MILFORD HAVEN WATERWAY
ENVIRONMENTAL SURVEILLANCE GROUP

GRŴP CADW GOLWG AMGYLCHEDDOL
AR DDYFRFFORDD ABERDAUGLEDDAU

BUSINESS REPORT 2008 - 2009

MILFORD HAVEN WATERWAY ENVIRONMENTAL SURVEILLANCE GROUP

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Report 2008 - 2009
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Milford Haven Waterway Environmental Surveillance Group

Report 2008 - 2009

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CHAIRMAN'S FOREWORD

The aftermath of the December 2009 Copenhagen summit has been difficult, with views ranging from some limited success to a complete shambles failing to live up to any expectation. Perhaps the most positive aspect was that the language used in framing climate change was consistent in that something needed to be done - a situation that would have been almost unthinkable only a few years ago.

Of more concern is the latest controversy over some of the conclusions drawn by scientists looking into climate change which is now being cited by opponents of manmade global warming as evidence that the science is both ambiguous and vague. This has highlighted how a real or perceived lack of valid, reliable and objective data prevents those making decisions from being certain that the right choice is being made.

As one of the largest natural deep-water harbours in the world, the Milford Haven Waterway is very fortunate to have a wealth of data gathered over the years. I am delighted therefore to welcome you to consider the continuing positive contributions the Milford Haven Waterway Environmental Surveillance Group has made to gathering data about the waterway over the last 16 years or so. Data that provides knowledge that can be used both directly to inform the decision makers as well as in academic research and scientific papers. I should add that the data is fully available from local libraries but may also be obtained from the Group's Project Officer via the contact e-mail address at the foot of the membership list opposite the contents page.

The group itself comprises of a mixture of organisations from both the private and public sector working in partnership for mutual benefit. The continued success of the group is due entirely to the time and effort committed by each of the members and our project officer to achieving our ever ambitious work programme, something for which I am very grateful and give my thanks.

Captain Mark Andrews

Milford Haven Port Authority

Chairman

RHAGAIR Y CADEIRYDD

Yn sgîl uwchgynhadledd Copenhagen, a gynhaliwyd yn Rhagfyr 2009, bu'n gyfnod anodd, pan oedd y farn yn amrywio o lwyddiant cyfyngedig i annibendod llwyr a fethodd â gwireddu unrhyw un o'r disgwyliadau. Dichon mai'r agwedd fwyaf calonogol oedd cysondeb yr iaith a ddefnyddid wrth gyfeirio at y newid yn yr hinsawdd, sef bod rhaid gwneud rhywbeth – sefyllfa na ellid bron ei dychmygu ychydig flynyddoedd yn ôl

Mater sy'n peri mwy o bryder yw'r ymryson diweddaraf ynghylch casgliadau rhai o'r gwyddonwyr a fu'n ymchwilio i'r newid yn yr hinsawdd, casgliadau a ddyfynnir fel tystiolaeth o amwysedd ac amhendantrwydd y wyddoniaeth, gan rai sy'n gwrthwynebu'r honiad mai dyn sy'n gyfrifol am y cynhesu byd-eang. Mae hyn wedi tanlinellu'r modd y gall diffyg, neu'r canfyddiad o ddiffyg data dilys, dibynadwy a gwrthrychol greu ansicrwydd yngl_n â'r dewisiadau ym meddyliau rhai sy'n gwneud y penderfyniadau.

Mae dyfrffordd Aberdaugleddau, sef un o harbyrau dwfn naturiol mwyaf y byd, yn hynod o ffodus yn y cyfoeth o ddata a gasglwyd amdani dros y blynyddoedd. Pleser o'r mwyaf i mi, felly, yw eich croesawu i ystyried cyfraniadau cadarnhaol pellach eto, a wnaed gan Gr_p Goruchwylio Amgylcheddol Dyfrffordd Aberdaugleddau, fu'n casglu data am y ddyfrffordd dros yr 16 mlynedd diwethaf. Data yw'r rhain y gellir eu defnyddio i oleuo penderfyniadau awdurdodau cyfrifol, yn ogystal ag ymchwil academaidd a phapurau gwyddonol. Dylwn ychwanegu bod y data hyn i gyd ar gael yn y llyfrgelloedd lleol, a hefyd gan Swyddog Prosiect y Gr_p, drwy'r cyfeiriad e-bost islaw'r rhestr aelodau gyferbyn â'r dudalen cynnwys.

