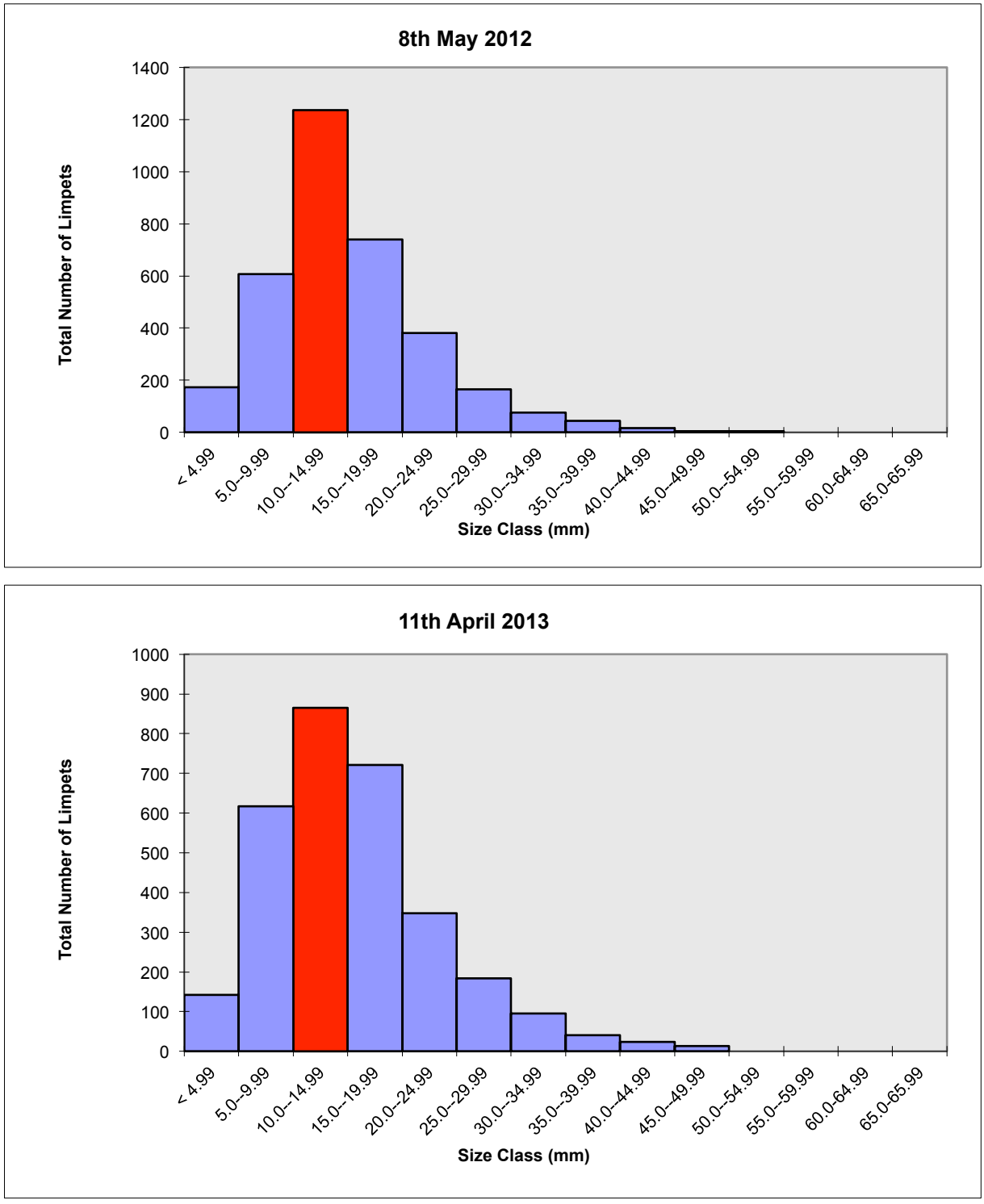

Figure 7. Number of limpets in each size class.

Further reading

For a more formal scientific paper on the early research up to and a few years after the Sea Empress oil spill see: Archer-Thomson J.H.S., (1999). The Sea Empress incident and the limpets of Frenchman's Steps. Field Studies **9**, 531-546; available as free download from the FSC's website here: http://fsj.field-studies-council.org/media/341399/vol9.3_253.pdf

Readers may also find some of the following of interest:

Branch, G.M., (1981). The biology of limpets: physical factors, energy flow and ecological interactions. Oceanography and Marine Biology: an Annual Review, **19**, 235-280.

Crothers, J.H., (1985). Dog-whelks: An introduction to the biology of *Nucella lapillus* (L.) Field Studies **6**, 291-360. (Free download as above).

