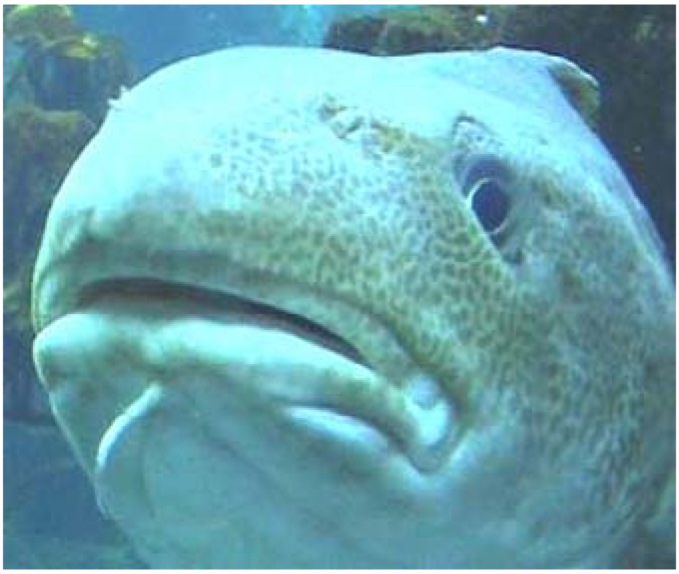
AQUATIC ZOOS

A critical study of UK public aquaria in the year 2004



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INTRODUCTION

Just as zoos are, public aquaria are a common and well-known feature of modern industrialised society. It is almost impossible not to come across one when browsing any developed country tourist information brochure, especially when looking at big cities by the sea, or coastal tourist resources.

The first known 'modern' public aquarium was the fish house at London Zoo, which opened in 1853 (Gosse, 1854). Soon public aquaria became quite popular in the Victorian era and were quickly constructed all throughout Europe (Gilbert, 1970). Since then, pretty much every fish that can be caught alive has been taken to public aquaria for exhibition, even if many might have not survived for long. Contrary to the popular belief, sharks began being displayed in public aquaria from the very beginning (Koob, 2001), in cities such as Berlin (1869), Frankfurt (1872), Napels (1874), Hamburg (1884), Helgoland (1892), Rovigno (1892), New York (1896), Monaco (1905), and, of course, Brighton (1872) and Plymouth (1888), which together with London probably represent the three main cities that gave birth to the public aquarium industry in the UK. By 1920 over 45 major public aquaria in the world were already drawing 10 million visitors a year (Koob, 2001).

Since then the public aquarium industry has flourished even more. A survey of the main European public aquaria undertaken six years ago (Blanch et al, 1999) found that in the whole of EU there were 70 public aquaria, 17 of which could be classed as new-generation 'exhibition' aquaria, which are characterised for their big sizes (between 1,400 and 18,000 square metres), big investments (between €4.5 and €92.5 million), huge water volumes (between 300 and 6000 cubic metres) and very big tanks (the biggest holding 4,700 cubic metres of water). Although in terms of investment and sizes American and Japanese new generation public aquaria outperform the EU ones, overall it does seem that public aquaria are growing both in numbers and sizes, all over the world. The same survey concluded that in 1998 Europe's leading public aquaria attracted 17,615,000 visitors, almost doubling the world figures for 80 years earlier. Although it is difficult to ascertain the accuracy of these estimations –it is obvious that the survey only looked at the main centres of each country– this information, together with the general impression of the state of the industry in the first years of this century, points towards the conclusion that the public aquarium industry is thriving rather than receding.

Indeed, the number of free-standing members of public aquaria in the American Zoo and Aquarium Association has more than doubled since 1989 (Hunter, 2003), and the number of new chains of public aquaria has proliferated in the last three years in the UK.

More than ever, it seems, fish and aquatic invertebrates are being kept in captivity for exhibition, and if there was ever anything wrong with this, or if ever there had been a more likely time to find aquatic animals exposed to the wrong environment, now seems to be the time to look at the problems public aquaria cause to the millions of animals they exhibit.

There are, however, other reasons beyond numbers for paying attention now to the welfare of animals kept in public aquaria. Some species that up until now had managed to escape life in an aquarium (i.e. deep sea animals, or the biggest sharks) are under increasing pressure of being the first to be exhibited by those public aquaria that try to beat the growing number of competitors by having something nobody else has. More and more animals exhibited are forced closer and closer to the general public in order to exploit people's thirst for 'close up' and 'hands on' experiences, without which a visit to the already commonly seen aquarium would perhaps be too boring. The recent incorporation of new practices into the landscape of UK public aquaria, such as visitors diving with sharks, are opening new possibilities of animal welfare and human safety problems that were not possible a few years ago.

The popularity of the recent film "Finding Nemo" has put fish into people's conscience in such a way that it seems to have awoken in some the realisation that, after all, fish are sentient beings with the same kind of problems any captive animal has. However, it also has generated an increase of the acquisition of tropical fish by both the private and the public industry, which has drawn the attention of organisations and individuals that care for the conservation and welfare of fish.

It is not just fish and aquatic invertebrates, though. Marine mammals are also animals often associated with captive aquatic environments, or with films that changed people's perception of them (such as 'Free Willy'). Jean-Michel Cousteau, the son of the famous marine explorer Jacques Cousteau, once said that *"aquariums, particularly marine mammals circus acts, are bound to disappear as public is educated and revolts against it"*. This indeed happened in the UK regarding dolphins, but although there has not been any cetacean in captivity in the UK since 1993, this practice, still heavily criticised by most animal welfare and conservation groups and experts, is still common in public aquaria and marine parks overseas. However, since very recently, some of the UK public aquaria are now part of international leisure business groups that own several dolphinaria around the world, and therefore there is a real danger that captive cetaceans may return to the UK, despite the general outrage this would provoke.

There are other specific reasons for paying special attention to public aquaria in the UK right now, in 2004. The new Zoo Licensing Act (Amendment) Regulations enacted in 2003 in the three UK nations is one of them. The 'conservation criteria' now present in UK legislation is one of the licensing conditions many aquaria are likely to fail, so it seems appropriate to address this issue now by assessing how much conservation takes place in UK public aquaria.

Another reason is a project that is luring in the London horizon and that is concerning several animal protection groups. Perhaps induced by this new law, but probably also by the increase of number of big new generation 'exhibition' aquaria (and their popularity), the Zoological Society of London is planning to open a 'state of the art' new aquarium in Silvertown (London) that, in their own words, *"will provide a rich and diverse experience, with immersive, 'you-are-there' natural exhibits that take you to different parts of the world…it will be unique in that it will be the first Aquarium in the world to have been planned from the outset to be based on principles of sound conservation and science*". There is concern that the potential size of such a new aquarium may radically increase the number of fish and aquatic invertebrates in captivity in the UK, and in consequence the animal welfare and conservation problems associated with it, but there is also the concern that, as happened in 1853 when the same organisation began the history of modern public aquaria that lead to the proliferation of aquatic animal captivity, the new aquarium may have a similar effect, making other cities wanting to have their own. Perhaps this so called 'unique' aquarium will not be as different from the others after all (there is no detailed information about the plans that will allow to ascertain that as yet), but perhaps it will open new avenues and practices of fish keeping and exhibiting that may end up worsening the welfare of captive animals as a whole, or increasing the conservation threat of wild populations, regardless of whether that may or may not be the intention of the planners.

