



**A condition assessment of Poole Harbour European Marine Site**



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## Summary

Natural England has a statutory duty to advise other relevant authorities on the conservation objectives for the European Marine Site in Poole Harbour. In order to facilitate this, Natural England wish to test the assumption that existing features are in favourable condition and quantify targets for 2000-2006. This report assesses the condition of the bird interest features of the Harbour, identifies damaging operations or activities, and recommends monitoring and management actions together with revised targets for the next reporting period.

Much of the information from which the conclusions in this report are derived have been based on research work carried out in Poole Harbour from studies commissioned and financed by English Nature. Other major contributors have been the Environment Agency and the Harbour Commissioners. It is recommended that these and other organisations put in place amore integrated monitoring scheme for the Harbour. This could be initiated by a symposium to identify the issues and main stakeholders.

Populations of those bird species for which the harbour was designated as an SPA are mostly stable or increasing. Breeding numbers of common terns and Mediterranean gulls have been rising and the wintering populations of black-tailed godwits and avocets have also been increasing. Shelduck numbers have declined but at a lower rate than those nationally. The size of the overall assemblage of wintering waterfowl has declined, but wader numbers excluding lapwings (which have fallen considerably) have risen and wildfowl numbers show no clear trend. Some wader roosts are threatened by saltmarsh erosion and disturbance from people and boats.

Changes in the areas of the habitats in the Harbour have taken place and are likely in the future. These include loss of saltmarsh habitat and possible changes to inter-tidal flats from climate change and sea level rise. These will need to be monitored and consideration given to managed retreat options to counteract the predicted effects.

With warmer winters, year round recreational activities may become more prevalent, with consequent increases in disturbance and in-combination effects with other Harbour users.

The recorded levels of potentially toxic contaminants in the Harbour waters and sediments are generally acceptable but the record is incomplete and possible bio-accumulation effects in the food chain are poorly understood. Further work on both aspects is needed together with careful monitoring of sediment disturbance through dredging in areas with suspected concentrations of TBT residues. Natural England should be satisfied that the precautions against oil spills, and clean up measures in the event of a spill, are rigorous and acceptable and that the level of consultation if a spill occurs is satisfactory.

There is evidence of high levels of nutrients in sediments, with consequent macro-algal summer mats which may effect invertebrate populations important as bird prey during autumn and winter. This needs monitoring.

A comprehensive survey of infaunal invertebrates carried out in the Harbour in 2002 provides a good baseline for repeat surveys when the opportunity should be taken to collect sediment samples and monitor changes in granulometry. A six year sediment management plan is desirable, and should include the monitoring of physical, chemical and biological characteristics of dredged material. As much dredged material as possible should be kept within the Harbour system.

The introduction of alien species into the Harbour is a possible consequence of ballast water disposal and the introduction of shellfish from elsewhere. Natural England should satisfy itself that the precautions adopted in relation to both these activities are rigorous and are adequately monitored.

Grazing by introduced sika deer has had a seriously deleterious affect on the saltmarsh and associated habitats around much of the harbour shoreline and encouragement should be given to the relevant landowners to reduce deer numbers.

A number of sediment perturbation activities are currently inadequately monitored, including bait digging and dragging and dredging for shellfish. These may have consequences both for sediment granulometry and the invertebrate populations within the sediments (infauna). Adequate monitoring of both these features is desirable. Both the dredging and dragging activities, together with wildfowling from within the harbour and from the shore, recreational and commercial boating, bird-watching and shoreline recreational activities, all have the potential to disturb wintering waterfowl. Currently none of these activities are adequately monitored and a baseline survey is urgently required. Time lags in identifying and redressing potentially damaging operations and activities dictate that the precautionary principle should be adopted for consenting and monitoring.

There is evidence of an increase in some activities eg. visiting boat numbers and the recent increase in pump scoop dredging for clams, and whilst in a normal year the levels of disturbance may be acceptable, there could be serious consequences at times when waders and wildfowl are stressed, for instance, during a cold winter. There is already some circumstantial evidence that the distribution of feeding and roosting waterfowl are affected by human disturbance, and this needs to be assessed and monitored.

<b>Contents</b>	<b>Page</b>
<b>Introduction</b>	7
<b>Area of Poole Harbour</b>	8
<b>Bird populations in Poole Harbour</b>	10
<b>Current status and trends of wintering and breeding Annex I birds in Poole Harbour</b>	11
Regularly occurring Annex I species	11
<i>Avocet</i>	11
<i>Mediterranean gull</i>	12
<i>Common tern</i>	12
Conclusions on regularly occurring Annex I species	12
Regularly occurring migratory species	13
<i>Shelduck</i>	13
<i>Black-tailed godwit</i>	14
Conclusions on regularly occurring migratory species	15
Internationally important assemblages of waterfowl	15
Overall conclusions	17
<b>Roosting birds</b>	18
<b>Potentially damaging features or activities</b>	19
Contaminants of water and sediments	19
<i>Metals</i>	20
<i>TBT (tributyltin)</i>	22
<i>Hydrocarbons</i>	22
<i>Pesticides, herbicides, PCBs, VOCs and other compounds</i>	23
Conclusions on toxic substances in Poole Harbour	24
Non toxic contaminants and indicators	25
<i>Total inorganic and organic nitrogen</i>	27
<i>Phosphates</i>	27
<i>Ammonia</i>	27
<i>Chlorophyll a</i>	27
<i>Dissolved oxygen</i>	28
<i>Micro-algal blooms</i>	28
<i>Macro-algal mats</i>	28

<b>Sediment granulometry</b>	29
<b>Invertebrates in Poole Harbour</b>	30
<b>Disturbance to sediments</b>	31
Activities that disturb sub-tidal and intertidal sediments	31
<i>Dredging</i>	31
<i>Bait digging and bait dragging</i>	33
<i>Shell fishing</i>	35
<b>Boating in Poole Harbour</b>	36
<b>Other activities</b>	39
Wilfowling	39
Deer grazing	39
Obstruction to site lines	40
Alien species	40
<b>Disturbance</b>	41
<b>Condition tables</b>	42
<b>Acknowledgements</b>	47
<b>References</b>	48
<b>Appendix 1</b>	53
<b>Appendix 2</b>	54
<b>Appendix 3</b>	55

## Introduction

Poole Harbour is a large lagoonal estuary of nearly 4,000 ha with a narrow entrance and a micro-tidal regime resulting in high water volumes throughout the tidal cycle. On the southern shore, the Harbour is bounded by extensive heathlands, grasslands and mires, with fringing reedbeds and saltmarsh. To the north, much of the area is developed within the Poole and Bournemouth conurbation but there are two large, shallow tidal extensions to the Harbour at Holes and Lytchett Bays. There are four islands, with the largest, Brownsea, containing a large, managed tidal lagoon. The Harbour supports important populations of breeding gulls and terns, with locally important breeding herons, waders and reed bed birds. The area is important for passage birds and wintering wildfowl and waders, providing feeding and roosting sites within the intertidal areas and on the adjoining wet grazing meadows.

Under Article 4.1 of the of the European Union's Directive on the conservation of wild birds (EC/79/409 as modified) (the 'Birds Directive'), Poole Harbour qualifies by supporting populations of rare or vulnerable species listed in Annex I (Article 4.1) or regularly occurring migratory species (Article 4.2). Under Article 4.1, Poole Harbour is of European importance for breeding common tern, and Mediterranean gull, passage aquatic warbler and little egret, and wintering avocet and little egret (JNCC 2001).

Under Article 4.2, the Harbour also supports internationally important wintering populations of the Icelandic population of black-tailed godwit and the Northwestern European population of wintering shelduck. It is also a wetland of international importance by regularly supporting at least 20,000 waterfowl. These include six wader species, four species of duck, dark-bellied brent goose, red-breasted merganser and cormorant as well as lesser numbers of other species.

Pursuant to Regulation 33 (2)(a) of the Conservation (Natural Habitats &c.) Regulations 1994, Natural England has a duty to advise other relevant authorities as to the conservation objectives for a European Marine site, (a site classified under Article 4.1 or 4.2 of the Birds Directive which consists of marine areas). English Nature (2000) advised that the conservation objectives for Poole Harbour shall include the maintenance in favourable condition of the shallow inshore waters, intertidal sediment communities, saltmarsh and reedbed for the internationally important populations of regularly occurring Annex I and migratory bird species and the internationally important assemblage of waterfowl.

In furtherance of these objectives, English Nature published a favourable condition table as a means of assessing the condition of interest features. Such assessments will be made against targets based on existing condition. Natural England have therefore decided to test the assumption that existing interest features on European Marine sites are in favourable condition and to quantify targets during the 2000-2006 reporting period.

In recent years English Nature have commissioned, promoted and financed a number of studies of the ecology and species of the Harbour, in order to help the process of evaluation for favourable condition, and much of this material has been central to this review.

The objectives of this project are therefore:

1. To assess the condition of the bird interest features of the Poole Harbour Special Protection Area and their habitat sub-features
2. To identify operations and activities that may be causing damage or disturbance to these features
3. To recommend management actions required to ensure that the designated site is maintained or restored to favourable condition
4. To assist Natural England in their statutory duty to advise other authorities on actual or potential threats, in order to maintain the harbour in a favourable condition for the designated features

(Scientific names of birds and plants are given at first mention in the text.)

### Area of Poole Harbour

The area of Poole Harbour as a whole has changed in the past due to sea level rise and coastal squeeze. Using aerial photographs, Born (2005) looked at the relative areas of saltmarsh and reedbed in the Harbour during 1947-1993 (Table 1).

**Table 1. Areas of saltmarsh and reedbed within Poole Harbour 1947-1993 from aerial photographs (from Born 2005)**

Habitat	Observed area (ha)			Loss/gain (ha)	% Loss/gain
	1947	1972	1993		
Saltmarsh	634	549	389	-245	-38.6
Reedbed	75	122	122	47	62.7
Total	709	671	511	-198	-27.9

A survey of the reedbed areas by Cook (2001) found a total of 174.6 ha of reedbeds in 2000, a further increase in area of 52.6 ha (43%) since 1993, and Edwards (2004), estimated the saltmarsh area (including lower, middle and upper saltmarsh communities) at 631.8 ha in 2001. Edwards (2004) precisely described the communities of the saltmarshes, and estimated the areas of each component and other intertidal habitats in the harbour.

Areas of intertidal habitat were estimated both from the WEBS counts (Pickess & Underhill-Day 2002) and from Admiralty Chart 2611 (in Thomas et al 2004), as 1312 ha and 2546.7 ha respectively. These figures illustrate the difficulty of measuring an area covered for much of the time by water to a varying degree, which although largely predictable can change depending on wind direction and strength. The Environmental Statement prepared by Simpson & White (2004) for the Borough of Poole and Poole Harbour Commissioners in relation to the channel deepening, estimated that net loss of saltmarsh during 1972-1993 was 7.5 ha/year., with the biggest losses around Furzey Island, and that rates of loss have slowed and are

currently at 5ha/year. Net loss of fine material from the Harbour was calculated as being 56,000-76,000 m<sup>2</sup>/year. Taken together, these changes represent a loss of intertidal area of between 0.6-3.4ha/year at mean low water, with conversion of saltmarsh to intertidal flats partly compensating for the loss of fine material from the flats themselves. There may also be changes due to erosion and accretion of the sediments from which the intertidal flats are derived.

**Table 2. Areas of vegetated intertidal habitat in Poole Harbour (from Edwards 2004)**

Habitat	Area (ha)
Lower saltmarsh	358.59
Mid-upper saltmarsh	64.82
Upper saltmarsh (Atlantic salt meadow)	175.04
Upper saltmarsh (Mediterranean salt meadow)	33.35
<i>Salicornia</i> on mud and sand	2.76
Mediterranean halophilous scrub	0.51
<i>Ammophila</i> dunes	0.67
Vegetated shingle	0.2
Annual driftlines	0.16
<b>Total vegetated tidal habitats</b>	<b>636.1</b>

A report by the standing Conference on Problems Associated with the Coastline (SCOPAC) (2006) summarises shoreline cliff erosion reported by various authorities during the last 35 years. The report notes that the die back of cord grass *Spartina anglica* has resulted in an increase in wave energy at some previously protected sites resulting in increases in erosion rates. The report details active erosion Rockley Cliffs, around Brownsea Island and Furzey Island, Brands Bay and the Goathorn Peninsula, Shipstall Point and the cliffs between Hyde's Quay and Russel Quay at Arne. Rates of recorded erosion range from 0.3-0.45mm/year (May 1969)

Sea level rise was estimated at 3mm/yearly during the 1980's and early 1990's, but was revised upwards by MAFF to 5mm/yearly in the mid 1990's and again by DEFRA to 6mm/yearly in 2006 (May 2006). In many places on the southern shore of the Harbour this will result in the migration of saltmarsh onto adjoining agricultural land or heathland, mire, reedbed or carr. On both sides of the Wareham Channel, however, where the coastline is protected by seawalls this will result in coastal squeeze and loss of saltmarsh. Climate change and sea level rise are likely to accelerate the rates of change and increase losses of lower saltmarsh to intertidal mudflats, and lower mudflats to sub-tidal sediment beds. A modelling study carried out by Durell et al (2006) identified; relatively low densities of the larger size classes of polychaete worms; management of surrounding terrestrial habitats; and the effects of sea level rise on periods when intertidal flats are available to birds for feeding, as key issues for the conservation of wintering shorebirds in Poole Harbour. They concluded that all species studied (dunlin, redshank, black-tailed godwit, oystercatcher and curlew) would all be seriously affected by the extent of sea level rise simulated by the model. These changes could represent the greatest threat to the integrity of the Harbour in the medium to long term.

Currently the best prospect for an increase in the Harbour area is by managed retreat in the wet grasslands adjoining the Frome River and Wareham Channel. However, these are also important feeding and resting sites for Harbour waterfowl, and should be replaced by upstream habitat restoration before a managed retreat scheme is implemented.

**The use of LIDAR and bathymetric surveys for recording current status and future changes to the areas of shallow water and sedimentary deposits within the Harbour should be explored. It is recommended that regular measurements of the areas of saltmarsh and reedbed be undertaken, based on aerial photography together with GPS ground truthing of saltmarsh and reedbed edges at six year intervals. The migration of wet meadow systems upstream in the Frome valley should be actively pursued, to release existing meadows lower down for managed retreat.**

### Bird Populations in Poole Harbour

The numbers and species of Annex I birds for which Poole Harbour was classified as an SPA are shown in Table 3.

