MILFORD HAVEN WATERWAY
ENVIRONMENTAL SURVEILLANCE GROUP

GRŴP CADW GOLWG AMGYLCHEDDOL
AR DDYFRFFORDD ABERDAUGLEDDAU

Milford Haven Waterway Environmental Surveillance Group: Twenty years of partnership surveillance, 2013

By Blaise Bullimore, MHWESG Project Manager, 2013

The drowned river valley - ria - of Milford Haven and the Cleddau estuaries was formed about 80,000 years ago as the sea rose and flooded deep channels created by glacial erosion during the last ice age maximum. It is the only ria in Wales and one of the most biologically diverse and important marine inlets in the UK, where marine wildlife penetrates deep inland in almost fully saline conditions but nearly completely sheltered from wave action.

Milford Haven has a long and distinguished history. Iron Age promontory forts are scattered on headlands at the entrance and along the course of the Haven and the Daugleddau. Several settlements bear names derived from Viking visitors. In his play Cymbeline, Shakespeare asks "how far it is to this same blessed Milford: and by the way tell me how Wales was made so happy as to inherit such a haven". Henry Tudor landed at Dale in 1485 before marching to defeat Richard III at the Battle of Bosworth. In his 1603 The Description of Pembrokeshire, George Owen claimed that Milford Haven was the most famous port of Christendom, and Nelson later described it as the next best natural harbour to Trincomalee in Sri Lanka and "*the finest port in Christendom*".

Human pressures in the Haven began long ago, most likely starting with fishing along the shores - Mesolithic tools believed to be limpet or shellfish scoops have been found near Dale - and late Bronze Age forest clearances for farming would have disturbed soils, causing erosion and flushing silt into the waterway.

Coal was exported from the 13th century and herring from the 14th; mine waters would have contaminated the Haven's sediments and water, and expanding fisheries moved exploitation from the shores into the waterway. Quays, jetties and landing places sprang up to serve the coal-mines and the large limestone quarries, claiming foreshore habitat and locally modifying sediment transport. The waterway was a hive of industry from the Medieval period, with saw-mills, paper mills, tanneries and limestone-burning on shores all contributing to the contaminant load; evidence of metal workings found during the construction of an LNG

terminal in the late 2000s hints at a level of industrialization around 800AD[1].

The use of sheltered deep areas as anchorages from at least the 16th century would have caused localized seabed disturbance; steam pumping to de-water coal-mines in the 1800s increased the input of contaminants to waterway, and by 1830 silt accumulation at Havefordwest had limited access for trading vessels.

Major habitat losses began with the claiming of mudflats to build a naval dockyard in the 1820s and a ship-breaking yard contributed increasingly persistent pollutants between the 1880s and 1970s.

Many thousands of vessels and aircraft used the Haven during the second World War, and in August 1940 the bombing of the Navy's fuel oil storage depot at Pembroke Dock started the largest 'single-seat' fire in the UK's history. The estimated 132,000 tons of oil that burned was about ten times that which went up in flames in the Buncefield fire in Hertfordshire in 2005. Not all the oil burned; some spilled into the Haven and the 'asphalt pavement' formed as it soaked into the sediments is still visible in places at the top of the foreshore below the former tank complex, while some soaked into the ground from where traces are still emerging in ground water and are captured in an interceptor to prevent it entering the Haven.

Although possibly not the first invasive non-native species to gain a foothold in the Haven, the slipper limpet *Crepidula fornicata*, a serious pest, was first found there in 1953. Assumed to have been introduced with cultivated oysters, it is now a dominant species in some locations.

Clearly, by the time Milford Haven's oil port era began in 1960, the waterway had already acquired a legacy of human impacts. However, oil importing got off to a shaky start when the first vessel to offload at the new Esso refinery terminal in 1960, Esso Portsmouth, suffered structural failure when unloading which caused an explosion and fire that severely damaged the ship and released oil into the Haven.

Over subsequent years, further, mostly minor, pollution incidents followed and in 1967 the Field Studies Council established the Oil Pollution Research Unit (OPRU) to undertake research into the effects of oil contamination in estuaries and coastal waters. OPRU undertook many experimental and surveillance studies in the Haven and these provided a firm foundation for the MHWESG's later work programme.