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3. FUTURE WORK PROGRAMME

The Group undertook a detailed review of its medium term work programme at the end of the year. Priority projects were agreed but, because the Group's budget had been substantially depleted by the SPI survey - the most expensive project undertaken by the Group by a wide margin, insufficient resources are available to undertake all these either at the planned intervals or, in some cases, potentially at all within the Group's current annual income. For example, the cost of a single round of bioaccumulation surveillance exceeds the Group's annual income contributions; to repeat this work would therefore necessitate avoiding expenditure one year to carry it forward to the next to fund this project, at the expense of one or more other routine projects which would have to be postponed or abandoned.

The planned projects for 2013 are repeats of the rocky shore and routine macrobenthic surveillance, and continuation of the annual summer shelduck breeding surveillance and wetland bird data collation and reporting. The requirement to record presence and abundance of invasive non-native species (INNS) will be included in project specifications where appropriate, *eg* rocky shore surveillance, rather than establishing INNS surveillance as a discrete project.

Decisions on the frequency of repeating projects within the rolling surveillance programme were deferred, though the Group is conscious of the reduced value of datasets caused by failing to sample at appropriate intervals. Several projects were postponed or added to a wish-list to be addressed as and when resources become available. These include:

- outstanding task-and-finish projects: a water quality review (which may be unnecessary depending on the outputs from an EAW review of nutrient status) and two of the investigations recommended by David Little in his 2008 sediment contaminants and transport review: paired analysis of sediment samples (to enable integration and comparison of currently incomparable datasets) and dated sediment core analyses (to investigate change in contaminant loadings over time);
- recommencing routine water quality surveillance should water quality review(s) identify a need for data additional to that collected for statutory monitoring purposes by EAW;
- commencing routine sediment contaminants surveillance;
- repeating bioaccumulation surveillance (recommended interval 5 - 6 yr);
- eelgrass *(Zostera)* surveillance (recommended interval 6 yr);
- saltmarsh vegetation surveillance (recommended interval 3 yr);
- repeat broadscale macrobenthic survey.

The Group has recently welcomed additional members from new industries around the Haven who have brought an increase in Group annual income through their contributions. Nevertheless, the contributions of the existing members have not increased since the Group was established in 1992 although the cost of surveillance work has increased substantially since then, and the scope and sophistication of the projects undertaken by the Group have developed considerably.

APPENDICES

APPENDIX 1: PURPOSE AND TERMS OF REFERENCE

Preamble

The Milford Haven Waterway[2] is an extensive natural inlet of the sea with a long and distinguished maritime history. Its deep waters provide a natural harbour of significant economic importance. It is one of the best examples of a ria system in Britain and supports a particularly diverse range of high quality marine and estuarine habitats and biological communities.

The identification and consideration of political and management issues or the setting of environmental standards are specifically excluded from these Terms of Reference. However, group members are free, and are expected to use the group's outputs to help meet their own requirements.

Purpose

To provide high quality environmental information to enable members of the Group, and other authorities and industry working in and adjacent to the Waterway, to contribute to the maintenance and enhancement of the rich and diverse marine environment of the Waterway.

Terms of Reference

The Milford Haven Waterway Environmental Monitoring Steering Group will:

1. Maintain surveillance of the quality of the marine physico-chemical environment, marine biology and ornithology of the Milford Haven Waterway

2. Undertake surveillance of the foreshore, seabed and waters of the Milford Haven Waterway from a line between St Anne's Head and Sheep Island to the tidal reaches of the Eastern and Western Cleddau Rivers and other tributaries to normal tidal limits by:

2.1 keeping under review all relevant survey, surveillance and monitoring;

2.2 commissioning surveys to fill gaps in knowledge and to establish baselines;

2.3 undertaking surveillance projects;

2.4 maintaining a literature and information database.

3. Jointly maintain, and keep under review, a prioritised programme of survey and surveillance projects.

4. Share technical output equally under joint ownership and copyright.

5. Function as a technical, science based, group.

6. Form and appoint specific sub-groups to undertake specific responsibilities as required.

7. Publish an annual report which will comprise a summary of work undertaken, the executive summaries from individual project reports, a financial statement and the planned work programme.

8. Make its output available to the wider community in addition to its membership.

Membership and Funding

Membership is comprised of statutory authorities, industry and others with an interest in the environmental quality of the Waterway. Membership will be at the invitation and discretion of the Group's existing members.

Each member will contribute to the functioning of the group, either in monetary terms or 'in kind'.

[2] The term Waterway in this document specifically refers to the waters, seabed and foreshore of the Milford Haven Waterway and the Daugleddau Estuary from a line between St Anne's Head and Sheep Island to the tidal reaches of the Eastern and Western Cleddau Rivers and other tributaries to normal tidal limits.