It does seem necessary and relevant, then, to study the present status quo of the UK public aquarium industry and concept, and for this reason the Captive Animals' Protection Society commissioned an investigation into the subject the result of which is this report.

Most of the issues that are part of the running of public aquaria that have some bearing on the welfare of the animals exhibited –in terms of both individuals and populations – were investigated with the aim of having a comprehensive picture of what is the reality of a captive life in an aquarium, and what are the implications of the existence of the public aquarium industry in 21st century Britain. Particularly attention was given, though, to fish and aquatic invertebrates, which are the captive animals that probably have received the least attention from animal protection groups.

This study was designed and developed to be as objective as possible in order to be able to unearth the truth about public aquaria, but this is a 'critical study', which means that the conclusions taken from it do not have to be always 'neutral'. It was not an exercise in listing all the pros and cons of public aquaria, nor an investigation trying to please either side of the so called 'captivity debate'. Most people do not care much about fish and/or aquatic invertebrates, which is in itself unfair considering that people have an effect on their lives, so attempting to be 'neutral' in the way we judge their situation would not compensate for such unfairness, but rather contribute to it. Indeed, the analysis of the information gathered has been conducted with the utmost objectivity, but the interpretation of the results been made thinking of the animals involved, not on the aquarists –in the same way a medical doctor thinks of the patient, not the virus or bacteria that might be infecting him/her. Nobody would accuse the medical scientist of being partial towards the patient, but it is likely that the public aquarium industry would accuse this report of being partial towards the animals. This is a criticism easy to embrace, because it does not invalidate the results obtained nor does it prevent others from arriving at their own conclusions with them. The methods used will be clearly explained so anyone can replicate the study, and references to other work have been used whenever possible so facts and opinions can be cross-checked.

Despite this study being commissioned by a particular organisation, the investigator and author of this report has remained independent. On no occasion has the commissioning organisation influenced the results or conclusions to prevent the report being independent. This is a report partial to the animals, and independent of any group or institution, including the aquarists and the public and private aquarium industry, the conservationists, the animal protection groups, the animal rights activists, and the different levels of government.

This report should be interpreted as an attempt to provide new, fresh and comprehensive information about the performance, claims and work of the UK public aquarium industry as a whole, so the review of their impact on the welfare of individual animals and populations can take place, and the rethinking on their role in a modern compassionate society such as the one the UK aspires to be may begin.

METHODS

This study used two main methodological approaches: scientific research and investigative journalism. The first one was based on developing general descriptive statistical analysis from data obtained through random sampling. The second one was based on *in cognito* visits to public aquaria posing as a normal visitor in order to get information difficult to obtain if the aquarium was aware of being investigated.

In order to minimise any possible subjectivity, and to allow second opinions, all the visits to the aquaria were recorded with a video camera, and most of the analysis took place from information obtained by viewing the recorded tapes.

Definition

The first step in an investigation of this type is to explicitly define what constitute the subjects of this study. The following definition of UK public aquarium, mainly based on the definition of a zoological collection as expressed in the Zoo Licensing Act 1981 –and therefore likely to be the closest to an official definition– was used:

> *"Any collection of captive animals in a particular site in UK territory in which one individual animal or more belongs to taxa not normally domesticated in the UK (according to the DEFRA's official criteria), that it is open to the public seven or more days in 12 consecutive months, and that exhibits* ***mainly fish and/or aquatic invertebrates****"*

The term 'mainly' in this definition should be interpreted as 'the majority of the individual animals', and the term 'animal' in the totality of this report should be interpreted as any member of the animal kingdom (therefore including fish and invertebrates).

In this investigation zoos or other types of zoological collections that kept mainly birds, mammals and/or reptiles, even if they also kept fish and aquatic invertebrates in specific 'aquarium' sections of their sites, were not included. However, public aquaria that kept any of these other animals if fish and aquatic invertebrates remained the main animals exhibited were included. Pet shops or any other premises that would not require a Zoo Licensing Act 1981 licence were excluded.

Note, also, that the definition used would not render as 'public aquarium' a dolphinarium that only exhibits cetaceans (which there are not any at present in the UK), or an otter or seal sanctuary that does not keep more fish than mammals (this has resulted in excluding some of these type of zoological collections present in the UK). The reason for this is that despite the aquatic nature of these collections, the husbandry techniques as well as the potential problems the animals kept may encounter would differ significantly from the aquaria that keep mainly fish, which is the focus of this investigation.

The use of the specific term 'public aquarium' (as opposed to only 'aquarium') throughout this report is intended to prevent any confusion with other type of aquarium (like dolphinaria or private/commercial aquaria involved in the aquarium trade) or with an actual aquarium tank.

Sampling and public aquarium visits

Having defined 'Public aquarium' the next step was to find out how many there were in the UK, so an appropriate sample size could be chosen for visiting. Unfortunately DEFRA (the Department of Food and Rural Affairs) does not have a centralised list of UK zoological collections, and therefore an official list of UK public aquaria does not seem to exist.

We used the following information to compile our own list of UK public aquaria.

1) Records from official sources (DEFRA, Scottish Executive, Welsh Assembly, and the Department of Agriculture of Northern Ireland) on establishments known to have had a zoo license.

2) Specialist websites dedicated to the subject of public aquaria, such as http://www.zoos.50megs.com and http://www.aquariauk.com

3) The websites of the chain public aquaria that own more than one aquarium in the UK

4) The most updated list of known UK public aquaria compiled by the Captive Animals' Protection Society

5) Information obtained by having traveled throughout the UK for the last five years in the study of zoological collections

At the time of beginning this study (March 2004) the most updated list generated with all this information contained 56 entries. Knowing the UK public aquaria population size (56) the minimum sample size to have acceptable representative results (in this case it was considered acceptable results with a 'Confidence Level' of at least 90% and a 'Confidence Interval' of a maximum of 10%) was calculated to be 31, which represents 55% of the population.

A computer generated random sample of 31 entries was created from the alphabetically ordered population list of 56 aquaria. However, while visiting the aquaria two new aquaria not in the list were discovered, one aquarium in the list was confirmed permanently closed and another aquarium of the list was taken out of it because after having been visited it turned out that it no longer fell into our definition (it now contained more terrestrial animals than fish and aquatic invertebrates). Therefore, the most up to date list of known UK public aquaria falling into our definition still contains 56 entries, although two of these entries have changed from the time the random selection was made. This change should not affect the results. Firstly, because the two new aquaria were visited anyway as 'extra' aquaria (since they both were located in Scotland, where a parallel study of Scottish public aquaria was being made) although the information obtained from them has not been included in the calculations and results shown in this report. Secondly, because despite the fact the two aquaria taken off the list were randomly selected, they were substituted by the closest geographically that had not been selected, which maintained both the sample size and the randomness. In the end, 31 selected aquaria and two 'extra' ones were visited from the 56 UK public aquaria known at the time of writing this report.