However, despite the pollution incidents, it wasn't until 1991 that a one-day conference to address pollution affecting the Milford Haven waterway was convened by the local authority. A key presentation by the Shetland Oil Terminal Environmental Advisory Group (SOTEAG) undoubtedly sowed the seed for the establishment of the MHWESG. Representatives of SOTEAG's forerunner had visited Milford Haven in the mid 1970s to learn from what was being done in West Wales; ironically they came back

[1] Medieval works found at LNG site, BBC News, 5 April 2005. Retrieved 12 February 2013

in 1991 to enable Milford Haven to learn from them!

The Milford Haven Waterway Environmental Monitoring Steering Group was established just a few months later as a consequence of discussions prompted by the conference. Membership comprised the major industries around the Haven, the Port Authority, local government and statutory environmental agencies.

The Group's stated vision was: "*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.*" It planned to achieve this by considering existing monitoring and future needs, collating and interpreting data and information for its members and funding future monitoring not being undertaken by others by contributing to a shared common resource. Members share common ownership of the Group's outputs and are free to use them as they wish; outputs are also placed in the public domain through local and academic libraries.

Members agreed to focus the Group's attention on scientific and technical issues only; political and management issues were to be explicitly excluded. This agreement has proved instrumental in contributing to the continuous cordial working relationship between the partners.

The first task undertaken by the Group was a review of the then current state of environmental knowledge of the Waterway. The comprehensive report, compiled by OPRU, included a Foreword by the then Secretary of State for Wales who welcomed and endorsed the collaborative approach demonstrated by the Group's membership. The review provided a detailed snapshot of the history of the Waterway, the physical, chemical and biological environments, the Waterway's industry, commerce and fisheries, environmental designations and responsibilities, and past and current research monitoring. It remains a valuable reference document despite now being over 20 years old.

Having developed a ten-year work plan, the Group commenced routine water quality sampling, annual wetland bird survey reporting and, in 1993, a series of major surveys. The first was a comprehensive investigation of metals in sediments (at 93 stations) and sublittoral sediment macrobenthos, particle size distribution, organic matter and hydrocarbons (40 stations; a subset of stations previously surveyed by OPRU in the 1970s and 80s), followed by an equally thorough survey of macrobenthos in sediment shores in 1994 (65 stations on 15 shores). Rocky shores were resurveyed the following year at 31 permanently marked sites, many of which had been established by Swansea University researchers in the 1960s and OPRU in the 1970s.

The surveys reconfirmed the high biological diversity of sediment communities and the heterogeneous distribution of sediment habitats. It revealed that sediment metal concentrations were elevated, though comparable with other estuaries in SW Britain, there was measurable organic

enrichment and hydrocarbons were present, particularly in sediment sinks.

The rocky shore re-survey collected semiquantitative data from discontinuous down-shore belt transects and was able to detect declines in some molluscs and the alga *Ascophyllum nodosum*. Some of the mollusc declines were considered likely to be attributable to TBT contamination from antifouling paints on both commercial and recreational craft.

The data collected during these surveys proved invaluable in the investigation of the environmental effects of the Sea Empress Oil Spill (SEOS) in 1996, although the semiquantitative rocky shore data proved relatively insensitive. Studies commissioned by the Sea Empress Environmental Evaluation Committee (SEEEC) used the Group's established sampling sites since they provided robust pre-spill data. As a consequence of SEEEC's work, and also because of increasing obligations on the statutory environmental agencies to undertake monitoring to assess progress toward European environment Directive targets, the Group modified its planned work programme earlier than anticipated.

Nevertheless, several other major projects were completed in the late 1990s, including establishing and surveying permanently marked sublittoral rock sites (which showed rock communities were also highly biodiverse, with high densities and biomass of many species) and the extensive eelgrass, *Zostera marina*, between Milford Haven and South Hook Point which had previously been surveyed by OPRU in the late 1970s and mid 80s. The area and footprint of the bed – the largest in Wales – had changed little since previous surveys; there was a welcome absence of green algal 'mats' (which are an indicator of elevated nutrient levels) and low levels of hydrocarbon contamination (particularly welcome just three years after the SEOS) though also a suspicion of evidence for the 'wasting disease' that had caused great loss of eelgrass beds in Northern Europe and North America in the late 1920s and early 1930s.

Other survey data collected by members during this time was made available to the Group as contributions in kind, including intertidal eel grass populations and annual shelduck surveys by the Pembrokeshire Coast National Park Authority and water quality monitoring data from the Environment Agency Wales (EAW).

