PGASE
Pwyllgor Gwerthusiad Amgylcheddol
Sea Empress

SEEEC
Sea Empress
Environmental Evaluation Committee

Effaith Amgylcheddol Arllwysiad Olew y Sea Empress

The Environmental Impact of the Sea Empress Oil Spill

Published by The Stationery Office

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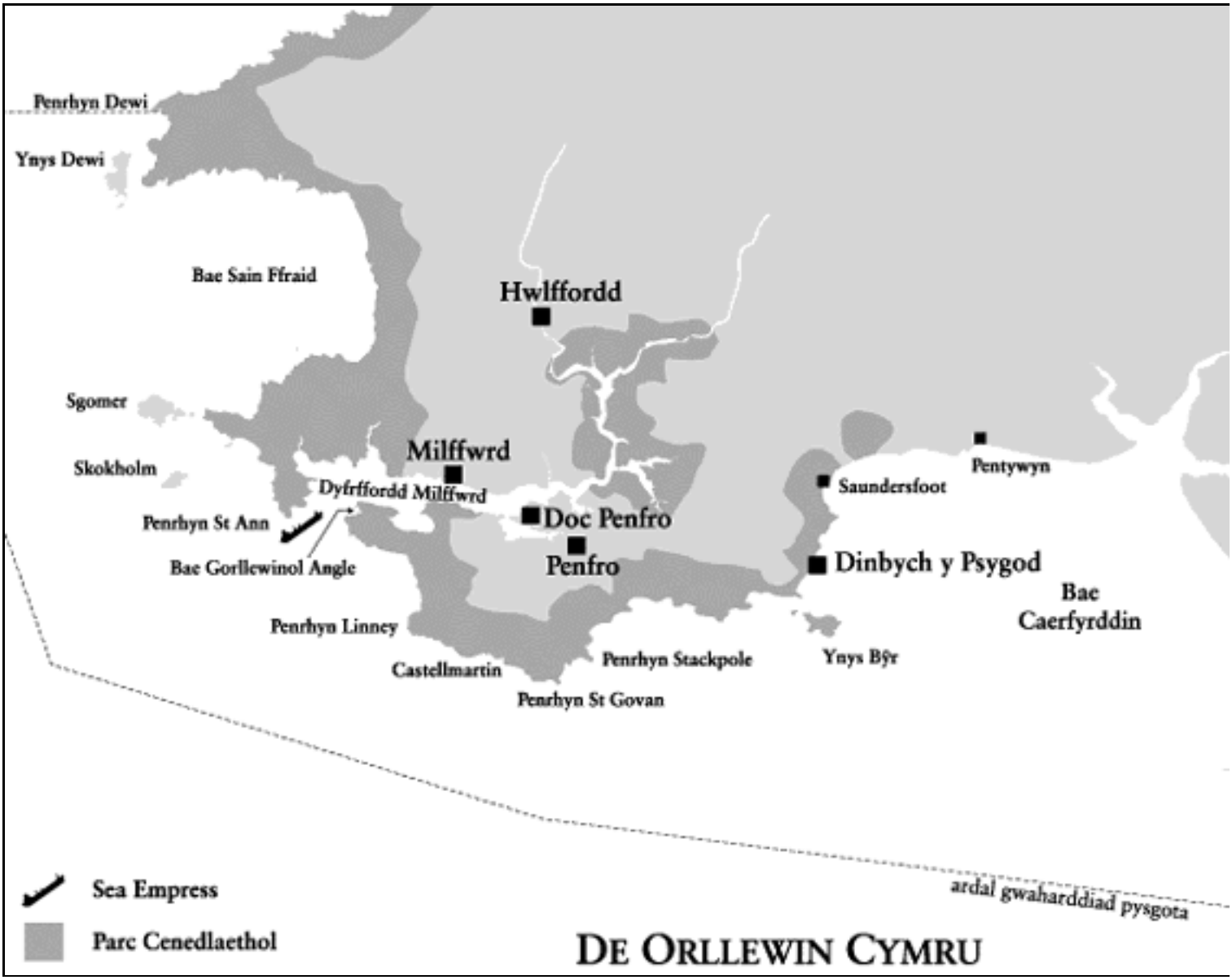

Adroddiad PGASE Crynodeb

1. Y Cyd-Destun

Ar 15 Chwefror 1996 aeth y *Sea Empress*, a oedd yn dod ag olew crai i Milffwrd yn ne-orllewin Cymru, ar y creigiau a thros yr wythnos ganlynol gollyngodd 72,000 tunnell fetrig o olew crai a 480 tunnell fetrig o olew tanwydd ir mr. Er gwaethaf ymateb buan ac effeithiol ar y mr i glirio a glanhau, daeth olew ir lan ar hyd 200 cm o arfordir llawer ohono mewn Parc Cenedlaethol mewn ardal o bwysigrwydd rhyngwladol ar gyfrif ei fywyd gwyllt ai brydferthwch naturiol. Gosodwyd gwaharddiad ar bysgota masnachol ac adloniadol yn y rhanbarth ac roedd pryder y byddai twristiaeth, syn bwysig ir economi lleol, yn cael ei effeithion andwyol gan y traethau a oeliwyd yn drwm. Cafodd rhai miloedd o adar oeliog eu golchi ir lan, gan arwain at ymgyrch mawr o lanhau a adfer.

Crynodeb yw hwn or adroddiad ar y gorlif a baratowyd gan Bwyllgor Gwerthuso Amgylcheddol y *Sea Empress* (PGASE), pwyllgor annibynnol a sefydlwyd ar 27 Mawrth 1996 gan lywodraeth y DGgydar amodau gorchwyl wediu rhestri ym mhocs 1.

Mae adroddiad llawn y pwyllgor yn disgrifior effaith maer olew wedi ei gael ar yr amgylchedd, ar y mr ac ar hyd yr arfordir. Maen edrych ar yr ymateb ir gorlif yr ymgyrch glanhau, y rhaglen monitorio amgylcheddol a glanhau adar oeliog ac yn argymell newidiadau yn y trefniadau i asesu ac ymateb i orlifoedd yn y dyfodol.

Dros gyfnod o 20 mis, daeth PGASE thimau o arbenigwyr at ei gilydd a chomisiynu tua 80 astudiaethau gwyddonol yn cynnwys y llywodraeth a chyrff cyhoeddus, prifysgolion, mudiadau gwirfoddol, sefydliadau ymchwil a chwmnau yn arbenigo mewn gorlifoedd olew ac asesu ecolegol. Bu i ganlyniadaur astudiaethau hyn ynghyd ag ymchwil gynt i ecoleg yr ardal a gwaith a wnaed gan gyrff eraill ddarparu gwybodaeth ar gyfer yr adroddiad hwn.

Bocs 1 Amoudau gorchwyl PGSAE:

- Cyd-drefnu gwaith monitorio a wnaed gan adrannau llywodraeth a chyrff cyhoeddus eraill i asesu effaith amgylcheddol gorlif olew y *Sea Empress* ar gweithredu glanhau dilynol.
- Sicrhau y ceir set gynhwysfawr o ddata ar ddosraniadau ac effeithiau amgylcheddol, gan gymryd i ystyriaeth astudiaethau gan fudiadau eraill ar angen am osgoi bylchau a gorgyffyrddiadau.
- Trwyr rhaglenni monitorio hyn, asesu effaith gyfan gwbl y digwyddiad ar adnoddau amgylcheddol yr ardal a effeithiwyd, yr adnoddau hyn i gynnwys pysgodfeydd, amaethyddiaeth, cadwraeth amwynderau a bywyd gwyllt, ac asesu adferiad dilynol yr adnoddau hyn. Bydd gwybodaeth am ddosbarthiad llygrwyr syn berthnasol i iechyd dynol yn cael ei gyflwyno i awdurdodau iechyd cyhoeddus iw hasesu.
- Cyhoeddi prif ddyfarniadau a chasgliadaur astudiaethau hyn gydar amcan o hysbysur Llywodraeth, y cyhoedd ar grwpiau penodol hynny a effeithiwyd yn uniongyrchol gan y digwyddiad. Gwneir argymhellion lle mae angen gwelliannau mewn gweithdrefnau neu weithredu pellach, a allai fod chymhwysiad ehangach.

Ymchwiliwyd ir ddamwain ei hun ar ymgyrch arbediad gan Adran Ymchwilio Damweiniau Morol Adran yr Amgylchedd, Trafnidiaeth ar Rhanbarthau (DETR) a gyhoeddodd ei hadroddiad yng Ngorffennaf 1997. Cynhyrchodd yr Uned Rheolaeth Llygredd Morol (MPCU) adroddiad manwl am yr ymgyrch glanhau. Yn fuan wedir gorlif, comisiynodd Cyngor Sir Penfro, gyda chefnogaeth cyrff cyhoeddus eraill, astudiaeth oi ganlyniadau economaidd potensial. Mae ymchwiliad i effeithiaur gorlif ar iechyd y cyhoedd yn cael ei wneud gan Awdurdod Iechyd Dyfed Powys ac mae adroddiad wedi ei gyhoeddi.

Cychwynnodd gwaith monitorio i asesur effaith wreiddiol yn fuan wedi tirior tancer, ac fe ychwanegodd PGASE at y gwaith hwn gyda rhaglen o astudiaethau mwy tymor-hir. Yr oedd yn amhosibl ymdrin phob agwedd o ecoleg y rhanbarth, ond cynhwyswyd yn y rhaglen yr holl brif fathau o amgylchoedd artraethol a morol, gan ganolbwyntio ar rywogaethau allweddol a oedd

- wedi eu heffeithion drwm gan yr olew
- yn arwydd o iechyd yr amgylchedd
- bwysigrwydd cadwriaethol ir ardal
- yn bwysig yn y gadwyn fwyd morol, neu
- werth economaidd

Cafodd y rhaglen ganlyniadol o tua 80 o brosiectau a awgrymwyd gan PGASE yn costio tua 2 filiwn ei hariannu gan y llywodraeth ai asiantaethau gyda chefnogaeth awdurdodau lleol, y Comisiwn Ewropeaidd (EC), mudiadau gwirfoddol a diwydiant.

Mae de-orllewin Cymru yn ardal o harddwch naturiol a diddordeb ecolegol arbennig. Mae tua thri chwarter yr arfordir yn glogwyni creigiog, craig-lwyfannau, clogfeini a graean bras, gyda mwyafrif y gweddill yn gynefinoedd llaid a thywod, yn cynnwys rhai traethau tywod o werth amwynderol uchel. Mewn cydnabyddiaeth o bwysigrwydd amgylcheddol y rhanbarth, rhoddwyd i lawer ardal statws cenedlaethol a rhyngwladol arbennig. Mae llawer or arfordir oddi mewn i Parc Cenedlaethol Arfordir Penfro, ac yn y brif ardal a effeithiwyd gan y gorlif mae tua 35 o Safleoedd o Ddiddordeb Gwyddonol Arbennig, 2 Warchodfa Natur Cenedlaethol (Stackpole a Sgomer) ac, o amgylch Sgomer, un o dair Gwarchodfa Natur Morol y DG. Mae hefyd Ardaloedd Arbennig Diogelu Adar a ddynodir gan yr EC, a thair Ardal Gwarchodaeth Arbennig a arfaethir gan y llywodraeth.

Prif drefydd de-orllewin Cymru yw Caerfyrddin (poblogaeth 14,600), Milffwrd (13,600), Hwlffordd (13,000), Doc Penfro (8,600) a Phenfro (7,200). Maer economi lleol yn wynebu problemau yn dilyn cau sefydliadau diwydiannol ac amddiffyn sylweddol ac, oherwydd dirywiad y sectorau prosesu olew ac amaethyddol, mae graddfeydd diweithdra ymhlith yr uchaf yng Nghymru. Dibynna economir rhanbarth yn helaeth ar ychydig o ddiwydiannau allweddol, yn enwedig olew, twristiaeth, amaethyddiaeth a physgota.

Mae twristiaeth yn chwarae rl hanfodol, gyda llawer o ymwelwyr yn aros yng nghyffiniau Dinbych y Pysgod a Saundersfoot. Cynigir cyfleoedd ar gyfer addysg amgylcheddol gan ganolfannau astudiaethau maes. Yn 1995 amcangyfrifir bod twristiaid wedi gwario 160 miliwn yn Sir Benfro.

Canolir y diwydiant pysgota o amgylch dyfrffordd Milffwrd. Ceir yn y rhanbarth ddigonedd o bysgod cregyn, crancod, draenogiaid y mr a physgod eraill, ac maer afonydd brithyllod mr ac eog yn denu llawer o bysgotwyr ymweliadol. Amcangyfrifir bod y pysgodfeydd hyn yn darparu 1,000 o swyddi ar dir a mr. Mae amaethyddiaeth yn y rhanbarth yn cynnwys tatws cynnar a llysiau, ffermio llaeth a da byw.

Mae hanes hir i ddyfrffordd Milffwrd fel porthladd olew, a ddatblygwyd yn ystod y 1950au ar gyfrif ei ddyfroedd dwfn ai gysgodfa naturiol nodweddion syn ei wneud yn ddelfrydol ar gyfer tanceri mawrion. Er iddo fod y porthladd mwyaf prysur ond un ym Mhrydain ar gyfer cynhyrchion petrolewm, mae costau trafnidiaeth uchel o Sir Benfro wedi peri ir purfeydd olew fod yn llai cystadleuol yn ystod y blynyddoedd diwethaf hyn.

2. Tynged yr Olew

Dros gyfnod o saith diwrnod tra oedd y *Sea Empress* ar y creigiau y tu allan i fynedfa dyfrffordd Milffwrd rhyddhawyd tua 72,000 tunnell fetrig o olew crai ysgafn, yn bennaf ar adeg y trai. Ar yr un adeg rhyddhawyd tua 250 tunnell fetrig o olew tanwydd trwm (a ddefnyddid i yrru peiriant y llong) gan gymysgu yn l pob tebyg r olew crai; rhyddhawyd 230 tunnell fetrig pellach wedi ir tancer gael ei dynnu i lanfa oddi mewn ir ddyfrffordd.

Tra oedd y tancer ar y creigiau, amrywiodd y gwynt rhwng awel ysgafn a thymestl ac i gychwyn (15-17 Chwefror) gyrrwyd yr olew a ryddhawyd tuag at Milffwrd. O 18 i 22 Chwefror (cyfnod pryd y rhyddhawyd tua 90% or olew) cariodd y gwyntoedd yr olew tuar de, i ffwrdd o arfordir Sir Benfro, gan ganiatu i wasgarwyr cemegol gael eu defnyddio i wasgarur olew i dwfn. Ar 23 Chwefror trodd y gwynt ir de-orllewin a thros yr ychydig ddyddiau nesaf cariwyd yr olew oedd yn weddill i draethau Bae Caerfyrddin o Ddinbych y Pysgod i Bentywyn.

Mae olew crai yn gymysgedd o nifer mawr iawn o wahanol gyfansoddion. Dangosodd profion yn y gorlif fod tua 40% or olew gan gynnwys llawer or cyfansoddion syn wenwynig i fywyd morol wedi anweddun gyflym ar l cael ei ryddhau. Yn ystod llawer or cyfnod hwn roedd y gwyntoedd alltraeth. Cafodd crynodiadau anwedd olew eu mesur trwyr amser ar y traeth, ond roeddynt yn isel, yn cyrraedd mwyafswm o 9 rhan y filiwn (rhyf). (Cytunasid y byddid yn gweithredu, er enghraifft cynghori pobl i aros dan do, petai crynodiadau yn codi yn uwch na 50 rhyf). Cadarnhaodd model rhagfynegol y byddai crynodiadau o anwedd olew dros y tir yn isel oherwydd bod cyfeiriadaur gwynt yn ffafriol yn gyffredinol.