**Table 3. Populations of internationally important Annex 1 birds for which Poole Harbour was classified as an SPA on 31.03.1999.**

Species	Populations (5 year peak mean)	Population status	Surveyed
<i>Regularly occurring Annex I species</i>			
Avocet	459 birds	36.1 % GB	1992/3-1996/7
Mediterranean gull	5 pairs	22.7-38.5% GB	1993-1997
Common tern	155 pairs	1.3% GB	1993-1997
<i>Regularly occurring migratory species</i>			
Shelduck	3,559 birds	1.2 % North-west Europe	
Black-tailed godwit	1,576 birds	2.3% Iceland	
<b>Internationally important assemblage</b>			
Wintering wildfowl	23,498 individuals (From data 1992/93)		

Poole Harbour also holds nationally important numbers of dunlin, cormorant, dark-bellied brent goose, teal, goldeneye, red-breasted merganser, curlew, spotted redshank, greenshank, redshank and black-headed gull (Natural England 2000). This list was updated by Pickess & Underhill-Day (2002), based on the annual peak

wintering or passage numbers 1991-1998. In addition to the above, they included wintering Slavonian and black-necked grebe, pintail, shoveler, pochard, passage/winter little egret and breeding little egret, sandwich tern, Cetti's warbler and bearded tit. A later report, (Chown & Cook 2004) suggests that the population of breeding water rails in the Harbour is likely to be of national importance.

### **Trends of wintering and breeding Annex I birds in Poole Harbour.**

#### Regularly Occurring Annex I Species

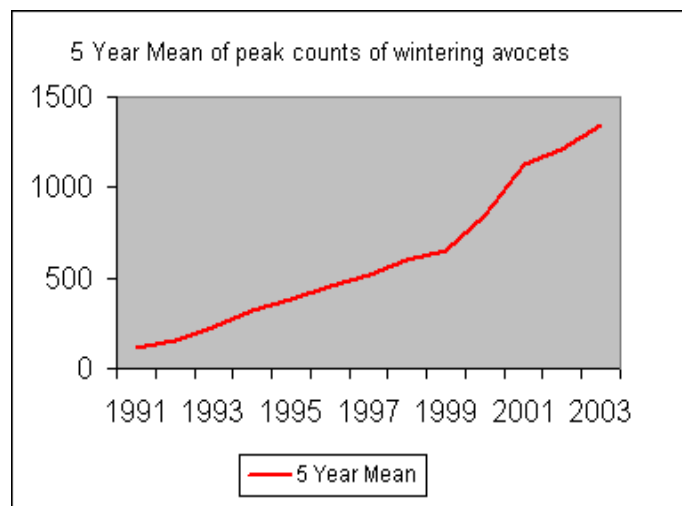
(The qualifying figure for internationally important numbers of wintering species was agreed by the contracting parties to the RAMSAR Convention in 1988. These were given in Cranswick et al 1992 for most species of wintering wildfowl and waders in the UK).

#### *Avocet*

The threshold for the number of wintering avocets of international importance was set in 1988 at 700 and remained at that level until 2001 when it was raised to 730 (Cranswick et al 2005). A monthly maximum count of avocets in Poole Harbour reached that figure for the first time in the Wetland Bird Survey (WEBS) count in December 1997 (Table 4, Figure 1), and has exceeded the international threshold in at least one winter month each year since then. The maximum WEBS count of avocets was in February 2002 at 1862 birds. Poole Harbour became the most important site for wintering avocet in 2002/03 and has retained that distinction in subsequent years.

**Table 4 and Figure 1 Maximum numbers of avocets recorded wintering in Poole Harbour in the WEBS counts 1991/91-2003/04 with month of highest count and five year running means. (International threshold 700 to 2001/02 then increased to 730)**

Winter	Max monthly Count	Month	Five year Mean
W 91/92	144	Jan	111
W 92/93	290	Feb	159
W 93/94	396	Nov	225
W 94/95	584	Jan	318
W 95/96	505	Jan	384
W 96/97	520	Dec	459
W 97/98	585	Dec	518
W 98/99	832	Nov	605
W 99/00	823	Oct	653
W 00/01	1491	Feb	850
W 01/02	1893	Feb	1125
W 02/03	1007	Oct	1209
W 03/04	[1493]	Nov	1341



### *Mediterranean gull*

Mediterranean gulls have nested on saltmarsh islands with large numbers of nesting black-headed gulls in Poole Harbour since 1977.

There were sporadic attempts at breeding before 1990, when six pairs were thought to have bred and a juvenile was seen. The number of pairs in the Harbour remained low (Table 5) with between 2 and 8 pairs until 2003.

The first comprehensive count of nests in 2006 indicated a substantial increase from earlier estimates and counts. Nationally numbers have risen from first nesting in 1968, to about 6 pairs in 1985, 110 pairs 1999-2002, and 140 nests in southeast England alone in 2004 (Mavor et al 2004). The population in Poole Harbour is of national importance, and the recent increase mirrors a substantial increase in Langstone Harbour in Hampshire. Formerly there was some illegal egg collecting of black-headed gull eggs, and this may have affected the productivity of the Mediterranean gulls, which could also have been collected, as the nests and eggs of the two species are somewhat similar.

\*Figures kindly supplied by P. Wood

**Table 5 Breeding pairs of Mediterranean gulls in Poole harbour**

**1990-2004**

Year	Breeding pairs
1990	6
1991	3
1992	2
1993	5
1994	2
1995	2
1996	6
1997	8
1998	3
1999	3
2000	5
2001	?
2002	3?
2003	4?
2004	10 est*
2005	10est*
2006	50nests*

### *Common Tern.*

The common tern colony on Brownsea Island increased from 104 pairs in 1988 (1% of UK population) to 246 pairs in 2004 (2.4% of national population), (Table 6 and Figure 2 ). Thus, the size of the colony has more than doubled over the last 17 years, at a mean rate of 2.9% pa and at a time when national numbers of breeding common terns have been relatively stable (1969/70, 14,890; 1998/00 14497; Mitchell et al 2000). In recent years there have been periods of poor productivity that have probably been weather related, but the possibility of chick losses through predation by rats, gulls and crows was mentioned in the Dorset Bird reports for 2001 and 2002 and rats were again noted in the Seabird Report for 2004 (Mavor et al. 2004). In the past, sparrowhawk predation has also been noted (Cook pers. comm.).

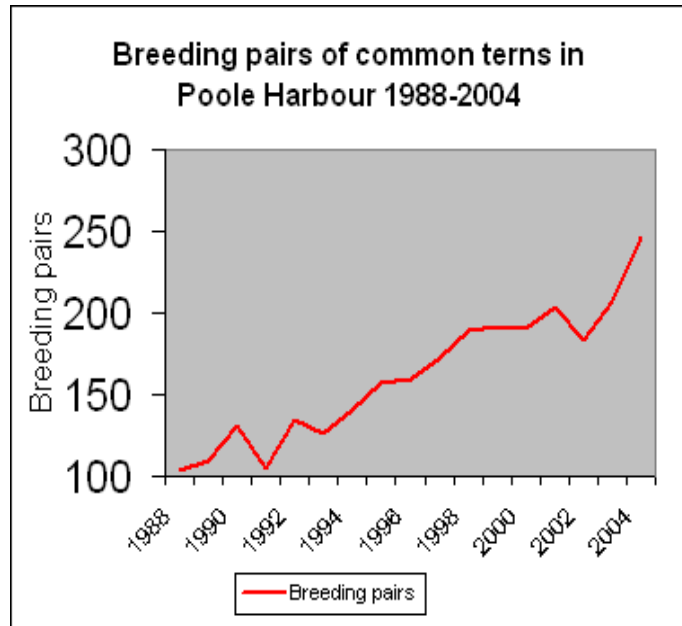
### Conclusions on Regularly Occurring Annex I Species

The population of wintering Avocets and breeding common terns have both increased substantially over the past decade, with common tern productivity varying widely from year to year but with no detectable trend. Mavor et al 2004) calculated population change and mean productivity for 18 and 15 years respectively at Brownsea. Based on an index set at 100 in 1986, the Brownsea population showed an increase of  $150 \pm \text{sd } 37$ , higher than similar calculations for Langstone and Chichester Harbours (72 and 22) but lower than for Scolt Head and Blakeney (171 and 204) in eastern England. Mean productivity during 1986-2003 was  $0.63 \pm \text{SE } 0.08$  chicks per pair. This was within the range recorded for various periods at eight other sites in

south west, south east and eastern England (range 0.33-1.57) and better than all other well recorded sites. It appears that the common tern colony on Brownsea Island compares well in terms of both rate of increase and productivity with other sites in southern England. Mediterranean gulls have bred in the Harbour for 16 years but have only recently increased substantially in numbers, in line with a similar increase in Langstone Harbour (Wood pers. comm.).

**Table 6 and Figure 2 Number of common tern pairs and fledged young and mean fledged young per pair in Poole Harbour 1988-2004**

Year	Breeding Pairs	Fledged Young	Fl. Young Per Pair
1988	104	80	0.66
1989	110		
1990	131	50	0.38
1991	105	50	0.48
1992	135	59	0.42
1993	126	104	0.82
1994	141		
1995	157	100	0.64
1996	160	97	0.61
1997	173	18	0.1
1998	189		
1999	192		
2000	191	82	0.43
2001	203	150	0.74
2002	183	10	0.05
2003	207	170	0.82



Regularly Occurring Migratory Species

*Shelduck*

International threshold was 2,500 birds to 1995/96 and Was then raised to 3,000

Shelduck numbers in Poole Harbour exceeded the international threshold only during the years 1994/5-6/7, with the highest count in January 1997 (Table 7). Since that time there has been a progressive decline in numbers to just over 2,000 birds in 2003/04. This follows the national figures which showed a gradual downward trend during the 1990's to an index value in 2002/3 which was the lowest since 1977/78 (Cranswick et al 2005) (Table 8, Figure 3). A comparison with Chichester Harbour, the only south coast estuary for which figures are available throughout the period is also shown. Poole Harbour has not been internationally important for this species since 1999/2000 (based on the five year means),

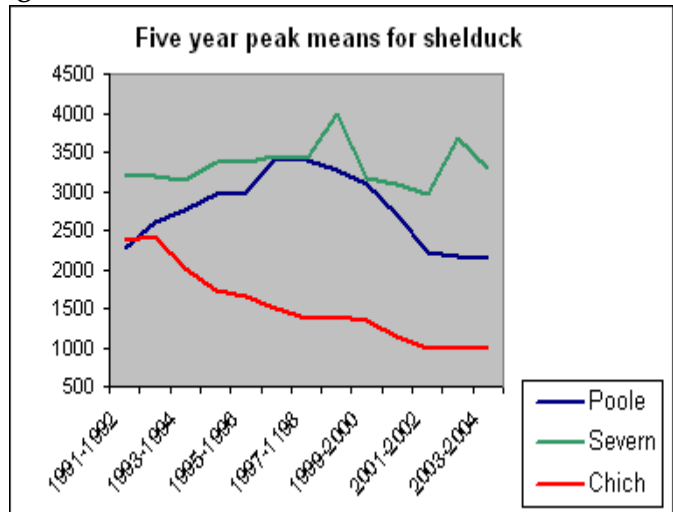
**Table 7 Peak shelduck Numbers in Poole Harbour 91/2-03/4**

Year	Maximum Monthly Count
91/92	2382
92/93	2769
93/94	2982
94/95	3177
95/96	3575
96/97	4650
97/98	2662
98/99	2318
99/00	2192
00/01	1748
01/02	2221
02/03	2385
03/04	2072

although numbers remain nationally important.

**Table 8 and Figure 3. Five year mean peak counts for shelduck in Poole Harbour, Chichester Harbour and the UK (/10) during the winters 1991-1992 to 2003-2004**

Year	Five Poole	Year Severn	Means Chich
1991-1992	2277	3220	2373
1992-1993	2602	3191	2433
1993-1994	2753	3152	2011
1994-1995	2952	3379	1723
1995-1996	2977	3361	1654
1996-1997	3431	3456	1510
1997-1998	3409	3418	1371
1998-1999	3276	3995	1391
1999-2000	3079	3165	1344
2000-2001	2714	3082	1146
2001-2002	2228	2957	987
2002-2003	2173	3667	980
2003-2004	2137	3283	975



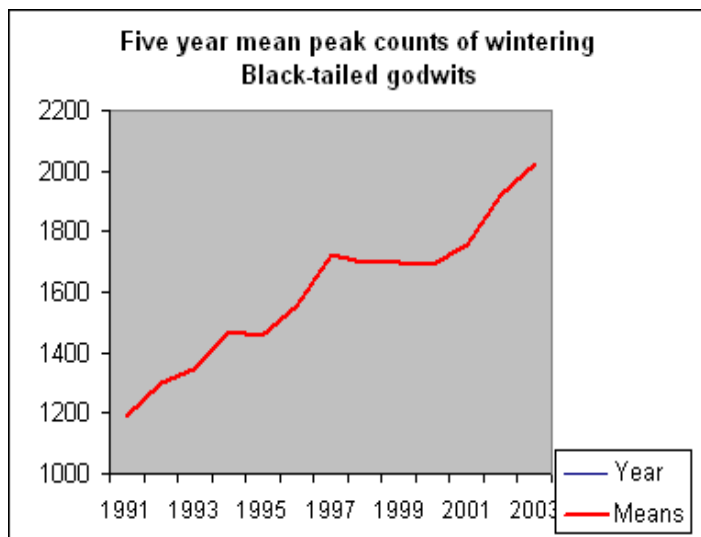
*Black-tailed godwit*

Numbers of black-tailed godwits wintering in Poole Harbour have risen steadily over the last 25 years, from under 600 in 1986/87 to over 2,000 in each of the last three winters for which data are available. The actual increase is likely to be larger than that shown in Table 9 and Figure 4, as the last three counts were incomplete. Numbers reached the threshold for international importance in 1987/88 and have remained above this level each year since.