In 2000, with a change in Chairmanship, the Group paused to review and reflect. A technical review was contracted out to scrutinise the Group's outputs to date, the outputs from SEEEC and the work programme in the context of the increased monitoring being begun by the EAW and Countryside Council for Wales (CCW). The reviewer endorsed most of the projects though recommended some adjustments in priorities and a revised work programme.

The Group also took the opportunity to review its governance, establishing a formal Memorandum of Agreement between the partners, and, acknowledging that it did not conduct monitoring in the strict sense of the word and neither did it steer others to do so, members agreed to changing the name, replacing 'Monitoring Steering' with 'Surveillance'.

The Group began the new millennium by mopping up some of the outstanding priorities from the original work programme that had been endorsed in the 2000 Review.

A very comprehensive re-survey of the Haven's salt-marshes was undertaken, building on surveys in 1970, 1982 and, following the SEOS, 1997-98. Whilst the survey estimated that there had been a 15% decrease in total salt-marsh area since 1982, there had been a roughly 25% increase in salt-meadow (the more biodiverse upper-salt marsh). It concluded that the marshes were no longer influenced by the oil spill but reported areas of active erosion, algal mats, litter and negative influences of livestock grazing and poaching.

The first step toward meeting the Group's aspiration for an inputs budget for the Haven was taken with an inventory of available inputs data. Whilst this identified data sources and provided a snapshot of the data available, it also suggested that developing a budget would be a significant and expensive task not to be undertaken lightly, particularly given its vulnerability to becoming rapidly outdated.

One of the most significant recommendations in the 2000 Review was to undertake more reviews, including detailed and critical reviews of the time-series data that existed and expert opinions on which work should be maintained so as best to meet the Group's goals.

The first of these reviews was conducted by the Plymouth Marine Laboratory (PML) on the eight macrobenthic datasets available to the Group. Although there were difficulties comparing some of the datasets, it concluded that the "data are of exceptionally high quality and value", that the studies showed higher than average values of biodiversity, there was "no indication of long term changes over the study period in eight spatial subtidal studies" and that "most of the stations are of Good or Moderate ecological status". However it also inferred that there had been "detrimental effects of the {dredging} outfall from the marina at Neyland."

The review made recommendations for reestablishing subtidal macrobenthic surveillance but for omitting intertidal sediment surveillance since it was a less sensitive indicator. These recommendations have been implemented (beginning in 2008) and integrated with Countryside Council for Wales (CCW) and EAW macrobenthic monitoring programmes for the European Habitats and Water Framework Directives respectively.

The second review was a very detailed appraisal of available sediment contaminants and transport data and studies. The time series data were even more difficult to compare than the macrobenthic datasets, with some being incomparable because of changes in laboratory techniques over time. Nevertheless, the review concluded that there had been no major qualitative changes in the status of contaminants since the 1980s, with decreases in some contaminants in some locations and increases in others, and that sediments had largely recovered from major spills. It also found that the data reviewed broadly confirmed the 1980s findings concerning sediment and contaminant transport.

Recommendations were made to undertake a forensic examination of sediment contaminants in samples from sediment sinks in comparison with a range of potential contemporary and legacy contaminant sources, including the only remaining samples of Sea Empress cargo and fuel oil; to recommence routine sediment contaminant surveillance, analysing the first round of samples using both contemporary and historical laboratory methods to provide a cross-calibration measure to enable better comparison with older datasets; and to undertake a comprehensive sediment facies survey using sediment profile imaging.

Thirdly, 25 years of wetland birds data were reviewed and reported in the context of UK trends. The annual abundance of each species was found to be variable, with some overall declines and increases. Declines in some species were not considered a result of pressures in the Haven but were attributed to milder winters resulting in less migratory birds moving to the far west from mainland Europe or the eastern UK.

A series of what are planned to be regular surveillance projects were commenced in 2008. The first was re-establishing subtidal macrobenthic sampling at the sites recommended in the PML review.

An initial round of contaminant bioaccumulation sampling and analysis, developed from previous work undertaken by EAW's predecessor body the National Rivers Authority (NRA), was also undertaken in 2007 - 08. The Marine Biological Association (MBA) collected samples of five species from 13 locations along the length of the Waterway and from two reference sites and analysed them for 42 determinands (13 metals, 6 organotins, 16 PAHs, 7 PCBs plus biometrics); the work was repeated and slightly expanded in 2010 to establish a robust baseline. The data were compared with the earlier NRA data where appropriate and set in a UK context.