Casgliad o sefydliadau o'r sectorau preifat a chyhoeddus yw aelodau'r Gr_p, sy'n cydweithio er budd pob un ohonynt. Mae parhad eu llwyddiant i'w briodoli'n llwyr i'r amser a'r ymdrech a gysegrir gan bob un o'r aelodau, a chan ein swyddog prosiect, i gyflawni'n rhaglen waith uchelgeisiol fel erioed, ac yr wyf yn arbennig o falch a diolchgar am hynny.

Y Capten Mark Andrews

Awdurdod Porthladd Aberdaugleddau

Cadeirydd

1. INTRODUCTION

This is the tenth business report of the Milford Haven Waterway Environmental Surveillance Group (formerly the Milford Haven Waterway Environmental Monitoring Steering Group). It covers the period 1 January 2008 to 31 December 2009.

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, not least for reasons of financial management and VAT recovery, 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 2008 - 2009

2.1 INTRODUCTION

The Group's outputs during the period are summarised below. Whilst the recent focus on desk-studies has continued, the emphasis on field-based surveillance has resumed.

The contract to review the last of four major topics and data-sets recommended in the 2000 review of Group work (Bent, 2000 [1]) was completed and reported. Dr David Little, formerly of the Oil Pollution Research Unit, Pembroke and more recently, until retirement, international consultancy Arthur D. Little (no relation we are assured), undertook a comprehensive review of sediment contamination and transport within the waterway and made recommendations for future survey and a sediment contaminant surveillance programme. Although David carried out the early work on sediment transport and contaminants in the Haven, which contributed to his PhD, the considerable volume of both historical and recent data proved somewhat of a surprise and the review task proved considerably greater than anticipated.

The first one-year contract of what is planned to become long-term programme of bioaccumulation surveillance was completed during 2009 by Dr Bill Langston from the Marine Biological Association, Plymouth, following sampling in spring and autumn 2008. A second, expanded round of sampling and analysis is planned for 2010.

Following recommendations detailed in Dr Richard Warwick's 2006 review of benthic and intertidal sediment macrofauna data [2] (reported and summarised in the 2006 Group business report) sublittoral sediment biology sampling was recommenced in 2008, integrated with the sampling programmes of the Countryside Council for Wales and Environment Agency (under the Habitats Directive and Water Framework Directive respectively). Sampling was undertaken from the EA's research vessel as a contribution in kind to the Group and the samples were all analysed by the same laboratories to maximise intercomparability. Delays in delivery of some data has meant that data analysis is as yet incomplete.

Wetland bird surveillance has continued as in previous years.

[1] Bent, E J (2000). *A review of environmental studies in Milford Haven Waterway 1992 – 2000.*

[2] Warwick, R M (2006). Review of benthic and intertidal sediment macrofauna data and development of a surveillance programme. Report to the MHWESG from the Plymouth Marine Laboratory.

2.2 BIOACCUMULATION SURVEILLANCE IN MILFORD HAVEN WATERWAY 2007- 2008

W J Langston, S O'Hara, M Imamura & N D Pope. Marine Biological Association

Executive Summary

Biomonitoring of contaminants (metals, organotins, PAHs, PCBs) has been carried out at sites along the Milford Haven Waterway and at a reference site in the Tywi Estuary during 2007_2008. The species used as bioindicators encompass a variety of uptake routes; i.e. *Fucus vesiculosus* (seaweed; dissolved contaminants); *Littorina littorea* (mollusc; grazer); *Mytilus edulis* and *Cerastoderma edule* (molluscs; suspension feeders that accumulate from both dissolved phase and suspended particulates); and *Nereis diversicolor* (ragworm; omnivore which often reflects bioavailable contaminants in sediment). Differences in feeding strategy and habitat preference can have subtle implications for bioaccumulation trends though, with few exceptions, contaminant body burdens in Milford Haven were higher than those at the Tywi reference site.