**Table 9 and Figure 4 Maximum numbers of black-tailed godwits recorded wintering in Poole Harbour in the WEBS counts 1991/91-2003/04 with month of highest count and five years running means.** (International threshold 700 to 2001/2 then reduced to 350)

Winter	Maximum monthly count	Month	Five year mean
W 91/92	1280	Mar	1188
W 92/93	1423	Mar	1298
W 93/94	1350	Oct	1348
W 94/95	2046	Mar	1467
W 95/96	1194	Feb	1459
W 96/97	1771	Mar	1557
W 97/98	1895	Feb	1727
W 98/99	1596	Feb	1700
W 99/00	2051	Jan	1701
W 00/01	1134	Nov	1689
W 01/02	[2115]*	Feb	1758
W 02/03	[2691]	Feb	1917
W 03/04	[2113]	Jan	2025

\* Incomplete counts



## Conclusions on Regularly Occurring Migratory Species

Black-tailed godwit numbers have increased by some 70% over the last 13 winters, such that Poole Harbour is now the most important site in Britain for the Icelandic race of this species. However, the WEBS counts can hide wide variation in the numbers from month to month. For example, during the first three months of 2001, there were few birds present, but in the flooded Avon Valley a maxima of 2630 birds were recorded with none in 1999/00 and only 3 recorded in 2001/02. There is a strong presumption that these were birds from Poole Harbour, suggesting that they can be highly mobile if an abundance of food becomes available elsewhere. Poole Harbour is, however, no longer internationally important for shelduck, although over the period as a whole numbers have declined by only 6%. In fact, internationally important numbers were recorded in the Harbour on only four occasions, Jan 1995, Feb 1996 and Jan and Feb 1997. Since that year there has been a steady decline. During the same period, Chichester Harbour has seen a nearly a 60% decline (Table 8), and Langstone Harbour which had been nationally important since the late 1980's, no longer met the qualifying levels (five year mean peak count of 750) from 2000/02. Poole Harbour has experienced a far less severe decline than the UK overall where numbers have declined over the same period by nearly 22%.

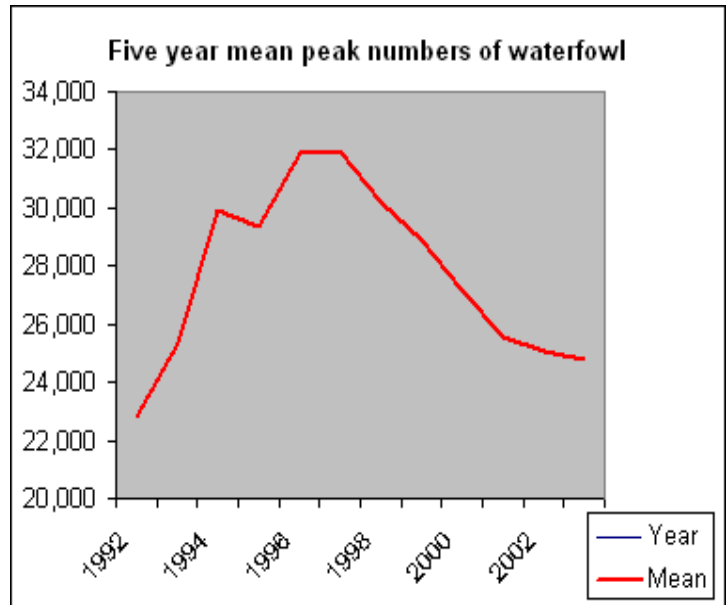
### Internationally important assemblages of waterfowl

Under the contracting parties to the RAMSAR Convention any wetland regularly holding 20,000 waterfowl is regarded as of international importance. This standard has since been embodied in the criteria for classification as an SPA. Overall figures for Poole Harbour are not available from the Wildfowl and Wader Count Reports prior to 1992-1993. The peak counts for all waterfowl in Poole Harbour increased until the winters of 1995/6 and 1996/7 and then declined steadily to 2003/2004. This is mirrored by the five year running means of peak counts (Table 10 and Figure 5). An examination of the figures for waders and wildfowl separately (Figure 6) indicates that wildfowl numbers have remained fairly stable apart from a peak in 1996/97, whereas, wader peak counts, after reaching a high in 1993/94, have since declined.

An analysis of the figures for individual species, shows that the reason for the decline in waders overall is a massive decline in the numbers of Lapwing counted in the Harbour with the peak counts dropping from between c.2000 and c. 10000 in the early 1990's to 3-600 in the early years of this century. In fact, with lapwing counts removed, the overall numbers of other wader species have increased in the Harbour during the period (Table 11 and Figure 8). Of those species listed as having nationally important numbers, dark-bellied brent geese, pintail and dunlin numbers have been relatively stable, pochard, redshank and possibly curlew have declined and cormorant, shoveler, teal, goldeneye and red-breasted merganser have increased. The only species for which the BTO found a statistically significant decline in the Harbour during 1974/75 to 1999/00 was pochard (Austin et al 2003). This may reflect a series of mild winters.

**Table 10 and Figure 5 Peak counts of wintering waterfowl in Poole Harbour together with five year running means from 1992/93-2003/04**

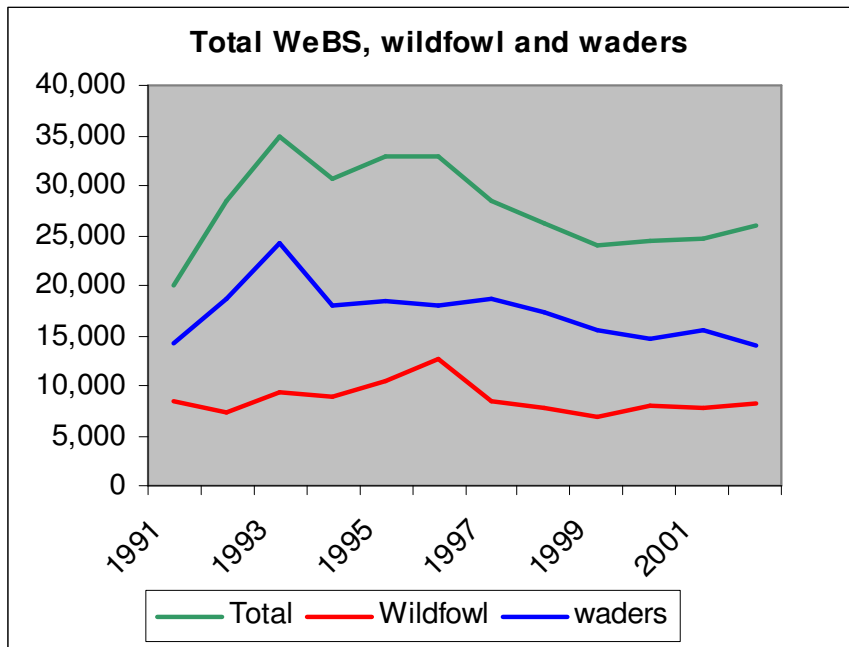
Winter	Waterfowl peak winter counts	Five year mean peak winter counts
W 90/91	35,791	N/A*
W 91/92	20,001	N/A*
W 92/93	28,437	22,821**
W 93/94	34,796	25,317
W 94/95	30,672	29,939
W 95/96	32,849	29,351
W 96/97	32,846	31,920
W 97/98	28,477	31,928
W 98/99	26,246	30,218
W 99/00	23,969	28,877
W 00/01	24,469	27,201
W 01/02	24,628	25,558
W 02/03	25,949	25,052
W 03/04	24,853	24,774



\* Total figures for Poole Harbour are not available from the published WEBS Reports for 1988/89 and 1989/90 so it was not possible to calculate five year means.

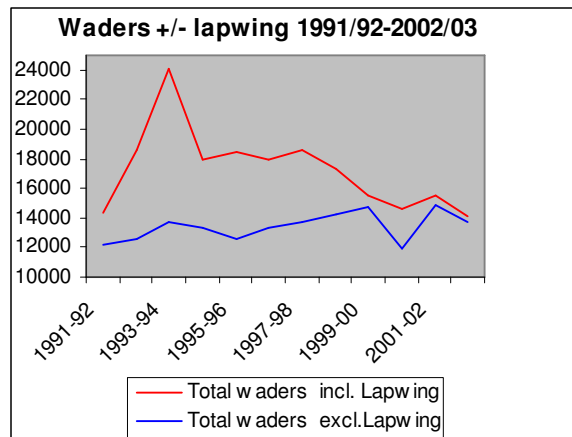
\*\* The difference in the figure here and the figure given in the SPA designation is due to later revisions of the annual totals and therefore five yearly means.

**Figure 7 Peak counts of waterfowl in Poole Harbour and for waders and wildfowl separately during 1991/92-2002/03**



**Table 11 and Figure 8 Peak counts of waders including and excluding lapwing in Poole Harbour for the years 1991/92-2002/02**

Year	Total waders incl. Lapwing	Total waders excl. Lapwing
1991-92	14296	12138
1992-93	18601	12596
1993-94	24,128	13,674
1994-95	17,936	13353
1995-96	18,435	12528
1996-97	17,946	13280
1997-98	18,600	13688
1998-99	17,325	14229
1999-00	15,481	14682
2000-01	14,618	11892
2001-02	15,524	14913
2002-03	14,039	13707



### Overall Conclusions

The overall conclusions on the status and recent trends of the Annex I species and assemblages of waterfowl for which the Poole Harbour SPA was designated are:

- Breeding Mediterranean gull and common tern numbers are both increasing
- Wintering avocet and black-tailed godwit are also increasing
- Shelduck numbers are decreasing, but this is part of a wider decline and does not seem attributable to factors which are particular to Poole Harbour
- Declining overall winter assemblage numbers are largely due to a drop in the numbers of lapwing using the Harbour, a species for which Poole Harbour has not been nationally important during the last 25 years
- There are no statistically significant declines in numbers of wintering dunlin, curlew, or redshank but both curlew and especially redshank may be declining
- There is no reliable data on numbers of migratory spotted redshank and greenshank
- There are no statistically significant declines in numbers of wintering dark-bellied brent goose, teal, goldeneye, pintail or shoveler, but pochard have declined significantly
- There appear to be increasing numbers of wintering cormorants, red-breasted mergansers and passage/wintering little egrets.
- Black-necked grebes numbers are stable but Slavonian grebes have declined (Liley et al 2006, in press)
- The modelling study by Durell et al (2006) suggests that areas of wet grassland adjoining the harbour could be particularly important for several species
- Numbers of breeding sandwich tern are currently higher than for some years and are monitored by the Brownsea warden.

- Black-headed gull nests were counted for the first time in 2006 (12,230 nests Pippa Wood pers. comm.), and there was a national census of Cetti's warbler (Wotton et al 1998) and a count of bearded tits in 1996, all of which will all provide baselines for future monitoring.

**Annual breeding tern counts and estimates of productivity should be continued on Brownsea Island, and Mediterranean gull nests counted every three years. It is strongly recommended that the WEBS counts should be continued, efforts should be made to obtain as complete a coverage as possible and the results collated and analysed every five years. It is important that all the count sections within the European Marine Site and the adjoining wet grasslands are counted. For migratory and summering waders, it is recommended that a survey, based on monthly counts between April-Aug be undertaken every six years. A night time, low tide, monthly winter survey of feeding waterfowl on the north shore would add considerably to the knowledge base of bird use of the harbour (see later)**

### **Roosting birds**

A recent roost survey in Poole Harbour was undertaken during Oct 2000-Mar 2003 (Morrison 2004). A total of 98 wader roost sites were surveyed, together with waterfowl roosts on the Harbour waters at high tide.

The future of about 20% of the roosts was threatened by *Spartina* die-back (10), habitat change (grassland to heathland, sand spit to intertidal) (3), disturbance by walkers, dog walkers and boats (4) and unknown factors (3). Altogether 44 roost sites consisted in whole or in part of *Spartina* saltmarsh, with die-back affecting areas in Whitley Bay, Brand's Bay, Newton Bay, Green Island, Fitzworth Point and parts of Holes Bay. Roost sites formerly recorded at Green Island, Vitower and Fitzworth Point have already disappeared. If die-back eliminates roost sites on the North Shore, there may be no other alternatives in that area. A further 10 roosts were considered to be heavily disturbed, (although still used by birds), by boat users including fishermen, canoe users and the RLNI hovercraft, 6 sites were moderately disturbed and 27 lightly disturbed, by walkers, dog walkers, boats, and on-shore fisherman (Table 12). Wildfowling was noted as disturbing 6 additional roosts intermittently.

Of the 98 roosts, the largest was on Brownsea lagoon, with the second largest on the Dolphin Haven breakwater, which consisted mostly of dunlin. Other large roosts of over 1000 birds were in the south-west of Brand's Bay, at Middlebere Lake and on Patchins Point. With the exception of Brand's Bay and the Dolphin Haven breakwater the other sites are on or adjoining nature reserves.

The highest levels of disturbance are on the northern shores but with a surprisingly high level of disturbance, much of it heavy, on the southern shores. Of the numbers recorded, nearly 70% of the Black-tailed godwits, nearly 92% of the avocets and just under 40% of the dunlin roosted on the Brownsea lagoon and in Middlebere. The other main wader species were scattered in between 27-40 smaller roost sites across the Harbour.

**Table 12. Roost sites and disturbance levels in Poole Harbour Data from Morrison 2004)**

	Southern Shore Pilots Point to Gold point	Wareham Channel Giggers Island Wood Bar Looe	Lychett Bay Sherford to Turlin Moor	Holes Bay	North Shore Hamworthy to North Haven & Brownsea
No. Roosts	51	15	9	10	13
Disturbance					
Heavy	8	0	0	1	1
Medium	1	0	0	0	5
Light	12	2	5	6	2
None	30	12	4	3	5
Unknown	0	1	0	0	0
Size					
<99	34	11	5	6	9
>100<499	12	3	4	4	2
>500<999	2	1	0	0	0
>1000<2499	2	0	0	0	0
>2500<5000	1	0	0	0	1
>5000	0	0	0	0	1

The main wildfowl roost was located to the east of Round Island, with a subsidiary roost at Wych Lake north. Bird concentrated at dusk but, depending on weather conditions, spread out overnight into adjoining parts of the Harbour. There were also roosts on the east side of Brand's Bay and in Bramble Bush and Dyke Bay. These roosts tend to reduce in size during the winter, but the reasons for this are unknown.