Gwasgarodd tua 50% or olew yn y golofn , o ganlyniad i gymysgu naturiol ar defnydd o 446 tunnell fetrig o wasgarwyr a chwistrellwyd ar yr olew o awyrennau. Cynyddodd y gwasgarwyr effeithiolrwydd y prosesau naturiol drwy achosi ir olew ffurfio defnynnau bychain a chymysgu r , gan leihau yn sylweddol swm yr olew ar yr wyneb ond gan gynyddu crynodiadau yn nyfnder y mr. Yn gyffredinol roedd yr olew a arosai ar wyneb y yn ffurfio emylsiwn (cymysgedd sefydlog o tua 70% o a 30% o olew) a oedd yn atal y broses gwasgaru naturiol, er roedd monitorio o gychod yn yr ardal lle chwistrellwyd y gwasgarwyr yn cadarnhau effeithiolrwydd y gwasgarwyr hyd yn oed ar yr emylsiwn. Yn ychwanegol at yr ymgyrch gwasgaru, casglwyd tua 1-2% or olew oddi ar wyneb y gan longau adferiad.

Mae olew yn gynnyrch naturiol ac yn y pendraw fe fydd y rhan fwyaf ohono wedi cael ei dorri i lawr gan ficro-organebau yn y . Erbyn diwedd Mawrth roedd crynodiadau olew yn y golofn yn isel (llai na 100 mg/l) ac yn agos at lefelau cefndir ar draws yr ardal a effeithiwyd.

Cynhaliwyd arolygon alltraeth helaeth er mwyn penderfynu a oedd olew wedi cyfuno gronynnau gwaddod ac wedi eu dyddodi ar welyr mr. Ni ddaethpwyd o hyd i grynodiadau olew sylweddol, heblaw am yn agos i rai traethau ller oedd swmp o olew wedi aros am gyfnodau hir.

Daeth olew ir traeth ar hyd 200 cm o arfordir, gydar ardaloedd a effeithiwyd waethaf o fewn dyfrffordd Milffwrd ac ar hyd arfordir de Sir Benfro. Mae amcangyfrifon yn awgrymu bod rhwng 3,700 a 5,300 tunnell fetrig wedi dod ir lan (5-7% or cyfanswm) a hynnyn gostwng i tua 500 tunnell fetrig erbyn diwedd yr haf o ganlyniad i ymgyrch sylweddol i lanhaur draethlin. Cafodd llawer or hyn a oedd yn weddill erbyn diwedd yr haf ei gladdu dan yr wyneb.

3. Effeithiau Morol

Fel mesur rhagofalus, yn fuan wedir gorlif gosodwyd gwaharddiad ar bob pysgota a chasglu planhigion a gwymon bwytadwy mewn ardal yn ymestyn o Benrhyn Dewi i Borth Eynon ar Benrhyn (gweler map). Hefyd gwaharddwyd pysgota am eog a brithyll mr yn yr afonydd syn llifo ir ardal hon. Cafodd samplau o amryfal rywogaethau o bysgod, pysgod cregyn a chramenogion eu dadansoddi am gynnwys olew dros y misoedd dilynol, a chodwyd y gwaharddiadau mewn camau wrth ir dadansoddi ddangos bod crynodiadau mewn dosbarthiadau amrywiol o organebau wedi dychwelyd i lefelau cefndir. I bob golwg ni effeithiwyd ar eogiaid a brithyll mr a chodwyd y gwaharddiad arnynt ar 3 Mai 1996, a chodwyd y gwaharddiadau ar bysgod eraill ar 21 Mai 1996. Codwyd y gwaharddiad ar grancod a chimychiaid y tu allan i ddyfrffordd Milffwrd ac ar wichiaid moch trwyr holl ardal ar 29 Awst 1996, a thros y flwyddyn ganlynol codwyd y gwaharddiadau yn gynyddol mewn camau hyd nes ir holl gyfyngiadau a oedd yn weddill gael eu diddymu ar 12 Medi 1997.

Tra nad oedd unrhyw dystiolaeth eglur o ddifrod i stociau masnachol o bysgod, bydd angen monitorio estynedig yn enwedig o unigolion wrth iddynt gyrraedd maint y gellir manteisio yn fasnachol arno er mwyn penderfynu a oedd bridio a recriwtio rhai rhywogaethau (yn cynnwys draenogiaid y mr, crancod bwytadwy, cimychiaid a gwichiaid moch) yn llwyddiannus wedir gorlif yn 1996.

Yn y Tywi gostyngodd graddfa dal brithyll mr er nid eog yn 1996, ond mae angen dadansoddiad pellach o ddata dal o afonydd eraill cyn y gellir priodolir gostyngiad hwn ir gorlif.

Yn yr wythnosau yn dilyn y gorlif golchwyd ir lan niferoedd mawrion o anifeiliaid marw neu ar farw gan mwyaf molysgiaid dwygragenog (megis cocos a chyllyll mr) ac anifeiliaid syn trigo mewn gwaddod yn y traeth isaf a than y

draethlin. Gall y ffenomen hon ddigwydd yn naturiol gyda rhai rhywogaethau, ond roedd yr amseru, nifer yr unigolion, ystod y rhywogaethau ac mewn rhai achosion lefelau uwch o hydrocarbonau meinwe yn awgrymu bod mwyafrif y tiriadau yn ymwneud dod i gysylltiad r olew. Dangosodd astudiaethau o welyr mr nad oedd fawr ddim o effaith o ganlyniad ir gorlif heblaw am absenoldeb deudroediaid (cramenogion bychain syn bwysig yn y gadwyn fwyd) mewn rhai ardaloedd yn agos at safler gorlif. Cofnodwyd marwolaethau deudroediaid a thiriadau molysgiaid yn dilyn gorlifoedd olew sylweddol eraill. Fe allai bod y defnydd o wasgarwyr, wrth wasgaru defnynnau olew yn ddwfn ir golofn , wedi cynyddur cysylltiad ag olew yn achos y rhywogaethau hynny syn byw mewn gwaddodion a chyfrannu at y tiriadau ar gostyngiad ym mhoblogaethau deudroediaid yn rhai ardaloedd.

4. Effeithiau ar y Traethlin

Lladdwyd niferoedd mawrion o lygaid meheryn ar draethau creigiog a oeliwyd yn drwm ger safler tirio, gydar marwolaethau yn 90% yn rhai rhannau o Fae Angle. Bu farw cregyn crib a gwichiaid hefyd, er mewn niferoedd llai. O ganlyniad i leihad mewn pori gan yr anifeiliaid hyn, bu tyfiant helaeth o algae (algae gwyrdd ar y cyfan) a rwystrodd larfae cregyn llong rhag sefydlu yn rhai safleoedd. Mae proses adferiad y llygaid meheryn a phoblogaethaur molysgiaid eraill wedi dechrau ond, o brofiad gorlifoedd blaenorol, mae adferiad llwyr yn debygol o gymryd sawl blwyddyn yn y safleoedd a effeithiwyd waethaf.

Roedd marwolaethau y deudroediaid yn ymestyn dros ardal eang ond roedd ail-wladychu sylweddol yn amlwg ym mwyafrif y safleoedd erbyn 1997. Mynegwyd pryder mawr ynglyn r effaith ar y sr clustog prin ym Mae Angle am fod y boblogaeth hon o gryn bwysigrwydd yn gadwraethol. Er gwaethaf marwolaethau a ostyngodd boblogaethau i niferoedd isel iawn, mae adferiad araf yn digwydd bellach. Nid oedd yn ymddangos bod unrhyw effaith ddifrifol arall ar gymdogaethau traethau creigiog na phyllau trai.

Maer effeithiau ar draethau gwaddodol yn gyffredinol yn llai hawdd iw canfod gan fod mwyafrif yr anifeiliaid yn guddiedig, ond roedd tiriadau nifer o rywogaethau dwygragenog yn amlwg wedir gorlif ac fe effeithiwyd poblogaethau deudroediaid. Manteisiodd rhai rhywogaethau oportiwnistaidd megis mwydod gwrychog ar gilfachau ecolegol gweigion a chynyddu mewn niferoedd dros dro, ond roedd tystiolaeth o adferiad y cydbwysedd blaenorol erbyn diwedd yr hydref 1996.


St David's Head
Ramsey Island
St Brides Bay
Haverfordwest
Skomer
Skokholm
Milford Haven
Milford Haven Waterway
St Ann's Head
West Angle Bay
Pembroke Dock
Pembroke
Saundersfoot
Pendine
Tenby
Carmarthen Bay
Linney Head
Castlemartin
Stackpole Head
St Govan's Head
Caldey Island
site of grounding
Pembrokeshire Coast National Park
limit of fisheries exclusion zone
SOUTH-WEST WALES

SEEEC Report Summary

1. Setting the Scene

On 15 February 1996 the *Sea Empress*, bringing crude oil to Milford Haven in south-west Wales, ran aground and over the following week released 72,000 tonnes of crude oil and 480 tonnes of fuel oil into the sea. Despite a rapid and effective clean-up response at sea, oil came ashore along 200 km of coastline much of it in a National Park in an area of international importance for its wildlife and natural beauty. A ban was imposed on commercial and recreational fishing in the region and there was concern that tourism, important to the local economy, would be badly affected by the heavily oiled beaches. Several thousand oiled birds washed ashore, leading to a major cleaning and rehabilitation operation.

This is a summary of the report on the spill prepared by the *Sea Empress* Environmental Evaluation Committee (SEEEC), an independent committee set up on 27 March 1996 by the UK Government with the terms of reference given below (*Box 1*).

The committees full report describes the impact the oil has had on the environment, both at sea and along the shore. It looks at the response to the spill the clean-up operation, the environmental monitoring programme and the cleaning of oiled birds and recommends changes in the arrangements for assessing and responding to future spills.

Over a period of 20 months, SEEEC brought together teams of experts and commissioned about 80 scientific studies involving government and public bodies, universities, voluntary organisations, research institutes and companies specialising in oil spill and ecological assessment. The results of these studies along with earlier research on the ecology of the area and work carried out by other organisations provided information for this report.

Box 1 SEEEC's terms of reference:

- To co-ordinate monitoring work carried out by government departments and other public bodies to assess the environmental impact of the Sea Empress oil spill and the subsequent clean-up activities.
- To ensure that a comprehensive set of monitoring data on environmental distributions and impacts is obtained, taking account of studies by other organisations and the need to avoid gaps and overlaps.
- Through these monitoring programmes, to assess the overall impact of the incident on environmental resources of the area affected, these resources to include fisheries, agriculture, amenity and wildlife conservation, and to assess the subsequent recovery of these resources. Information on the distribution of pollutants relevant to human health will be passed to public health authorities for assessment.
- To publish the principal findings and conclusions of these studies with the purpose of informing the Government, the public and those specific groups directly affected by the incident. Recommendations will be made where improvements in procedures or further actions are required, which might have wider application.

The accident itself and the salvage operation were investigated by the Marine Accident Investigation Branch of the Department of the Environment, Transport and the Regions (DETR) which published its report in July 1997. The Marine Pollution Control Unit (MPCU) produced a detailed account of the clean-up operation. Soon after the spill, Pembrokeshire County Council, supported by other public bodies, commissioned a study of its potential economic consequences. The effects of the spill on public health are being investigated by the Dyfed Powys Health authority and a report has been published.

Environmental monitoring work to assess the initial impact started soon after the grounding of the tanker, and SEEEC supplemented this work with a programme of longer-term studies. It was clearly impossible to cover every aspect of the ecology of the region, but all the main types of onshore and marine environments were included in the programme, focusing on key species that were:

- heavily impacted by the oil,
- indicative of the health of the environment,
- of conservation importance to the area,
- important in the marine food chain, or
- of economic value.

The eventual programme of projects proposed by SEEEC costing about 2 million was funded by the government and its agencies with support from local authorities, the European Commission (EC), voluntary organisations and industry.

South-west Wales is an area of great natural beauty and ecological interest. Around three quarters of the shoreline is made up of rocky cliffs, rock platforms, boulders and shingle, with most of the rest being mud and sand habitats, including some sandy beaches of high amenity value. In recognition of the regions environmental importance, many areas have been given special national or international status. Much of the coastline lies within the Pembrokeshire Coast National Park, and in the main area affected by the spill there are about 35 Sites of Special Scientific Interest, 2 National Nature Reserves (at Stackpole and Skomer) and, around Skomer, one of the UKs three Marine Nature Reserves. There are also EC designated Special Protection Areas for birds, and plans for three Special Areas of Conservation are proposed by the government.

The main towns in south-west Wales are Carmarthen (population 14,600), Milford Haven (13,600), Haverfordwest (13,000), Pembroke Dock (8,600) and Pembroke (7,200). The local economy faces problems from the closure of major industrial and defence establishments and from the decline of the oil-processing and agricultural sectors. Unemployment rates in Pembrokeshire are amongst the highest in Wales. The regions economy relies heavily on a few key industries, particularly oil, tourism, agriculture and fishing.

Tourism plays a vital role, with many visitors staying in the vicinity of Tenby and Saundersfoot. Opportunities for environmental education are offered by field studies centres. In 1995 tourists spent an estimated 160 million in Pembrokeshire.

The fishing industry is centred around the Milford Haven waterway. The region has abundant shellfish, crabs, lobsters, sea bass and other fish, and the local salmon and sea-trout rivers attract many visiting anglers. These fisheries provide an estimated 1,000 land- and sea-based jobs. Agriculture in the region includes early potatoes and vegetables, dairy and livestock farming.

The Milford Haven waterway has a long history as an oil port, developed during the 1950s for its deep waters and natural shelter features making it ideal for large tankers. Whilst it is the second busiest port in Britain for petroleum products, high transport costs from Pembrokeshire have lead to the oil refineries becoming less competitive in recent years.

2. Fate of the Oil

Over a period of seven days while the *Sea Empress* was grounded outside the entrance to Milford Haven waterway about 72,000 tonnes of light crude oil was released, mainly at low tide. About 250 tonnes of heavy fuel oil (used to power the ships engine) was also released at this time and probably mixed with the crude oil; a further 230 tonnes was released after the tanker had been towed to a jetty within the waterway.

While the tanker was grounded, the wind varied between a moderate breeze and a near gale and initially (15-17 February) the released oil was driven towards the Haven. From 18 to 22 February (a period during which about 90% of oil was released) the winds carried the oil south, away from the Pembrokeshire shoreline, allowing chemical dispersants to be used

to disperse the oil into deep water. On 23 February the wind veered to the south-west and over the next few days carried residual oil to the beaches of Carmarthen Bay, mainly from Tenby to Pendine.

Crude oil is a mixture of a very large number of different components. Tests at the spill showed that about 40% of the oil including many of the components that are toxic to marine life evaporated rapidly after release. For much of this period the winds were offshore. Oil vapour concentrations were measured continuously on shore, though these remained low, reaching a maximum of 9 parts per million (ppm). (It had been agreed that action, for example advising people to stay indoors, would be taken if concentrations rose above 50 ppm) A predictive model confirmed that concentrations of oil vapour over land would be low because of the generally favourable wind directions.

About 50% of the oil dispersed in the water column, due to natural mixing and the use of 446 tonnes of chemical dispersants sprayed onto the oil from aircraft. The dispersants enhanced the effectiveness of natural processes in causing the oil to form small droplets and mix into the water, substantially decreasing the amount of oil on the surface but increasing concentrations at depth. Oil remaining on the sea surface generally formed an emulsion (a stable mixture of about 70% water and 30% oil) which impeded the natural dispersion process, though monitoring from boats in the area where the dispersant was being sprayed confirmed the effectiveness of the chemical dispersants even on emulsion. In addition to the dispersant operation, around 1-2% of the oil was collected from the sea surface using recovery vessels.

Oil is a natural product and eventually most of it will have been broken down by micro-organisms in the water. By the end of March concentrations of oil in the water column were low (less than 100 g/l) and near to background levels over the affected area.