A second level of randomness was introduced by creating the visiting schedule. Due to the fact that the visiting period included Easter, it was important that the investigator would not choose which aquaria to visit in Easter and which ones immediately before or after. Great Britain, the UK territory from which aquaria had been selected (although aquaria in Northern Ireland had been included in the initial list, none turned out to be selected) was divided into three main latitudinal zones ('South', 'Central', and 'North'), whilst the 'South' zone was divided into two longitudinal sub-zones ('Southwest' and 'South-Southeast') and the 'North' into two further latitudinal ones ('North England' and 'Scotland'). The order in which each of these zones would be visited was determined randomly by first allocating a number to each main zones and generate a computerised random number that would select the order (although , for logistical reasons, the 'Central' zone was chosen 'a priori' as the second zone regardless of which would be the first one to visit), and then by allocating two numbers for each of the sub-zones applying the same process to select which one would be visited first. The result was the following visiting order: 'Southwest', 'South-Southeast', 'Central', 'Scotland' and 'North England'. Wales was considered part of the 'Central' area.

Once the area order had been selected, it was accommodated into a six week visiting schedule in the most efficient logistic way. As a consequence all aquaria were visited, following the selected area order, between 03/04/04 and 20/05/04.

The list of all public aquaria visited (and their substitutions when needed), their general location and date of visit can be seen in table 1.

Public Aquaria visited, 2004						
Rand.num.	**CODE**	**County**	**Country**	**Date**	**status**	**Substitution**
51.812108	**A-ABE52**	Ceredigion	Wales	22/04/04	Successful	
8.311982	**A-AQU08**	Cumbria	England	10/05/04	Successful	
	A-BLA26	Lancashire	England	11/05/04	Successful	
2.604564	**A-BLU03**	Cheshire	England	16/05/04	Successful	
	A-BLU06	Cornwall	England	04/04/04	Successful	
20.585296	**A-BOL21**	Greater Manchester	England	14/05/04	Successful	
1.766701	**A-BRI02**	Bristol	England	08/04/04	Successful	
31.275054	A-CAN31	Manchester	England	14/05/04	Non-aquarium	A-BLA26
48.466544	**A-DEE48**	Fife	Scotland	28/04/04	Successful	
25.177925	**A-FOR25**	Isle of Wight	England	11/04/04	Successful	
4.129803	**A-FOW04**	Cornwall	England	10/04/04	Successful	
23.763871	**A-ISL24**	Isle of Wight	England	12/04/04	Successful	
	A-LOG46	Dumfries & Galloway	Scotland	08/05/04	Successful	
15.513807	**A-LYM16**	Dorset	England	06/04/04	Successful	
44.031943	**A-MAC44**	Aberdeenshire	Scotland	30/04/04	Successful	
50.269942	**A-MAR50**	Inverness-Shire	Scotland	05/05/04	Successful	
9.506002	**A-MAT10**	Derbyshire	England	25/04/04	Successful	
	A-MAT58	Derbyshire	England	25/04/04	Successful	
4.996990	A-MEV05	Cornwall	England	03/04/04	closed	A-BLU06
40.666357	**A-NAT41**	West Midlands	England	19/04/04	Successful	
46.750454	**A-NAT47**	Edinburgh	Scotland	27/04/04	Successful	
55.525457	**A-OCE56**	Pembrokeshire	Wales	21/04/04	Successful	
	A-OCE57	Highlands	Scotland	06/05/04	Successful	
44.970056	**A-SCO45**	Argyll and Bute	Scotland	04/05/04	Successful	
0.735657	**A-SEA01**	Avon	England	09/04/04	Successful	
11.093799	**A-SEA11**	Devon	England	05/04/04	Successful	
16.937205	**A-SEA17**	Dorset	England	07/04/04	Successful	
20.023225	**A-SEA20**	Essex	England	15/04/04	Successful	
26.633996	**A-SEA27**	Lancashire	England	12/05/04	Successful	
32.274074	**A-SEA32**	Merseyside	England	13/05/04	Successful	
33.489100	**A-SEA33**	Norfolk	England	17/04/04	Successful	
52.936078	**A-SEA53**	Denbighshire	Wales	23/04/04	Successful	
49.060146	**A-STA49**	Fife	Scotland	02/05/04	Successful	
22.906094	**A-THE23**	Hull	England	20/05/04	Successful	
28.468092	A-TOW28	Lancashire	England	15/05/04	closed	A-MAT58
17.542494	**A-UND18**	East Sussex	England	14/04/04	Successful	

Table 1.List of all 31 randomly selected UK public aquaria that were visited during this investigation together with substitutions and extra aquaria, ordered alphabetically by code name. The first column shows the computer generated random number used to select each aquarium (the absence of number indicates that the aquarium was either a substitution or an 'extra' aquaria, see text), the second column show the code of the aquarium that was visited (in bold for successfully visited aquaria, in italics for 'extra' aquaria visited beyond the randomly selected ones, and in normal font for the cases that required a substitution), the fifth column shows the date of visit, the sixth column shows the outcome of the visit ('Successful' if a randomly selected aquarium was visited uneventfully, 'closed' if the aquarium was found to be permanently closed to the public or temporarily closed during the visiting period of the area in particular where the aquarium was, and 'Non-aquarium' for the cases where the visit concluded that the collection no longer falls into the definition of aquarium used in this investigation), and the final column shows the code of the aquarium that substituted the unsuccessful visit. To protect the identity of the aquaria investigated only code numbers have been used in this report, but on request a list with the names associated to the codes may be provided to official sources. The letters in the code number are not necessarily related to the aquarium's name, hence no conclusion should be drawn from the code number in respect of which actual aquarium it represents.

Analysis of the data

In order to make the results of this investigation as widely available as possible, all calculations were limited to very basic descriptive statistics (mainly percentages of occurrences of events or states in the whole population of UK public aquaria, per type of public aquarium, or per public aquarium).

Almost all the information from which quantification was possible was recorded in the videotapes obtained from the visits, which were conducted following the same method (recording all exhibits and their inhabitants in the order encountered, attending all talks and recording them in their entirety, counting exhibits and visitors present after all the exhibits have been recorded, studying how often visitors read signs from a sample of signs, and engaging into casual conversations with members of the aquarium staff).

While viewing the tapes the logging of the type of exhibit seen, type and number of animals seen, special events attended, relevant content of conversations with the aquarium staff, cases of abnormal behaviour witnessed, cases of animal health problems identified, and any other relevant information was logged into computerised timesheets together with the time of occurrence and the public aquarium code. This not only allowed finding any event logged in the tapes if it needed to be watched again, but also created the basis for quantification. All 'timesheets' from each public aquarium were merged into a 'master timesheet', from which specialist 'timesheets' were created (abnormal behaviour 'timesheet', taxa 'timesheet', health issues 'timesheet', etc.).