**It is considered that this roost survey constitutes a good base line for further monitoring. In view of the rapid changes in the Spartina saltmarshes in the Harbour, it is recommended that the roost survey is repeated every 6 years. Disturbance levels to roosts should form part of a wider study of disturbance to feeding and roosting waterbirds in Poole Harbour**

### Potentially damaging features or activities

#### Contaminants of water and sediments

Contaminants in the water column and estuarine sediments may be damaging to the qualifying features of Poole Harbour, as they could affect bird species or communities directly, or indirectly, by impacting on the abundances or distribution of the species which make up their food.

A detailed assessment of the water and sediment quality of Poole Harbour together with an attempt to identify those areas within the Harbour where conditions might result in effects on the species or habitat for which the site was designated, was produced in 2003 (Langston et al 2003). The reviewers carried out an extensive search of both published and unpublished sources, reviewed and summarised these and

assessed the evidence for likely impact. They also highlighted shortcomings in the existing data sets and made recommendations for further research and survey. This section draws largely on the MBA report and its conclusions, but supplements this with later material where appropriate.

The contaminants which might affect the condition of the Harbour and the species within it, fall into a number of classes:

#### Potentially toxic contaminants

- Metals, including copper (Cu), zinc (Zn), Lead (Pb), Cadmium (Cd), Manganese (Mn), iron (Fe), Nickel (Ni), Mercury (Hg), Vanadium (V), Boron (B), arsenic (As), selenium (Se), aluminium (Al) and Chromium (Cr)
- TBT (tributyltin), an antifouling compound used on boats but banned for use on smaller vessels from 1987
- Hydrocarbons, mostly derived from crude oils or processed products such as petrol, diesel, propylene, acetylene, benzene, toluene, naphthalene and PAHs.
- Pesticides, herbicides, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs) and endocrine disruption compounds
- Radionuclides

#### Non-toxic contaminants

- Nitrogen and phosphorus enrichment (eutrophication)
- Turbidity
- Chlorophyll *a* and micro algae (indicators of nutrient enrichment)
- Macro algae (indicator of nutrient enrichment)

#### *Metals*

Data collected in the 1970s suggested high levels of Cu, Ni and Zn and abnormally high levels of Cd and Pb in Holes Bay. These were mostly derived from former chemical industries based in Poole. These sources have now closed and any further significant inputs are now likely to be only from sewage treatment works (STWs). Thus there is now a residue of toxic metals in the sediments of the Harbour, with the highest concentrations in Holes Bay (Cd, Cr, Cu, Pb, Hg and Zn-Appendix 1) and with the highest loadings associated with the finer sediments. These results should be treated with caution as they are now nearly 15 years old, and most exceed probable effect levels (PEL) guidelines by a relatively small margin.

A more recent study (Emu Ltd. 2003) reported that aluminium (Al) had increased significantly in Holes Bay during 1991-2002 but could not ascribe any reason for this. The report also noted that if Al were to be used in the STW discharging into Holes Bay, as it is a flocculent, it may end up in the sludge rather than in discharge waters. Little is known about the toxicity of Al to sediment fauna.

Emu Ltd (2003) also reported heavy metal concentrations in tissue levels for a sample of cockles from Holes Bay and found that the levels of Cd, Pb, Zn and Hg were within international standards and the range of historic values for UK estuaries.

As part of the invertebrate fauna sampling carried out by Thomas et al (2004) (see later) in 2002, 46 samples from areas throughout the harbour were sent to the Environment Agency for sediment sampling. The results (Witt pers comm.), showed that levels of As, Cd, Cr, Cu, Hg and Pb were below well below the concentrations which SEFAS has set for acceptability for dumping at sea, with the exception of one sample off Keyworth Point. Sediment quality guidelines have also been set in Canada for the protection of aquatic life which are widely used elsewhere, and these give a minimal level (TEL) below which adverse effects rarely occur and a probable effect level (PEL) above which adverse effects frequently occur. Between the two levels adverse effects occasionally occur. All the samples fell below the PEL levels for heavy metals except for two Pb samples one from Keyworth Point and the other from Holes Bay. In fact all the higher samples of heavy metals recorded were from the Wareham Channel and Holes Bay, scarcely surprising in view of the long history of industrial use onshore at both sites.

Most heavy metal concentration in the rest of the Harbour were low, except for Al and Zn which were found at high levels (but not above CEFAS or PEL standards)) across the harbour. Reasons for this are unknown

Sequential abstractions suggest that a significant fraction of the metal loading in the sediments has potential for remobilisation. In other words, disturbance of contaminated sediments could release toxins into the wider environment of the Harbour. Comparison with the relatively unpolluted Avon Estuary in Devon shows that metal contamination is higher for most metals in Poole Harbour, most significantly for silver (Ag), selenium (Se), Cd and Hg, but not for As or Mn. More recent analysis (1996 & 1997) of dredgings from the lower part of Holes Bay and the Wareham Channel showed that the metal concentrations were within accepted guidelines. However, bioaccumulations of metals in a ragworm (*Nereis diversicolor*) and the clam (*Scrobicularia plana*) showed increased Ag, Cd, Hg, Cr, Ni, Pb and Sn in Holes Bay compared to the Devon Avon. *Nereis diversicolor* may be a vector for the transference of metals to waterbirds and fish, particularly in parts of Holes Bay where it may be the only, or dominant infaunal species.

Elsewhere in the Harbour, tests have indicated elevated levels of Zn at Rockley and Hg in seaweed from Brownsea Island although the latter were not exceptional. A recent study (Bowles & English 2005) have shown significantly reduced concentrations of Fe and As and significantly increased concentrations of Al between 1991 and 2002 in the sediments of the north-eastern parts of Holes Bay. Bowles & English (2005) also collected a sample of cockles for tissue analysis and to act as a base line for future studies. They found no association between metal contaminant levels and invertebrate fauna. Metal contaminants can bio-accumulate to attain toxic levels higher up the food chain, and can have lethal or sub-lethal effects on aquatic larvae and juveniles of some invertebrates. Some metals, notably Cd, Pb and Hg may have endocrine disrupting effects, and Se can affect reproduction and embryo development. The report notes that "The extent of ecological impact due to metal

contamination in Poole Harbour is largely unknown, but is probably restricted to parts of Holes Bay”.

### *TBT (tributyltin)*

The use of tributyltin has been banned on small boats in the UK since 1987, and a recent EC Directive (2002/62) prohibits the application or reapplication to all ships of tributyltin compounds in antifouling systems from Jan 1<sup>st</sup> 2003. These compounds can cause sex changes in female molluscs, so that they no longer breed, and populations decline or die out. Before 1987, the mollusc populations of Poole Harbour were considered to be particularly at risk, due to the large numbers of small vessels and the restricted tidal flushing regime. Following the banning of these compounds, tests showed a marked reduction in contamination, but at a reducing rate, and it is possible that TBT is still being released from sediments. The highest mean concentrations of TBTs from periods both before and after the ban have been recorded in the northern parts of the Harbour; areas of greatest boating activity. Sediment-bound TBT and its product DBT, are slower to breakdown than concentrations in the water column. Sediment dwelling molluscs appear to accumulate the highest concentrations and breakdown rates are close to those in the sediments themselves. It is now more than ten years since analysis of sediment linked concentrations of TBT were systematically measured or mollusc populations were sampled and it is recommended in the Characterisation Report that further work should now be carried out. In the meantime, there is concern at the perturbation or dredging of sediments in or around boatyards where TBT concentrations could be highest. Such activities could re-mobilise toxic TBT reservoirs and damage populations of deposit feeders and infauna. In Holes Bay, particularly, elevated levels of Cu may also contribute to sediment toxicity. Dredged samples from Holes Bay and Wareham channel have been noted as being toxic in bioassays of lugworms *Arenicola marina*, the amphipod *Corophium volutator* and the copepod *Tisbe battagliai*.

### *Hydrocarbons*

Oil pollution carries with it a direct risk to birds, from plumage damage and subsequent ingestion whilst preening. Oil and its associated hydrocarbons can cause mortality to shellfish and other benthic invertebrates, can kill eggs and the planktonic larval stages of fish and invertebrates in surface waters and can damage saltmarsh vegetation and cover intertidal sand and mudflats. Hydrocarbons becoming incorporated into sediments (particularly the finer material) may cause changes in fecundity, feeding, grooming and behaviour by infauna. The use of dispersants may pose additional threats to fauna and flora. Apart from oil spills from shipping, sources could also include rivers, (from road runoff and discharges to sewers), diffuse discharges from industrial sites or oil production facilities and atmospheric inputs of polycyclic aromatic hydrocarbons (PAHs).

PAHs are of particular concern as the lower molecular weight compounds are toxic to marine organisms and metabolites of the higher molecular weight PAHs are carcinogenic.

There is no environmental quality standard (EQS) for hydrocarbon oils in estuarine waters, and the EQS for shellfish waters is difficult to quantify. No general data exists on hydrocarbons for the rivers or estuarine waters of the Poole Harbour SPA, and there are no data for the wider harbour. There is only limited general data on PAHs in water or discharges in Poole Harbour, although a national survey in the late 1990's, which included Poole Harbour, reported relatively low concentrations of PAHs in the Harbour waters outside Holes Bay (Law et al 1997). However, concentrations of PAHs are generally highest in sediments and lowest in the water column. In Holes Bay, concentrations of PAHs were at moderate levels and below the EU maximum thresholds (although above those of the equivalent USA criteria), and might contribute to sub-lethal biological effects.

In the sediments, concentrations of PAHs are classed as moderate for the Harbour with levels in Holes Bay elevated to the extent that they may make a contribution to the threat of harmful effects on benthic organisms, including fish

Further work is recommended on the biological consequences of PAHs in the harbour.

#### *Pesticides, herbicides, PCBs, VOCs and other compounds*

Organochlorines are highly toxic, stable and long lasting compounds, dissolving readily in body fats and concentrating up food chains. They could pose a particular risk for high level predators such as waterbirds. They are also endocrine disrupting substances. A number of these compounds tend to breakdown into dieldrin, a pesticide also in its own right, which is highly toxic to fish and other aquatic animals. As organochlorines were progressively withdrawn, they were replaced as a general insecticide by organophosphates, seen as less toxic but able to act as a neurotoxin and known to have lethal and sub-lethal effects of fish at very low concentrations.

The organochlorine polychlorinated biphenyls (PCBs) are among the most persistent of toxic contaminants, particularly in sediments. They can cause endocrine disruption, deformities, eggshell thinning in birds, and, concentrating up the food chain, impaired reproductive success in mammals and fish. They are also carcinogenic. Other industrial compounds include chloroform, carbon tetrachloride, the chlorinated ethylenes and trichloroethane. These substances can affect the growth of marine invertebrates particularly during the larval stage. The s-triazine family of herbicides (simazine and atrazine) are toxic but not accumulated by organisms. They are very widespread and derive mainly from agricultural use and run-off.

The Environment Agency carry out analyses of water column samples at six sites in the Harbour (Poole Bridge, Salterns Marina, Wareham Channel, Hutchins Buoy, South Deep and Harbour entrance). These samples are analysed for dissolved Cd and Hg and organochlorines and hydrocarbons. Sampling for other compounds has been fragmentary in biota and sediments, but where data are available, concentrations have generally been low (Appendix 3).

Some evidence exists for the presence of radionuclides in the sediments of Poole Harbour, derived from the prototype heavy water reactor at Winfrith. However, the radiation dose measured in shellfish is extremely low and is believed to be declining.

### Conclusions on Toxic Substances in Poole Harbour

The collection of data on concentrations of toxic substances in the waters and sediments of Poole Harbour has been sporadic and fragmentary in the past. Where water sampling has been carried out in recent years, it has generally shown that concentrations are below the thresholds set by statutory limits. The main potential problems in the Harbour derive from residues incorporated in sediments derived from former industries, most of which discharged into Holes Bay, and from the main sewage outfall for Poole which also discharges there. Since the closure of these industries and the improvement of the sewage treatment works (STW), contaminant levels appear to have declined, (except for AI), helped by the banning of antifouling paints (in 1987) and the progressive withdrawal of other compounds (eg organochlorine pesticides). It is not known though, whether toxic substances, incorporated in sediments are affecting the biota. Moreover, very little is known about the in combination effects of the cocktail of contaminants known to be present. Many of the published studies on the species richness, abundance and distribution of invertebrates in Poole Harbour are now out of date (eg IOE 1986, Dyrinda 1983, 1987, Howard & Moore 1988).

To monitor these issues, a comprehensive survey of sediment contaminants and a series of bioassays would need to be done. Much of this work could be carried out in Holes Bay, which is the most polluted part of the Harbour for virtually all toxins for which there is information. Investigations recommended by Langston et al (2003) :

- More extensive, targeted sampling, incorporating samples from Holes Bay (where effects might be expected to be most prevalent) to test for the presence of PCBs, heavy metals, pesticides and PAHs
- Incorporation into any studies of the presence of Se distribution in Holes Bay
- Ascertaining the cause of the high levels of Zn in the Holes Bay and Lake Pier areas.
- Bioassays to test for lethal and sub-lethal effects of observed concentrations and combinations of pollutants
- Incorporation into monitoring programmes of detritivores and other infaunal types (molluscs are excellent bio-accumulators of contaminants)
- Resurveying of TBT monitoring sites to update the effective half-lives and re-evaluate the prognosis for recovery
- Obtain up-to-date information on oyster body metal burdens.
- A baseline should be set for all significant toxic contaminants against which to measure future changes.

In general the available data suggests that there is no cause for immediate concern and no evidence that toxin levels in water columns or sediments are having adverse effects on the infauna or affecting bird numbers in the harbour. However, no studies have looked specifically at these issues across the harbour. these, there are no

quantified UK EQS's for contaminants of in situ marine sediments. In the absence of UK guidelines, the CEFAS guideline action levels for the disposal of dredged material and the Canadian Sediment Quality Guidelines can be used as an initial approximation as to whether the biota is at risk (Cole et al 1999)

A further complication is that the effects of toxins in combination are possibly more toxic than the individual substances, though isolation and the degree of toxicity will vary according to the particular cocktail of substances derived from both historical sources and current inputs at a particular point.