Extensive offshore surveys were conducted to determine if oil had combined with sediment particles and been deposited on the sea bed. No major concentrations of oil were found, except near to some shores where bulk oil had remained for long periods.

Oil came ashore along 200 km of coastline, with the worst hit areas within the Milford Haven waterway and along the south Pembrokeshire coast. Estimates suggested that between 3,700 and 5,300 tonnes of oil came ashore (5-7% of the total); this was reduced to about 500 tonnes by late summer as a result of a major shoreline clean-up operation and natural cleaning. Much of the oil remaining by the end of summer was buried below the surface.

3. Marine Impacts

As a precautionary measure, a ban on all fishing and the collection of edible plants and seaweeds was imposed shortly after the spill for an area stretching from St Davids Head to Port Eynon on the Gower (see map). Fishing for salmon and sea trout was also banned in the rivers flowing into this area. Samples of various species of fish, shellfish and crustaceans were analysed for oil content over the subsequent months, and the closure orders were lifted in stages as analysis showed that oil concentrations in different classes of organism had returned to background levels. Salmon and sea trout did not appear to have been affected and the ban on these was lifted on 3 May 1996, while that for other fish was lifted on 21 May 1996. The ban was lifted for crabs and lobsters outside the Milford Haven waterway and for whelks throughout the whole area on 29 August 1996, and over the following year the ban was progressively lifted in stages until all remaining restrictions were removed on 12 September 1997.

Whilst there was no clear evidence of damage to commercial stocks of fish, extended monitoring particularly of individuals reaching commercially-exploitable size will be required to determine whether breeding and recruitment of some species (including bass, edible crabs, lobsters and whelks) was successful after the spill in 1996.

The catch rate in the Tywi of sea trout though not of salmon decreased in 1996, but further analysis of catch data from other rivers is required before this decrease can be attributed to the spill.

In the weeks following the spill large numbers of dead or moribund animals were washed ashore mostly bivalve molluscs (such as cockles and razor shells) and sediment-dwelling animals of the lower shore and below the shoreline. This phenomenon can happen naturally with some species, but the timing, number of individuals, range of species and in some cases increased levels of tissue hydrocarbons suggested that most of the strandings were related to exposure to the oil. Studies of the seabed showed little impact resulting from the spill except for the absence of amphipods (small crustaceans which are important in the food chain) in some areas near to the site of the spill. The death of amphipods and the stranding

of molluscs have both been recorded following other major oil spills. The use of dispersants, in distributing oil droplets deep into the water column, may have increased the exposure to oil of those species living in sediments and contributed to the strandings and the decrease in amphipod populations in some areas.

4. Shoreline Impacts

Large numbers of limpets were killed on heavily-oiled rocky shores near to the grounding site, with 90% mortality recorded in some parts of West Angle Bay. Topshells and periwinkles also died, though in lower numbers. As a result of reduced grazing by these animals, there was an extensive growth of algae (mostly green algae) which prevented the settlement of barnacle larvae at some sites. The recovery process of limpet and other mollusc populations has started but, from experience with previous spills, complete recovery is likely to take several years at the worst-affected sites.

Amphipod mortalities were extensive but substantial recolonisation was evident at most sites by 1997. Great concern was expressed about the impact on the rare cushion star (*Asterina phylactica*) at West Angle Bay as this population is of considerable conservation importance. Despite mortalities which reduced the populations to a very low number, a slow recovery is now under way. There did not appear to be any other serious impact on rocky shore or rock pool communities.

Impacts on sedimentary shores are generally less easy to discern as most animals are hidden, but strandings of several bivalve species were evident after the spill and amphipod populations were affected. Some opportunistic species such as polychaete worms exploited vacant ecological niches and temporarily increased in numbers, but there was evidence of a restoration of the former balance by the late autumn of 1996.

5. Tyfiant Morol ac Amaethyddiaeth

Cyn pen 10 diwrnod wedir gorlif gwreiddiol roedd samplau glaswellt a gymerwyd o safleoedd arfordirol a mewndirol wedi dangos lefelau dyrchafedig o HAP*, y crynodiadau uchaf ar arfordiroedd noeth o Benrhyn y Santes Ann i Gastellmartin. Mewn samplau pellach, a gymerwyd 10 diwrnod yn ddiweddarach mewn safleoedd detholedig, roedd y crynodiadau wedi gostwng 40% ar gyfartaledd. Mewn gwrthgyferbyniad, lefelau HAP isel oedd mewn samplau blodfresych a gymerwyd ger yr arfordir 9 diwrnod wedir gorlif. Roedd dadansoddiad o samplau meinwe o bori defaid yn yr ardal arfordirol yn dangos bod lefelau hydrocarbon yn normal. Dywedodd Adran Diogelwch Bwyd MAFF nad oedd y gorlif olew wedi peri unrhyw berygl ir gadwyn fwyd ddynol o fwyta cynnyrch amaethyddol.

Ni chanfuwyd unrhyw effaith ar blanhigion prin y mr-glogwyni nac ar gennau morol heblaw am y rhai a drochwyd ag olew hylif, ac ychydig iawn o ddifrod a welwyd i lystyfiant naturiol uwchlawr gylchfa trochion. Derbyniodd rhai morfeydd heli yn nyfrffordd Milffwrd gyflenwadau mawrion o olew ond roedd tystiolaeth o ddifrod wedi ei gyfyngu i rywfaint o farwn-l yn achos llygwyn ariannaidd a brwyn morfa heli. Fodd bynnag, fel fydd rhaglen monitorio cyson yn asesur effeithiau tymor-hir ar ddau blanhigyn syn genedlaethol brin, y llyrlys a lafant y mr llac-flodeuog. Mae dyfrffordd Milffwrd yn cynnal poblogaethau pwysig o wellt y gamlas culddail syn genedlaethol brin, y gwyddys ei fod yn fregus yn wyneb olew a gwasgarwyr. Er yr oelio ar safleoedd lle ceir gwellt y gamlas, nid oedd unrhyw effaith yn amlwg ar wahan i beth difrod cyfyngedig a achoswyd gan gerbydau glanhau.

6. Mamaliaid

Yn yr ardal a effeithiwyd gan olew, roedd mamaliaid a oedd yn ddichonol fregus yn cynnwys morloi llwydion, morfilod (yn enwedig llamidyddion harbwr a dolffiniaid trwynbwl), dwrgwn, a ystlumod pedol mawr yn gaeafu mewn ogofau arfordirol. Fodd bynnag, ni chofnodwyd unrhyw effaith gan y gorlif olew ar y mamaliaid hyn.

7. Adar

Mae de-orllewin Cymru yn cynnal tua hanner miliwn adar mr syn bridio, gan gynnwys poblogaethau o fulfrain gwynion o bwysigrwydd rhyngwladol, palod Manaw, gweilch y penwaig, pedrynod drycin a phalod.

Cafodd tua 7,000 o adar oeliog eu golchi ir lan yn dilyn y gorlif (er maen debygol fod cyfanswm nifer yr adar a laddwyd lawer iawn yn uwch na hyn). Awgrymodd archwiliad o gyrff adar mr fod y mwyafrif wedi marw yn uniongyrchol o halogiad olew yn hytrach na, er enghraifft, effeithiau cadwyn fwyd. Roedd 90% or adar oeliog yn perthyn i dair rhywogaeth mr-hwyaid duon, heligogod a gweilch y penwaig. Gwelwyd bod y rhywogaethau plymio a oedd yn gaeafu yn yr ardal hefyd yn fregus, gyda chyfran helaeth yn oeliog ac wedi eu golchi ir lan. Mewn gwrthgyferbyniad, ac er gwaethaf digonedd eu niferoedd, ychydig iawn o wylanod a ddarganfuwyd ar y traethau. Cadarnhaodd yr effaith ar heligogod a gweilch y penwaig gan gyfrifau or poblogaethau bridio. Roedd 13% yn llai o heligogod a 7% yn llai o weilch y penwaig a gyfrifwyd yn nythfeydd bridio yn yr ardal yn 1996 oi gymharu 1995, tra bod niferoedd y ddwy rywogaeth wedi cynyddu mewn nythfeydd cyfagos. Erbyn tymor bridio 1997, roedd y niferoedd wedi gwellan sylweddol.

Roedd rhai rhywogaethau, yn enwedig palod, palod Manaw ac adar drycin, heb ddychwelyd ir ardal i fridio ac felly wedi osgoi effaith sylweddol. Ni effeithiwyd y mulfrain gwynion gan nad oedd yr olew wedi cyrraedd y nythfa ar Ynys Gwales, y trydydd o ran maint yn y byd. Maer asesiad or effeithiau ar sawl rhywogaeth arall, gan gynnwys y mulfrain gwyrdd, yn para yn amwys oherwydd yn rhai achosion nid oedd y lleihad mewn cyfrifau yn 1966 wedi ei gyfyngu ir ardal a effeithiwyd.

Cafodd y gorlif olew effaith sylweddol ar y boblogaeth o fr-hwyaid duon a oedd yn gaeafu ym Mae Caerfyrddin a gwyddys

i 3,500 farw. Mae cyfrifau 1996 yn dangos bod tua 10,000 yn llai o adar yn ymweld Bae Caerfyrddin nag uchafbwynt 1996 (er fe allai fod ffactorau eraill yn ymglymedig gan fod niferoedd yn amrywio o flwyddyn i flwyddyn). Mae cynlluniau ar y gweill i fonitorior boblogaeth yn gyson hyd at 2001 er bod angen yn ogystal ymchwil fwy sylfaenol i ecoleg mr-hwyaid duon.

Awgrymodd astudiaeth o adar yn nyfrffordd Milffwrd mai bach iawn o effaith a gafodd yr olew os o gwbl.

8. Glanhau Adar ac Adferiad

Cyd-drefnodd y RSPCA ymgyrch glanhau adar a oedd yn cynnwys llawer o fudiadau lles anifeiliaid eraill. Sefydlwyd canolfan argyfwng ger Milffwrd lle derbyniwyd 3,100 o adar oeliog o 20 rhywogaeth wahanol, y mwyafrif ohonynt rhwng 24 Chwefror a 2 Mawrth. Pan oeddynt yn abl i deithio, cymerwyd yr adar i gyfleusterau glanhau lleol a chenedlaethol gan gynnwys ysbyty bywyd gwyllt y GFACA yn West Hatch, Gwlad yr Haf lle triniwyd 2,300 o adar. O gofio anferthedd yr ymarferiad, bu casglur adar, cymorth cyntaf a thrafnidiaeth yn gweithion dda ond ar adegau roedd nifer yr adar ymhell y tu hwnt ir gallu glanhau a oedd ar gael.

Er mor ddymunol y byddai hynny, nid oedd yn bosibl rhyddhau adar gln ger y lleoliad y casglwyd hwy ohono oherwydd y llygredd olew parhaol, ac fe rhyddhawyd y mwyafrif mewn safleoedd addas ger y canolfannau glanhau, megis Bae Lyme, Y Wash a Bae Lerpwl. Goroeswyd y broses lanhau gan tua 60% or adar a anfonwyd ir canolfannau glanhau ac feu rhyddhawyd, ond roedd llwyddiant yn amrywio rhwng rhywogaethau roedd yr elyrch dof yn hydwyth, ond graddfa goroesiad isel iawn oedd i adar megis y trochyddion gyddf-goch yn ystod y glanhau.

Cafodd tua 1,000 o adar yn perthyn i 18 rhywogaeth eu modrwyo cyn cael eu rhyddhau. Y 750 o mr-hwyaid duon a fodrwywyd ywr nifer mwyaf erioed ym Mhrydain ac Iwerddon iw nodin unigol. Rhoddwyd modrwyau lliw i rai heligogod er mwyn cynorthwyo adnabyddiaeth mewn nythfeydd bridio dan arsylliad.

Mae gwaith diweddar yn UDA wedi dangos bod sawl rhywogaeth o adar (gan gynnwys heligogod, gwyachod y gorllewin, mr-hwyaid melfedog a mr-hwyaid yr ewyn) graddfa goroesiad isel iawn yn dilyn glanhau a rhyddhau. Comisiynwyd astudiaeth gan BGASE i ddadansoddi data blaenorol ar heligogod y rhywogaeth fwyaf cyffredin a oeliwyd o amgylch y DG. Dangosodd hyn fod mwy na 70% or adar a lanhawyd wedi marw cyn pen 14 diwrnod wedi eu rhyddhau a dim ond 3% a oroesodd am dau fis. Nid oes data goroesiad cyffelyb ar gael ar gyfer rhywogaethau eraill. Maer canlyniadau yn dangos nad oes cyfiawnhad cadwraethol dros lanhau a chodir y cwestiwn pun ai, yn achos heligogod, a ywn well, o safbwynt lles anifeiliaid, iw darostwng i straen y broses lanhau a marwolaeth gynnar debygol wrth eu dychwelyd ir gwyllt ynteu eu lladd yn drugarog wedi eu casglu. Maen bwysig darganfod mwy ynghylch lefel y straen a ddioddefir gan yr adar yn ystod y glanhau, ar ffactorau allweddol syn penderfynu pa adar syn goroesir broses lanhau a rhyddhau.

Gwnaed astudiaeth bellach i adolygur holl waith casglu a glanhau yn dilyn gorlif y *Sea Empress* a gwnaed argymhellion am newidiadau ir trefniadau cyfredol.

9. Hamdden ac Archeoleg

Cafodd y gorlif olew effaith ar werth hamdden yr ardal mewn sawl ffordd. Roedd olew yn weladwy ar y traethau ac yn y mr ac roedd ei sawr yn annymunol. Roedd pryderon gan y cyhoedd ynglyn ag ansawdd nofio ar ddechraur tymor nofio. Caewyd rhannau o lwybr yr arfordir (trywydd cenedlaethol) am resymau diogelwch yn ystod y gweithgareddau glanhau; cynghorwyd dringwyr yn erbyn defnyddio dwy or ardaloedd gorau yn Sir Benfro. Fodd bynnag, symudwyd olew swmp or traethau twristaidd erbyn tymor gwyliaur Pasg, ac erbyn diwedd Mai datganwyd bod y dyfroedd nofio yn ddiogel.

Nid oes llawer o ddulliau ar gael ar gyfer asesiad gwrthrychol o effaith esthetig olew, i olrhain adferiad tymor-hir, ac i ddarparu meini prawf ar gyfer penderfynu pryd y dylid dod r glanhau i ben. Yn dilyn y gorlif datblygwyd methodoleg ar gyfer graddio effaith esthetig olew; dangoswyd bod hyn yn sensitif i newidiadau mewn oelio, ond mae angen gwaith pellach i raddnodi a phrofir gweithdrefnau ac i ddiffinio safonau derbynioldeb.

Mae pysgota eog a brithyll mr yn economaidd bwysig yn y rhanbarth. Er nad oedd tystiolaeth o ddifrod i stociau, roedd adwaith pysgotwyr yn anffafriol, gyda llai o ymweliadau a thrwyddedau yn cael eu gwerthu.

Roedd arolwg o ymwelwyr yn ystod haf 1996 wedi dangos er eu bod yn ymwybodol or gorlif, nid oedd hyn wedi effeithio eu penderfyniadau gwyliau nau gweithgareddau gwyliau gan gynnwys defnydd traethau. Er hynny, roedd gwerthfawrogiad eang or effeithiau sylweddol ar fywyd gwyllt ar amgylchedd naturiol.

Roedd dadansoddiad or effaith ar dwristiaeth yn Sir Benfro drwyddi draw yn awgrymu bod cwymp o tua 2 filiwn yn y sector gwasanaeth masnachol yn 1996 oi osod yn erbyn amcangyfrif o 160 miliwn a gyfrannwyd gan dwristiaid yn 1995. Er y boddhad gydag ansawdd yr amgylchedd ymhlith y rheiny a oedd yn ymweld r ardal, roedd tystiolaeth o holiaduron pellach yn dangos yn achos un o bob pump a oedd yn ystyried ymweld Sir Benfro yn 1996 fod gorlif y *Sea Empress* yn arwyddocaol wrth arwain at wrthodiad.