When dealing with taxon names it was necessary to homogenise the master timesheet so the same taxa with different common names did not appeared as different taxa. The checking of each common name through bibliographic research was a laborious process but necessary for accurate results. With the exception of seahorses, the common names chosen during this homogenisation process for each taxa had been used in this report, and individuals whose taxa could not be determined have been described with general terms (i.e. Cichlid, killifish, etc.)

When examples were needed to illustrate points raised during the discussion of the results, the logged information into the various 'timesheets' was used to find the right event on the tapes so still captures from the video could be created. All the photos in this report were obtained in this way.

Additional information was found by recording all the contents of the websites of the public aquaria visited, by reading the collections leaflets and guidebooks, and by general bibliographic research.

The study involved over 92 hours of 'field' work in the aquaria. The average visit time was about three hours (n=31, STD = 2 hours and 3 minutes) per aquarium, the maximum time was over six hours, and the minimum time was about 10 minutes. The total number of tape recorded hours from all the visits to all the selected aquaria was 55, with an average of one hour and 47 minutes (n=31, STD =1 hour and 5 minutes) recorded time per aquarium.

Specific methods for the analysis of specific subjects will be described in their respective chapters.

UK PUBLIC AQUARIA PROFILE

In this chapter a description of the current UK public aquarium industry will be given. Only information obtained through this investigation –and available to the general public– was used, and any economic or strictly business data (such as accounts, number of staff, legal status, etc) was not considered.

Types of public aquaria

Not all the establishments that fall under the definition of UK public aquarium used are the same type of zoological collection. For example, the activities and problems that can occur in a site only composed of a small local fish pond may be quite different from the ones in a big public aquarium belonging to an international chain which keeps tropical fish in big tanks with underwater tunnels. Therefore, it would be informative to subdivide the public aquaria into categories with similar characteristics for a more detailed analysis and better comparison. The definitions follow:

> **Chain Public Aquarium (CHPA)** = Public aquarium belonging to a chain company/organisation that owns two or more public aquaria, all of them having as their main activity the keeping and exhibition of captive live fish and/or aquatic invertebrates
>
> **Big Independent Public Aquarium (BIPA)** = Public aquarium not belonging to any chain company/organisation that owns two or more public aquaria, being its main activity the keeping and exhibition of captive live fish and/or aquatic invertebrates, and keeping either 30 aquatic exhibits or more, or at least one aquatic exhibit consisting of a tank bigger than 200 cubic metres in volume.
>
> **Small Independent Public Aquarium (SIPA)** = Public aquarium not belonging to any chain company/organisation that owns two or more public aquaria, being its main activity the keeping and exhibition of captive live fish and/or aquatic invertebrates, and keeping less than 30 aquatic exhibits none of which consists of a tank bigger than 200 cubic metres in volume.
>
> **Auxiliary Aquarium (APA)** = Public aquarium not belonging to any chain company/organisation that owns two or more public aquaria, and having as its main activity any practice other than the keeping and exhibition of captive live fish and/or aquatic invertebrates.

At present in the UK, as far as we are aware, all CHPA are themselves 'Big' in the sense they keep either 30 aquatic exhibits or more, or at least one aquatic exhibit consisting of a tank bigger than 200 cubic metres in volume. Also, most big public aquaria (CHPA and BIPA) tend to have at the same time more than 30 exhibits and at least one tank bigger than 200 cubic metres in volume. Examples of CHPA aquaria (not necessarily having being all investigated in this study) are Sealife Centres, The Blue Planet/Deep Sea World, Blue Reef Aquarium, Seaquarium and Underwater World. We considered 'independent' the aquaria that were formally part of a chain but are now independent (there are two of these cases in the sample). Examples of BIPA (not necessarily having been investigated in this study) are the National Marine Aquarium in Plymouth or The Deep in Hull. Examples of APA are Museums that have few tanks with live fish, hatcheries whose main function is to breed fish or aquatic invertebrates for food despite being open to the public, or amusement parks which have an aquarium as one of their attractions (only if they do not have other type of live animal attractions that would exclude them from our definition).

Using the total population list of 56 public aquaria –as opposed to just the random sample– and having estimated the aquarium type for the collections the investigator had not visited at the time of writing (which is less than a quarter of the population) we found that that all types of public aquaria are more or less equally represented (figure 1), with a slight majority for 'Small Independent Public Aquaria' (SIPA) and 'Chain Public Aquaria' (CHPA) –which together sum 59% of the aquaria. Half of the aquaria are 'big', If we compare it with traditional zoos using information of other studies (Casamitjana & Turner, 2001), we can see that in the UK there are about three times more small zoos than large ones

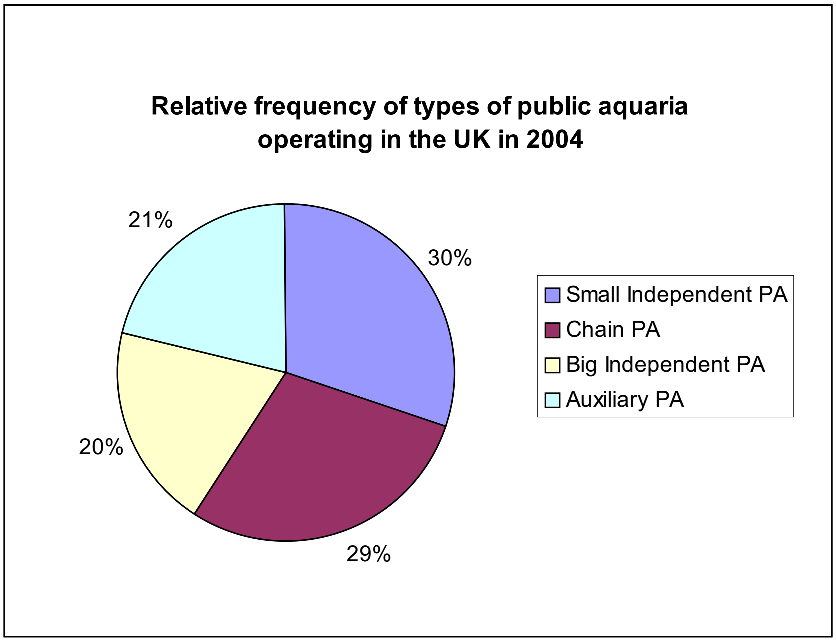

Figure 1. Relative frequency of types of public aquaria operating in the UK in 2004.
The percentages have been calculated using all the population of 56 Public Aquaria (PA).
See text for type definitions.

Animals kept in UK public aquaria

Under the guidelines of the World Conservation Union, zoological collections all over the world, including public aquaria, use and recognise both the scientific and the common name in the description of taxa (a taxon is a taxonomic group such as a species or subspecies). Therefore, in this study the unit used to group the different kinds of animal has also been 'taxon'. Since the chosen taxa in this study are those defined precisely by the public aquaria investigated (unless no sign was available), and accepted by IUCN, any possible bias created by different classification systems has been avoided.