Substantially elevated metal concentrations were observed at individual Milford Haven sites for manganese (molluscs, seaweed), cobalt (mussels, seaweed), tin (bivalves), nickel (cockles) and iron (ragworm), whilst arsenic and selenium (molluscs and seaweed) were consistently at the higher end of the UK range for much of the Milford Haven Waterway. However, for the majority of metals, distributions in Milford Haven biota were not exceptional by UK standards. Several metal-species combinations indicated increases in bioavailability at upstream sites, which may reflect the influence of geogenic or other land_based sources - enhanced in some cases by lower salinity (greater proportions of more bioavailable forms).

TBT levels in mussels were below thresholds considered by OSPAR [3] to be acutely toxic, though based on these guidelines, sub-lethal effects cannot be ruled out at Milford Haven sites. TBT (and other BT) levels in the Tywi were close to zero. Phenyltins were not accumulated appreciably in *Mytilus*, whereas some *Nereis* populations in Milford Haven may have been subjected to localised (historical) sources retained in sediments.

PAHs in *Nereis* tended to be evenly distributed across most sites, but with somewhat higher values at Dale for acenaphthene, fluoranthene, pyrene, benzo(a)anthracene and chrysene, whilst naphthalenes tended to be enriched further upstream in the mid_upper Haven (a pattern which is seen in mussels for most PAHs). Whilst concentrations in *Mytilus* were above OSPAR backgrounds, there was little indication that generalized exotoxicological guidelines for PAHs would be exceeded (although there has been no ground-truthing of these assumptions). PAH body burdens in Milford Haven biota were generally (but not always) higher than those in the Tywi Estuary.

Lipophilic PCBs in mussels were between upper and lower OSPAR guidelines and were unusual in their distribution in that highest levels occurred at the mouth of Milford Haven. This may be a function of better condition and nutritional status (lipids) here, rather than contamination.

Overall, condition indices of bivalves (cockles and mussels) were highest at the Tywi reference site, and at the mouth of Milford Haven, but decreased upstream in the Waterway. There were a number of significant (negative) relationships between condition index and body burdens and it is possible that a combination of contaminants could have an influence on this

[3] The Convention for the Protection of the marine Environment of the North-East Atlantic: the 'OSPAR Convention'

pattern in the condition index (and other markers of organism 'health'). Cause and effect needs to be tested more rigorously as there a number of (natural) factors which may be influential. Contextual physicochemical information and published data on sources, pathways and toxicology of contaminants has been included as part of the discussion of bioaccumulation results.

The strategy for biomonitoring undertaken in this project builds on established sampling protocols and is proposed as a basis for a rolling program against which future change could be measured. Complementary, harmonised monitoring in which biological condition and environmental parameters are measured and interpreted alongside body burdens - using multivariate techniques to help assess the status of the site more comprehensively - are also recommended for the future.

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

2.3 SEDIMENT CONTAMINANTS AND TRANSPORT REVIEW

David I. Little

Executive Summary

The review has found that over the long history of sediment quality monitoring in the Milford Haven waterway, different analytical methods for both hydrocarbons and heavy metals inevitably have been used at different times, resulting from the various broad phases and leadership of surveys, especially those before and since the *Sea Empress* incident in 1996. Regrettably, this has led to the partial or total incomparability of many contaminant datasets in the long-term. As a result, defensible, quantitative comparisons of changes through time were made in the present review on the strict basis of their wide spatial distribution and *t*-test significance level. These comparisons were often made on transformed data and were only made between pairs of surveys with similar coverage and methods (1980s and separately again in the 1990s). Except for between the years 1982-1984 no valid comparisons of sediment metals data through time are made. The significant changes are shown below for zinc, chromium, copper, nickel and vanadium along with the more frequent and significant ($p<0.001$, unless shown otherwise) changes in oil content (ALI=aliphatic hydrocarbons, ARO=aromatic hydrocarbons, THC=total hydrocarbons by gravimetry, and TPH=total petroleum hydrocarbons by ultra-violet fluorescent spectroscopy):

Years	Location	Increase in means	Decrease in means
1978-1982	Pembroke River	-	-
1978-1982	Jetty area	ALI	-
1982-1984	Pembroke River	Zn, Cr	ALI, THC, Cu, Ni
1982-1984	Jetty area	Cr	ALI, THC, V, Cu
1984-1989	Daugleddau	ARO ($p<0.005$ THC)	-
1993-1996	Lower waterway	-	-
1993-1996	Whole waterway	-	-
1996-1997	Lower waterway	-	($p<0.005$ TPH)