Under the Habitats Directive the Environment Agency (EA) has monitored 20 sites throughout the Harbour with one sample taken at each site between October 2004-March 2005. A further three samples were taken in June 2005. These samples were analysed for heavy metals, a range of hydrocarbons, DBT, TBT, nitrogen and organic carbon and particle size. The data from this survey is currently being written up and will shortly be available as a report. Further data from 46 sediment samples collected around the Harbour by Thomas et al (2004) (see below) has also been analysed for heavy metals, organic carbon and particle size. EA also collect water column data on six sites with nutrient suites collected monthly, metals and pesticides monitored at three sites two to four times a year under the Shellfish Directive, and with additional monitoring at Poole Bridge and the Harbour entrance.

**Natural England should ask EA to make available data from their regular sampling programme on a yearly basis with, to aid interpretation, a comparison against the marine and estuaries environmental quality standards set by the Dangerous Substances Directive for water samples and against the CEFAS or Canadian Sediment Quality Guidelines for sediments. Priority should be given to carrying out an up-to-date study on the distribution of contaminants in the sediments of Holes Bay, and to undertaking bioassays of those invertebrate species which, through bio-accumulation, are likely to have the greatest cumulative effects on avian predators higher up the food chain. Analyses of TBT residues in sediments associated with any boatyard or marina channel should be required before any dredging proposals are approved. Natural England should ask to be kept informed of any suspected oil spills in the harbour.**

#### Non-Toxic Contaminants and Indicators

The substances dealt with in this section include nutrients (nitrogen, phosphorus), oxygen depleting effects from micro and macro algae and turbidity. Nutrient inputs arise from point sources (SWTs and discharges) and diffuse sources (mostly agriculture and atmospheric). In Poole Harbour, the rivers Frome and Piddle are major sources of inorganic nitrogen, and the STWs at Poole, Dorchester and Wareham are the source of most phosphates. Poole STW also sources nitrates and is the largest source of ammonia. There may also at times be mobilisation of nutrient from sediments. As nutrient levels in tidal waters vary with salinity and freshwater

flows, the determination of the nutrient status of estuaries is extremely difficult and there are no statutory water quality standards for estuarine nutrients in the UK.

The result of high inputs is eutrophication which can facilitate micro algal blooms and macro algal mats. When these die off, bacterial activity can cause oxygen depletion with lethal and sub-lethal effects on fish and invertebrates. Some micro algae can produce toxins causing death in shellfish and other invertebrates. Macro algae mats can cover intertidal flats and can cause oxygen depletion, anoxia in surface sediments and during decomposition, high levels of ammonia. The latter may be toxic to sediment dwelling invertebrates and those that use the water in the boundary layer between the sediment and the water column for feeding and respiration. This includes molluscs, crustacean and most annelids. At higher levels of temperature and pH and lower levels of oxygen, ammonia can be toxic to marine organisms, particularly the early life stages of invertebrates.

A report by the Environment Agency (2001) found that:

- Data collected 1997-2000 suggested that the Harbour and particularly Holes Bay is eutrophic or in danger of becoming eutrophic
- Rivers Frome and Piddle and Poole STW are major nutrient sources to Harbour
- Highest nutrient levels in Harbour are in Wareham Channel and Holes Bay
- Nutrient removal at Poole STW would reduce summer nutrient levels in Holes Bay by 62% and by 50% on average annually
- The area of Holes Bay covered by macro algal mats has increased significantly since 1995
- Substantial algal mats are found elsewhere in Harbour (Blue Lagoon, Lytchett Bay, Keyworth Point, Ower and Brands Bays) but it is unclear if these have increased in recent years
- Shellfish mortalities 1995/97 were linked to macro-algal growth and micro-algal toxins

Given the difficulties of direct nutrient measurement, it is usual to also measure other variables including chlorophyll-a (a measure of primary production) dissolved oxygen (DO) and turbidity. Recent data for suspended solids (one measurement of turbidity) in the Harbour shows that levels are low in comparison to other estuaries (Cole et al 1998), and declined between 1991/99 although there has been some increase during 2000/02.

There are no statutory standards for nutrient loadings in estuarine or marine SPAs although a number of authors have suggested guideline values. One of these recommends the use of the combined concentrations of nitrates, nitrites and ammonium (total inorganic nitrogen, TIN). For phosphorus, Total Reactive Phosphorus (TRP) is measured. In both methods, providing salinities are known, a freshwater equivalent value can be obtained.

### *Total inorganic and organic nitrogen*

- Using data from the Environment Agency, Langston et al (2003) have calculated TIN and TRP values for the rivers entering Poole Harbour. Their results suggest that water entering the Harbour from the Frome and Sherford and possibly the Piddle contain the highest concentrations of nutrients but that these are not elevated in comparison with other UK estuaries. A study by Murdoch & Randall (2001) considered that the Frome represents the most significant source of TIN together with Poole STW, and that the Wareham discharge is probably not significant (although the data for Wareham were incomplete). Highest levels of organic C recorded in the 2002 samples from across the Harbour taken by Thomas et al (2004) were in the Wareham Channel and Holes Bay (Witt pers comm). There have been increases in nitrate concentration in a number of rivers and in STW discharges during the period 1990/99. Recent values for nitrates in tidal waters in the Harbour indicate hyper-nutrication, with the highest levels at Poole Bridge and in the Wareham Channel.

### *Phosphate*

Langston et al (2003) found that TRP concentrations in the rivers and streams were not particularly high when compared to other SW estuaries. Highest concentrations (but not total volumes discharged) were at Brownsea, Corfe and Studland. In tidal waters, highest concentrations found were at the mouth of Holes Bay and in the Wareham Channel.

### *Ammonia*

Recent measurements of ammonia in the freshwaters entering the Harbour suggest these are low in comparison with discharges from STWs. Of 94 samples from Poole STW in 2001, 18% failed to comply with ammonia standards for discharges. Between 1995/97 there was a significant reduction in discharged ammonia from Poole STW but subsequently, these have been increasing (as they have also at Keysworth). The highest values in tidal water of the Harbour have been recorded at the mouth of Holes Bay and in Wareham Channel, probably reflecting discharges from the STWs at Poole and Keysworth. Mean annual values have been steadily increasing at all sample points 1999/02. Some of this increase may be from sediment during macroalgal declines, but the contribution from this source is unquantified.

### *Chlorophyll a*

Chlorophyll *a* samples from tidal waters exceeded levels which indicated suspected eutrophic conditions in 2001 in the Wareham Channel and at North Harbour sites in May, and at most sample sites in August, 1995. High levels were also recorded in January 1996, at a time of year when levels would be expected to be low. Highest

concentrations in 2001 for fresh waters entering the Harbour were in the Corfe River. Overall, chlorophyll-a data are not indicative of phytoplankton blooms, but the situation needs monitoring as conditions may favour such an occurrence.

### *Dissolved Oxygen*

This too is an indicator of possibly high nutrient levels so there are recommended EQSs for DO levels in estuaries and coastal waters. Normally lowest levels are expected in summer when temperatures are highest. Generally, DO is high during the day due to photosynthetic activity, and lowest at night. During algal die-offs, microbial decomposition can cause acute oxygen depletion with lethal and sub-lethal effects to fish and invertebrates. Data for DO in tidal waters of Poole Harbour (2001) show these are above EQS levels. The lowest values throughout the Harbour are in September, when macro-algal mats are dying back (Jones 2003). Oxygen depletion also occurs in the minor streams entering the Harbour, but mean DO has remained relatively constant in the main rivers.

### *Micro-algal blooms*

A number of bloom forming algae and diatom species have been noted in Poole Harbour, and blooms have been recorded, particularly in 1995 and 1996. Potentially toxic algae have also been recorded, and there have been incidences of shellfish poisoning, notably in 2000.

### *Macro-algal mats*

The problem of macro-algal mats in Holes Bay is not new. There were problems in the late 1960's with the cooling water intake screens of the Power station (now gone).

*Ulva* and *Enteromorpha* ssp were recorded throughout the harbour in the late 1980's (Dyrynda 1987) and were reported to be causing low diversity invertebrate communities in Holes bay and Blue Lagoon (Howard & Moore 1988).

A study by Jones (2003) looked at the algal mats in Holes Bay in 2002. He found that the main species was *Ulva lactuca* (sea lettuce), and that mat coverage rose from 5% of the intertidal flats area in June to 73% in July and a maximum of 91% in August. There was then a decline to 83% in September, 17% in October and 4% in November. He found that the mat coverage and nitrogen and phosphate levels in the sediments were significantly positively correlated, but that coverage was significantly negatively correlated with both invertebrate species richness and abundance. The abundance of both the ragworm *Nereis diversicolor* and polychaete worms was negatively correlated with mat cover but there was no correlation with numbers of bivalves. In fact the most abundant invertebrate associated with the algal mats was the mollusc *Hydrobia ulvae*, but as the mats broke down this species migrated (possibly into nearby saltmarsh) as there were few found in the exposed sediments. Overall infaunal biomass declined as the mats developed but recovered to pre-mat levels by Oct/Nov. Jones suggested that the nitrates and phosphates may be stored in

the surface layers of the sediments as the algal mats decay, and thus be available for mat growth in future years. The paucity of some common species in the tidal flats might, he thought, be due to impoverishment of the infauna through mat coverage in previous years, so that the invertebrate assemblage could be mediated by the sediment types and previous distribution of algal mats. He suggested that climate change might result in longer coverage by algal mats as the onset of mat development appears to be mediated by a temperature threshold. In a later summary of this study (Pinn & Jones 2005) the authors considered that the algal blooms could impact on the important wildfowl populations of the area.

During a more recent survey of Poole Harbour for invertebrates, Thomas et al (2004), assessed the cover of the algal mats across the harbour and found there to be 100% cover in Sept/Oct in parts of East Holton Bay, off Keyworth Point, in Arne Bay, Off Middlebere and Fitzworth Points, in Ower and Brands Bays, to the north-east and north-west of Green Island and in the north-west and south-west of Holes Bay. A comparison of the results from the sample points located within the 100% areas of mat coverage and all other sample points in the Harbour found no differences in either the abundances ( $t=0.28$ ,  $df=78$ , ns) or the biomass ( $t=0.94$ ,  $df=78$ , ns) of invertebrates in the sediments below 100% mats or those with a lower coverage. However, Dyrinda (2005) considered that algal mats pose the threat of mass mortalities of invertebrates, smothered by live or decaying seaweed or asphyxiated by low dissolved oxygen levels associated with high rates of decay of organic matter. Dyrinda & Brown (1998) also considered that smothering of mussel beds by *Ulva rigida* each summer during 1995-1997 could have contributed to mussel mortalities during that time. Dyrinda (1998) also suggested that high frequencies of shell disease in brown shrimp *Crangon crangon* may be a consequence of eutrophication.

**Natural England should ask EA to supply annual data on nutrient suites from their regular samples. Regular surveys of the algal mats in Poole Harbour associated with the invertebrate monitoring are highly desirable. This could most easily be done by the analysis of aerial photographs.**

#### Sediment granulometry

Granulometry of the sediments in estuaries is of concern, as the proportion of fine to coarse particles is an important determinant of the invertebrate communities associated with different sediment types, and highest abundances of invertebrates has been found in areas of finer sediments (Thomas et al 2004). This suggests that an increase in the proportion of coarse particles in the Harbour sediments could be detrimental to invertebrate populations and the birds which feed on them. Slight coarsening of the sediments in Holes bay was reported by Emu Ltd (2003) during 1991-2002.

**The most comprehensive assessment of sediment granulometry undertaken recently in the Harbour was the examination by EA of the 46 samples collected as part of the prey availability study in 2002. It is suggested that this forms a good baseline for further monitoring which could be done in association with repeat sampling for invertebrate populations at six year intervals (see below).**

## **Invertebrates in Poole Harbour**

There have been a number of historical and several recent studies of invertebrates in Poole Harbour both of the in-fauna of the Harbour sediments and saltmarshes and the saltmarsh vegetation and transitional communities on the Harbour edge. The character of Holes Bay as a depository for a number of toxins in the past and as the receptor site for the Poole STW, makes it of especial interest for the invertebrate populations there, and these have been reviewed by Caldow et al (2005). They reported that an invertebrate study had been carried out in each of the last four decades and that the patterns of invertebrate assemblage found were similar to the Harbour as a whole. *Scrobicularia plana* and *Macoma baltica* had been virtually absent since the 1970s, while *Cerastoderma edule* and *Abra tenuis* had increased, the latter, markedly so. *Hydrobia* ssp hadh also increased. Generally worm and crustacean numbers had fluctuated, as has *Corophium volutator*, but with no synchrony between species. Consequently, the total numbers of invertebrates has been fairly consistent over time, with the exception of the 1980s when the numbers of all groups were reduced.

A study by Thomas et al (2004), took core samples from the sediments to a depth of 30cm at 80 points located on a 500m grid across the Harbour, and identified and counted all the main invertebrates. They also calculated biomass for each invertebrate or group and used these data to assess the biomass availability per m<sup>2</sup> for each section of the Harbour which is separately counted for winter waterfowl under the Wetland Bird Survey (WEBS). Using the average WeBS peak monthly figures for 1991-1998, they then calculated the average winter usage by each of the most important wetland birds. Using standard data on energy needs for each species, they were able compare the minimum winter energy requirement of the birds with the invertebrate energy available for each section of the Harbour.

They recorded the highest abundances where the finer sediments were found and there was little algal cover in Wareham Channel and Lychett Bay, although abundances varied greatly between samples (range 8->100,000 m<sup>2</sup>).

The calculations suggested that the overall invertebrate energy available within the Harbour was 3½-4 times greater than that required by the wildfowl and waders that winter there. Based on published studies of the main food prey of individual species, a further series of calculations were made of the available food resources and needs of each of the main wintering wader and wildfowl species. For most, the available resource was at least ten times greater than that required, but was below this level for

curlew, oystercatcher and shelduck, with the requirements of curlew and shelduck exceeding the available supply in parts of Brands Bay and Wareham Channel. As noted earlier, shelduck have declined in Poole Harbour, but this reflects a national trend and there is no evidence that any features of the harbour have contributed to this. Both curlew and oystercatcher also declined in numbers during the 1990s, although there is no explanation for this (Pickess & Underhill-Day 2002). Of the sectors counted by WeBS, three of the four most underused by birds have relatively high invertebrate biomasses, whereas all five of the most heavily used sectors have relatively low biomasses. This suggests that factors other than food supply are limiting waterfowl numbers, at least during the day (all WeBS counts were daytime), and human disturbance is an obvious candidate (Pickess & Underhill-Day 2002). The infauna of the saltmarshes was quantified at Arne as part of a larger study of the effects of grazing by sika deer (Diaz et al 2005). Only three infaunal species were recorded, *Hydrobia ulvae*, a *Gammarus* spp and *Nereis diversicolor*, of which only *H. ulvae* was recorded in numbers exceeding 4 per core. These findings suggest that saltmarsh invertebrate populations in Poole Harbour may be small and species poor, and that any future monitoring would more profitably be undertaken on the intertidal flats.