APPENDIX 2: MEMORANDUM OF AGREEMENT

THIS AGREEMENT is made the 1st day of July 2004

BETWEEN:

(1) **ChevronTexaco Limited** whose principal office is at Pembroke Refinery, Pembroke SA71 5SJ

(2) **Countryside Council for Wales** whose principal office is at Llanion House, Llanion Park, Pembroke Dock, Pembrokeshire. SA72 6DY

(3) **Environment Agency (Wales)** whose principal office is at Rivers House, Hawthorn Rise, Haverfordwest, Pembrokeshire. SA61 2BQ

(4) **Milford Haven Port Authority** whose principal office is at Gorsewood Drive, Hakin, Milford Haven, Pembrokeshire SA73 3ER

(5) **Pembrokeshire Coast National Park Authority** whose principal office is at Llanion Park, Pembroke Dock, Pembrokeshire SA72 6DY

(6) **Pembrokeshire County Council** whose principal office is at County Hall, Haverfordwest, Pembrokeshire SA61 ITP

(7) **Petroplus Tankstorage (MH) Ltd** whose principal office is at Waterston, Milford Haven, Pembrokeshire SA71 IDR '

(8) **South Wales Sea Fisheries Committee** whose principal office is at Queens Buildings, Cambrian Place, Swansea SAl 1TW

(9) **Total Refinery** whose principal office is at PO Box 10, Milford Haven, Pembrokeshire SA73 3JD

(10) **Welsh Water-Dwr Cymru** whose principal office is at Pentwyn Road, Nelson, Treharris, Caerphilly. CF46 6LY

(11) **Wildlife Trust South and West Wales** whose principal office is at The Welsh Wildlife Centre, Cilgerran, Cardigan SA43 2TB

Here and after referred to as "the Parties"

RECITAL

The parties have agreed to enter into this agreement to record and regulate the terms of their co-operation in order to provide high quality environmental information to the parties so enabling the parties to contribute to the maintenance and enhancement of the rich and diverse marine environment of the Waterway (as hereinafter defined) and to perform the objects set out in clause 2.2 under the terms of this Agreement

AGREEMENT

The parties agree as follows:

1. INTERPRETATION

1.1 In this agreement unless there be anything in the context inconsistent therewith the following expressions shall have the following meanings:

"Committee" has the meaning ascribed to it by clause 3.1 1. "Group" means the Milford Haven Waterway Environmental Surveillance Group created by this agreement and any agreement supplemental to it

"Group Members" means all of the parties listed above or some of them as the context admits and Group Member shall have a corresponding meaning

"Objects" means the objects of the Group more particularly itemised in clause 2.2

"Waterway" means the waters, seabed and foreshore of the Milford Haven Waterway and the Daugleddau Estuary from a line between St Anne's Head and Sheep Island to the tidal reaches of the Eastern and Western Cleddau Rivers and other tributaries to the normal tidal limits.

2. SCOPE OF THE JOINT VENTURE

2.1 The Group Members agree with one another to enter into this Agreement to provide high quality environmental information to enable the Group Members to contribute to the maintenance and enhancement of the rich and diverse marine environment of the Waterway and to perform the objects set out in clause 2.2 under the terms of this agreement

2.2 The Objects of the Group are:

2.2.1 to maintain surveillance of the quality of the marine physico-chemical environment and marine biology, and ornithology, of the Waterway;

2.2.2 to undertake surveillance of the Waterway by:

2.2.2.1 keeping under review all relevant survey, surveillance and monitoring as well as undertaking surveillance projects when necessary;

2.2.2.2 commissioning surveys to improve current knowledge and establish baselines; and

2.2.2.3 maintaining a literature and information database.

2.2.3 to share technical output equally under joint ownership and copyright

2.2.4 to function as a technical, science based, group

2.2.5 to make its findings available to the wider community in addition to Group Members

2.3 For the avoidance of doubt, nothing in this Agreement shall be deemed to override or in any way restrict the statutory duties or obligations of any of the Group Members

3. CONTROL AND MANAGEMENT

3.1 A committee ("the Committee") comprising of a representative nominated by each of the Group Members will be established for the purposes of:

3.1.1 discussing determining and approving the purpose, Terms of Reference and work programme of the Group

3.1.2 exchanging information

3.1.3 reporting on progress to include publishing an annual report that comprises of a summary of all work undertaken for the year, a financial statement and planned work programme for the forthcoming year

3.1.4 preparing an annual business plan

3.2 Each Group Member shall notify the Chairperson, or Secretary, in writing of their nominated representative and shall be entitled to appoint alternative representatives