Mae gan arfordir Sir Benfro safleoedd archeoleg morol pwysig. Daeth astudiaeth wedir gorlif ir casgliad nad oedd fawr ddim o dystiolaeth o halogiad olew (ar wahan i beth staentio o longddrylliad HMS Tormentor) neu o ddifrod a achoswyd gan y gweithgareddau glanhau.

10. Y Glanhau

Roedd gweithgareddau glanhau y *Sea Empress* yn gynhwysfawr ac effeithiol. Roeddynt yn cynnwys ar y mr: chwistrellu gwasgarwyr, adfer mecanyddol, defnyddio rhwystrau amddiffynnol; ac ar y lan: adfer mecanyddol, torri ffosydd, golchi traethau, a defnyddio gwasgarwyr ac amsugnwyr. Yn eithaf yr ymateb roedd mwy na 50 o longau, 19 o awyrennau a 25 o fudiadau yn uniongyrchol ymglymedig gyda 250 o staff yn gweithio ar yr ymateb ar y mr a 950 yn gweithio ar y draethlin. Roedd tm bach yn glanhaur draethlin yn dal i weithio 18 mis wedir gorlif. Cyfanswm y gost oedd tua 23m.

Defnyddiwyd gwyliadwriaeth awyrol, synhwyro pell ac arolygon tir i leoli olew arwyneb; rhagfynegwyd symudiadau olew, ar yr wyneb ac yn y golofn , gan ddefnyddio model cyfrifiadurol a ddarparwyd gwybodaeth am symudiadau gwynt a cherrynt. Gwnaed y synhwyro pell or olew a ollyngwyd or *Sea Empress* yn bennaf o awyrennau. Awgrymodd adolygiad o ddefnydd lloerennau na fydd systemau lloeren-seiliedig a ffurfiau eraill o ddelweddaeth loeren yn disodli defnydd synhwyro pell o awyrennau yn y dyfodol agos.

Gollyngwyd mwyafrif yr olew rhwng 18 a 21 Chwefror ar adeg pan oedd gwyntoedd gogleddol yn chwythur olew i ffwrdd or arfordir. Mewn ymgyrch sylweddol, chwistrellwyd tua 440 tunnell fetrig o wasgarwyr (yn bennaf ar olew o fewn ychydig oriau or adeg y gollyngwyd ef) gan awyrennau. Roedd samplu a wnaed o gychod or o dan yr olew arwyneb yn cadarnhau effeithiolrwydd yr ymgyrch. Yn achos olew newydd ei ollwng, maen debyg fod gwasgarwyr yn treblur raddfa gwasgaru naturiol ac yn cynyddu swm yr olew a wasgarwyd o tua 18,000 tunnell fetrig, gyda phob tunnell fetrig o wasgarwyr yn peri bod tua 40 tunnell fetrig o olew yn cael ei gwasgaru. Roedd y gwasgaru gwell hwn wedi lleihau yn sylweddol ffurfiant emylsiwn arwyneb ac o ganlyniad wedi lleihau swm yr olew a oedd ar gael i ddod ir lan.

Roedd ffigurau cymharol ar gyfer cost-effeithiolrwydd agweddau gwahanol yr ymgyrch glanhau yn anodd iw cadarnhau oherwydd trefniadau prisio gwahanol. Mae amcangyfrifon arwyddol yn awgrymu, fodd bynnag, fod costaur ymgyrch gwasgaru yn gywerth 40-65 y dunnell fetrig o olew a wasgarwyd oi gymharu 2,000 y dunnell fetrig am olew a symudwyd trwy adfer mecanyddol ar y mr a 9,000 y dunnell fetrig am lanhaur draethlin.

Mae gwasgarwyr yn peri ir olew gymysgu r , gan leihaur swm ar yr wyneb (ac syn gallu dod ir lan) ond gan gynyddu amlygiad i olew organebau yn y ac ar welyr mr. Heb ddefnydd gwasgarwyr, gallasai marwolaethau adar fod yn uwch ac effeithiau ar y traethlin yn fwy, ac maen debyg y buasai trafferthion mawr wrth lanhaur traethlin. Ar y llaw arall, gallasai crynodiadau ar welyr mr achosi marwolaethau rhai dwygragenogion a deudroediaid. Rhaid i benderfyniadau ynglyn defnydd gwasgarwyr gymryd i ystyriaeth yr amrywiaeth llawn o adnoddau amgylcheddol a effeithir er mwyn penderfynu a fydd budd amgylcheddol net yn debygol o ddeillio ou defnyddio.

Cyfyngwyd ar adfer mecanyddol ar y mr gan y gwyntoedd cryfion cyffredinol, heblaw am gyfnod byr ddiwedd Chwefror a dechrau Mawrth, ac ar y cyfan dim ond rhwng 1% a 2% or olew a orlifodd a adferwyd. Petai llongau adfer arbenigol mawrion wedi bod ar gael ar unwaith amcangyfrifir y gallasair canran hwn ddim codi i fwyafswm uwch na 5%.

Defnyddiwyd rhwystrau i geisio amddiffyn rhai ddarnau sensitif or arfordir rhag olew a oedd yn dod i mewn ond roeddent yn effeithiol mewn ardaloedd cysgodol yn unig. Roedd ardaloedd priodol wedi eu dynodi yng nghynllun cyfwng Cyngor Sir Dyfed ar gyfer gorlif olew lleol.

Amcangyfrifir bod tua 11,000 i 16,000 tunnell fetrig o emylsiwn (cywerth thua 3,700 i 5,300 tunnell fetrig o olew) wedi dod ir lan ar hyd 200 cm o arfordir. Yr ardaloedd a effeithiwyd waethaf oedd Bae Gorllewin Angle i Benrhyn Linney, Bae Caerfyrddin gorllewinol a thraeth deheuol dyfrffordd Milffwrd. Y blaenoriaethau dechreuol oedd i lanhau olew swmp o safleoedd hygyrch a thraethau twristaidd megis Dinbych y Pysgod a Saundersfoot ar gyfer gwyl y Pasg. Defnyddiwyd amrywiaeth eang o dechnegau ar gyfer glanhau swmp a gweddilliol ac ychydig iawn o enghreifftiau o ddefnydd amhriodol a gafwyd. Defnyddiwyd tua 12 tunnell fetrig o wasgarwyr i symud olew hindreuliedig oddi ar wyneb creigiau cyfagos at draethau amwynderol. Roedd oedi rhag glanhau rhai safleoedd a oeliwyd yn drwm oherwydd diffyg hygyrchedd y tir (ee Hafan Skrinkle) wedi peri problemau cylchol yn rhai lleoedd o achos ail-ymddangosiad olew a gladdwyd mewn gwaddod.

Cynhaliwyd arbrofion er mwyn cymharu adferiad traethau tywod a lanhawyd rhai nas glanhawyd ac i brofi gwerth ychwanegu maetholion at draethau oeliog i wella ymddatodiad naturiol olew gan ficro-organebau (bioadferiad). Wedi tua 16 mis roedd y traethau a adawyd heb eu glanhau wedi adfer i raddfa gyffelyb ir rheiny a lanhawyd. Roedd yn ymddangos bod bioadferiad wedi cyflymu ymddatodiad yr olew heb ganlyniadau andwyol (hyd nes ir safle brawf gael ei dinistrio mewn storm) ond ni phrofwyd ei gost-effeithiolrwydd.

Cynhyrchodd yr ymgyrch glanhau ar y tir swm mawr o wastraff oeliog ac roedd ei waredu yn achos problem sylweddol yn weithredol ac yn gyfreithiol. Yn ffodus triniwyd y mwyafrif ar y fferm ar dir Texaco ond rhaid oedd cludo rhywfaint ohono 160 cm i safle claddu sbwriel. Nid yw trefniadau trwyddedu cyfredol yn mynd ir afael r angen am lecynnau dal dros dro a safleoedd gwaredu parhaol, problem y mae angen ymgodymu hi ar fyrder.

Ar y cyfan mae Cynllun Cyfwng Cenedlaethol y DG ar gyfer delio gorlifoedd olew morol yn gadarn, ac yntau wedi ei adolygu yn dilyn digwyddiad y *Braer* yn 1993. Roedd cyflymder yr ymateb i orlif y *Sea Empress*, ynghyd r cydweithrediad rhwng cyfranogwyr lleol, yn darparu tystiolaeth i ymarferoldeb y Cynllun. Roedd adnoddau digonol ar gyfer defnydd awyrol gwasgarwyr ac adferiad olew ar y mr yn ogystal ag ar gyfer glanhaur draethlin. Ar y cyfan roedd yr ymgyrch wedi ei reolin dda. Fodd bynnag, argymhellir nifer o welliannau gan gynnwys:

- egluro swyddogaethau, a chynnwys Rheolwr Cyffredinol y MPCU ar leoliad y digwyddiad;
- sawl agwedd ar drefniadaeth y Canolfan Ymateb ar y Cyd;
- dewis a hyfforddi traethfeistri a gweithwyr;
- iechyd a diogelwch y rheiny syn ymglymedig glanhaur traethlin;
- cyswllt r cyfryngau.

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*Hydrocarbonau aromutig polysiclig - cytansoddyn pwysig mewn olew

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5. Maritime Vegetation and Agriculture

Within 10 days of the original spill grass samples taken from coastal and inland sites showed elevated PAH* levels, the highest concentrations being on exposed coasts from St Anns Head to Castlemartin. In further samples, taken 10 days later at selected sites, concentrations had fallen by an average of 40%. In contrast, cauliflower samples taken near the coast 9 days after the spill had only low PAH levels. Analysis of tissue samples from sheep grazing in the coastal area showed hydrocarbon levels to be normal. MAFFs Food Safety Directorate advised that the oil spill had resulted in no risk to the human food chain from the consumption of agricultural produce.

No impact was detected on the rare plants of the sea-cliffs or on maritime lichens except where splashed by liquid oil, and very little damage was observed to natural vegetation above below the splash zone. Some saltmarshes in Milford Haven waterway received large quantities of oil but evidence of damage was limited to some initial die-back of sea purslane and saltmarsh rush. However, a continuing monitoring programme will assess the longer-term effects on two nationally scarce plants, the glasswort and the lax-flowered sea-lavender. Milford Haven waterway supports important populations of the nationally scarce narrow-leaved eelgrass, known to be vulnerable to oil and dispersants. Despite oiling at sites where eelgrass occurs, no impact was apparent apart from some limited damage caused by clean-up vehicles.

6. Mammals

In the area affected by oil, potentially vulnerable mammals included grey seals, cetaceans (particularly harbour porpoises and bottlenose dolphins), otters, and greater horseshoe bats hibernating in coastal caves. However, no impact of the oil spill on these sea mammals was recorded.

7. Birds

South-west Wales supports about half a million breeding seabirds, including internationally- important populations of gannets, Manx shearwaters, razorbills, storm petrels and puffins.

Around 7,000 oiled birds were washed ashore following the spill (though it is likely that the total number of birds killed was several times higher than this). Examination of seabird corpses suggested that most died directly from oil contamination rather than, for example, food chain effects. Over 90% of the oiled birds were of three species common scoter, guillemot and razorbill. Diver species wintering in the area also proved vulnerable, with a high proportion oiled and washed ashore. In contrast, and despite their abundance, very few dead gulls were found on beaches. Counts of the breeding populations confirmed the impact on guillemots and razorbills. There were 13% fewer guillemots and 7% fewer razorbills counted at breeding colonies in the area in 1996 compared with 1995, while numbers for both species increased at nearby colonies. By the 1997 breeding season, numbers had recovered significantly.

Some species, particularly puffins, Manx shearwaters and storm petrels, had not returned to the area to breed and so avoided significant impact. Gannets were not affected as the oil did not reach the important nesting colony on Grassholm Island, the third largest in the world. The assessment of the effects on several other species, including the shag, remain equivocal as in some cases decreases in counts in 1996 were not restricted to the affected area.

The oil spill had a significant impact on the wintering population of common scoters in Carmarthen Bay and 3,500 are known to have died. 1997 counts showed about 10,000 fewer birds visiting Carmarthen Bay than the 1996 peak (though factors other than the oil spill may have been involved as numbers generally fluctuate from year to year). Continued monitoring of the population until 2001 is planned although more fundamental research on scoter ecology is also needed.

A study of waterfowl in Milford Haven waterway suggested the oil had had little or no effect.

8. Bird Cleaning and Rehabilitation

The RSPCA co-ordinated a bird cleaning operation which included many other animal welfare organisations. An emergency centre was set up near Milford Haven at which 3,100 oiled birds of 20 different species were received, most of them between 24 February and 2 March. When fit to travel, birds were taken to local and national cleaning facilities including the RSPCA wildlife hospital at West Hatch, Somerset where 2,300 birds were treated. Given the enormity of the exercise, the collection of birds, first aid and transportation worked well but at times the sheer number of birds exceeded the available cleaning capacity.

It was not possible, however desirable, to release clean birds near the location where they were collected because of continued oil pollution, and most were released at suitable sites near to the cleaning centres, such as Lyme Bay, The Wash and Liverpool Bay. About 60% of the birds sent to cleaning centres survived the cleaning process and were released, but success varied greatly between species the mute swan being resilient, but birds such as the red-throated diver having a very poor survival rate during cleaning.

About 1000 birds of 18 species were ringed before release. The 750 scoters ringed is the largest number in Britain and Ireland ever individually marked. Some guillemots were given coloured rings to aid identification at breeding colonies under observation.

Recent work in the USA has shown that several bird species (including guillemots, western grebes, and velvet and surf scoters) have very poor survival rates following cleaning and release. A study was commissioned by SEEEC to analyse previous data on guillemots the most common species oiled around the UK. This showed that more than 70% of the cleaned birds died within 14 days of release and only 3% survived for two months. Similar survival data are not available for other species. These results show that there is no conservation case for cleaning and call into question whether, for guillemots, it is better, from an animal welfare viewpoint, to subject them to the stress of the cleaning process and probable early death when returned to the wild or to kill them humanely after collection. It is important to find out more about the level of stress suffered by birds during cleaning, and the key factors which determine which birds survive the cleaning and release process.

A further study reviewed the whole collection and cleaning operation following the *Sea Empress* spill and made recommendations for changes to current arrangements.

9. Amenity and Archaeology

The oil spill affected the amenity value of the area in several ways. Oil was visible on the beaches and in the sea and its smell was unpleasant. There were public concerns about bathing water quality at the start of the bathing season. Parts of the coast path (a national trail) were closed for safety reasons during clean-up operations; climbers were advised against using two of the best areas in Pembrokeshire. However, bulk oil was removed from the tourist beaches by the Easter holiday period, and by late May bathing waters had been declared safe.

Few methods exist for the objective assessment of the aesthetic impact of oil, for tracking long term recovery, and for providing criteria for deciding when clean-up should end. A methodology for scoring the aesthetic impact of oil was developed following the spill; this proved to be sensitive to changes in oiling, but further work is required to calibrate and test the procedures and to define standards of acceptability.

Salmon and sea-trout fishing is economically important in the region. Although there was no evidence of damage to stocks, the reaction of anglers was adverse, with fewer visits and licences sold.

A survey of visitors during the summer of 1996 showed that whilst they were aware of the spill, this had not affected their holiday decisions or pattern of holiday activities including the use of the beaches. Nevertheless, there was a wide appreciation of the substantial effects on wildlife and the natural environment.