**The methodology used by Thomas et al (2004) was simple, repeatable and comprehensive, and it seems sensible to repeat this at least every ten years and preferably every five years.**

## **Disturbance to sediments**

### Activities that physically disturb sub-tidal and intertidal sediments

Effects of perturbation of sediments either sub-tidal or inter-tidal resulting from dredging, bait digging/dragging or shellfish dredging could be:

- Direct damage to infaunal and benthic communities (Dyrynda 2005)
- Increases in turbidity and deposition of fine material over infaunal communities
- Indirect damage to infaunal communities through re-sorting of sediment particles (eg replacing fine with coarse sediments)
- Release of nutrients and contaminants from dredged sediments
- Changes to intertidal topography through subsequent deposition or erosion of sediments
- Release of sediments from the Harbour into Poole Bay, with consequent loss of sediments within the system and possible changes in sediment particle size.
- Changes in community composition as near-surface living, slower maturing molluscs are replaced by more quickly maturing, deeper burrowing polychaetes

## *Dredging*

There have been few studies of the effects of dredging on the fauna of the Harbour either directly or indirectly. The main source of information is the Environmental Statement prepared for the recent deepening of the main channel by Royal Haskoning for the Poole Harbour Commissioners (Simpson & White 2004).

This reports, inter alia, that:

1. The levels of suspended sediments are generally low (50mg/l under calm conditions) with the main inputs of sand from offshore, and with silts/mud from saltmarsh and mudflat erosion within the Harbour.
2. Dredged material arises from maintenance dredging of the main ship channels and turning basin and from marinas and boat yards. The volumes of material dredged and disposed at sea ranges from over 1 million hopper tonnes (1992) to 40,000-400,000 hopper tonnes in normal years
3. The capital dredging was expected to release 100,000 tons of fine material which, when settled out was expected to lead to an increase in intertidal mudflats of between 0.4-2.6ha.
4. The report recommended that future monitoring should be by a combination of bathymetric survey data, GPS surveying, and ground truthed LIDAR data.

During the consultations for the channel deepening, concern was expressed at the removal of fine material from the Harbour, and as a result, dredging practices were changed to keep as much fine material as possible within the system, and to produce a sediment management plan for the Harbour. This is still in preparation (PHC 2006).

A summary by SCOPAC (2006) of the sedimentary studies in the harbour concludes that:

1. It is not known
  - a) whether the overall sediment budget is positive or negative
  - b) what are the rates and volumes of sediment transport at the Harbour entrance
2. The fate of the large quantities of sediment released by the large scale die-back of *Spartina* over the last 65 years is not known
3. It is unclear whether the morphological configuration of the channels and intertidal flats has reached equilibrium.
4. There is uncertainty as to how past dredging and reclamations have affected the sedimentary transport and bedload systems in the Harbour

In the light of these uncertainties and the highly technical and costly investigations by which they might be answered, the proposed sedimentation plan can only plan to retain as much fine material in the Harbour as possible during dredging activities in the hope that this will maintain the integrity of the system.

**It is recommended that any sediment management plan includes an assessment of likely dredging requirements for five years ahead, with appropriate monitoring of the physical, chemical and biological characteristics of the dredged material before dredging takes place. This is particularly important in relation to dredging around boatyards and marinas. All dredging operations should be designed to retain as much material within the Harbour as possible.**

### *Bait digging and bait dragging*

These activities have the potential to:

- Deplete populations of the target species
- Cause direct disturbance to feeding birds
- Damage infaunal communities by trampling and disturbance to substrates
- Alter sediment particle distribution by releasing finer particles into the water column
- Release sediment bound toxins

Whereas bait digging for personal use is considered ancillary to the right to fish, commercial bait digging or dragging is not a public right and requires the consent of the landowner. Fowler (2001) reported from a questionnaire survey that bait digging and dragging is reported to take place almost everywhere in Poole Harbour, but that the evidence for depletion of stock from over-digging was largely anecdotal, and he suggested that a reduction in worm stocks caused (usually) by commercial digging was temporary, with recovery within 12 months. Some respondents suggested that worm stocks had declined in areas where there had been substantial improvement to sewage outfalls and a consequent reduction in food organic material on which worms feed.

There is little information available on the extent and distribution of bait diggers in the Harbour, apart from Dyrinda & Lewis (1994) who surveyed the distribution of diggers on the north shore of the Harbour on a number of occasions during December 1993 and January 1994. S bait diggers belong to the Solent Bait Diggers Association (SBDA), with whom there is a voluntary agreement for zoning digging activities in Holes Bay by digging in Creekmoor Lake or Upton Lake, but not both simultaneously, and for a ban on digging north of the railway line, to reduce disturbance to feeding birds (Morrison 2006). The Poole Harbour Steering group and National Federation of Sea Anglers have produced a voluntary good practice code for bait diggers.

Morrison (2006) reports that moderate disturbance was caused by bait diggers operating within 50m of the shoreline but beyond this disturbance could be severe with all birds within 100m of the digger, moving away and some leaving the area altogether. He recorded moderate disturbance, as birds stopping feeding and moving up to 50m away, and severe disturbance, as birds moving over 50m. Of eight occurrences, he recorded that birds took 5-15 minutes to return in four cases, and

none returning in the other four, after the bait diggers had left the area. No birds were observed within 50m of the bait diggers while they were present. From his observations it appeared that the disturbance levels were roughly in the order: Oystercatcher>Redshank>Black-tailed godwit>curlew, with oystercatchers moving 10-30m and continuing to feed and curlew always leaving the area altogether. He also noted that when birds were disturbed they would often fly away, picking up birds further away as they flew over, so that although the disturbance was initially localised, there was a ripple effect as birds moved away.

Morrison (2006) reported that feeding birds tended to avoid dug over areas, (but were seen feeding in adjoining undisturbed areas), although redshank were observed picking over recently disturbed areas. Areas which had been dug over could take between 2-10 weeks to weather down depending on tidal exposure and protection from wind. He also noted that bait dragging apparently affected far larger areas of substrate than bait digging and potentially could have a much greater effect.

There have been few recent studies of the effect of bait digging on infaunal communities, although there is some evidence of damage to macrofaunal numbers from associated trampling in a Californian study (Wyneberg & Branch 1997), that larger disturbed areas take longer to recover than smaller ones (Kaiser et al 2001), and that recovery of populations following over-exploitation can take place where there are unexploited populations nearby (Olive 1992). Dyrinda & Lewis (1994) found that recovery of lugworm *Arenicola marina* populations was rapid after digging in coarse, loosely consolidated sand, but that long term impacts are likely to be greater in medium to fine sands, and recovery is slowest in soft muds and fine sands overlying mixes containing stone, shells and gravel. Recovery of soft muddy shores is moderately fast. There are no recent studies on other effects.

A preliminary experimental study was carried out by Dyrinda (1995) to examine the effects of bait dragging on a commercial shellfish bed and on natural seabed communities. Most bait dragging is on areas of soft or inaccessible mud for the king ragworm *Nereis virens*, and is carried out both by professional and amateur fishermen. Dyrinda (1995) reported about 15 boats engaged in bait dragging in Poole harbour in 1995, but a later report (Fowler 2001) found this had declined to six in 2001. Fowler also reported a decline in bait diggers and noted that most bait collectors claimed that there had been reductions in the abundance of bait (mostly king ragworms) and there was evidence that bait diggers were spending longer, and digging larger areas to find worms, than had been the case during the 1970's and 80's.

Dyrinda found that the drag scars featured sub-surface sediment, shell material and cockles, with disturbance penetrating 0.3 m from the surface, causing softening of the sediment layers but no change in particle composition. He found some evidence of injury to non-target species, but no significant differences in the abundances of small invertebrate samples before and after dragging, although, as these samples were taken randomly across the dragged area, many would have come from undisturbed sediment where change would not have been expected. He reported that field

observations of Brands Bay showed disturbance to the sediments at all levels from bait dragging and digging. For both commercial shellfish beds and natural seabed, the degree of damage was proportional to the intensity of dragging with potentially significant effects on both invertebrate populations and sediment consistency. Dyrinda noted that this activity was unregulated and in view of its potential incidental impacts, he felt this constituted an anomalous situation. He recommended that further studies be carried out with more sustained dragging, monitoring after dragging and at intervals of one month and six months and that monitoring included paired comparisons of core samples from dragged and un-dragged areas.

**The conclusion is that bait digging and bait dragging is not adequately monitored in Poole Harbour and that the distribution and extent of these activities needs to be established and monitored. This would be a necessary prerequisite for deciding whether any controls were required.**

### *Shell fishing*

In Poole Harbour cockles *Cerastoderma edule* are harvested between May 1<sup>st</sup> and January 31<sup>st</sup>, using hand raking and pump dredging. Manila clams *Tapes philippinarum* were introduced into the Harbour in 1989 and are now harvested using pump scoop dredges. The fishery is licenced under the Poole Order and fishing takes place from late October to early January.

There have been a considerable number of studies both in the UK and abroad of the effects of various forms of dredging for shellfish on infaunal communities. Moore (1990) found a reduction in both the abundance and richness of invertebrate communities after dredging in a study site in Wales, but noted that recovery was rapid. Studies in Lavan Sands in Wales and the Solway Firth in Scotland, found that the infauna recovered quickly from a single hydraulic dredging, and that there were no significant impacts on non-target species after a three month dredging period (Moore 1991). Studies of the effects of mechanical dredging on benthic non-target infauna in the Solway Firth found that this imposed high levels of mortality, but that recovery of disturbed sites was rapid and approached that of undisturbed controls within 56 days (Hall & Harding 1997). A long-term study in the Wadden Sea by Piersma et al (2001) during 1988-1999. concluded that in areas suction dredged for cockles, sediment size increased and there were changes to the infaunal abundance.

In Poole Harbour pump scoop dredging can impose changes in the initial abundance non-target species with an increase in the abundance of some species and a decrease in others (Parker 2003, Parker & Pinn 2005), and an initial change in community composition (Cesar 2003), but no evidence for longer term community composition effects (over two years) (Jensen et al in SSFDC 2005). Two further studies agree that the disturbed sites are able to recover and that there is no significant effect on infaunal communities or on the bird populations which feed on them (Smith 2005, Neale 2006).

There is some evidence that the depletion of the target species can affect shorebirds particularly oystercatchers which feed on cockles and mussels (Goss-Custard et al 2003, Atkinson et al 2003, Verhulst et al 2004), but that levels of exploitation need to be high for this to happen (West et al 2003).

#### Conclusions on shell fishing

- None of the studies showed significant differences in sediment granulometry following pump scoop dredging in the Harbour
- All studies showed differences in the invertebrate assemblages between different sampling stations or groups of stations
- Most studies showed short term declines in invertebrate abundance, with some studies finding increases and decreases in the abundance of individual species. In all cases, the studies concluded that there was no detrimental effect on the invertebrate populations which would significantly affect the prey availability of wintering birds in Poole Harbour.
- All studies using non-fishing control areas either found difficulty in finding unused areas or relied on anecdotal and possibly unreliable evidence to locate un-fished controls. No information on the fishing effort either numerically or spatially exists. There is no baseline, comparable pre pump scoop dredging data
- No study considered the cumulative effect of continued disturbance to benthic communities from repeated dredging in consecutive seasons
- No studies measured other variables which might have affected infaunal communities such as the removal of a proportion of the target mollusc population on other species, chemistry, toxicology and organic content of sediments, salinities, predator-prey relationships and other sediment disturbance activities such as bait digging or dragging
- There are considerable difficulties, particularly in any short term study, in separating the possible effects of dredging for shellfish on the benthic invertebrate communities, from the natural fluctuations due to biological and physical factors.

**There is a need for longer term monitoring of the effects of repeated shellfish dredging activities over a period of several years together with the establishment of long term guaranteed un-fished and undisturbed controls with as far as possible, an identical tidal regime. Sampling should include measurement of other parameters including sediment chemistry, organic content, particulates and salinities.**

## Boating in Poole Harbour

Poole Harbour is a major resource for commercial and recreational boating\*

- The port of Poole handles 500,000 metric tons of cargo per annum
- The port is also used by Ro-Ro ferries and other commercial craft
- The Royal Marines base and onshore oilfield both use the Harbour
- There are c. 2,500 swinging moorings and c. 2,300 pontoon and marina berths
- Within the Poole basin there are 8 yacht clubs with c. 7,500 members
- Some 5,000 yachts visit the harbour each year, there are two public slipways
- There are 7 marinas with dry storage for c. 2,000 craft
- The harbour supports 35 charter craft, and a fishing fleet of c. 100 boats
- Other waterborne activities include windsurfing, kite-surfing, water-skiing, jet skis and other personal watercraft, motor boating and canoeing
- Activities include diving, angling, bird watching and sight-seeing

*\*Data from Drake (2006)*

There are designated zones for water-skiing and personal watercraft within the Harbour both of which require permits. An area off Whitley Lake is set aside for wind surfers but they are not confined to this, and the area to the south of the harbour is designated as a quiet area, although this is only enforced in relation to activities taking place outside permitted areas or violations of the speed limits. Generally speed limits are 10 knots, but with six knots in some enclosed parts of the Harbour. The number of wet moorings provided by pontoons and marinas has increased in recent years, but the policy of the Harbour commissioners has been to reduce swinging mooring numbers as other wet berths become available. This policy has resulted in a small reduction in wet berths in the Harbour since 1994.

Based on a questionnaire survey, Southgate (2006) estimated the popularity of various water borne activities within the Harbour (Figure 9).