3.3 The Committee shall appoint a Chairperson from its number to chair Committee meetings and a Vice Chairperson to chair committee meetings in the absence of the Chairperson. In the absence of both the Chairperson and the Vice Chairperson those nominated representatives present shall appoint one of their number present to act as Chairperson for that particular meeting. The term of office of the Chairperson and the Vice Chairperson will be subject to an annual review

3.4 The quorum for meetings of the Committee shall be 5 nominated representatives of the Group Members. Minutes of all meetings of the Committee shall be taken and kept in designated minute books by the Milford Haven Port Authority and copies of such minutes circulated to Group Members as soon as practicable after each meeting

3.5 Questions arising at a meeting of the Committee, that cannot be resolved by consensus, shall be decided by a majority of votes and each nominated representative shall have one vote. In the case of an equality of votes the Chairperson of the meeting shall have a casting vote. The nominated representatives may regulate the conduct of the meetings of the Committee as they consider appropriate

3.6 The Committee shall be entitled to delegate any of its functions to sub-committees or to other persons as it considers appropriate for the task; provided that the delegation and the reasons therefore are recorded in writing

3.7 Group Members shall not make any decisions on matters of principle relevant to the Terms of Reference of the Group without consulting the Committee

3.8 The Committee will meet as often as necessary or desirable for the purposes of achieving the objects set out in clause 2.2 at a convenient time and venue and any Group Member may call such a meeting by giving to the other Group Members 14 days prior notice in writing to that effect designating the time venue and items for the agenda of the meeting

3.9 The Group Members shall at all times co-operate with each other and act in good faith to enable the Group objects to be attained

4. RESOURCING

4.1 Each of the Group Members will provide either a monetary contribution or some other contribution eg services, premises that shall be agreed by all the Group Members for the furtherance of the Objects of the Group in accordance with the annual business plan referred to in clause 3.1.4. The contributions are to be provided promptly within the time frame agreed for contributions

4.2 Milford Haven Port Authority shall receive all financial contributions by Group Members and shall keep such monies in a separate interest bearing bank account in trust for the Group. Milford Haven Port Authority shall make payments on behalf of the Group in respect of

commitments agreed at clause 4.3 below but may not make any other payments or commitments on behalf of the Group without the prior approval of the Committee. Milford Haven Port Authority shall provide quarterly statements to the Committee in respect of such account

4.3 Under the terms of this Agreement Milford Haven Port Authority shall have the authority to enter into contracts including, without limitation, for the appointment of professionals, advisers and consultants on behalf of the Group subject to the prior approval of the Committee

4.4 No contracts shall be entered into unless there are sufficient funds available within the interest bearing bank account referred to in clause 4.2 to meet the obligations under the contract

5. INTELLECTUAL PROPERTY RIGHTS

5.1 All rights which may now or in the future subsist in respect of or derived from any intellectual property including without limitation all copyright, design rights, registered designs, trade and service marks (whether registered or not) and moral rights (including in all such cases any applications for any such rights or protections and any rights to apply therefore and all renewals continuations extensions renewals and divisions)(the "IP Rights") developed or generated by the Group in pursuance of the Objects shall be owned by the Group Members jointly

5.2 Any Group Member shall be entitled to use any IP Rights free of charge provided that any such use shall not compromise the Objects of the Group and provided further that if any Group Member wishes to license or authorise any third party to use or exploit any IP Rights, such third party shall be required to pay a licence fee calculated on an arms length basis

5.3 All costs and expenses and all receipts in respect of any intellectual property shall be shared equally by the Group Members

5.4 Each Group Member shall retain all IP Rights to all materials, information etc. contributed by that Group Member

6. LIABILITY

The Group Members agree that all losses, damages, costs and/or expenses incurred as a result of participation in the Group and/or any action taken in accordance with this Agreement shall be borne equally by all Group Members provided that if any such losses, damages, costs and/or expenses arise as a result of an act or omission attributable to one or more Group Members, for example a breach of clause 4.2 or if the action of one or more Group Members is not in proper pursuance of the Objects or if the action of one or more Group Members gives rise to a breach of a contract referred to in clause 4.3 or if any Group Member infringes the IP Rights of a third party, then that Group Member or those Group Members shall bear those particular losses, damages, costs and/or expenses and shall indemnify the other Group Members accordingly

7. TERM AND TERMINATION

7.1 The provisions of this Agreement shall come into force on the date stated above

7.2 A Group Member may at any time terminate its participation in respect of this Agreement subject to three months' notice in writing to the Chairperson with no right of return of contribution