Notwithstanding these problems, no major qualitative changes were noted in the status of contaminants between these two decades, or since, and the estuarine sediments appear to have substantially recovered from the few major oil spills the waterway has suffered. Unlike the *El Omar* aromatics in the Daugleddau (above) the *Sea Empress* resulted in no statistically-significant changes in seabed THC or total PAH throughout the waterway. Although difficult to find because of the overwhelming pyrogenic fingerprints, new work as part of this review has shown that low concentrations of crude oil may indeed have been present in the lower estuary until at least October 1996 at stations aligned from the lower estuary and Angle Bay up the flood-tide transport path to Wear Point. If verifiable, this is encouraging because it confirms earlier sediment transport findings and suggests that contaminants are for the most part dispersed, weathered or sequestered in fine sediment areas, and this helps explain the low level of biological impacts. It is in itself also interesting because the dramatic improvements in pollution source control and hence the reduced effluent loadings arguably should be reflected in dramatically reduced sediment contamination since the peak of the 1980s. Average trace metals content of the integrated sediment samples taken as part of MCEU dredging control between the grouped years 1984-1992 and 1993-2006 show significant reductions from 36% (Ni), 50% (Zn), 62% (Pb), and 67% (Cu), up to 85% (Hg).

Due to salinity changes causing increased flocculation from SPM the contaminants gravitate to sedimentary sinks, and so sediment transport processes appear to effectively trap and episodically recycle a proportion of the pollutants. Although not enough has been done on sediment contaminants other than oil and metals, recent CCW data suggest that similar trapping has occurred, at least for the hydrophobic substances, in the mid-upper flats of the inner estuary and tributary pills. In the light of the above working hypotheses on contaminant fate, behaviour and effects, it is recommended that:

- Stored sediment samples (15 intertidal stations) from the CCW contaminant survey of 2007 should be forensically re-analysed for hydrocarbon and selected other compounds at the same time as the analysis of the three remaining archived Forties blend cargo and HFO bunker samples from the *Sea Empress* in 1996. Forensic analyses using PAH and biomarkers should also be simultaneously performed on a careful selection of other current and historical candidate hydrocarbon sources in Milford Haven waterway (e.g. Middle East crudes such as Kuwait used in the port as part of the refineries' earlier feedstocks, and light Iranian as spilled by *El Omar* in 1988, Daugleddau anthracite coal, sewage sludge, selected effluent samples, urban runoff, airborne particulates, etc.)
- In the next major MHWESG survey of sediment hydrocarbons in Milford Haven, a repeat of *both* THC (by gravimetry) and TPH (by UVF) should be made on matched pairs of sub-samples at *all* of the limited number (~25) of stations planned. This is in order to update definitively the long-term trends in contaminant status since the 1980s and 1990s respectively, and will not need to be done on each routine sampling occasion in future, when fully accredited methods would be used alone. Selected samples should be retained for possible further PAH analysis by GC-MS
- In the next major MHWESG survey of sediment major and trace elements in Milford Haven, a repeat of *both* total metals (by HF digestion/ICP) and available metals (by *Aqua regia* extraction/AAS) should be made on matched pairs of sub-samples at *all* of the limited number (25-50) of stations planned. This is to update the long-term trends in contaminant status since the 1980s and 1990s respectively, and will not need to be done on each routine sampling occasion in future, when only accredited methods are to be used
- A repeat of the July 1986 dated core studies should be made at the same depositional sites of fine sediment (i.e. 'sinks') as before (Daugleddau, Jetty area, Pembroke River), possibly supplemented by one or more of Cosheston Pill, Carew/Cresswell Rivers or Garron Pill. Work should include radionuclides (post-Chernobyl), oil and metals in 10-15 successive core sections of 1-2 cm thickness as before, but this time supplemented by a *full* suite of PAH including alkyl homologues. Also PCBs and chlorinated pesticides by GLC-ECD, coal residues by CHN analyser, TBT, and Pb isotopic analyses should be included. The latter substances have not been monitored extensively in Milford Haven sediments, and are hopefully now primarily of historical interest. Hence the recommendation only to analyse them in the proposed dated core study, where their first appearance, presence and decline through time in the cores will give further datum points in the chronologies of the waterway's contaminants in relation to catchment inputs.