It is estimated that, in 2004, there are over 40,000 individual animals kept in UK public aquaria (from which over 20,000 are vertebrates). In this investigation about 12,000 vertebrates were seen. As expected, the vast majority of animals kept in UK public aquaria are fish and aquatic invertebrates, representing together 99% of the types of animals (n=11,623, figure 2)

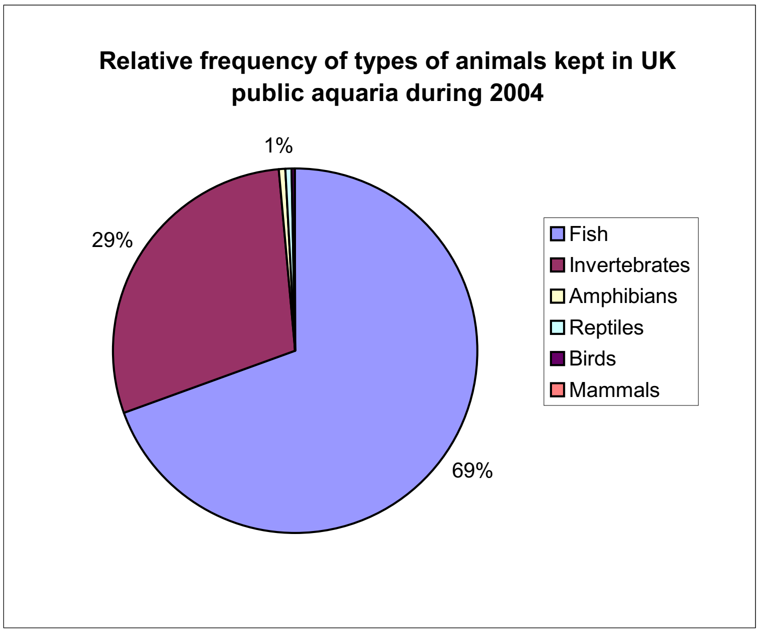

Figure 2. Relative frequency of types of animals kept in UK public aquaria during 2003, calculated from the number of taxa identified. N= 11,623

It is possible that there are more invertebrates than vertebrates kept in UK public aquaria, but the former are more difficult to see due to their size and their hiding tendencies. Because of this, and because individual animals in colonial species (such as corals) or microscopic species (such as Brine shrimp) were not counted, more vertebrates than invertebrates appear in the results as 'seen'. The 100 most common taxa seen in UK public aquaria during spring 2004 can be seen in table 2.

Rank	**Taxa**	**taxa displays (TD)**	**individuals seen (IS)**	**TD x IS**
1	Grey mullet	47	520	24440
2	Lesser spotted dogfish	67	350	23450
3	Beadlet anemone	54	322	17388
4	Bass	37	376	13912
5	Golden trevally	13	659	8567
6	Snakelocks anemone	27	310	8370
7	Common starfish	46	166	7636
8	Yellow tang	23	277	6371
9	Cushion starfish	12	429	5148
10	Thornback ray	34	140	4760
11	Plaice	39	117	4563
12	Dahlia anemone	26	162	4212
13	Ballan wrasse	42	97	4074
14	Pollack	29	130	3770
15	Wimplefish	15	234	3510
16	Greater spotted dogfish	31	109	3379
17	Brittlestar	13	235	3055
18	Shore crab	30	95	2850
19	Blue chromis	16	176	2816
20	Shanny	33	68	2244
21	Mono	11	197	2167
22	Common lobster	48	43	2064
23	Mackerel	9	220	1980
24	Common prawn	25	77	1925
25	Common sea urchin	26	74	1924
26	Spider crab	26	71	1846
27	Red bellied piranha	12	153	1836
28	Hermit crab	26	69	1794
29	Common clownfish	21	84	1764
30	Pulmose anemone	25	70	1750
31	Regal tang	18	85	1530
32	Corckwing wrasse	23	63	1449
33	*Hippocampus.abdominalis*	16	90	1440
34	Turbot	24	51	1224
35	Edible crab	33	34	1122
36	Lumpsucker	12	84	1008
37	Cod	19	51	969
38	Bib	15	59	885
39	Black sea bream	15	54	810
40	Foxface	10	80	800
41	Goldsinny	21	36	756
42	3-spined sitckleback	12	62	744
43	Cuckoo wrasse	19	38	722

44	Starry smooth hound	18	39	702
45	Gilthead	14	50	700
46	Yellow tailed chromis	10	69	690
47	*Hippocampus reidi*	12	57	684
48	Sailfin tang	11	59	649
49	Common mussel	9	66	594
50	Dead man's fingers	10	57	570
51	Cichlid	5	107	535
52	Humbug damsel	10	52	520
53	Tompot blenny	16	31	496
54	Spiny starfish	16	30	480
55	Goldfish	9	52	468
56	Blue and green chromis	6	78	468
57	Conger eel	21	22	462
58	Small eyed ray	17	25	425
59	Neon tetra	3	134	402
60	Tetra	5	75	375
61	Batfish	10	37	370
62	Greater pipefish	9	41	369
63	Common sunstar	16	23	368
64	Cardinal tetra	3	115	345
65	Velvet swimming crab	12	28	336
66	Deep snouted pipefish	7	47	329
67	Carp	6	54	324
68	Dace	4	81	324
69	Lesser weever	7	46	322
70	Cuttlefish	10	32	320
71	Rudd	6	52	312
72	Tropical anemone	8	38	304
73	Cleaner shrimp	10	30	300
74	Rainbow trout	4	75	300
75	Sea squirt	4	72	288
76	Brown trout	4	70	280
77	Common bream	8	34	272
78	Porkfish	7	38	266
79	Rock cook	8	33	264
80	Undulate ray	14	18	252
81	Lionfish	12	21	252
82	Domino damselfish	8	31	248
83	Smooth hound	12	20	240
84	Trevally	2	120	240
85	Tub gurnard	13	18	234
86	Pumkinseed	3	78	234
87	Green chromis	7	31	217
88	Common brittlestar	3	71	213
89	Minnow	5	42	210
90	Scallop	8	26	208
91	Sea scorpion	17	12	204
92	Herring	1	200	200
93	Wolf fish	11	18	198
94	Common eel	9	22	198

95	Tomato clownfish	9	22	198
96	Bangaii Cardinalfish	6	33	198
97	Cleaner wrasse	12	16	192
98	Soldierfish	6	32	192
99	Grey triggerfish	10	17	170
100	Picasso triggerfish	13	13	169

Table 2. The 100 most common taxa kept in UK public aquaria during spring 2004. Their rank (first column) has been estimated by multiplying the number of taxa displays (TD) by the total number of individuals seen for each taxon (IS), product that can be seen in the last column. A taxon display equates to an exhibit, so it could be that the same aquarium has more than one entry per taxon. The total list has 779 ranks, but the 100 shown represent 73% of the individuals seen. Due to the common disagreement on which English names correspond to which seahorse scientific name, all taxa have been expressed in English terms except seahorses (genus *Hippocampus*). Planktonic or microscopic invertebrates, including jellyfish and coral polyps, have not been counted.