7.3 In the event that any Group Member is in breach of this agreement which they fail to remedy within 14 days of written request by the Committee then such Group Member's involvement in the Group may be terminated by notice given to them by the Committee at any time following expiry of the said period of 14 days

7.4 Subject to clauses 7.2 and 7.3 this agreement will terminate on completion of the Objects stated in clause 2

7.5 Upon termination of this agreement the Group shall be terminated forthwith and the parties shall take such further steps as may be necessary in order to wind up the Group in a fair and reasonable manner. The assets of the Group at winding up should be distributed pro rata to the direct financial contributions by Group Members. If a Group Member's participation in the Group is terminated in accordance with clause 7.2 or 7.3 the provisions of clauses 5.1 to 5.3 shall no longer apply in respect of such Group Member

8. GOVERNING LAW

This agreement shall be governed by and construed in all respects in accordance with the laws of the European Union, England and Wales and all parties will submit to the jurisdiction of the courts of England and Wales

9. THIRD PARTIES

Nothing in this Agreement shall create any rights for third parties under the Contracts (Rights of Third Parties) Act 1999. No variation to this Agreement and no supplemental or ancillary agreement to this Agreement shall create any such rights unless expressly so stated in any such agreement by the parties to this Agreement. This does not affect any right or remedy of a third party that exists or is available apart from that Act

10. NO PARTNERSHIP

Nothing in this Agreement shall be construed as establishing or implying any partnership between the Parties hereto and nothing in this Agreement shall be deemed to constitute either of the Parties hereto as the agent of the other Party or authorize either Party (i) to incur any expenses on behalf of the other Party (ii) to enter into any engagement or make any representation or warranty on behalf of the other party (iii) to pledge the credit of or otherwise bind or oblige the other Party or (iv) to commit the other Party in any way whatsoever without in each case obtaining the other Party's prior written consent

11. SUCCESSORS

References in this Agreement to the parties shall include their respective heirs successors in title permitted assigns and personal representatives This Agreement shall be binding upon and enure to the benefit of the parties and their respective successors

12. ASSIGNMENT

No Member may assign its interests in this Agreement without prior approval of the Committee (not to be unreasonably withheld) except that no such approval is required for an assignment to a company in the same group as the Member

13. ARBITRATION

13.1 Any dispute or difference arising out of or in connection with this Agreement shall be referred to the arbitration of a sole arbitrator to be appointed in accordance with Section 16(3) of the Arbitration Act 1996 ("the Act") the seat of such arbitration being hereby designated as London England 13.2 In the event of failure of the parties to make the appointment pursuant to Section 16(3) of the Act the appointment shall be made by the President for the time being of the Chartered Institute of Arbitrators

13.3 The Arbitrator shall decide the dispute in accordance with the substantive laws of England and Wales

APPENDIX 3: CHRONOLOGICAL LIST OF MHWEMSG / MHWESG[3] REPORTS

1992

Hobbs, G and Morgan, C I (eds.) (1992). *A review of the current state of environmental knowledge of the Milford Haven Waterway*. Report from Oil Pollution Research Unit; xi &140pp

Hobbs, G and Morgan, C I (eds.) (1992). *A review of the current state of environmental knowledge of the Milford Haven Waterway; Executive Summary*. Report from Oil Pollution Research Unit, 12pp

MHWEMSG (1992). *Report of the Milford Haven Waterway Environmental Monitoring Steering Group 1992*. 6pp

1993

Hodges, J E (1993). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey: report for 1993*. Report from Pembrokeshire Coast National Park Authority, 8pp + appendices

1994

Ellis, R & Poole, A (1994). *Cleddau Estuary wader and wildfowl counts 1993 – 94. 20* pp + appendices

Hodges, J E (1995). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey: report for 1995*. Report from Pembrokeshire Coast National Park Authority,8pp + appendices

Levell, D, Smith, J and Hobbs, G (1994). *Milford Haven macrobenthic survey October 1993*. Report from Oil Pollution Research Unit; xii, 26pp + figures, tables & data appendices.

MHWEMSG (1994). *Report of the Milford Haven Waterway Environmental Monitoring Steering Group 1993/94*. 20pp

Smith, J and Hobbs, G (1994). *Metal concentrations in Milford Haven sea bed sediments - data storage, analysis and initial interpretation*. Report from Oil Pollution Research Unit; v, 8pp + tables & maps

1995

Hodges, J E (1995). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey: report for 1995*. Report from Pembrokeshire Coast National Park Authority 10pp + appendices

Howe, M (1995). *Monitoring of eelgrass populations in the Milford Haven waterway and Daugleddau Estuary*. Report from Pembrokeshire Coast National Park Authority; 7pp