The state of knowledge of sediment transport in Milford Haven is not as advanced as that in some other adjacent systems, for example the Bristol Channel/Severn estuary and the Irish and Celtic Seas. However, the then novel sediment trend analysis (STA) work that has been done is generally consistent with the:

- Statistical residuals from univariate and multiple regression models of numerous contaminants and sediment parameters - all these tests were performed using the fully-interpreted 1980s surveys of grain size, hydrocarbons and metals. (section 2)
- Pollutant chronologies in radionuclide-dated sediment cores taken in the potential sediment sinks first predicted by analysis of the above regression residuals (section 3)
- Field observations of tidal streams (e.g. ebb/flood separation) and models of seabed wave-induced orbital velocity (section 7)
- In addition, historic and ongoing ecological and engineering changes in estuarine morphology have been shown to have substantial possible effects on the balance between erosion, transport and deposition in particular affecting fine sediment behaviour:
  - ✓ Dredging 'disturbance' – 5 million m^3 disposed at LU170 since the dredging of berths first began, and from 1996 0.5 million m^3 at LU168/169, removing mud that potentially returns (in part), or attracting new mud to dredged berthing slots
  - ✓ Reclamation/impoundment 'losses' – 1.605 km^2 mostly for Pembroke power station, Pembroke dockyard, Carew and Pembroke millponds, Mullock Bridge/Gann, Neyland marina and Waterloo waste disposal, permanently burying mud
  - ✓ Historic quarrying 'gains' – 0.426 km^2 mostly at West Williamston, Garron and Landshipping Pills, and Uzmaston, potentially trapping mud in new tidal flats
  - ✓ *Spartina townsendii* arrival and spread in mid-20th century, 'die-back' accelerating between 1982 and 2002 – 1 km^2 mostly E. Cleddau (37% decline) and Carew/Cresswell (20% decline), releasing mud from tidal flats

Although some data were reported in biological monitoring studies by OPRU, or published in peer-reviewed publications at the time, much of the information has not been fully summarised before in MHWESG reviews, partly because it was carried out during various studentships. Above all, routine and special studies of grain size and contaminants were broadly confirmed in 1987 by sediment trends analysis, which has subsequently also been verified in the Bristol Channel/Severn estuary and elsewhere. The fundamental STA method has not changed, although MHWESG may wish to compare the long-term STA predictions with specific sediment transport modelling using for example MIKE-21. Nothing in the subsequent Milford Haven survey data reviewed for MHWESG has fundamentally challenged the 1980s findings concerning sediment and contaminant transport. However, by now of course the contaminant loading of the estuary should have recovered from acute spills and the chronic inputs from industry and municipalities that were less regulated in the comparatively recent past.

All or most stations selected for contaminant monitoring should be located in what are thought to be relatively fine-grained sediment areas, because elsewhere interpretation of the contaminant results will be confounded by coarse grain sizes, extremely poor sediment sorting, strong tidal streams and other disturbances and variations in sedimentation rate (including the absence of sedimentation). It is therefore recommended that in addition to the above-mentioned and 'once-only' dated core study, repeats of the 2007 CCW survey are made especially in the following sedimentary sink areas. These should be used by MHWESG for routine contaminant surveillance in future. Between 3 and 6 stations should be established in each selected area, and 3 replicate grabs sampled (one to be archived) to 5-10 cm depths:

- Daugleddau (e.g. Picton Point to Hook Reach)
- Jetty area (e.g. Former Esso Jetty to ChevronTexaco/Newton Noyes)
- Pembroke River
- Cosheston Pill
- Carew/Cresswell Rivers
- Garron Pill

The sinks are not necessarily of particular sediment infauna monitoring interest, although the tributary pills are of course important for fringing marshes, wintering wildfowl, breeding shelduck and passage waders, and are of great scenic and historic value. With the exception of the Jetty area, the above-listed areas are mainly intertidal, and so in addition to them it would be advisable to include a small number of subtidal stations arranged axially along the waterway. Station locations should be as far as possible determined based on previous sampling stations (OPRU, EA, MHWESG, etc). It is recommended that the same stations as suggested by Warwick (2006) are occupied, preferably at the same time intervals.