An analysis of the impact on tourism throughout Pembrokeshire suggested a downturn of about 2 million in the commercial service sector in 1996 set against an estimated 160 million contributed by tourists to the economy in 1995. Despite satisfaction with the quality of the environment by those visiting the area, there was evidence from further questionnaires that for one in five who actually considered visiting Pembrokeshire in 1996, the *Sea Empress* spill was significant in leading to rejection.

The Pembrokeshire coast has important marine archaeology sites. A post-spill study concluded that there was little evidence of oil contamination (apart from some staining of the wreck of *HMS Tormentor*) or of damage caused by clean-up activities.

10. Clean-up

The *Sea Empress* clean-up operations were wide ranging and effective. At sea these included dispersant spraying, mechanical recovery, and the use of protective booms; and on shore, mechanical recovery, trenching, beach washing, and the use of dispersants and sorbents. At the height of the response more than 50 vessels, 19 aircraft and 25 organisations were directly involved with 250 staff working on the response at sea and 950 working on the shoreline. A small shoreline clean-up team was still working 18 months after the spill. The total cost was approximately 23m.

Aerial surveillance, remote sensing and ground surveys were used to locate surface oil. Movements of oil, on the surface and in the water column, were predicted using a computer model provided with information of wind and current movements. Remote sensing of the oil discharged from *Sea Empress* was principally from aircraft. A review of the use of satellites suggested that current satellite-based radar systems and other forms of satellite imagery will not replace the use of remote sensing from aircraft in the near future.

Most of the oil was released between 18 and 21 February at a time when northerly winds blew the oil away from the coast. In a major dispersant operation, about 440 tonnes of dispersants were sprayed (mainly on oil within a few hours of its release) by aircraft. Direct sampling from boats of water beneath the surface oil confirmed the effectiveness of the operation. With freshly spilled oil, dispersants trebled the rate of natural dispersion and increased the amount of oil dispersed at least 18,000 tonnes, with each tonne of dispersant resulting in about 40 tonnes of oil being dispersed. This enhanced dispersion greatly reduced the formation of surface emulsion and consequently greatly reduced the quantity of oil available to come ashore.

Comparable figures for the cost-effectiveness of different aspects of the clean-up operation were difficult to establish due to different charging arrangements. Indicative estimates suggest, however, that the costs of the dispersant operation were equivalent to 40-65 per tonne of oil dispersed compared with 2,000 per tonne of oil removed through mechanical recovery at sea and 9,000 per tonne for shoreline clean-up.

Dispersants result in the oil mixing into the water, reducing the quantity on the surface (and so able to come ashore) but increasing the exposure to oil of organisms in the water and on the sea bed. Without dispersant use, bird mortalities might have been higher and shoreline impacts greater, and there would probably have been major shoreline clean-up difficulties. On the other hand, higher oil concentrations at the sea bed may have caused mortalities of some bivalves and amphipods. Decisions about dispersant use must take into account the full range of environmental resources affected in order to determine if a net environmental benefit is likely to result from their use.

Mechanical recovery at sea was limited by the generally high winds, except for a short period at the end of February and beginning of March, and overall only 1-2% of the oil spilled was recovered. If large specialised recovery vessels had been immediately available it is estimated that this percentage could only have increased to a maximum of 5%.

Booms were used to protect some sensitive stretches of coast from incoming oil but were only effective in sheltered areas. Suitable areas had been identified in Dyfed County Councils local oil spill contingency plan.

Around 11,000 to 16,000 tonnes of emulsion (equivalent to about 3,700 to 5,300 tonnes of oil) is estimated to have come ashore along 200 km of coastline. The worst affected areas were West Angle Bay to Linney Head, western Carmarthen Bay and the southern shore of Milford Haven waterway. Initial priorities were to clean bulk oil from accessible sites and tourist beaches such as Tenby and Saundersfoot for the Easter holiday. A wide variety of techniques were employed for bulk and residual cleaning and there were only a few examples of inappropriate use. About 12 tonnes of dispersant were used to remove weathered oil from rock faces adjacent to amenity beaches. Delaying clean-up on some heavily oiled sites because

of poor land accessibility (eg Skrinkle Haven) caused recurrent problems afterwards at some locations through the reappearance of oil buried in near-shore sediment.

Experiments were carried out to compare the recovery of cleaned and uncleaned sandy beaches and to test the value of adding nutrients to oiled beaches to enhance the natural breakdown of oil by micro-organisms (bioremediation). After about 16 months the left-alone sandy beaches had recovered to a similar degree to those which had been cleaned. Bioremediation appeared to accelerated the breakdown of oil without adverse consequences (until the test site was destroyed in a storm).

The clean-up operation on land generated a large amount of waste and its disposal presented a major problem both operationally and legally. Fortunately most was treated at the Texaco land farm but some had to be transported 160 km to a landfill site. Current licensing arrangements for waste disposal do not address the need for temporary holding areas or permanent disposal sites, a problem which needs to be tackled urgently.

The UK National Contingency Plan for dealing with marine oil spills is generally sound, having been revised after the *Braer* incident in 1993. The speed of the response to the *Sea Empress* spill, as well as the co-operation between local participants, provided evidence of the Plans practicality. There were adequate resources for aerial application of dispersants and recovery of oil at sea as well as for shoreline clean-up. The operation was generally well managed. However, several improvements are recommended including:

- clarification of roles, and the involvement of the MPCU Overall Commander at the scene of an incident;
- aspects of organisation of the Joint Response Centre;
- selection and training of the beachmasters and workers;
- health and safety of those involved in shoreline clean-up;
- liaison with the media.

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*Polyoyclic aromatic hydrocarbons - an important constiuent of oil

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Casgliadau ac Argymhellion

(Ail-cynhyrchwyd yn llawn o adroddiad PGSEA)

11.1 Rhagarweiniad

Wedi adolygur gwaith a gomisiynwyd gan PGASE i asesu effaith amgylcheddol y gorlif olew ac effeithiolrwydd yr ymgyrch glanhau, erys y gwaith o ddwyn at ei gilydd brif gasgliadaur pwyllgor, a gofnodwyd yn fanwl yn y penodau blaenorol, ac i wneud argymhellion gan cynnwys lle yr ystyrir y gellir gwneud gwelliannau trefniadol y gallai gael defnydd mwy eang.

11.2 Casgliadau

11.2.1 Effeithiau ac adferiad

Roedd y prif effeithiau amgylcheddol yn cynnwys:

- Cafodd niferoedd mawrion o organebau morol (ee llygaid meheryn a chregyn llong) eu lladd un ai pan oedd olew ffres yn dod ir lan neu pan oedd lefelau uwch o hydrocarbonau yn y golofn yn effeithio molysgiaid dwygragennog a rhywogaethau eraill syn trigo yn y gwaddod.

- Diflannodd poblogaethau o ddeudroediaid (cramenogion bychain) o rai ardaloedd ac feu disbyddwyd yn ddifrifol mewn mannau eraill, at y tir ac ar welyr mr ger safler tirio.

- Sawl mil o adar oeliog, llawer eisoes yn farw, wedi eu golchi ir lan, gyda chyfanswm yr adar a laddwyd yn debygol o fod yn uwch o lawer na hyn. Yr effaith fwyaf oedd ar adar syn treulio llawer ou hamser ar wyneb y , yn enwedig y mr-hwyaid duon, rhywogaethau trochyddion, heligogod, gweilch y penwaig a throchyddion. Dangosodd astudiaethau fod effaith sylweddol ar heligogod bridio yn neilltuol.

- Lleihad sylweddol yn y boblogaeth o sr mr clustog *Asterina phylactica* ym mhyllau trai Bae Gorllewin Angle, yn agos at safler tirio, gyda niferoedd yn gostwng o fwy na 150 i 13 o unigolion.

Yn ychwanegol at hyn roedd difrod dros dro i rai algae, cennau a llystyfiant morfa heli. Roedd marwolaethau ymysg rhai rhywogaethau traethlinol wedi gadael anghydbwysedd mewn eco-systemau, gan arwain at gynnydd mewn rhywogaethau eraill, megis algae gwyrdd ller oedd llygaid meheryn wedi cael eu lladd a rhai rhywogaethau o fwydod gwrychog mewn traethau gwaddodol. Parhaodd crynodiadau o olew mewn molysgiaid dwygragennog, megis cregyn gleision, am sawl mis.

Comisiynwyd sawl astudiaeth i chwilio am effeithiau pellach, yn ddi-oed ac yn y tymor hir. Yn ogystal chwilio am newidiadau mewn maint poblogaethau a dosbarthiad amrywiaeth o rywogaethau, canolbwyntiodd astudiaethau ar effeithiau is-angheuol a newidiadau yn llwyddiant bridio. Daeth yr astudiaethau hyn ir canlyniad:

- Nid oedd yn ymddangos bod unrhyw effaith ar famaliaid.

- Er bod crynodiadau meinwe o gyfansoddion olew wedi cynyddu dros dro yn rhai rhywogaethau pysgod ni effeithiwyd mwyafrif y pysgod ond i raddau bychain, os o gwbl, a bach iawn a fu farw.

- Roedd sawl poblogaeth bwysig o adar mr na chafodd eu heffeithion sylweddol, ac nid oedd tystiolaeth o unrhyw effeithiau ar lwyddiant bridio adar mr.

- Ni effeithiwyd yn sylweddol ar blanhigion prin yn yr ardal.

Mae maint poblogaethau llawer or rhywogaethau yn amrywion naturiol o flwyddyn i flwyddyn. Roedd hyn, ynghyd diffyg data gwaelodlin rhai rhywogaethau a lleoliadau neu ddiffyg gwybodaeth ynghylch ffactorau eraill a oedd yn effeithio ar y boblogaeth yn golygu fod canlyniadau sawl astudiaeth yn amwys. Roedd y rhain yn cynnwys effeithiau ar rai o boblogaethau adar mr megis bilidowcars a rhai rhywogaethau anifeiliaid y traeth gwaddodol. Fe fydd angen monitorio yn y dyfodol i wirio nad oedd dosbarth 1996 o sawl rhywogaeth o anifeiliaid morol yn cynnwys y rheiny syn dwyn elw masnachol: crancod, cimychiaid, draenogiaid y mr, gwichiaid moch wedi ei effeithio gan y gorlif.

Digwyddodd y prif effeithiau ar adeg y gorlif neu yn fuan wedi hynny, ac nid ywn ymddangos bod llawer o effeithiau sylweddol tymor-hir. Yn wir, mae sawl un or rhywogaethau a effeithiwyd yn ymddangos fel petaent wedi adfer yn sylweddol. Mae niferoedd heligogod a gweilch y penwaig wedi eu hadfer i raddau helaeth, adenillodd sawl rhywogaeth yn dda ar hyd llawer or draethlin a effeithiwyd ac mae arwyddion fod rhai o rywogaethaur deudroediaid wedi ailsefydlu yn rhai ardaloedd. Nid ywn ymddangos bod unrhyw effeithiau tymor-hir ar bysgodfeydd y rhanbarth y gellir eu priodoli ir gorlif, er fe fydd angen arsylliadau cyson ar rai stociau i wirior casgliad hwn. Maen debygol, fodd bynnag, y bydd yr anghydbwysedd yn eco-systemau y darnau or draethlin a effeithiwyd waethaf yn cael ei adfer yn araf, o brofiad yn y gorffennol o gorlifoedd olew, ac maen rhaid bod pryder ynghylch adferiad poblogaeth ryngwladol bwysig y mr-hwyaid duon, y sr mr clustog prin a rhywogaethau deudroediaid yn yr ychydig leoliadau ller oeddynt yn dal i fod yn absennol flwyddyn wedir gorlif. Bydd monitorio yn para i gofnodi eu hadferiad ac fe ddylai gadarnhau pun ai a oes effeithiau tymor-hir, na sydd yn amlwg eto.

Er bod swm mawr iawn o olew wedi gorlifo mewn ardal neilltuol o sensitif, maen ymddangos bod yr effaith gryn dipyn yn llai llym nag yr oedd llawer o bobl wedi disgwyl. Roedd hyn iw briodoli i gyfuniad o ffactorau yn arbennig, amser y flwyddyn, y math o olew, amgylchiadaur tywydd ar adeg y gorlif, yr ymateb glanhau a gwydnwch naturiol llawer or rhywogaethau morol.

Roedd pysgod a mamaliaid yn gallu osgoi gwaethar olew, ac maen debyg fod unrhyw olew y gallai fod wedi ei amsugno ganddynt wedi ymddatod yn fuan drwy eu systemau ensym effeithlon. Roedd llawer o rywogaethau yn gallu goroesi graddfa o oelio; er enghraifft, gwelwyd gwylanod oeliog sawl mis wedir gorlif, ac ar adeg y gorlif nodwyd bod rhai organebau morol wedi goroesi hyd yn oed oelio trwm. Mae llawer o rywogaethau morol yn gallu ail-boblogi ardal yn gyflym yn dilyn lleihad mewn niferoedd, yn enwedig lle mae wyau a ieuenctid yn mynd trwy gyfnod planctonaidd hy cnt eu cario gan gerhyntau yn y ac felly gallant gael eu dwyn i ardal a effeithiwyd o ardaloedd cyfagos.

Er bod y defnydd buan, ar raddfa helaeth o wasgarwyr ar y mr yn l pob tebyg wedi cynyddu amlygiad anifeiliaid ar welyr mr i olew ac o bosibl wedi cyfrannu at diriadau molysgiaid dwygragennog a rhywogaethau eraill ar lleihad ym mhoblogaethau deudroediaid yn rhai ardaloedd, rhwng popeth maen debygol ei fod o fudd yn lleihau effaith amgylcheddol gynhwysfawr y gorlif. Canlyniad yr ymgyrch oedd llawer llai o olew ar wyneb y mr, a hynny yn ei dro yn lleihaur perygl i adar ar swm a allasai ddod ir lan. Gan ddysgu o orlifoedd blaenorol, cafodd yr ymgyrch i lanhaur draethlin ei weithredun ofalus er mwyn sicrhaur effaith amgylcheddol leiaf. Roedd Y Tm Amgylcheddol yn y Ganolfan Ymateb ar y Cyd (JRC) wedi chwarae rhan bwysig yn y strategaeth ar gyfer glanhau, cynghori ynghylch blaenoriaethau ar dewis o dechnegau. Roedd hin ffodus hefyd fod cyfeiriad y gwynt yn ystod y gorlif wedi golygu mai cymharol ychydig olew a gyrhaeddodd y safleoedd adar mr pwysig ar Sgomer a Sgogwm ac ni chyrhaedodd unrhyw olew Gwales.

Ar lawer ystyr roedd amserur gorlif yn ffodus. Roedd llawer poblogaeth bwysig o adar, gan gynnwys palod Manaw a phalod, heb ddychwelyd eto ir rhanbarth i fridio. Cymharol ychydig o bysgod oedd yn yr ardal, roedd sawl rhywogaeth yn dal i fod allan yn y mr am y gaeaf, ac roedd gweithgaredd bwydo wedi cyrraedd yr isafbwynt tymhorol. Petair gorlif wedi digwydd yn ddiweddarach yn y flwyddyn, er enghraifft yn ystod tymor bwrw cenawon y morloi, fe allair effaith drwyddi draw wedi bod yn wahanol iawn.

11.2.2 Hamdden

Cafodd gwerth hamdden de-orllewin Cymru yn enwedig y traethau ei effeithion uniongyrchol gan yr olew, ond dros dro bur effeithiau a dychwelodd hamdden i normal o fewn ychydig wythnosau. Mewn rhai achosion, fodd bynnag, parhaodd amgyffredion or effaith ar hamdden yn hwy a chyfrannodd hyn mwy na thebyg at leihad gwerthiant trwyddedau pysgota a gostyngiad yn nifer yr ymwelwyr a oedd yn aros mewn gwestyau.