MHWEMSG (1995). *Report of the Milford Haven Waterway Environmental Monitoring Steering Group 1994/95*. 19pp

Poole, A & Ellis, R (1995). *Cleddau Estuary including Milford Haven Waterway: wildfowl and wader counts 1994 – 95*. 30pp

Rostron, D M (1995). *The macrobenthos of the foreshore soft sediments of Milford Haven, 1994*. Report from SubSea Survey; 2 vols, 17pp + maps, figures & data appendices

[3] The Group changed its name in 2000

1996

Hodges, J E (1996). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey: report for 1996.* Report from Pembrokeshire Coast National Park Authority, 8pp + appendices

MHWEMSG (1996). *Report of the Milford Haven Waterway Environmental Monitoring Steering Group 1995/96.* 14pp

Poole, A (1996). *Milford Haven and Cleddau Estuary wetland bird survey 1995-96*. 18pp

1997

Hodges, J E (1997). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey: report for 1997.* Report from Pembrokeshire Coast National Park Authority. 10pp + tables & appendices

MHWEMSG (1997). *Report of the Milford Haven Waterway Environmental Monitoring Steering Group 1996/97.* 36pp

Moore, J J (1997). *Rocky shore transect monitoring in Milford Haven, October 1995.* Report from Oil Pollution Research Unit. OPRU Report No OPRU/14/96. 36pp + appendices

Poole, A (1997). *Milford Haven Waterway and Cleddau Estuary bird survey 1996-97*. 13pp + appendices

1998

Hodges, J E (1998). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey – report for 1998.* Report from Pembrokeshire Coast National Park Authority. 9pp + tables & appendices

Munro, C (1999). *Monitoring of the rocky sub-littoral of Milford Haven: May-July 1998.* Report from Marine Biological Surveys. v, 38pp + appendices, photographs and videorecording

Poole, A (1998). *Milford Haven Waterway and Cleddau Estuary bird survey 1997-98*. 12pp + appendices

1999

Hodges, J E (1999). *Daugleddau Estuary and Milford Haven Waterway annual shelduck survey – report for 1999.* Report from Pembrokeshire Coast National Park Authority. 8pp + tables & appendices

Irving, R and Worley, A (1999). *Survey of sublittoral Zostera marina bed in Milford Haven. Field Report*. Report from Posford Duvivier. 4pp

Kitts, H (1999). *Quantification of inputs to Milford Haven*. Report from Hyder Ltd. 29pp + tables & appendices

MHWEMSG (1999). *Report of the Milford Haven Waterway Environmental Monitoring Steering Group 1997 - 1999*. 25pp

Poole, A (1999). *Milford Haven Waterway and Cleddau Estuary Bird Survey 1998-99*. 13pp + appendices

Posford Duvivier (2000). *A survey of subtidal Zostera beds in Milford Haven*. 36pp + appendices

2000

Bent, E J (2000). *A review of environmental studies in Milford Haven Waterway 1992 – 2000*. iv, 65 pp + tables & maps

Hodges, J E (2000). *Daugleddau Estuary and Milford Haven Waterway annual shelduck Survey – Report for 2000.* Report from Pembrokeshire Coast National Park Authority. 10pp + tables + appendices

MHWESG (2000). *Milford Haven Waterway Environmental Surveillance Group Annual Report 1999 - 2000*. 20pp & appendices

Poole, A (2000). *Milford Haven waterway and Cleddau Estuary Bird Survey 1999-2000*. 15pp + appendices

2001

Hodges, J E (2001). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2001.* Report from Pembrokeshire Coast National Park Authority. 8pp + appendices

Poole, A (2001). *Milford Haven Waterway and Cleddau Estuary bird survey 2000-01*. 14pp + appendices

2002

Hodges, J E (2002). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2002.* Report from Pembrokeshire Coast National Park Authority. 8pp + appendices

Poole, A (2002). *Milford Haven Waterway and Cleddau Estuary bird survey 2001-02.* 12pp + appendices

2003

Bent, E J (2003). *Milford Haven Waterway review of work programme 2000 – 2010*. 32pp

Hodges, J E (2004). *Daugleddau Estuary and Milford Haven waterway surveillance of summer shelduck populations: report for 2003.* Report from Pembrokeshire Coast National Park Authority. 9pp + appendices

Poole, A (2003). *Milford Haven Waterway and Cleddau Estuary bird survey 2002-03.* 16pp + appendices

Prosser, M V & Wallace H L (2003). *Milford Haven salt-marsh survey 2002.* Report from Ecological Surveys (Bangor). 2 vols. 58pp + appendices, photographs & maps

2004

Hodges, J E (2004). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2004.* Report from Pembrokeshire Coast National Park Authority. 7pp + appendices