The attempts in the present review to reconstruct the broader, landscape-scale knowledge from sediment facies and biotope mapping, historical mapping, satellite imagery and aerial photography, coring and trenching photography - all done at different times with differing aims - have only been partially successful in the intertidal zone and have hardly been achieved at all in the subtidal zone. This is because of the diversity and patchiness of the mosaic of sediments in the waterway. Nevertheless, the landscape-scale habitat information remains vital to management of the waterway, and should be compiled into a MHWESG GIS, along with discrete point sediment data.

Before deciding on anything more than 'shadowing' the periodic benthic fauna monitoring programme, as mentioned above, it is thus recommended that a broad-scale survey be undertaken of the entire waterway using sediment profile imaging (i.e. REMOTS®). This is a non-invasive, rapid method of assessing the condition of benthic biotopes, involving minimal laboratory work-up. The value cannot be over-stated of obtaining a synoptic view of the sediment mosaic of the entire estuary before MHWESG settles on a surveillance programme involving only a very limited number of sites.

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

2.4 ANNUAL WADERS & WILDFOWL SURVEYS 2007 – 08 / 2008 - 09

A Haycock, Pembrokeshire WeBS Coordinator

Executive Summary

The Wetland Bird Survey was carried out on the Cleddau estuary system between September 2007 and March 2008 and September 2008 and March 2009, with additional counts for June and July 2007 and 2008 made by Jane Hodges during the annual survey of summer shelduck populations .

Methodology followed that set out by the British Trust for Ornithology, as in previous years.

Four species reached levels of National Importance in 2007 – 08: wigeon (max. 7130 in November), teal (max 1991 in December), greenshank (max 25 in November) and curlew (max 1832 in July). Teal fell below the required level (max. 1171 in January),

Four species also reached levels of National Importance in 2008 –09: wigeon (max. 7429 in November), , greenshank (max 29 in January), golden plover (max 2851 in December) and curlew (max 1528 in July). Teal fell below the required level (max. 1171 in January), while shelduck numbers (763 in January) almost reached nationally important levels (782).

Total peak counts of 26,567 and 25,239 birds between November and February in 2007 – 08 and 2008 – 09 respectively confirms that the estuary system remains of international importance for its waterfowl populations, even though the peak counts were lower for several species than they have been in recent years.

Comparison of counts with the national report for 2006-07 (the most recent that is available) show that for most species, the local trends in populations are similar to those experienced nationally.

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

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

2.5 ANNUAL SHELDUCK SURVEYS 2008 -2009

J E Hodges, PCNP Ecologist

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 that has been the subject of annual summer boat surveys carried out between 1991 and 2008. The summer boat surveys were repeated in June and July 2008 and 2009, as part of the Group's programme of environmental surveillance in the estuary system. The aims, objectives and methods used, together with the data obtained, are described and presented in the reports.

The 2008 results indicate that, in terms of the numbers of broods recorded, 2008 (in common with 2007) was a very poor year for shelducks in the estuary system. The persistent cold, very wet weather in June and July is thought to have played a significant part in limiting breeding success. Disturbance and predation may also have contributed to the second poorest season for shelducks in the estuary system since 1994. 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.

The results of the 2009 surveys show that, in terms of the numbers of broods seen in the estuary system, 2009 was another poor year for breeding shelducks, with only 11 broods recorded during the boat surveys, and an average brood size of 6.4 ducklings per pair. In addition, a further three pairs and only one brood of four ducklings were reported from the Gann Estuary by local ornithologists. The very wet weather in late June and throughout July is thought to be a contributory factor in the generally low levels of breeding success and subsequent survival of ducklings to fledging. Disturbance, and in particular, predation may also have contributed to the third successive poor year for breeding shelducks in the estuary.

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. A total of 3,166 birds were counted during the July 2008 boat survey, of which 1,674 were curlew. Significant numbers of redshank, oystercatcher and common sandpiper were also recorded. Little egrets are now firmly established as an all year round resident in the estuary system. Canada geese appear to be continuing to slowly increase in numbers throughout Pembrokeshire, although the population remains centred on the estuary system. Finally a single knot seen in July was an unusual record for the estuary system at this time of year.

The reports conclude with a recommendation for continued annual surveillance of summer shelduck populations in the estuary system, as part of the Group's annual work programme.