The taxa with the highest number of individual vertebrates estimated to be kept in the sample of 31 UK public aquaria during spring 2004 can be seen in table 3.

Rank	**Taxa**	**Individuals estimated**	**%**	**accum %**
1	Golden trevally	660	6%	6%
2	Grey mullet	522	4%	10%
3	Bass	378	3%	13%
4	Lesser spotted dogfish	377	3%	16%
5	Yellow tang	277	2%	19%
6	Wimplefish	224	2%	21%
7	Mackerel	270	2%	23%
8	Herring	200	2%	24%
9	Mono	197	2%	26%
10	Blue chromis	177	2%	27%
11	Red bellied piranha	153	1%	29%
12	Thornback ray	140	1%	30%
13	Neon tetra	134	1%	31%
14	Pollack	132	1%	32%
15	Trevally	120	1%	33%
16	Mediterranean anchovies	120	1%	34%
17	Plaice	134	1%	35%
18	Cardinal tetra	116	1%	36%
19	Greater spotted dogfish	111	1%	37%
20	Cichlid	107	1%	38%
21	Ballan wrasse	102	1%	39%
22	*Hippocampus abdominalis*	90	1%	40%
23	Regal tang	85	1%	40%
24	Lumpsucker	87	1%	41%
25	Common clownfish	84	1%	42%
26	Dace	82	1%	43%
27	Foxface	160	1%	43%
28	Pumkinseed	78	1%	44%
29	Blue and green chromis	78	1%	45%
30	Tetra	75	1%	45%
31	Rainbow trout	75	1%	46%
32	Brown trout	70	1%	46%

33	Yellow tailed chromis	70	1%	47%
34	Shanny	74	1%	48%
35	Lake malawi cichlids	67	1%	48%
36	Corckwing wrasse	64	1%	49%
37	3 spined sitckleback	64	1%	49%
38	Sailfin tang	59	1%	50%
39	Bib	60	1%	50%
40	Sand smelt	57	0%	51%
41	*Hippocampus reidi*	86	0%	51%
42	Killifish	54	0%	52%
43	Carp	54	0%	52%
44	Black sea bream	54	0%	53%
45	Rudd	52	0%	53%
46	Humbug damsel	52	0%	54%
47	Goldfish	52	0%	54%
48	Turbot	61	0%	54%
49	Cod	55	0%	55%
50	Smooth tailed trevally	50	0%	55%
51	Red-eared terrapin	50	0%	56%
52	Longfinned tetra	50	0%	56%
53	Gilthead	50	0%	57%
54	Deep snouted pipefish	49	0%	57%
55	Lesser weever	47	0%	57%
56	Brook charr	46	0%	58%
57	Minnow	42	0%	58%
58	Greater pipefish	42	0%	58%
59	Starry smooth hound	41	0%	59%
60	Zebra danio	39	0%	59%
61	Porkfish	128	0%	59%
62	Lookdown	38	0%	60%
63	Cuckoo wrasse	39	0%	60%
64	Batfish	37	0%	60%
65	Goldsinny	44	0%	61%
66	Common carp	35	0%	61%
67	Mimic surgeonfish	34	0%	61%
68	Common bream	35	0%	62%
69	Saroy cichlid	33	0%	62%
70	Rock cook	34	0%	62%
71	Common perch	33	0%	62%
72	Bangaii Cardinalfish	54	0%	63%
73	Tinfoil barb	32	0%	63%
74	Soldierfish	89	0%	63%
75	Scad	32	0%	64%
76	Cuttlefish	32	0%	64%
77	Butterfly goodeid	32	0%	64%
78	Tompot blenny	35	0%	64%
79	Green chromis	121	0%	65%
80	Domino damselfish	31	0%	65%
81	Blacktip reef shark	32	0%	65%
82	Long nosed butterflyfish	27	0%	65%
83	Sandsmelt	26	0%	66%

84	Small eyed ray	25	0%	66%
85	Pacu	24	0%	66%
86	Mirror carp	24	0%	66%
87	Horse eye jack	24	0%	66%
88	Scat	23	0%	67%
89	Sand goby	24	0%	67%
90	Grass carp	23	0%	67%
91	Dragonet	23	0%	67%
92	Tomato clownfish	71	0%	67%
93	Conger eel	27	0%	68%
94	Common eel	25	0%	68%
95	Chub	22	0%	68%
96	Axolotl	22	0%	68%
97	Anthias	22	0%	68%
98	Lionfish	22	0%	69%
99	Dover sole	21	0%	69%
100	Smooth hound	21	0%	69%

Table 3. The 100 taxa with the highest number of individual vertebrates estimated to be kept in UK public aquaria during spring 2004, ordered by rank. The first column shows the rank number (from most common to less common), the second column shows the vertebrates' taxa names, the third column shows the number of individuals vertebrates estimated to be kept in the 31 sample of UK public aquaria, the fourth column the percentage of individuals vertebrates estimated for each taxon respect all the vertebrates estimated for the sample (n= 11,623), and the last column the accumulative percentage of the percentages of the previous column. In this table only the most common taxa of vertebrates seen covering up to 69% of all estimated have been shown. Due to the common disagreement on which English names correspond to which seahorse scientific name, all taxa have been expressed in English terms except seahorses (genus *Hippocampus*)

Number of exhibits in UK pubic aquaria

The average number of live exhibits per UK public aquarium is 26.8 (n=31, STD= 16.29). Separated tanks of what appears to be the same exhibit where considered separate exhibits if they had different species in them. Figure 3 shows the variation in number of exhibits across the public aquaria investigated.

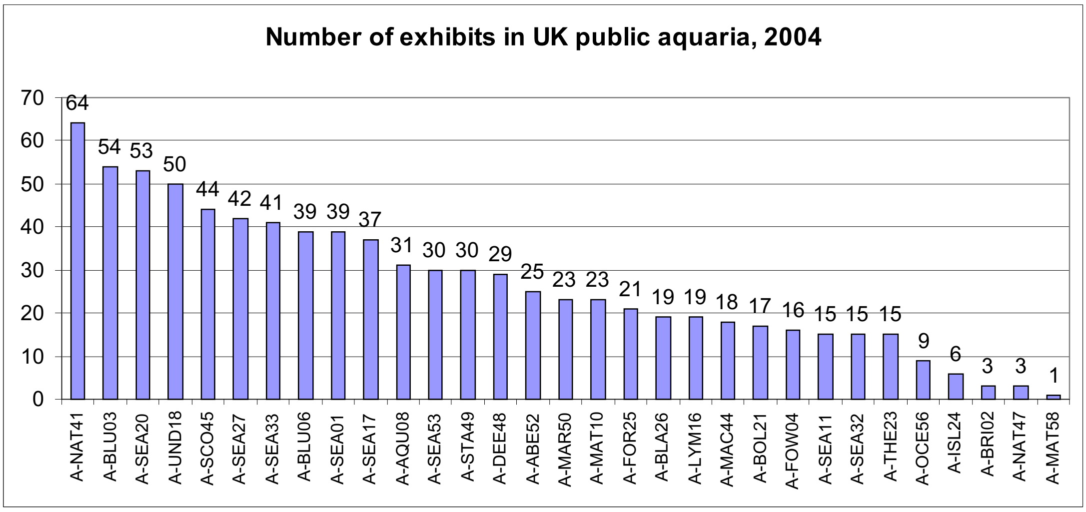

Figure 3. Number of exhibits found in the UK public aquaria investigated during 2004

Table 4 shows the average number of live exhibits per type of public aquarium. As can be seen in figure 3 and table 4 the number of exhibits found per type of public aquarium varies, expectably, according to the type. It is interesting to notice that CHPA have an average of about ten exhibits more than BIPA, despite both types being 'big' public aquaria.