There was considerable variation in bioaccumulated contaminants between species and locations in the waterway, reflecting differences in feeding strategy and habitat preference, physiological and ecological attributes, and chemical properties of the different determinands. Metal concentrations in the majority of biota samples (94%) were at the lower-middle part of the UK range. Metals data revealed a number of changes between surveys, both increases and decreases. All TBT concentrations were above the lower Environmental Assessment Criteria for mussels (sub-lethal effects possible) but below thresholds considered by OSPAR to be acutely toxic. The majority of PAHs in mussels were above OSPAR background levels, but not excessively so.

Long overdue, rocky-shore surveillance was re-established in 2010. In an attempt to improve it's sensitivity for detecting change, the sampling methodology was substantially modified, adopting the method developed at the Skomer Marine Nature Reserve in the mid 2000s. Replicate, quantitative (rather than semi-quantitative) samples are collected at three selected shore heights (rather than a semi-continuous belt transect) to provide statistically robust data which may still be compared with the earlier semi-quantitative data. A subset of six of the historical sites was selected to integrate with CCW's Habitats Directive

rocky-shore monitoring which is based on a further six of the historical OPRU / Group sites. Additional data were collected using MarClim (UK wide marine biodiversity and climate change project) protocols.

Once again, it proved difficult to compare the data collected with historical data: methods had varied, not all data were statistically valid, and some sites had been relocated. Nevertheless, it was concluded that the rocky intertidal communities were structurally and functionally healthy. Temporal changes and increasing abundance trends of several species were generally in line with wider UK responses to climate warming, though modified by local factors. Dogwhelks, *Nucella lapillus*, were noted to have increased in abundance at some sites since the use of TBT antifoulants had been prohibited. Non-native species were recorded at every site with the highest number of nonnatives ever recorded during a MarClim survey.

Two of the sediment-review recommendations were taken forward in 2011 – 12. The forensic investigation of sediment contaminants from sediment sink areas found that 5-15% of total hydrocarbon (THC) residues were of biogenic origin; 2-6% of THC residues were PAHs, about half each recent petrogenic and older pyrogenic sources with recent contributions from refinery waste water and potentially African crudes; the remaining 70-85% of THC was heavily weathered petrogenic residues from historic spills. SEOS cargo was undetectable but Sea Empress heavy fuel oil was detected further up the Waterway than previously recorded. The 'fingerprints' of the Iranian crude oil spilled by the El Omar in 1988 and fuel oil from the wartime bombing at Pembroke Dock were also tentatively identified.

The sediment facies survey proved to be the most ambitious and expensive project undertaken by the Group. It was carried out by the developer of the sediment profile imaging technique and involved flying half a ton of equipment from his base in Seattle, Washington. Over a period of twelve days in May 2012 more than 550 stations, with three replicates at each, were successfully sampled using the seabed penetrating camera system. Sediment surface images were also obtained by a 'plan view' camera at a higher than anticipated proportion of the sites. The final outputs from the survey are eagerly anticipated.

Throughout the life of the Group there have been changes in membership as industries come and go from the Haven or change hands, and major change is anticipated in 2013 as CCW and EAW are dissolved and replaced by a single body, Natural Resources Wales.

The future is certain to bring new developments to the Waterway and new pressures to the environment necessitating more and new information. The Group has an ambitious, costed, work programme including the maintenance of routine sublittoral macrobenthic, rocky shore and bioaccumulation surveillance; recommencing sediment and water-column contaminant surveillance; and potentially finally developing an inputs budget and, if substantial resources become available, extending the bioaccumulation work to include the use of sublethal effects indicator tools.

The outputs from the Group send several ‘take home’ messages about surveillance to detect change. Apart from the obvious – timing (allowing for seasonality), site relocation (comparing like with like), the value and utility of replicated, quantitative data being considerably greater than single, semi-quantitative samples – the value of integration between projects in the Waterway to maximise the possible signals of change and to provide context for interpreting change, and of integration with projects elsewhere to place the Milford Haven findings in context have become very clear. Perhaps the strongest message is the need to ensure that, as methods evolve, measures are taken to ensure that new data remains “backwards-compatible” and comparable with historical data so that the objective of detecting change has a fighting chance of being realised.