Haycock, A (2004). *Milford Haven Waterway and Cleddau Estuary Bird Survey 2003-04.* 14pp + appendices

2005

Atkins (2005). *Development of an Inputs Budget for Milford Haven Waterway.* 68pp + cd database & GIS data

Hodges, J E (2005). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2005.* Report from Pembrokeshire Coast National Park Authority. 8pp + appendices

Haycock, A (2005). *Milford Haven Waterway and Cleddau Estuary Bird Survey 2004-05.* 7pp + appendices

2006

Hodges, J E (2006). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2005.* Report from Pembrokeshire Coast National Park Authority. 8pp + appendices

Haycock, A (2006). *Milford Haven Waterway and Cleddau Estuary Bird Survey 2004-05.* 7pp + appendices

Warwick, R (2006). *Review of benthic and intertidal sediment macrofauna data and development of a surveillance programme*. 105pp + electronic data annex

2007

Hodges, J E (2007). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2006.* Report from Pembrokeshire Coast National Park Authority. 8pp + appendices

2008

Haycock, A (2008). *Wildfowl and wader counts on the Milford Haven Waterway 2006-07* 20pp

Haycock, A (2008). *A review of the status of wetland birds in the Milford Haven waterway and Daugleddau estuary*. A report to the Milford Haven Waterway Environmental Surveillance Group. 122pp

Hodges, J E (2008). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2008*. Report from Pembrokeshire Coast National Park Authority. 26pp + appendices

2009

Haycock, A (2009). *Wildfowl and wader counts on the Milford Haven Waterway 2007-08* 20pp

Hodges, J E (2009). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2009*. Report from Pembrokeshire Coast National Park Authority. 9pp + appendices

Langston, W J, O'Hara, S, Imamura M & Pope, N D (2009) *Bioaccumulation surveillance in Milford Haven Waterway 2007-2008*. Report to the Milford Haven Waterway Environmental Surveillance Group from the Marine Biological Association Plymouth. 66pp + appendices

Little, D I (2009) *Sediment Contaminants & Transport Review*. A report to the Milford Haven Waterway Environmental Surveillance Group. 368pp + appendices

2010

Haycock A (2010). Wildfowl and wader counts on the Milford Haven Waterway, 2009-10. A report to the Milford Haven Waterway Environmental Surveillance Group. 24pp

Hodges, J E (2010). *Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2010.* Report from Pembrokeshire Coast National Park Authority. 8 pp + appendices

Mieszkowska, N. (2011). Reestablishment of intertidal rocky surveillance. A report to the MHWESG from the Marine Biological Association on ot the UK. 54pp + appendices.

2011

Haycock A (2011). Wildfowl and wader counts on the Milford Haven Waterway, 2010-11. A report to the Milford Haven Waterway Environmental Surveillance Group. 24pp

Hodges, J E (2011). Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2011. Report from Pembrokeshire Coast National Park Authority. 8pp + appendices

2012

Fugro-ERT (2012). Investigation into the source of hydrocarbons present in sediment samples from Milford Haven waterway. Report to the Milford Haven Waterway Environmental Surveillance Group from the Fugro-ERT (Fugro Geoconsulting). v&40pp + appendices

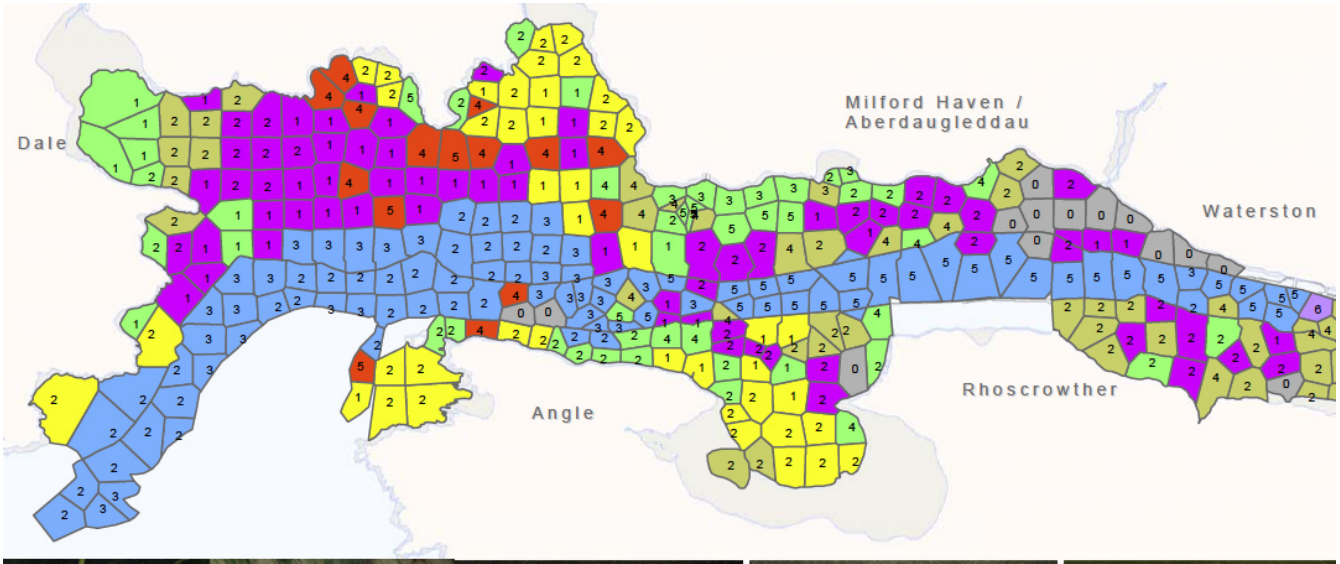
Hodges, J E (2012). Daugleddau Estuary and Milford Haven Waterway surveillance of summer shelduck populations: report for 2012. Report from Pembrokeshire Coast National Park Authority. 9pp + appendices