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

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. 9 pp + appendices

2.6 MILFORD HAVEN WATER QUALITY – MACROALGAE

Environment Agency Wales (EAW) and Countryside Council for Wales (CCW) have reported to the Group the issue of excessive macro algae growth within the Haven.

The two organisations carry out monitoring and assessment of macroalgal growth throughout the Haven. The role of EAW is to prepare a case for designation of the Haven as a sensitive water under the Urban Waste Water Directive and as a polluted water under the Nitrate Directive, if this is deemed necessary.

EAW has carried out its assessment which has included recruiting expert advice from colleagues working on the Solent, where macro algae levels are problematic. The conclusion of this assessment is that there is currently not sufficient reliable information to make a case for designation.

The assessment has made a number of recommendations for possible monitoring and modelling activity. The purpose of this would be to come to a reliable conclusion. Some of the recommendations are for work which would be over an above the statutory duties of EAW and CCW and they may approach the group for help with this work. The benefit to the MHWESG members would be the potential for a more sophisticated understanding of the causes of macroalgae growth which in turn would help make better quality regulatory decisions.

2.7 PEMBROKE POWER STATION BASELINE AQUATIC SURVEYS

This section summarises work undertaken on behalf of RWE as part of the Haven monitoring programme associated with the Pembroke Power Station project. Work planned for 2010 follows the same survey pattern as for 2009.

2.7.1 Marine water quality

Surveys have been undertaken in –

2006 – October;
2007 – February, May, August;
2008 – February, May, August, November;
2009 - February, June, August, November

Ten stations from Popton Point to Pembroke Dock were sampled. Sample locations upstream of the cooling water discharge point were sampled on the flood tide; sample locations downstream of the cooling water discharge point were sampled on the ebb tide. In-situ sample recordings were taken at one metre depth intervals from the seabed to the surface.

Samples were analysed for:

- Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAH);
- Metals comprising arsenic, cadmium, chromium, lead, mercury, selenium, boron, copper, nickel, zinc;
- Phenols, cyanide, sulphate;
- Total alkalinity / acidity;
- Nutrients including ammoniacal nitrogen, nitrite, nitrate, phosphates;
- Seawater parameters including calcium, potassium, sodium, chloride, bromide and fluoride;
- Biological and Chemical Oxygen Demand (BOD and COD);
- Polychlorinated biphenyls as Aroclors (PCBs);
- Total suspended solids;
- pH;
- Conductivity.

2.7.2 Fish and invertebrate species

Surveys have been undertaken in –

2006 – October;
2007 – February, May, August;
2008 – February, May, August, November;
2009 - February, June, August, November

The seasonal baseline surveys of fish and invertebrate communities were undertaken by otter trawl at 13 locations and seine net at 7 locations between Newton Noyes and Llanreath in the main channel and within Pennar Gut and outermost Pembroke River.

Samples were analysed for:

- General community analysis (total number of species, abundance, and biomass);
- Commercially important species (abundance and biomass);
- Size frequency (selected fish species);
- Community analysis:
- Similarity analysis;
- Non-metric multi-dimensional scaling (MDS);

- Analysis of similarity (ANOSIM) and SIMPER analysis;
- Cluster analysis with a similarity profile (SIMPROF).

2.7.3 Intertidal ecology

Surveys have been undertaken in –

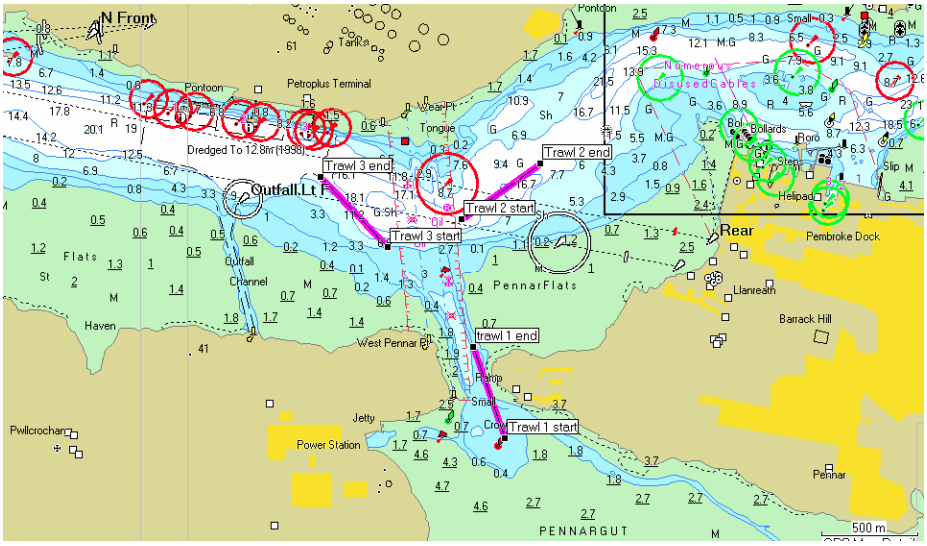
2006 – October;
2008 – October.
2009 - October