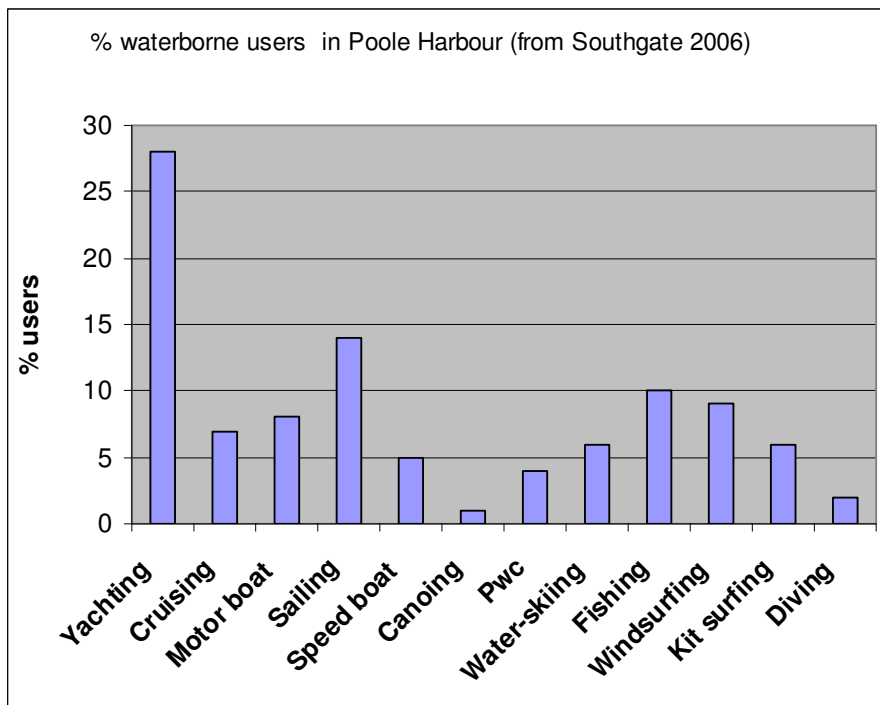
Monitoring of the spatial use of Poole Harbour by recreational boat traffic within moderate cost is difficult due to the size and complexity of the Harbour, the numerous islands and the daily and seasonal changes in boat traffic, which are influenced by tides and weather. Following the termination of the aerial surveys as too expensive (used for the first Aquatic Management Plan), in 1997, line of sight surveys were begun at the Harbour entrance and the lifting bridge, and from 2000, from Lake Pier.

The available figures for mean number of boat movements for the line of sight surveys do not have standard errors, so statistical comparison is not possible, and in any event may not be meaningful for the short time series available. The mean figures of daily use suggest some increase in harbour usage from 1994, and although the number of wet berths has declined slightly, there is an increasing trend in the number of visiting boats being launched from the public slipway at Baiter as evidenced by the fitted trend line (Figure 10).

An analysis of activities by Johnson (2002), suggested an increase in the number of people fishing, and a decline in speedboats and dingies, (although no changes in numbers were significant), with no change in waterbuses or personal watercraft, from counts at the Harbour entrance during 1999-2002.,.

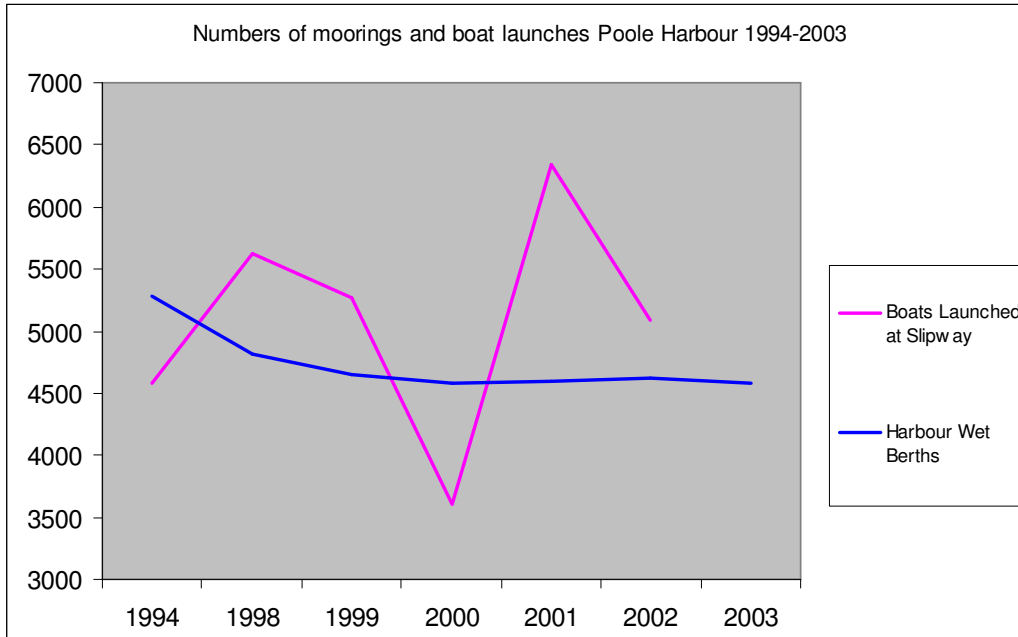
Although the line of site counts give some idea of the level of boating use of the Harbour, and these data can be supported by counts of visiting boats, boat launches at slipways and number of available moorings, they give no information on the spatial distribution of boats in the Harbour over the summer, and, more importantly, during the winter. It is likely that the main effect of boating in the Harbour on the SPA interest will be to cause disturbance to birds on the adjoining flats, saltmarshes, shingle and other habitats, particularly during the winter months.

**Figure 9. The percentage of waterborne users from a questionnaire (from Southgate 2006)**



The line of site, moorings and slipway launch data should continue to be collected as consistently as possible from year to year, and obtained from PHC.

**Figure 10. Number of wet berths and boat launches from the baiter slipway 1994-2003.** (from PH Steering Group Report 2003)



## Other Activities

### Wildfowling

Wildfowling is carried out within the Harbour by members of the Poole Harbour Wildfowling Club. Wildfowling is carried out by club members using boat access on Crown foreshore between mean high and mean low water. Wildfowling is also carried out on wet grassland and other Harbour edge habitat on the southern shore between Wytch Channel and Goathorn, on Patchins Point, on part of The Moors and at Swineham. As far as is known these activities are not coordinated between different parties. Wildfowling returns held by Natural England suggest that the majority of quarry species are teal and wigeon neither of which has declined in the Harbour during 1991/2-2002/3.

**Data on wildfowler disturbance should be collected by the club with a summary of shooting dates and locations, and from shore based shooters on bags and shooting dates.**

There are a number of other activities which may have an affect on bird numbers and distribution including shore based activities such as walking and dog walking and bird watching. Apart from the roost survey, noted earlier, there is virtually no information on any of these activities.

### Deer grazing

Grazing by sika deer *Cervus nippon* has become a problem in parts of the Harbour and particularly on the Arne Peninsula. Heavy grazing of saltmarsh here has led to the decline of communities dominated by the perennial cord grass *Spartina anglica*, and their replacement by the annual Glasswort *Salicornia ramosissima* (Diaz et al 2005). In places the vegetation has been almost entirely removed by grazing and trampling, leaving bare mud which is colonised by the glasswort, normally a pioneer species of lower saltmarsh. Diaz et al (2005) also found higher grazing levels led to higher abundances of the infaunal species, *Nereis diversicolor*, *Hydrobia ulvae* and *Gammarus* sp., all of which can be eaten by birds.

Deer damage to reedbeds was reported by Cook (2001) with particular problems at East Holton and some damage to most of the Harbour reedbeds. At Arne, heavy grazing and trampling has eliminated two small tidal reedbeds altogether and heavily damaged other reedbeds on the Peninsula. Deer grazing is likely to be the single greatest threat to the reedbeds of Poole Harbour. Other threats noted by Cook (2001) include drying out, an increase in salinity in banded freshwater beds due to damage by deer and lack of maintenance, scrub encroachment, uncontrolled cattle grazing and neglect.

### Obstruction to site lines

Obstruction to site lines for feeding and roosting birds may make some areas unacceptable to some species, especially some waders and possible brent goose. The demand for piers and jetties in the northern part of the Harbour has led to concerns that these will restrict the areas available for feeding waders. A survey by Donnelly et al (2003) recommended the division of the north shore into sectors and made recommendations on the degree of importance of each sector for wintering birds. From these data, sectors were recommended for no new structures, new structures only with mitigation and sectors where existing structures should, where possible, be removed. Planning applications should also be monitored and objections made to new structures close to important wader roosts.

### Alien species

The history of cord grass colonisation and decline in the Harbour has been well documented (Gray & Benham 1990, Raybould 2005), and is mentioned in a number of places in this report. A brief summary of other alien species in and around the Harbour was given by Underhill-Day and Dyrinda (2005). Within the intertidal and sub-tidal areas of the Harbour, there are a substantial number of alien seaweeds and invertebrates (Dyrinda 1987, 2003). These include Japanese seaweed *Sargassum muticum* in channel margins, Korean sea squirt *Styela clava* on mollusc shells and other channel substrates and Australian barnacles *Elminius modestus* on docks and piers. A significant and deliberate introduction into the Harbour in the late 1980's was

the Manila clam *Tapes philippinarum*, which has subsequently spread across much of the SPA. Once introduced, little can be done to control alien species, and the evidence suggests that only a handful of native species have been seriously affected by introductions into the marine environment (Dulvy et al 2003). However the precautionary principle should prevail. Most introductions are via ship fouling organisms ballast water or associates of introduced shellfish, and where possible measures should be taken to prevent introductions.

**Natural England should monitor the steps taken by the Harbour Authorities to provide safe ways of disposing of ballast water, or preventing disposal in the Harbour waters, and by the Fisheries Authorities to prevent the introduction of alien species with introduced shellfish. Where necessary, this should form part of the Environmental Impact Assessment of specific proposals.**

## **Disturbance**

The main effect of both water and shore based activity is likely to be disturbance to nesting, feeding or roosting birds. The main tern colonies are on protected areas on Brownsea Island, but the gull colony in Wareham Channel is easily available to small boats and landing is possible. There is no information on landings here, but illegal egg collecting was known to occur here until a few years ago and could become a problem again. The main nesting species on the saltmarshes is the redshank (Chown & Cook 2004), and disturbance could affect breeding success of this species, particularly as heavy deer grazing has, in places, pushed the breeding pairs into higher vegetation at the saltmarsh edge.

It is during the winter that disturbance is likely to have the greatest effect when over 20,000 waterbirds over-winter or pass through the Harbour on passage. Although boat traffic is likely to be reduced in winter (although there is no available data on boat use in the most important areas of the Harbour on the south shore during the year), other activities increase.

Wildfowling is a winter activity, legally permissible from September 1<sup>st</sup> to February 20<sup>th</sup> on foreshore, while the licenced clam fishery runs from October to January. Some fishermen collect cockles in winter both from dredging and hand raking, and bait digging takes place all the year round. While these activities taken individually may engender acceptable levels of disturbance under normal tidal and weather conditions, when birds can move to undisturbed areas to feed, taken in combination they could have a profound effect, particularly during hard weather. No proper assessment of the disturbance to waterfowl from these activities has been attempted.

Disturbance at times in the tidal cycle or in freezing weather could bear particularly hard on avocet or grey plover which have a limited distribution, linked to the patchy occurrence of their main prey species, or birds such as oystercatcher and curlew where the abundance of their prey species is in places too low to meet their winter

energy requirements. There is no data on the in-combination disturbance from these and other on shore-based activities for the Harbour, nor on the likely effects.

In the medium to longer term, milder winters could encourage greater year-round recreational activities with consequent disturbance both alone and in-combination with other activities. Existing in-combination effects have been little studied, and the increases in a number of wintering species in the Harbour may simply reflect changes in distribution due to factors elsewhere. These may mask effects of changing distribution and intensities of activities within the Harbour about which little is known. Moreover, any effects may take some time to influence population trends, and further time before causes can be identified. Under these circumstances, the precautionary principle should be adopted in consenting potentially damaging operations and further research and monitoring initiated.

**It is strongly recommended that a study be carried out on the in-combination levels of disturbance from winter human related activities in the Harbour and that this be used as a baseline for future monitoring and as a guide to future zoning proposals or any necessary restrictions during periods of hard winter weather. It is also recommended that the main agencies and other stakeholders with an interest in the Harbour should co-operate in putting in place an integrated research and monitoring programme for the SPA, initiated by a symposium to scope the requirements for future work.**

### **Condition Tables**

The recommendations contained in this report have been summarised in Condition Tables. These give the features, sub-features and attributes of the European Marine Site, with an assessment of current condition and potentially damaging actions or operations. The final column makes management and monitoring recommendations.