11.2.3 Glanhau adar ac adferiad

Cafodd mwy na 3,000 o adar oeliog eu casglu or traethau au cymryd iw glanhau. Daeth adolygiad or broses hon ir casgliad fod yr ymgyrch wedi cael ei reolin dda ar y cyfan, ond awgrymwyd gwelliannau ar gyfer gweithredu yn y dyfodol. Dangosodd dadansoddiad manwl o ddata ar oroesiad heligogod o brofiadau blaenorol glanhau olew, fodd bynnag, fod yr adar hyn pan cnt eu rhyddhau wedir glanhau, yn marw bron bob un yn fuan iawn. Mae hyn yn codi cwestiwn pun ai a ydyw, o safbwynt lles adar, yn well i lanhaur adar hyn ynteu a fyddain fwy caredig iw lladd yn drugarog er mwyn eu harbed rhag dioddef. Mae angen mwy o wybodaeth ar faint y straen a ddioddefir gan heligogod a rhywogaethau adar eraill yn ystod y glanhau a pha ffactorau syn penderfynu adferiad mwy llwyddiannus adar gln yn l ir gwyllt.

11.2.4 Tynged yr olew

Mater pwysig iw benderfynu oedd tynged tymor-hir y 72,000 tunnell fetrig o olew crai ar 480 tunnell fetrig o olew crai trwm. Anweddodd tua 40% yn fuan wedi iddo orlifo. Byddai hyn wedi gwanhau yn yr awyrgylch yn fuan iawn ac wedyn, gyda threigl y dyddiau ar wythnosau canlynol, byddai wedi cael ei ddatod gan olaur haul neu wedi gwaddodi mewn crynodiadau hynod isel dros ardal eang iawn. Gwasgarodd tua 52% yn y lle byddair cyfan bron ohono wedi cael ei ddatod gan ficro-organebau. Mae arolygon ar y mr wedi awgrymu nad ywr olew hyn wedi gwaelodi yn waddod mewn meintiau sylweddol. Casglwyd tua 1-2% or olew oddi ar wyneb y mr ai gymryd i burfa a thiriwyd rhwng 5% a 7% ar y traeth. Flwyddyn wedir gorlif, roedd llai na 1% yn dal ar y traeth, gydar gweddill un ai wedi ei waredu yn dilyn yr ymgyrch glanhau helaeth, wedi biodiraddio neu wedi ei olchi yn l ir mr lle y bu iddo wasgaru neu gronni mewn gwaddodion ger y traeth. Maen eglur or dadansoddiad hwn mai cyfran fach iawn or olew a orlifodd a arhosodd mewn ffurf a fyddain achosi unrhyw broblemau amgylcheddol tymor-hir.

11.2.5 Yr ymgyrch glanhau

Roedd yr ymgyrch glanhau drwyddi draw wedi ei reoli, ei gynllunio ai weithredun dda. Mae bron yn sicr fod y mesurau ymateb morol yn enwedig yr ymgyrch chwistrellu gwasgarwyr wedi lleihau lefel grynswth oelior draethlin ac yn gyffredinol ni wnaed effeithiau anochel y gorlif yn waeth drwy ddefnyddio technegau glanhau anaddas a mewnwthiol. Gan mwyaf, roedd y technegau a ddefnyddiwyd yn llwyddiannus wrth gyflawnir blaenoriaethau a gytunwyd ar gyfer glanhaur draethlin megis glanhaur prif draethau twristaidd i raddau digonol i ganiatu eu defnydd gan dwristiaid adeg y Pasg dim ond naw wythnos wedir gorlif. Awgrymir nifer o welliannau a gynhwysir yn yr argymhellion syn dilyn.

Monitoriwyd y defnydd o wasgarwyr ar y mr o gychod yn ystod yr ymgyrch ac fe ddarparodd hyn wybodaeth ddefnyddiol i gynorthwyor rheiny oedd yn gweithredur ymateb, yn ogystal ag arwain at well dealltwriaeth o dynged yr olew.

11.2.6 Y rhaglen asesu

Comisiynodd PGASE raglen eang o astudiaethau, ac er i nifer ohonynt ddangos nad oedd tystiolaeth o effaith a oedd yn gysylltiedig r olew, yr oedd er hynny yn bwysig fod yr astudiaethau hynny wedi ei gwneud. Dewiswyd yr astudiaethau yn ofalus, ac maen annhebyg y buasai rhai ychwanegol wedi datgelu unrhyw effeithiau amgylcheddol pellach o bwys.

Roedd llawer or astudiaethau wedi elwa or swm mawr o ddata gwaelodlin sydd ar gael ar rai rywogaethau a safleoedd yn y rhanbarth, ond daeth nifer o fylchau yn yr wybodaeth ir amlwg, yng nghyswllt amrywiant rhai rhywogaethau yn yr ardal, ar mecanweithiau wrth wraidd rhai or ffenomenau a welwyd (megis ms-diriadau rhai dwygragenogion a hyglwyfedd rhai rhywogaethau megis deudroediaid). Hefyd mewn rhai achosion llesteiriwyd asesiadau o effeithiau gan ddiffyg gwybodaeth sylfaenol am rai rhywogaethau, gan gynnwys, er enghraifft, bwyd arferol mr-hwyaid duon.

Un corff pwysig o wybodaeth a oedd ar gael dim ond yn rhannol oedd lefel yr amlygiad i olew yn cynnwys swm yr olew, y math ar amser y bu iddo aros yn yr ardaloedd or draethlin a astudiwyd. Byddai gwybodaeth fanwl am hyn wedi bod o gymorth mawr wrth wneud dadansoddiad llawn o effeithiau ar y draethlin. Byddai wedi bod o fudd hefyd petai rhai astudiaethau allweddol wedi dechrau yn union wedir gorlif. Maer sylwadau hyn yn ymwneud ag argymhellion syn dilyn a wnaed mewn perthynas chynllunio cyfwng asesu effeithiau.

Datblygwyd rhai technegau newydd yn ystod y rhaglen asesu, gan gynnwys technegau monitorio ar gyfer pyllau trai a

ffawna gludafaelion gwymon, a methodoleg ar gyfer asesu lefel effaith esthetig oelior draethlin. Fe all y rhain fod o ddefnydd gyda gorlifoedd y dyfodol.

11 Conclusions and recommendations

(Reproduced in full from the SEEEC Report)

11.1 Introduction

After reviewing the work commissioned by SEEEC to assess the environmental impact of the oil spill and the effectiveness of the clean-up operation, it remains to draw together the committees principal conclusions, recorded in some detail in the preceding chapters, and to make recommendations including where it is considered that procedural improvements can be made which might have wider application.

11.2 Conclusions

11.2.1 Impacts and recovery

The main environmental impacts of the spill included:

- Large numbers of marine organisms were killed either as fresh oil came ashore (eg limpets and barnacles) or when raised levels of hydrocarbons in the water column affected bivalve molluscs and other sediment-dwelling species.
- Populations of amphipods (small crustaceans) disappeared from some areas and were severely depleted in others, both onshore and on the seabed near the site of the grounding.
- Several thousand oiled birds, many already dead, washed ashore, with the total number of birds killed likely to be far greater than this. The greatest impact was on birds which spend much of their time on the sea surface, particularly the common scoter, diver species, guillemots, razorbills and divers. Studies showed that there was a significant impact on breeding guillemots in particular.
- A significant decrease in the population of the rare cushion starfish *Asterina phylactica* in the rock pools of West Angle Bay, close to the site of the grounding, with numbers falling from more than 150 to 13 individuals.

In addition there was temporary damage to some algae, lichens and saltmarsh vegetation. Deaths amongst certain shoreline species left an imbalance in eco-systems, leading to temporary increases in other species, such as green algae where limpets had been killed and some species of polychaete worms in sediment shores. Concentrations of oil in bivalve molluscs, such as mussels, remained high for many months.

Many studies were commissioned to look for further impacts, both immediate and longer term. As well as checking for changes in population size and distribution of a variety of species, studies also focussed on sub-lethal effects and changes in breeding success. These studies concluded that:

- There appeared to have been no impacts on mammals.
- Although tissue concentrations of oil components increased temporarily in some fish species, most fish were only affected to a small degree, if at all, and very few died
- Several important populations of seabirds were not significantly affected, and there was no evidence of any effects on seabird breeding success.
- Rare plants in the area were not significantly affected.

The population sizes of many species fluctuate naturally from year to year. This, coupled with a lack of baseline data for some species or locations -- or a lack of knowledge of other factors affecting the population meant that the results of several studies were equivocal. These included impacts on some of the seabird populations such as cormorants and some animal species of the sediment shore. Future monitoring will also be needed to check that the 1996 year class of several species of marine animals including the commercially-exploited crabs, lobsters, bass and whelks was not impacted by the spill.

The main impacts all occurred at the time of the spill or shortly afterwards, and there appear to have been few major longer term effects. Indeed, several of the affected species seem to have substantially recovered. Guillemot and razorbill numbers have largely recovered, there has been good recruitment of many species along much of the affected shoreline; and there are signs that some of the amphipod species have become re-established in some areas. There do not seem to have been any longer term effects on the fisheries of the region which can be attributable to the spill, although continued observations on some stocks are needed to verify this conclusion. It is likely, however, that the imbalance in the eco-systems of the worst affected stretches of shoreline will recover slowly, based on past experience of oil spills, and there must be concern over the recovery of the internationally important population of common scoters, the rare cushion starfish and amphipod species in the few locations where they were still absent a year after the spill. Monitoring will continue to record their recovery and should establish whether there are longer-term effects, not yet apparent.

It appears that although a very large amount of oil was spilled in a particularly sensitive area, the impact was far less severe than many people had expected. This was due to a combination of factors -- in particular, the time of the year, the type of oil, weather conditions at the time of the spill, the clean-up response and the natural resilience of many marine species.

Fish and mammals were able to avoid the worst of the oil, and any oil they may have absorbed probably broke down fairly rapidly through their efficient enzyme systems. Many species were able to survive a degree of oiling; for example, oiled gulls were seen alive many months after the spill, and at the time of the spill it was noted that some marine organisms had survived even heavy oiling. Many marine species are able to re-populate an area rapidly following a decrease in numbers, particularly where the eggs and juveniles go through a planktonic stage -- ie they are carried by currents in the water and so can be brought to an affected area from nearby areas.

Although the rapid, large scale use of dispersants at sea probably increased the exposure to oil of animals on the sea bed and may have contributed to the strandings of bivalve molluscs and other species and the decrease in amphipod populations in some areas on balance it is likely that it was of benefit in reducing the overall environmental impact of the spill. The operation resulted in far less oil on the sea surface, which in turn reduced the risk to birds and the quantity that could come ashore. Learning from previous spills, the shoreline clean-up operation was carefully carried out to ensure the minimum environmental impact. The Environment Team in the Joint Response Centre (JRC) played an important role in the strategy for clean-up, advising on priorities and the choice of techniques. It was also fortunate that the direction of the wind during the spill resulted in relatively little oil reaching the important seabird sites at Skomer and Skokholm and none reaching Grassholm.

The timing of the spill was, in many respects, fortunate. Several important bird populations, including Manx shearwaters and puffins, had not yet returned to the region for breeding. Relatively few fish were in the area, several species being still out to sea for the winter, and feeding activity was at a seasonal low. Had the spill occurred later in the year, for example during the seal pupping season, the overall impact may have been quite different.

11.2.2 Amenity

The amenity value of south-west Wales particularly the beaches -- was directly affected by the oil, but the effects were temporary and amenity, in the main, had returned to normal within a few weeks. In some cases, however, perceptions of the impact on amenity remained for longer and this probably contributed to the decrease in sales of fishing licences and a reduction in the number of visitors staying in hotels.

11.2.3 Bird cleaning and rehabilitation

More than 3,000 oiled birds were collected from beaches and taken for cleaning. A review of this process concluded that the operation had generally been well-managed, but suggested improvements for future operations. A detailed analysis of data on the survival of guillemots from previous oil cleanings showed, however, that when these birds are released after

cleaning, almost all of them die very rapidly. This calls into question whether it is, from a bird welfare viewpoint, better to clean these birds or whether it might be kinder to kill them humanely to relieve their suffering. More information is needed on the amount of stress guillemots and other bird species undergo during cleaning and what factors determine more successful rehabilitation of cleaned birds into the wild.

11.2.4 Fate of the oil

An important issue to resolve was the long-term fate of the 72,000 tonnes of crude oil and 480 tonnes of heavy crude oil. About 40% evaporated soon after being spilled. This will have rapidly become very dilute in the atmosphere and then, over the course of subsequent days and weeks, will have been broken down by sunlight or deposited in extremely low concentrations over a very wide area. Around 52% of the oil dispersed into the water where almost all of it will eventually have been broken down by micro-organisms. Surveys at sea have suggested that this oil has not been deposited in sediments in significant quantities. About 1-2% of the oil was collected from the sea surface and taken to a refinery and between 5% and 7% stranded on the shore. A year after the spill, well under 1% remained on the shore, with the rest either disposed of following the extensive clean-up operation, biodegraded or washed back into the sea where it dispersed or accumulated in sediments near the shore. It is clear from this analysis that only a very small proportion of the spilled oil remained in a form that could cause any longer term environmental problems.

11.2.5 The clean-up operation

Overall, the clean-up operation was well-managed, planned and executed. The marine response measures particularly dispersant spraying operation almost certainly considerably reduced the gross level of shoreline oiling and the inevitable environmental impacts of the spill were generally not made worse by the use of inappropriate or intrusive clean-up techniques. In the main, the techniques employed were successful in meeting the agreed priorities for shoreline clean-up such as cleaning the main tourist beaches to a sufficient degree to allow their use by tourists at Easter just nine weeks after the spill. A number of improvements are suggested, which are contained in the recommendations which follow.

The application of dispersants at sea was monitored from boats during the operation and this provided useful information to assist those carrying out the response, as well as leading to a greater understanding of the fate of the oil.

11.2.6 The assessment programme

SEEEC commissioned a wide-ranging pro-gramme of studies, and although many of these showed no evidence of an impact related to the oil, it was nevertheless important that those studies were carried out. The studies were carefully chosen, and it is unlikely that additional ones would have revealed any further major environmental impacts.

Many of the studies benefited from the large amount of baseline data available on some species and sites within the region, but a number of gaps in the knowledge became apparent, regarding both the natural variability of some species within the area, and the mechanisms behind some of the observed phenomena (such as the mass strandings of some bivalves and the vulnerability of species such as amphipods). Impact assessments were also hindered in some cases by a lack of basic knowledge on some species, including, for example, the normal food of common scoters.

One important body of information which was only partially available was the level of exposure to oil including the amount of oil, the type and the time it remained at the areas of shoreline studied. Detailed knowledge of this would have been of great help in making a full analysis of shoreline effects. It would also have been beneficial if several key studies could have started immediately following the spill. These observations relate to recommendations made with respect to impact assessment contingency planning which follow.

Some new techniques were developed during the assessment programme, including monitoring techniques for rock pools and the fauna of seaweed holdfasts, and a methodology for assessing the level of aesthetic impact of shoreline oiling. These may be of use at future spills.

11.3 Argymhellion

Mae argymhellion PGASE yn rhannu i ddau gategori llydan:

- Y rheiny syn gysylltiedig yn fwy penodol gorlif y *Sea Empress* ar ardal o dde-orllewin Cymru lle y digwyddodd effeithiau amgylcheddol. Maer rhain yn bennaf yn ymwneud monitorio parhaol mewn amgylchiadau lle na ellir asesu hyd yn hyn effeithiau llawn y gorlif.

- Y rheiny o bwysigrwydd cenedlaethol a ddeilliodd o brofiad y *Sea Empress*, syn argymell ymchwil a gweithredu i wella gweithdrefnau ymateb ac asesu lle bynnag y gallai gorlif mawr arall yn digwydd yn y DG.