Langston, WJ, O'Hara, S, Davey, M, Shortridge, E, Pope, ND, Harino, & Vane, CH. (2012) Bioaccumulation surveillance in Milford Haven Waterway Phase II (2010) Report to the MHWESG from the Marine Biological Association UK. 85pp + appendices

2013

Germano & Associates (2013). Sediment-Profile Imaging Survey of Milford Haven Waterway, Wales, UK - May 2012. Report to the Milford Haven Waterway Environmental Surveillance Group from Germano & Associates, Inc., Seattle, Washington, USA. vii&34pp + tables, figures and appendices

Haycock A (2013). A review of the status of wetland birds in the Milford Haven Waterway and Daugleddau Estuary 2013 A report to the Milford Haven Waterway Environmental Surveillance Group. 123pp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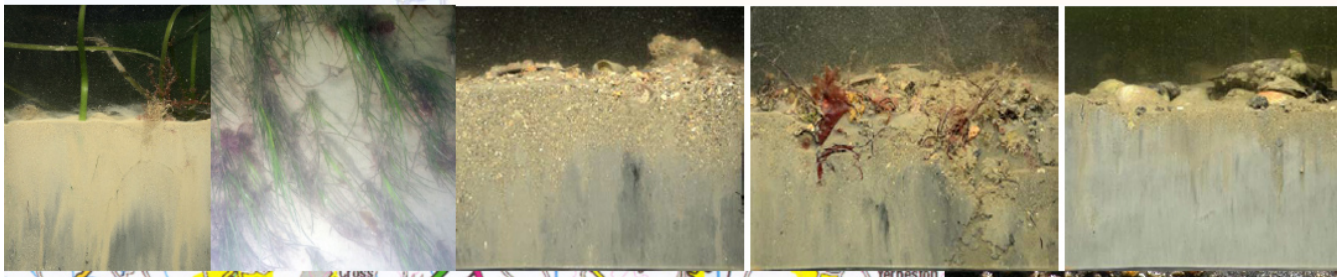

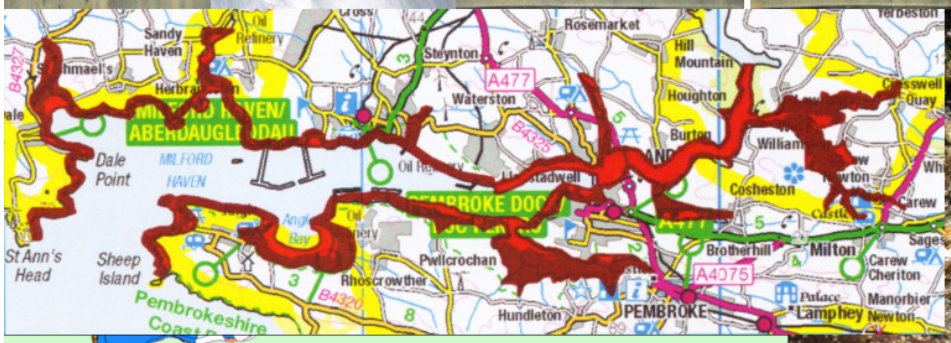
Sandy Haven
Steynton
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Milton
Brotherhill
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MILFORD HAVEN
St Ann's Head
Sheep Island
Pembrokeshire
Rhoscrowther
Pwllcrochan
Hundleton
PEMBROKE
Lamphey
Manorbier
Newton