FEATURE	SUB-FEATURE	ATTRIBUTE	CURRENT CONDITION	TARGETS	POTENTIALLY DAMAGING ACTIONS/OPERATIONS	MONITORING/ MANAGEMENT
Internationally important populations of regularly occurring Annex I bird species Avocet	All sub-features	Disturbance in feeding, nesting and roosting areas	Wintering avocets numbers have increased tenfold since 1991/19912	Peak means stable or increasing and numbers within WeBS sections not significantly changed from mean peaks 2000-2005	Wintering avocets mostly roost on protected areas on Brownsea and at the end of Wytch & Middlebere Channels. They are vulnerable to disturbance when feeding in Wytch/ Middlebere channels	WeBS counts should continue. Counts in sections 5, 7 and 8 should be annually monitored. Disturbance to area from and including Arne Bay, east of Round Island to the southerly tips of Wytch and Middlebere Channels should be minimised.
Mediterranean gull			Mediterranean gull numbers appear to have increased in 2006	Breeding numbers no lower than 2006 (50 nests)	Mediterranean gulls are vulnerable to disturbance and illegal egg collection	Monitor Mediterranean gull nest numbers once every three years. Make police and other enforcers in Harbour aware of vulnerability of nesting colony
Common tern			Common tern numbers have doubled since the early 1990's	Mean breeding pairs within 20% of mean 2000-2005 (180 pairs) Mean productivity $\pm 0.5$	Common terns breeding areas are protected from disturbance	Monitor breeding numbers annually. (Currently carried out by DWT wardens)
	Shallow inshore Waters	Extent and distribution of habitat		No overall change in total combined areas of sub-tidal and inter-tidal habitat	Built structures, dumping of dredged material. Lack of management or sea wall failure on Brownsea'	Aerial surveys, LIDAR and bathymetric surveys (when available). Sediment management Plan and EIA for all channel and marina/boatyard dredging. Monitoring of sea wall and hydrology of Brownsea lagoon
		Food availability	No information		Water column contaminants and turbidity	EA water column analysis interpreted against European Dangerous Substances Directive EQS. Monitoring should include turbidity. Monitor fish invertebrate food (see below). Monitor annual catch data from SSF

FEATURE	SUB-FEATURE	ATTRIBUTE	CURRENT CONDITION	TARGETS	POTENTIALLY DAMAGING ACTIONS/OPERATIONS	MONITORING/ MANAGEMENT
Internationally important populations of regularly occurring Annex I bird species	Intertidal sediment Communities	Extent and distribution of habitat	Limited information suggests that losses are compensated by saltmarsh erosion	No overall change in total combined areas of sub-tidal and inter-tidal habitat	Sea level rise, dredging, bait digging and dragging, pump scoop dredging for shellfish	Aerial surveys, LIDAR and bathymetric surveys (when available). Sediment management Plan and EIA for all channel and marina/boatyard dredging. Long term monitoring of the effects of repeated shellfish dredging and establishment of un-fished controls Regulation of shellfish dredging and survey of distribution and frequency of bait digging and bait dragging. Managed retreat
		Food availability	Surveys suggest low numbers of infauna individuals and species in some areas (Thomas et al 2004)	Stable or increasing benthic invertebrate numbers and species richness in all sections of the Harbour	Build up of sedimentary toxins, nutrients or organic materials. Summer algal growth, gradual changes in sediment particle size	Baseline analysis of the sedimentary contaminants and invertebrate bioassays in Holes Bay. Mapping of extent of algal mats from aerial surveys and infaunal survey after Thomas et al (2004) 6 yearly. with particle size monitoring Receipt of EA sediment and water column analysis interpreted through Canadian sediment quality guidelines and EU EQS.
	Saltmarsh	Extent and distribution of habitat	Spartina die-back and saltmarsh erosion	No overall change in total combined areas of sub-tidal and inter-tidal habitat	Shoreline erosion, sea level rise, deer grazing/trampling	Six yearly GPS surveys of saltmarsh edges, coupled with aerial surveys, LIDAR and bathymetric surveys (when available ) Six yearly reedbed condition Managed retreat
		Food availability	Unknown but probably variable	No deterioration of abundance of infauna	Overgrazing by deer and cattle, oil spill pollution	Sample infauna after Diaz et al (2205) At six yearly intervals
		Vegetation characteristics	overgrazed by deer in some areas		Overgrazing by deer and cattle, oil spill pollution	Twelve yearly NVC and plant species survey after Edwards (2004). Monitor grazing pressures Monitor vegetation height on selected roosts every six years

FEATURE	SUB-FEATURE	ATTRIBUTE	CURRENT CONDITION	TARGETS	POTENTIALLY DAMAGING ACTIONS/OPERATIONS	MONITORING/ MANAGEMENT
Internationally important assemblage including internationally important populations of migratory species	All sub-features	Disturbance in feeding and roosting areas	Adequate roosts are apparently currently available	Acceptable levels of disturbance to feeding waterfowl and to roosts	Human activities on water and onshore disturb feeding waterfowl Roosts threatened by erosion and disturbance	Continue to monitor wintering bird populations annually through WeBS Carry out repeat roost survey at 12 year intervals after Morrison (2004), Collect data on shooting dates and locations from Wildfowlers Club and bags and shooting dates from shore based shooters. Carry out major baseline survey of spatial and temporal disturbance activities in the Harbour. Monitor boats and boat launches
	Shallow inshore Waters	Extent and distribution of habitat	Current status unknown swinging moorings declining in number as a result of PHC policies	No overall change in total combined areas of sub-tidal and inter-tidal habitat	Built structures, dumping of dredged material. Lack of management or sea wall failure on Brownsea Swinging moorings	Aerial surveys, LIDAR and bathymetric surveys (when available). Sediment management Plan and EIA for all channel and marina/boatyard dredging. Monitoring of sea wall and hydrology of Brownsea lagoon. Monitor moorings
		Food availability	Unknown		Water column contaminants and turbidity	EA water column analysis interpreted against European Dangerous Substances Directive EQS. Monitoring should include turbidity. Monitor fish invertebrate food See below) Monitor annual catch data SSF Encourage deer control
	Intertidal sediment Communities	Extent and distribution of habitat	Limited information suggests that losses are compensated by saltmarsh erosion	No overall change in total combined areas of sub-tidal and inter-tidal habitat	Sea level rise, dredging, bait digging and dragging, pump scoop dredging for shellfish	Aerial surveys, LIDAR and bathymetric surveys (when available). Sediment management Plan and EIA for all channel and marina/boatyard dredging. Long term monitoring of the effects of repeated shellfish dredging and establishment of un-fished controls Regulation of shellfish dredging and survey of distribution and frequency of bait digging and bait dragging

FEATURE	SUB-FEATURE	ATTRIBUTE	CURRENT CONDITION	TARGETS	POTENTIALLY DAMAGING ACTIONS/OPERATIONS	MONITORING/ MANAGEMENT	
		Food availability	Surveys suggest low numbers of infauna individuals and species in some areas (Thomas et al 2004)	Stable or increasing benthic invertebrate numbers and species richness in all sections of the Harbour	Build up of sedimentary toxins, nutrients or organic materials. Summer algal growth, gradual changes in sediment particle size	Baseline analysis of the sedimentary contaminants and invertebrate bioassays in Holes Bay. Mapping of extent of algal mats from aerial surveys and infaunal survey after Thomas et al (2004) 6 yearly. with particle size monitoring Receipt of EA sediment and water column analysis interpreted through Canadian sediment quality guidelines and EU EQS.	
	Saltmarsh	Extent and distribution of habitat	Spartina die-back and saltmarsh erosion	No overall change in total combined areas of sub-tidal and inter-tidal habitat	Shoreline erosion, sea level rise, deer grazing/trampling	Six yearly GPS surveys of saltmarsh edges coupled with aerial surveys, LIDAR and bathymetric surveys (when available). Six yearly reedbed condition surveys. Monitor grazing pressures	
		Food availability	Unknown but probably variable		Overgrazing by deer or cattle, oil spill pollution	Sample infauna after Diaz et al (2205) Obtain data on spillages from PHC	
Internationally important assemblage including internationally important populations of migratory species	Saltmarsh	Food availability	Unknown but probably variable	No deterioration of abundance of infauna	Overgrazing by deer or cattle, oil spill pollution	Twelve yearly NVC and plant species Survey after Edwards (2004). Monitor Deer and cattle grazing pressures	
		Vegetation characteristics	Some areas heavily over-grazed by deer		Vegetation height too high for roosting waders. Erosion of saltmarsh eliminates roost sites	Carry out repeat roost survey at 12 year intervals after Morrison (2004). Six yearly GPS surveys of saltmarsh edges	
		Absence of obstructions to viewlines	Some existing jetties should be removed	No further obstructions or mitigation after Donnelly et al 2003	Construction of structures including power lines, telecommunication masts, jetties, piers etc. in Harbour	Monitor planning applications and follow guidelines laid out in Donnelly et al (2003) for piers and jetties. Monitor applications for structures close to important roosts	
	Reedbed	Extent and distribution of habitat	Some reedbeds seriously over-grazed, some areas drying out	Reedbed overgrazing Eliminated. Wet up dry reedbeds	Reedbed overgrazing Eliminated. Wet up dry reedbeds	Overgrazing by deer. Lack of hydrological management	Carry out repeat condition survey at ten year intervals after Cook (2001). Deer Control encouraged. Install water control structures as appropriate
		Food availability	Unknown	No deterioration of abundance of reedbed Invertebrate fauna	No deterioration of abundance of reedbed Invertebrate fauna	Overgrazing and trampling by deer and cattle	Monitor grazing pressures baseline survey of reedbed invertebrate fauna

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## Appendices

### Appendix 1

Metals sampled in Poole Harbour tidal waters and the rivers discharging into it, latest dates for analysis, detected trends and conclusions

Metal	Sites sampled	Trends	Conclusion
Arsenic (As)	Frome, Piddle (2001) and 6 sites in Harbour (1998/01)	No obvious trends	For monitored sites, dissolved As poses little threat
Cadmium (Cd)	Frome, Piddle (2001) and 10 sites in Harbour (1996/01)	No temporal trends	No untoward inputs from rivers. Little evidence to suggest Cd concentrations would be acutely harmful, There is no tidal data for Holes Bay
Chromium (Cr)	Frome, Piddle (2001), Holton Heath Stream (1993) and 8 sites in Harbour (1996/02)	No obvious trends	All river samples examined would comply with even the lowest standard. In estuary, median standards for all sites is lower than EQS* but with occasional elevated levels. More data are needed to assess sources in Holes Bay and South Deep and any sub-lethal impacts on biota
Copper (Cu)	Frome, Piddle, Sherford, Corfe River (2001). Holton Heath Stream (1992/95) and 8 sites in Harbour (1996/01)	No temporal trends	Only the Holton Heath Stream might be a cause for concern but average dissolved Cu showed a significant downward trend there in early 90s. In estuary waters, in the majority of sample sites dissolved Cu appears to be normal, but elevated levels at Poole Bridge, implying sources in Holes Bay. More comprehensive data are needed in Holes Bay.
Iron (Fe)	Frome, Piddle (2001), Holton Heath Stream (1992) and 8 sites in the Harbour (1996/01)	No obvious trends No distinctive trends	Median values for all sites well below EQS, unlikely that Fe a threat to marine biota at the site. Occasional elevated levels at Poole Bridge, presumably originates from Holes Bay.
Nickel (Ni)	Frome, Piddle (2001) Holton Heath Stream (1993). 7 sites in Harbour (1996/02)	No unequivocal trends	Both river and Harbour samples are well below EQS. It is unlikely that Ni would represent a threat to marine biota at the site
Lead (Pb)	River Frome & Piddle (2001) & 6 sites in Harbour (1996/7)	No unequivocal trends	Virtually all data are at or below detection limits in rivers and Pb concentrations at estuarine sites are more than an order of magnitude below EQS, probably of little concern for biota.
Zinc (Zn)	Frome, Piddle (2001) and 8 sites in Harbour (1996/01)	No long term trends	Freshwater levels are compliant with EQS. In the estuary, median levels appear to fall below current standards, and it is unlikely they would represent an acute threat to most marine biota. However, there are elevated levels at Lake Pier, Poole Bridge and Lytchett Bay which would not meet proposed revised standards.
Mercury (Hg)	Frome, Piddle 1990/02), and six sites in Harbour (2001)	No apparent trends	Annual averages for freshwaters fall significantly below the EQS. In the Harbour, averages are invariably below the EQS. For the sites monitored, dissolved Hg poses little threat.
Vanadium (V0) & Boron (B)	From Frome and Piddle only (1991/00)	No trends	Boron was at a level equating to normal ambient concentrations in seawater, and it is unlikely that EQS would be exceeded even within mixing zone. Vanadium levels were invariably below EQS and so it is not considered a problem. However trade effluent samples have Occasionally exceeded this limit and it may be advisable to investigate this further

## Appendix 2

Metal and TBT loadings in Poole Harbour sediments with main distribution of medium and high loadings as defined by interim marine sediment quality guidelines\* and probable effect levels\*\*

Metals	Areas of Medium Loads	Areas of High Loads	Areas of High Loads
Chromium	N, E and W Holes Bay		None
Arsenic	Most of N, and S-W Harbour		Luscombe Stream outfall
Copper	Most of N and S_W Harbour		None
Cadmium	Holes Bay and Blue Lagoon		N Holes Bay by STW outfall
Zinc	Lytchett, Holes Bay, Blue Lagoon Parkstone Bay and Wych Channel		N Holes Bay by STW outfall
Mercury	Keyworth Point, Lychett Bay, Wych Channel, Brands Bay		N, W, E, S Holes Bay, Blue Lagoon, Parkstone Bay
Lead	Lytchett and S Holes Bay, Wych Channel, Brands Bay		N, E, W, Holes Bay, Blue Lagoon, Parkstone Bay
TBT			Lytchet and Holes Bay, Parkstone Bay Wych Channel, Brands Bay

\* Medium =Concentrations between ISQG's and PEL's, where effects on biota cannot be excluded

\*\* High= Concentrations where harmful effects on biota might be expected

### Appendix 3

#### Toxic contaminants in Poole Harbour.

Compounds	Uses	Sampling	Comments
$\gamma$ -HCH Lindane	Seed dressings and parasites of farm animals	Frome, Piddle (1999) West Quay (1990/95), six sites in Harbour 1996/00)	Samples in rivers consistently below EQS. West Quay discharges (now ceased) posed low risks for biota. Samples in Harbour below EQS. Threat appears relatively small
DDT, dieldrin, aldrin, endrin	Seed dressings and soil insecticides,	Frome and Piddle (2001) Tidal waters (no date)	River samples, STW and tidal waters samples had very low levels. Impact on marine site is minimal
Endosulphan		Frome, Piddle (2002) Tidal waters (mid 1990s)	Concentration in freshwater, STW discharges and tidal waters have all been low. Detection limits above EQS make an accurate assessment of effects not possible
Atrazine, Simazine	Herbicides	Frome, Piddle (1990/02)	Majority of values low but occasional elevated values, although none above EQS. Unlikely triazine herbicides represent a significant threat to the marine site.
Organophosphates	Sheep dips	Frome, Piddle (1990/02)	Only likely source is rivers and levels low. Threat negligible
PCBs		Frome (1990 & 1994)	All samples very low. No data on PCBs in Harbour sediments
Pentachlorophenol	Wood preservative	Frome, Piddle tidal waters (no date)	Majority of samples low and below EQS. Historically, discharges in Holes Bay-still higher values at Poole Bridge
Chloroform	Industrial solvent	Frome, Piddle, (1990/01)	All freshwater samples and STW discharges below EQS. So these sources are not a major threat. Annual averages in estuarine waters quite low and below EQS
Tetrachloromethane	Industrial solvents	Frome, Piddle and tidal	Concentrations of all three volatile organics were invariably
Trichloroethylene	and other industry	waters (dates not given)	below EQS, implying little threat.
Trichloroethane	Uses		