	Average. num. exhibits	**STD**	**N**
CHPA	40.5	7.79	11
BIPA	29.4	14.98	5
SIPA	16.2	7.61	9
APA	11.5	8.38	6

Table 4. Average number of exhibits found in UK public aquaria. N= number in the sample, STD= Standard deviation

Biomes of taxa kept in UK public aquaria

Although the definition of public aquarium used in this study always implies aquatic animals, there are several types of aquatic habitats, and in consequence the husbandry techniques necessary to attempt reproducing them in captivity may vary considerably depending on the type.

Environmentally speaking, aquatic animals can live in three different biomes: freshwater, marine/sea water, and blackish water (which is an intermediate between fresh and marine water, mainly found in estuaries and mangrove areas). In this study, when animals kept in UK public aquaria naturally live in any other biome besides the three mentioned above, its biome was classed as 'terrestrial'.

Figure 4 shows the relative frequency of the different types of biomes of the animals kept in UK public aquaria (calculated from estimated specimens). It clearly shows that UK public aquaria keep mainly marine species. There are aquaria specialised only in freshwater animals, but only represent 19% of the public aquaria, and there are 13% of public aquaria that solely keeps marine taxa.

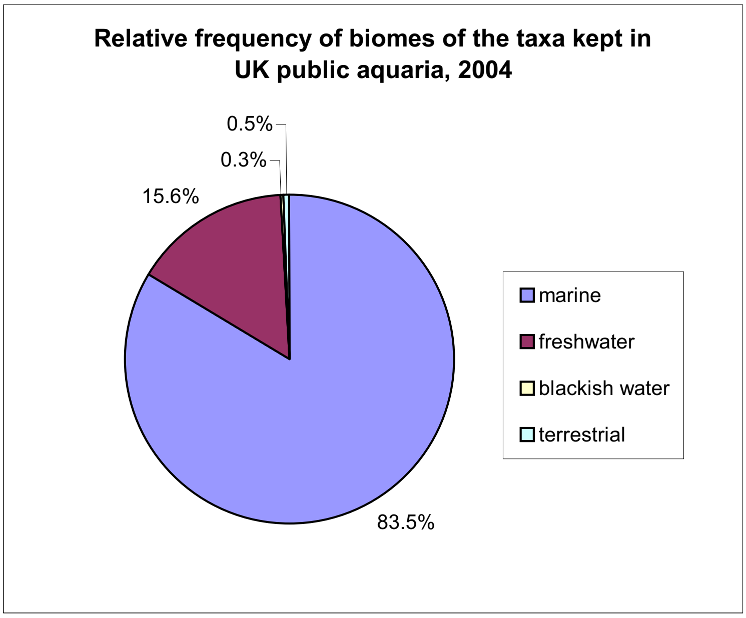

Figure 4. Relative frequency of biomes where taxa kept in UK public aquaria in 2004 naturally live. N=16,283

Exotic versus local taxa kept in UK public aquaria

The concept of 'exotic animal' has traditionally been associated with zoos. In the case of public aquaria, however, the presence of only local species would not be considered as 'odd' as a zoo that only keeps local wildlife, perhaps because most people would consider the sea as exotic enough. There are nevertheless significant different implications when an animal is placed in captivity in the same area where it normally lives (and therefore with similar climate, circadian rhythms and possibly even part of its diet) or when it is far away from it, specially latitudinally speaking (such as tropical animals in temperate zoological collections). In the case of public aquaria, due to the fact that water tanks present quite a different environment from local seas, rivers or lakes, as far as environment adaptation to captivity is concerned the differences between exotic and local animals may not be as pronounced as in terrestrial animals. However, in terms of acquisition of specimens (i.e. use of dealers, or long distance travelling) or conservation issues (i.e. fish 'escaping' into the wild, or collection of exotic specimens from tropical decimated populations) the differences between the implications of keeping a local or exotic stock may be considerable.

In this study the term 'exotic' has been used as synonymous of 'not native of the British Isles or surrounding seas'. *The Species Directory of the Marine Fauna and Flora of the British Isles and Surrounding Seas* (Howson & Picton, 1997) published by the Marine Conservation Society was the main source to identify marine taxa as local or exotic, while other sources were used in the case of freshwater fish and aquatic invertebrates (Miller & Loates, 1997; Wheeler, 1992; Dipper & Powell, 1984).

Figure 5 shows that in 2004 the UK public aquarium industry kept almost as many exotic individual animals as local ones (an 18% majority for 'locals'), although more public aquaria specialised in local taxa than exotics (45% of public aquaria specialised in local fauna, 23% specialised in exotic fauna, and 32% not really specialised in either; n=31). These values would differ considerably with the ones we would expect to find in traditional zoos.

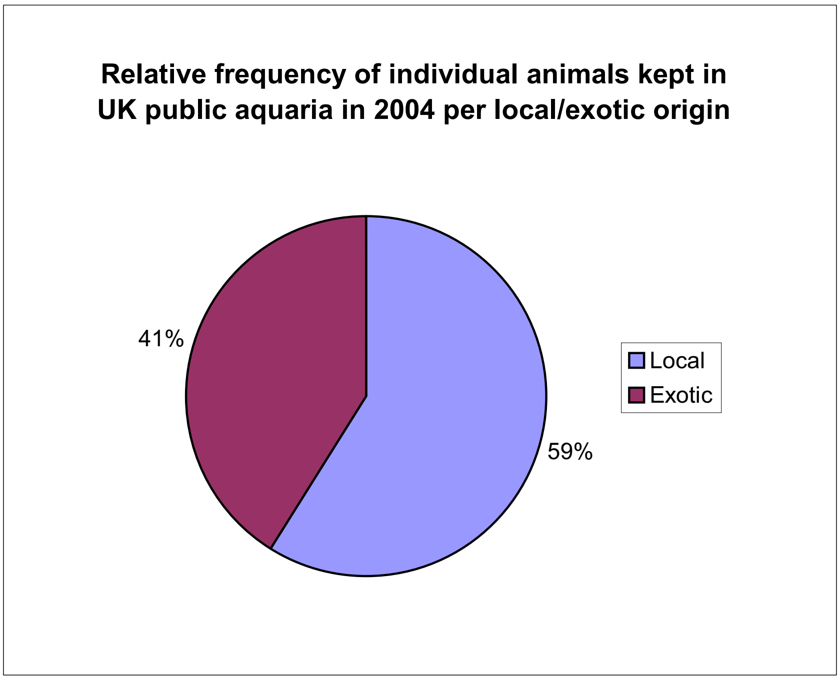

Figure 5. Relative frequency of individual animals kept in UK public aquaria in 2004 per local or exotic origin. The results have been calculated from the number of taxa estimated to be present (N=16,283)