Ten rocky shore and five low shore sediment survey locations were sampled between Martin's Haven and Pennar Mouth. Data analyses included:

- Biotope coding and boundaries;
- Species assemblage;
- Trochid gastropods population analysis (paired t-tests);
- Species presence/absence analysis;
- Analysis of large substrate groups;
- Biotic benthic cover/abundance analysis.

2.7.4 Ichthyoplankton

Monthly surveys were undertaken between September 2006 and September 2007 (fortnightly between April 2007 – May 2007) and in June (twice) and July 2009 offshore from, and up and downstream from Pennar Gut (as shown on map).



Ten, 10 minute, sample tows were taken at each site on each occasion, five each on the ebb and flood tide, and the number of fish and other species, fish eggs and fish larvae quantified.

2.7.5 Eelgrass

Monitoring of the condition of seagrass beds in Pembroke River is part of a longer term survey programme to confirm the extent or otherwise of any smothering effects from dredging operations. The survey undertaken in autumn 2009 was the first survey undertaken and provides pre-dredging results.

Eelgrass monitoring in 2010 will be undertaken in late summer or early autumn (September-October, this is during periods of optimum coverage and before winter die off. The purpose of this survey is to monitor the seagrass beds post-dredging.

2.7.6 Subtidal benthos

One set of surveys will be conducted in 2010. Ideally this would be done in spring but may be undertaken later to coincide with work undertaken in July 2006: timing is also dependent on dredging. Sampling timings and sites have still to be agreed but this work is primarily related to the current dredging activities.

3. FUTURE WORK PROGRAMME

Following completion of the necessary reviews of previous Group work and information and data available, the Group has returned to more field-based projects rather than desk-studies.

A medium-term work outline programme identifies tasks for the coming decade, though with the flexibility to bring forward or delay projects depending on the pace of individual projects, unforeseen opportunities to integrate with other projects and the available budget.

Priorities for 2010 include:

- a second round of bioaccumulation surveillance;
- a long overdue recommencement of rocky intertidal surveillance, using revised and extended methodology;
- determination of a refined water quality surveillance programme taking account of monitoring by the Environment Agency to meet Water Framework Directive obligations
- assessment of the initial year's results from the targeted macrobenthic surveillance;
- issue of a second edition of a report archive CD for members and libraries;

as well as continuing the annual summer shelduck breeding surveillance and wetland bird data collation and reporting.

Beyond these priorities, the Group intends to move forward with:

subject to the necessary integration with the Environment Agency's macrobenthic faunal sampling programme, a further round of sampling for the revised macrobenthic project;

one or more of the recommendations detailed in the David Little sediment review.

The report of the first bioaccumulation study included recommendations to consider implementing a number of interesting novel biological effects of contaminants analytical tools. However, as the costs of these tools is high and the recommendations arising from the sediments review rather more urgent, the Group has postponed consideration of the tools for the time being and will revisit them when the second bioaccumulation study reports in about 18 months time

The Group's budget remains healthy at the present time and has been boosted by a further contribution from a new member, RWE Npower. The Group looks forward to welcoming further new members from the new industries around the Haven – and their contributions, though at the same time it is conscious of the resource cuts facing some of the public body members of the Group and anticipates commensurate reductions in their contributions will be likely in the short-term.

APPENDICES

APPENDIX 1: PURPOSE AND TERMS OF REFERENCE

Preamble

The Milford Haven Waterway[4] 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'.

[4] 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[5] 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

[5] The Group changed its name in 2000

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

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

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