Mae rhai or argymhellion yn ymwneud ag asiantaethau llywodraeth penodol neu gyrff eraill. Mewn achosion felly, enwir y corff ar ddiwedd y paragraff.

11.4 Argymellion Pherthnasedd Lleol

Mae ein hargymhellion yn eithrior rhaglenni monitorio syn bod eisoes, a gefnogir gan yr asiantaethau a rhai cyrff gwirfoddol, syn darparu data gwaelodlin pwysig am rai rhywogaethau bywyd gwyllt, yn enwedig mamaliaid ac adar, sydd o werth hanfodol pan ddigwydd gorlif neu ddigwyddiad niweidiol arall. Yn ychwanegol, mae asiantaethau eisoes wedi cytuno i gomisiynu rhai prosiectau arbennig megis monitorio llystyfiant morfa heli (CCC), ac o stociau eog a brithyll mr (EA). Maer mentrau hyn yn bwysig ond maent ar droed eisoes.

Gwneir cynigion yn adran 3.11 am barhad rhaglenni monitorio ar gyfer sawl rhywogaeth fasnachol o bysgod asgell a physgod cregyn, yn enwedig or boblogaeth penwaig yn nyfrffordd Milffwrd, ac o grancod bwytadwy, cimychiaid, gwichiaid moch a draenogiaid y mr dros ardal ehangach, oherwydd maen dal yn ansicr pun ai a yw dosbarth blwyddyn 1996 (ac o bosibl 1997) wedi cael ei leihau gan y gorlif. Er yn bennaf pherthnasedd lleol, gallair canlyniadau fod ag arwyddocd ehangach mewn perthynas n dealltwriaeth o effeithiau gorlifoedd olew ar bysgodfeydd, o gofio ansawdd y data gwaelodlin sydd ar gael am rai or poblogaethau hyn. Mae budd yn ogystal mewn parhau i arolygu poblogaethau dyfnforol infertebrata mewn ardaloedd a effeithiwyd yn drwm lle digwyddodd marwolaethau deudroediaid. Yn ddiamau bydd angen gwneud penderfyniadau gan MAFF ac eraill blaenoriaethau priodol y rhaglenni monitorio hyn pan fo ariannu yn cael ei ystyried (MAFF).

Yn yr un modd, dynodwyd sawl effaith ar y draethlin, ond yma maen ymddangos bod adferiad ar droed ac ar drywydd a ddisgrifiwyd yn gynt am orlifoedd olew blaenorol. Er hynny, mae rhai rhywogaethau megis y sr mr clustog *Asterina phylactica* o bwysigrwydd cadwriaethol arbennig ac yn dal i fod yn hyglwyf; mae angen rhoi peth blaenoriaeth i arsylliad parhaol or rhywogaethau hyn (CCC).

Yn achos adar mr, oherwydd pwysigrwydd yr ardal ar gyfer gaeafu a bridio, maer data gwaelodlin eisoes yn helaeth. Er hynny, mae angen adolygu argaeledd data, ac yn achos y mr-hwyaid duon yn neilltuol, byddai astudiaethau parhaol pellach yn fuddiol yn wyneb pwysigrwydd rhyngwladol y boblogaeth syn gaeafu ym Mae Caerfyrddin (CCC).

11.5 Argymhellion Pherthnasedd Cenedlaethol

11.5.1 Ymchwil

Roedd sawl un o effeithiau gorlif y *Sea Empress*, er eu bod wedi eu cofnodi adeg gorlifoedd blaenorol, yn aros heb eu hegluro ac syn galw am ymchwiliadau pellach. Yn eu plith roedd hyglwyfedd deudroediaid i halogiad olew ac ymddygiad

sawl rhywogaeth o ddwygramenogion, megis cyllyll mr, wrth symud allan or gwaddodion. Gan fod yr anifeiliaid hyn yn bwysig mewn cadwyni bwyd morol ac felly o arwyddocd ecolegol, byddain ddiddorol cael gwell dealltwriaeth o union achos yr effeithiau a welwyd ar rhesymau dros sensitifrwydd ymddangosiadol rhai rhywogaethau morol i lefelau isel o olew, er gall dyfeisio methodolegau arbrofol priodol brofin heriol (NERC).

Roedd hefyd awgrymiadau y gallai rhai cymunedau rhynglanwol ac islanwol yn enwedig rhywogaethau anifeiliaid mewn gludafaelion mr-wiail (Laminaria) a thyweirch algaeol mewn pyllau trai brofin ddefnyddiol ar gyfer monitorio effeithiau olew. Maent yn haeddu ystyriaeth bellach, fel mae archwilior cyfle a rydd modelu rhagfynegol o gymunedau cyn-gorlif wrth ystyried priodoleddau materol eu hamgylchedd, oherwydd ni fydd gan lawer o ardaloedd lle gallai gorlifoedd ddigwydd ddisgrifiadau cyn-gorlif iw cymharu rhai de-orllewin Cymru. Maer math hwn o fodel wedi profin erfyn gwerthfawr i fesur straen halogiad mewn afonydd wrth gymharu cymunedau a oedd yn agored i halogiad r cymunedau hynny a ddisgwylid yn yr un safleoedd heb halogiad (EA, Asiantaethau Cefn Gwlad).

Dangosodd y rhaglen glanhau adar amrediad eang o raddfeydd llwyddiant, wedi eu cysylltu o bosibl ffactorau megis graddfa straen, y cyflwr ffisiolegol dechreuol a graddfa oelio adar, rhywogaethau, y lefel o drafod arbenigol yn ystod y broses glanhau, ayb. Mae angen archwilior rhain a ffactorau eraill er mwyn optimeiddio prognosis a threfniadau glanhau ar gyfer adferiad llwyddiannus (RSPCA).

11.5.2 Glanhau adar ac adferiad

Roedd astudiaethau a gomisiynwyd gan BGASE yn dilyn gorlif y *Sea Empress* yn cwestiynu gwerth o safbwynt lles anifeiliaid glanhau ac adfer adar oeliog yn enwedig ar gyfer y rhywogaethau hynny graddfeydd marwolaeth uchel yn ystod y glanhau neu yn fuan wedir rhyddhau ir gwyllt. Yn achos digwyddiadau oelior dyfodol, rydym yn cynnig y dylid gwneud gwaith pellach i asesu ffactorau straen yn ystod glanhau a datblygiad arfau diagnostig gwell er mwyn gwerthuson gynnar siawns goroesi adar unigol fel y gellir gwneud dyfarniad mwy deallus phun ai parhau gyda glanhau or fath neu beidio.

Daeth yr astudiaeth hefyd ir casgliad fod angen adolygiad cenedlaethol eang ei amrediad or trefniadau syn bod eisoes mewn perthynas yn neilltuol

- cynllunio a rheolaeth
- gweithdrefnau glanhau
- argaeledd a hyfforddiant staff a gwirfoddolwyr

Er bod yr RSPCA yn elusen ac nid yn gorff statudol ac or herwydd yn gallu penderfynu ei pholisi ei hunan yng nghyswllt y mater hwn, mae PGASE yn credu y byddai adolygiad or fath, wedi ei symbylu gan yr RSPCA, yn werthfawr ac amserol ac y byddain peri gwelliant sylweddol ir trefniadau cyfredol. Hefyd (ynghyd i chyrff cyfatebol yn yr Alban a Gogledd Iwerddon) dymar unig gorff sydd r adnoddau, y sgiliau, y drefniadaeth ar gefnogaeth eang iw weithredu (RSPCA).

11.5.3 **Gorchmynion cau ar gyfer** pysgodfeydd

Mae gorchmynion cau (hy Gorchmynion Cadw Allan a gyhoeddir dan y Ddeddf Bwyd ac Amddiffyn yr Amgylchedd 1985) yn gwahardd pysgota rhywogaethau a enwir mewn ardaloedd diffiniedig ac yn cael eu cyhoeddi gan adrannau llywodraeth penodol. Yn dilyn cyhoeddi gorchmynion or fath wedi gorlif y *Sea Empres*s a hefyd wedi ir gwaharddiadau gael eu codi yn ddiweddarach, roedd dryswch eang yn y gymuned bysgota ac ymhlith y cyhoedd yn gyffredinol ynghylch sail y gorchmynion hyn. Er iddynt gael eu cyhoeddi fel mesurau rhagofalus i amddiffyn defnyddwyr rhag bwyta pysgod a physgod cregyn a oedd r potensial i fod yn halogedig, feu dehonglwyd ar brydiau fel tystiolaeth neu debygolrwydd o ddifrod ir stociau go iawn. Yn y dyfodol dylid gwneud achos y fath orchmynion yn gliriach pan yu cyhoeddir a phan yu codir (WO, MAFF).

11.5.4 Asesur glanhau

Er llwyddiant sylweddol y gweithdrefnau glanhau ar fr a thir, mae gennym sawl argymhelliad a fyddai, ou dilyn, yn arwain at welliannau. Trafodir hwy yn llawn yn y bennod Glanhau adran 10.10 ac maent yn cynnwys:

- diffiniad cliriach tasgau a neilltuir i reolwyr penodol o fewn y corff ymateb;

- yr angen am y Rheolwr Cyffredinol i fod yn bresennol ar safle digwyddiad pwysig i weithredu fel llefarydd awdurdodol ar ran y MPCU ac Asiantaeth Gwylwyr y Glannau;

- yr angen am ailenwir Ganolfan Ymateb ar y Cyd (JRC) i wneud yn glir ei swyddogaeth yn unig yn glanhau y draethlin;

- ffafriaeth o blaid apwyntio prif swyddog awdurdod lleol i gadeirior JRC ar gwelliant dilynol tebygol yng nghyswllt cefnogaeth weinyddol a lefelau staffio;

- gwell dogfennaeth a chadw cofnodion i hwyluso paratoi a thalu ceisiadau am iawndal yn ddiymdroi;

- yr angen am sefydlu criteria eglur ar gyfer terfynu gwaith glanhaur draethlin mewn safleoedd unigol, gan gydnabod bod prosesau glanhau naturiol yn digwydd hefyd;

- yr angen i osod ar awdurdodau lleol gyfrifoldeb y rhwymedigaeth statudol i baratoi cynlluniau cyfwng lleol ac i gyflawni gwaith glanhaur draethlin a derbyn fod adnoddau digonol ar gael. Yn achos y digwyddiad hwn roedd cynlluniau wedi cael eu paratoi ac fe ddangoswyd eu pwysigrwydd. Argymhellodd ymchwiliad yr Arglwydd Donaldson y dylai awdurdodau lleol fod dyletswydd statudol or fath er bod Deddf Llongau Masnach a Diogelwch Morol 1997 ond yn darparu pwerau galluogi yn hytrach na dyletswydd statudol i fabwysiadur swyddogaeth hon.

- pwysigrwydd glynu wrth ofynion Iechyd a Diogelwch ar gyfer y gweithlu glanhau ac o sylw manwl i gynllunio rhestrau dyletswyddau i sicrhau nad yw staff dan straen gormodol o ganlyniad i weithio oriau eithafol.

- gwell darpariaeth o wybodaeth gwirioneddol a rhagfynegol dosraniadau olew, yn enwedig lle mae effeithiau helaeth ar y draethlin. Dylid gwneud mwy o ddefnydd o gyfleusterau TG ar gyfer paratoi ac archifo mapiau gwyliadwriaeth awyrol gyda dilysiad gan ddefnyddio gweithdrefnau cofnodi safonol. Ni chafodd y gweithdrefnau safonol hyn eu defnyddio yn achos gorlif y *Sea Empress* ac er y gallai eu defnydd wedi bod o fudd ir ymgyrch glanhau, fe ddaeth yn eglur y gallai eu datblygiad pellach ddarparu yn ogystal wybodaeth a fyddain ddefnyddiol ar gyfer asesu effeithiau ecolegol.

- yr angen i ymateb ir cyfryngau mewn dull mwy positif a chyd-drefnus.

- pwysigrwydd datblygu gweithdrefnau argyfwng a threfniadau ar gyfer gwaredu gwastraff oeliog ar lefel leol a chenedlaethol. Maer trefniadau trwyddedu cyfredol ar gyfer argyfyngau yn anfoddhaol ac mae angen eu datrys ar fyrder (o fewn blwyddyn), yn gyntaf trwy drafodaethau rhwng EA, MPCU a chymdeithasau awdurdodau lleol.

Mae rhai or argymhellion uchod yn faterion syn bennaf berthnasol i Asiantaeth Gwylwyr y Glannau, ac, yn fwy penodol, i MPCU: maer materion hyn yn cael eu hystyried yn barod gan yr asiantaeth honno yn yr adolygiad cyfredol or cynllun at raid cenedlaethol. Mater ir llywodraeth yw ystyried yr angen i osod ar awdurdodau lleol y cyfrifoldeb statudol o baratoi cynlluniau at raid lleol ac i gyflawnir gwaith o lanhau y draethlin. (DETR).

11.5.5 Trefniadau ar gyfer asesiad effaith yn y dyfodol

Er bod cynlluniau at raid ar lefel genedlaethol a lleol i ymateb i arllwysiadau olew, gydar ymateb yn dibynnu ar faint yr arllwysiad ai effaith cyffredinol, nid oes cynlluniau ymateb cyfatebol ar gyfer asesu effeithiau amgylcheddol. O ganlyniad, yn ystod dyddiau cynnar yr arllwysiad, pan fo casglu gwybodaeth amgylcheddol or pwys mwyaf, dibynnir ar drefniadau ad hoc. Argymhellodd Adroddiad ESGOSS, yn dilyn arllwysiad olew y *Braer* yn Shetland, y dylid sefydlu cyd-lynu cyn gynted ag y bod modd ym mhob arllwysiad syn cynrychioli bygythiad sylweddol ir amgylchedd. Yn achos arllwysiad y *Sea Empress* roedd nifer o ffactorau arbennig yn lleihaur broblem, nid y lleiaf or rhain oedd ar gaeledd arbenigwyr lleol i gasglu gwybodaeth yn syth wedir arllwysiad a gweithredu cyflym gan asiantaethau arbennig. Serch hynny, roedd nifer o enghreifftiau o ymatebion cynnar heb eu cyd-lynu. Wedi ychydig wythnosau cyfarfu Cyd-lynu Technegol Dros Dro i asesu gweithgareddau monitro y prif fudiadau ac i sicrhau bod unrhyw or-gyffwrdd neu fylchau yn cael eu lleihau, a thua chwe wythnos wedir arllwysiad sefydlwyd PGASE i fynd ar amcanion hynny ymlaen. Roedd hyn yn gyfnod byr iawn, ond yn ystod yr wythnosau cynnar hynny byddai agwedd mwy strwythurol a chyd-lynol, gan fabwysiadu trefniadau clir a

phrotocolau samplo a dadansoddi, ynghyd a darparu sylfaen gyllidol sicr ar gyfer y rhaglen, wedi bod o fantais mawr.

Argymhellir y dylid paratoi cynlluniau ymateb i argyfwng yn genedlaethol er mwyn sefydlu Asesu Effaith (GAE) amgylcheddol i gyflawnir monitro ar mesurau amgylcheddol angenrheidiol pan fo arllwysiad difrifol yn digwydd. Prif feysydd amcanion yr GAE fyddai:

- crynoadau o olew yn yr amgylchedd, yn enwedig rhywogaethau a chynefinoedd sensitif, gan gymharu rhain gyda data sylfaenol;
- tynged yr olew dros amser;
- effeithiau amgylcheddol (yn y tymor byr ar tymor hir) yr arllwysiad ar ymateb glanhau a disgrifio graddfeydd yr adferiad;

Byddain rhaid ir , er yn gweithion agos gydar JRC ac yn cyd-weithio ar agweddau o gasglu data ac esbonio, gael amcanion ar wahn wediu diffinion glir. Byddain symhwyrol cydweithredu ar:

- ddisgrifio math, lleoliad a maint yr olew ar y mr ac ar y tir;
- ragdybio cyfeiriad y sliciau olew ar rhannau or traethlin a fyddain debygol o gael eu llygru;
- ragdybio effeithiaur mesurau gwrth-lygredd ar dynged yr olew ar y mr ac ar y tir.

Byddai angen ir GAE ganolbwyntio ar angenhenion tymor byr ac asesiadau tymor hir. Fel arfer byddai angen sefydlu strwythur tebyg i PGASE. Disgwylir i drefn debyg ir GAE gael ei sefydlu yn dilyn digwyddiadau o lygredd cemegol ar y mr a bod hyn yn cael ei ystyried yn ystod y broses gynllunio.

Wrth sefydlu blaenoriaethau bydd angen ir GAE gyd-weithio gyda awdurdodau iechyd y cyhoedd a diogelwch bwyd gan fod gor-gyffwrdd sylweddol yn y data sydd ei angen (ee crynoadau o lygredd mewn rhywogaethau o bysgod masnachol). Ni ddylair GAE, serch hynny, gynnig cyngor ar faterion yn ymwneud iechyd y cyhoedd.

Bydd angen adolygu ar gaeledd data amgylcheddol sylfaenol ar gyfer traethau a arfordiroedd a gosod trefniadau archifol addas yn eu lle. Bydd angen hefyd i fabwysiadu a chadarnhau dulliau samplo a dadansoddi safonol. Dylid adolygur angen i sefydlu sytemau monitro pellach.

O ran y cyfrifoldeb o sefydlu a chynnal yr GAE, mae cyfrifoldebau statudol presennol (gan gynnwys trefniadau argyfwng mewn perthynas digwyddiadau o lygredd) Asiantaeth yr Amgylchedd (ac Asiantaeth yr Amgylchedd yr Alban), ynghyd i rhwydwaith o swyddfeydd, staff gwyddonol a chyfleusterau, yn golygu mai hi ddylai fod yn gyfrifol am sefydlu yr GAE a threfnu yr ymateb amgylcheddol i ddigwyddiad o bwys. Serch hynny, dylid ystyried opsiynau eraill. Rhagwelwn y dylai aelodau eraill yr GAE gynnwys asiantaethau statudol cefn gwlad, awdurdodau lleol, a adrannau priodol y llywodraeth.

Disgrifir yr GAE yma fel endid cenedlaethol ond rhagwelir o fewn y fframwaith cyffredinol, gyda chynlluniau a threfniadau safonol, y byddai trefniadau lleol yn cael eu sefydlu gyda staff cymwys ar gael mewn rhanbarthau arfordirol. Byddai aelodaeth y ar gyfer unrhyw ddigwyddiad penodol yn dibynnu i raddau ar yr adnoddau amgylcheddol a effeithir. Disgwylir ir NGOau gyfrannu fel mudiadaun cyflawni tasgau arbennig ar asesiad effaith.

Barn y pwyllgor yw y dylai cost asesiadau effaith amgylcheddol or math yma gael ei dalu gan y rhai syn gyfrifol am yr arllwysiad, neur cyrff hynny sydd chyfrifoldeb i dalu iawndal. Serch hynny, gwerthfawrogwn mai dim ond astudiaeth difrod syn dod o fewn y diffiniad o ddifrod llygredd yn y confensiynau rhyngwladol perthnasol a ystyrir ar gyfer iawndal gan Gronfa Iawndal Llygredd Arllwysiad Olew Rhyngwladol (IOPC). Sefydlwyd y confensiynau hyn er mwyn sicrhau iawndal cyflym ac addas ir rhai syn ymgymryd mesurau glanhau rhesymol neu syn dioddef colledion economaidd o ganlyniad i arllwysiad o olew amrwd neu olew tanwydd trwm o dancer. Nid ywr pwyllgor yn dymuno gweld y bwriad hwn yn cael ei golli ond credir y dylid ystyried ymhellach y posibilrwydd o gyllido asesiadau effaith amgylcheddol a gynlluniwyd ac a gyd-lynwyd yn gywir yn dilyn arllwysiad sylweddol o dancer ac syn gymesur ir llygriad ar effeithiau a ragwelir, ac syn ystyried y wybodaeth wyddonol sydd ar gael.

11.3 Recommendations

SEEECs recommendations fall into two broad categories:

- Those which are more specifically related to the *Sea Empress* spill and the area of south-west Wales where environmental impacts occurred. These mostly involve continued monitoring in circumstances where the full effects of the spill cannot yet be assessed.

- Those of national significance derived from the *Sea Empress* experience, which propose research and actions to improve response and assessment procedures wherever another major spill should occur in the UK.

Some of the recommendations relate to specific government agencies or other organisations. Where this is the case, the organisation is named at the end of the paragraph.

11.4 Recommendations of Local Relevance

Our recommendations exclude the existing monitoring programmes, supported by the agencies and some voluntary bodies, which provide important baseline data for some wildlife species, particularly mammals and birds, which are of crucial value when a spill or other damaging event occurs. Additionally, agencies have already agreed to commission certain special projects such as the monitoring of salt marsh vegetation (CCW), and of salmon and sea trout stocks (EA). These initiatives are important but are already in progress.

Proposals are made in the Marine Impacts chapter (3.11) for the continuation of monitoring programmes for several commercial species of fish and shellfish particularly of the herring population within Milford Haven waterway, and of edible crabs, lobsters, whelks and sea bass over a wider area for it is still uncertain whether the 1996 (and possibly 1997) year class has been reduced by the spill. Whilst primarily of local relevance, the results could be of wider significance in relation to our understanding of the effects of oil spills on fisheries, given the quality of the baseline data available for some of these populations. There is also merit in continuing to survey the benthic populations of invertebrates in heavily impacted areas where mortalities of amphipods occurred. Decisions will no doubt need to be made by MAFF and others concerning the respective priorities of these monitoring programmes when funding is considered. (MAFF)

Similarly, several shoreline impacts were identified, but here the pattern of recovery seems to be under way and on a path described earlier for other oil spills. Nevertheless, some species such as the cushion star Asterina phylactica are of particular conservation importance and are still vulnerable; some priority needs to be afforded to the continued observation of these species. (CCW)

With respect to birds, because of the importance of the area for both over-wintering and breeding, baseline data are already extensive. Nevertheless, the availability of data needs to be reviewed and, with respect to the common scoter in particular, some further ongoing studies are advisable in view of the international importance of the over-wintering population in Carmarthen Bay. (CCW)

11.5 Recommendations of National Relevance

11.5.1 Research

There were several effects seen following the *Sea Empress* spill which, although reported at previous spills, remain unexplained and require further investigation. Amongst these were the vulnerability of amphipods to oil pollution and the behaviour of several bivalve species, such as razor shells, in moving out of the sediments. As these animals are important in marine food chains and are therefore of ecological significance, it would be of interest to gain a better understanding of the

exact cause of the observed effects and the reasons for the apparent sensitivity of certain marine species to low levels of oil, although devising appropriate experimental methodologies may prove challenging. (NERC)

There were also suggestions that certain intertidal and subtidal communities in particular animal species in oarweed *(Laminaria*) holdfasts and algal turfs in rockpools might prove useful for monitoring effects of oil. These deserve further consideration, as does the exploration of the opportunity of predictive modelling of pre-spill communities from the physical attributes of their environment, for many areas where spills might occur will not have pre-spill descriptions comparable with those of south-west Wales. This type of model has proved a valuable tool in measuring pollution stress in rivers by comparing communities exposed to pollution with those communities expected at these same sites without pollution. (EA, Countryside Agencies)

11.5.2Bird cleaning and rehabilitation

Studies which SEEEC commissioned following the *Sea Empress* spill called into question its animal welfare value of oiled bird cleaning and rehabilitation particularly for those species with high mortalities during cleaning or soon after release into the wild. In future oiling incidents, we propose further work to assess stress factors during cleaning and the development of better diagnostic tools for an early evaluation of the chance of survival of individual birds so that a more informed judgement can be made about whether such cleaning is continued. The factors related to successful cleaning and rehabilitation need to be investigated further to optimise prognosis and cleaning arrangements.

The study also concluded that there was a need for a wide-ranging national review of arrangements currently in place with particular respect to:

- planning and management
- cleaning procedures
- availability and training of staff and volunteers.

Although the RSPCA is a charity and not a statutory body and can therefore determine its own policy in this matter, SEEEC believes that such a review, initiated by the RSPCA, would be valuable and timely and would bring about a significant improvement in current arrangements. Furthermore (with its equivalent bodies in Scotland and Northern Ireland) it is the only organisation with the resources, skills, organisation and widespread support to carry it out. (RSPCA)

11.5.3 Closure orders for fisheries

Closure orders (ie Exclusion Orders issued under the Food and Environmental Protection Act 1985) prohibit fishing for named species in defined areas and are issued by specific government departments. Following the issue of such orders after the *Sea Empress* oil spill and also the subsequent lifting of these restrictions, there was widespread confusion both in the fishing community and amongst the general public about the basis of these orders. Although issued as precautionary measures to protect consumers from eating potentially contaminated fish and shellfish, they were sometimes interpreted as evidence or likelihood of damage to the actual stocks. In future the causation of such orders should be made clearer both when they are issued and when they are lifted. (WO,MAFF)

11.5.4 Clean-up assessment

Despite the considerable success of the clean-up procedures both at sea and on shore, we have several recommendations which, if followed, should lead to improvements. These are discussed fully in the Clean-up Operation chapter, 10.10, and include:

- the clearer definition of tasks allocated to specific managers within the response organisation;
- the need for the Overall Commander to be at the scene of a major incident to act as authoritative spokesman for the MPCU and Coastguard Agency;

- the need to rename the Joint Response Centre (JRC) to make clear its role solely in shoreline clean-up;

- preference for the appointment of a local authority chief officer to chair the JRC and the likely consequential improvement in administrative support and staffing levels;

- improved documentation and record keeping to assist the prompt preparation and payment of claims for compensation;

- the need to establish clear criteria for terminating shoreline clean-up at individual sites, recognising that natural clean-up processes also occur;

- the need to charge local authorities with the statutory obligation to prepare local contingency plans and to carry out shoreline clean-up provided adequate resources are made available. In this incident local plans had been prepared and their importance was demonstrated. Lord Donaldsons inquiry recommended that local authorities should have such a statutory duty although the Merchant Shipping and Maritime Security Act 1997 only provides enabling powers rather than a statutory duty to adopt this role.

- the importance of adherence to Health and Safety requirements for the clean-up workforce and of close attention to planning duty rosters to ensure that staff are not unduly stressed through working excessive hours;

- better provision of actual and predictive information on oil distributions, particularly where there are extensive shoreline impacts. Greater use should be made of IT facilities for preparing and archiving aerial surveillance maps with validation using standard reporting procedures. These standard procedures were not used in relation to the *Sea Empress* spill and it became clear that whilst their use might have been beneficial to the clean-up operation, their further develop-ment might also provide information useful in the assessment of ecological impacts.

- the need to respond to the media in a more positive and co-ordinated manner;

- the importance of developing emergency procedures and arrangements for the disposal of oily wastes at both national and local level. The current licensing arrangements applying to emergencies are unsatisfactory and need to be resolved urgently (within one year), initially through discussions between EA, MPCU and local authority associations.

Some of the above recommendations are matters which apply principally to the Coastguard Agency and, more specifically, to MPCU: these matters are already being considered by that agency in its current review of the national contingency plan. (MPCU)

It is for government to consider the need to charge local authorities with the statutory obligation to prepare local contingency plans and carry out shoreline clean-up (DETR).

11.5.5 Future arrangements for impact assessment

Although there are contingency plans at a national and local level for responding to oil spills, with the response action dependent on the scale of the spill and its overall impact, there are no comparable response plans for assessing environmental impacts. In consequence, during the early days after a spill, when the collection of environmental information is crucially important, reliance is placed on *ad hoc* arrangements. The ESGOSS Report (the equivalent to SEEECs report following the *Braer* oil spill in Shetland), proposed that a liaison group be established as soon as possible at all spills posing a significant threat to the environment. In the case of the *Sea Empress* spill there were special factors which reduced the problem, not least the availability of local experts to gather information immediately after the spill took place and rapid action by particular agencies. Nevertheless, there were several examples of early uncoordinated responses. After a few weeks an Interim Technical Co-ordinating Group met to assess the monitoring activities of the main organisations and to ensure overlaps and gaps were minimised, and about six weeks after the spill SEEEC was established to carry these objectives forward. This was a commendably short period, but during those early weeks a more structured, co-ordinated approach, adopting clearly defined procedures and sampling and analytical protocols, and providing an assured funding base for its programme, would have proved highly beneficial.

It is recommended that emergency response plans are prepared at national level so that, whenever a serious spill occurs, an

environmental Impact Assessment Group (IAG) is established to carry out the necessary monitoring and environmental measurements. The main objectives of the IAG would be to determine:

- concentrations of oil in the environment, particularly in sensitive species and habitats,
- and compare these with baseline data;
- the fate of oil over time;
- environmental effects (both short term and long term) of the spill and of clean-up responses, and to describe rates of recovery.

This group, although working closely with the JRC and co-operating over aspects of data collection and interpretation, must have clearly defined and separate objectives. Examples of where collaboration would seem sensible are:

- describing the type, position, extent and state of oil at sea and onshore;
- predicting the future track of oil slicks and areas of shoreline likely to become polluted;
- predicting the effects of anti-pollution measures on the fate of the oil at sea and onshore.

The IAG will need to focus on both the short term needs and longer term assessments. It would not normally be necessary to set up a special SEEEC-type structure. It is envisaged that a similar arrangement to the IAG would be established following incidents involving chemical pollution at sea and that this will be considered during the planning process.

In establishing priorities it will be necessary for the IAG to co-operate with the public health and food safety authorities as there is considerable overlap in the data needed (eg concentrations of contaminants in commercial fish species). The IAG should not, however, become involved with providing advice on public health matters.

It will also be necessary to review the availability of baseline environmental data for the UK shores and coastal areas and put in place suitable archiving arrangements. Standard sampling and analytical methods will also need adoption and validation. The desirability of establishing further monitoring systems should also be reviewed.

Concerning the responsibility for setting up and maintaining the IAG, the existing statutory duties (including emergency procedures in relation to pollution incidents) of the Environment Agency (and the Scottish Environment Protection Agency), together with its network of offices, scientific staff and facilities, makes it the preferred organisation for being charged with providing the lead in establishing the IAG and organising the environmental response to a major incident. However, other options for a lead agency should be explored. We envisage that other members of the IAG should include statutory countryside agencies, local authorities, and government departments with appropriate territorial and functional responsibilities.

The IAG has been described here as being a national entity but it is envisaged that within an overall national framework, with standard plans and procedures, local arrangements would be put in place with trained staff available in coastal regions. Membership of the group for any specified incident would be in part dependent on the environmental resources affected. It is expected that NGOs would participate as organisations carrying out specific tasks on impact assessment.

It is the committees view that the costs of environmental impact assessments of the type undertaken by SEEEC (and proposed for the IAG) should be met by those responsible for the spill, or by those bodies which are required to pay compensation. However, we appreciate that such costs are currently only considered an admissible claim by the International Oil Spill Pollution Compensation (IOPC) Fund to the extent that the studies relate to damage that would fall within the definition of pollution damage in the relevant international conventions. These conventions were established to ensure that those who undertake reasonable clean-up measures or who suffer economic losses as a result of a spill of crude oil or heavy fuel oil from a tanker receive prompt and adequate compensation. The committee has no desire to see this primary objective impaired but it believes that further consideration should be given by the IOPC Fund to the possibility of funding properly designed and co-ordinated environmental impact assessments following major tanker spills that are in proportion to the severity of the pollution and predictable effects, and that take into account existing scientific knowledge.