Trend in the taxa kept in UK public aquaria over the years

It is possible to make some comparisons between the UK public aquaria today and the UK public aquaria of recent past. Between the years 2000 and 2002 the investigator also visited many UK zoological collections for other reasons. Some of these visits were also based on a computerised random sampling, and on many occasions public aquaria were visited. In fact, during the period mentioned, annual random visits to zoological collections produced visits to 37 public aquaria during the two-year period. Because of the similarities between sample size (37 in 2000-2002 and 31 in 2004), the fact that the population of UK public aquaria is very similar, and both visits were random and independent, some information obtained during those past visits can be compared with information from this study. In particular, since during both types of visits all signs were recorded, and in consequence an estimation of the taxa displayed can be made, it is possible to see whether during the two years that have passed there has been any substantial change on the types of animals public aquaria display.

Because during the 2000-2002 period only taxa signs were recorded (as opposed to taxa seen, which would include taxa that had no signs), only taxa with signs for 2004 was used in the comparison. Both lists of taxa were ordered in a rank by the number of occurrences found in the lists (which roughly equates to number of displays where the taxa were supposed to be). As a result, 70% of the 10 most commonly displayed taxa in UK public aquaria were the same comparing the 2000-2002 period with 2004, 55% of the 20 most common were the same, and 42% of the 30 most common were the same. There is, then, a somewhat significant difference because already more than half of the 30 most common taxa have changed in just two years.

Table 5 shows the top 100 ranks of most commonly displayed taxa in UK public aquaria during the 2000-2002 period, and in 2004.

rank	Taxa (signs) 2004	Occurrence	Taxa (signs) 2000-2002	Occurrence
1	Lesser spotted dogfish	45	Beadlet anemone	49
2	Common lobster	35	Grey mullet	38
3	Grey mullet	29	Bass	37
4	Bass	27	Ballan wrasse	34
5	Beadlet anemone	26	Common lobster	34
6	Plaice	22	Common starfish	34
7	Thornback ray	22	Greater spotted dogfish	34
8	Greater spotted dogfish	19	Lesser spotted dogfish	32
9	Shanny	19	Plaice	31
10	Common sea urchin	17	Hermit crab	29
11	Conger eel	17	Thornback ray	26
12	Sea scorpion	17	Conger eel	25
13	Goldsinny	16	Shore crab	22
14	*Hippocampus.abdominalis*	16	Turbot	22
15	Pulmose anemone	16	Pollack	21
16	Common clownfish	15	Tub gurnard	20
17	Snakelocks anemone	15	Edible Crab	19
18	Cod	14	Snakelocks anemone	19
19	Corkwing wrasse	14	Dahlia anemone	18
20	Starry smooth hound	14	Shanny	18
21	Cuckoo wrasse	13	Black sea bream	16
22	*Hippocampus reidi*	12	Cuckoo wrasse	16
23	Bib	11	Greater pipefish	16
24	Regal tang	11	Plumose anemone	16
25	Tompot blenny	11	Starry smooth hound	16
26	Velvet swimming crab	11	Brill	15

27	Common sunstar	10	Cod	15
28	Cuttlefish	10	Smooth hound	15
29	Lumpsucker	10	Spiny spider crab	15
30	3 bearded rockling	9	Blonde ray	14
31	Black sea bream	9	Common prawn	14
32	Blonde ray	9	Corkwing wrasse	14
33	Grey triggerfish	9	Gilthead	14
34	Smooth hound	9	Tompot blenny	14
35	Snake pipefish	9	Whiting	14
36	Wolf fish	9	Bib	13
37	Yellow tang	9	Common mussel	13
38	3-spined sitckleback	8	Sea scorpion	13
39	Cushion starfish	8	Undulate ray	13
40	Greater pipefish	8	3-spined stickleback	12
41	Spiny spider crab	8	Butterfish	12
42	Spiny starfish	8	Clownfish	12
43	Brill	7	Common seal	12
44	Butterfish	7	Crawfish	12
45	Dead man's fingers	7	Dab	12
46	Deep snouted pipefish	7	Goldsinny	12
47	Green sea urchin	7	Small-eyed ray	12
48	Horseshoe crab	7	Spotted ray	12
49	Lesser weever	7	3-bearded rockling	11
50	Lionfish	7	Common sea urchin	11
51	Mackerel	7	Flounder	11
52	Common eel	6	Stingray	11
53	Crawfish	6	Big bellied seahorse	10
54	Long horn cowfish	6	Perch	10
55	Long spined sea urchin	6	Ray	10
56	Norway lobster	6	Velvet swimming crab	10
57	Saithe	6	Wolf fish	10
58	Spotted ray	6	Cuttlefish	10
59	Stingray	6	Carp	9
60	15-spined stickleback	5	Lumpsucker	9
61	Axolotl	5	Spiny starfish	9
62	Bangaii Cardinalfish	5	Cleaner wrasse	8
63	Common goby	5	Common octopus	8
64	Dover sole	5	Red bellied piranha	8
65	Eelpout	5	Spider crab	8
66	Emperor angelfish	5	Triggerfish	8
67	*Hippocampus erectus*	5	Brittlestar	7
68	*Hippocampus guttulatus*	5	Common sunstar	7
69	Lesser octopus	5	Dragonet	7
70	Moon jellyfish	5	Lionfish	7
71	Red tailed catfish	5	Mackerel	7
72	Rock cook	5	Tope	7
73	Sea cucumber	5	Tropical wrasse	7
74	Wimplefish	5	Brown trout	6
75	5-bearded rockling	4	Grey gurnard	6
76	Blacktip reef shark	4	Ling	6

77	Blue stripped squat lobster	4	Pike	6
78	Cleaner wrasse	4	Saithe	6
79	Common octopus	4	Snake pipefish	6
80	Dragonet	4	Topknot	6
81	Feather star	4	Yellow tang	6
82	Golden trevally	4	Axolotyl	5
83	Green chromis	4	Blenny	5
84	H.barbouri	4	Cleaner shrimp	5
85	H.kuda	4	Common goby	5
86	H.whitei	4	Copper banned butterflyfish	5
87	Nurse shark	4	Eelpout	5
88	Porcupine pufferfish	4	Green sea urchin	5
89	Queen scallop	4	Lesser octopus	5
90	Rainbow trout	4	Lesser weever	5
91	Red hairy hermit crab	4	Moray eel	5
92	Sailfin tang	4	Pipefish	5
93	Zebra shark	4	Pufferfish	5
94	Asiatic short clawed otter	4	Queen scallop	5
95	Achilles tang	3	Roach	5
96	Archerfish	3	Rock cook	5
97	Barbel	3	Rudd	5
98	Bearded dragon	3	Sea cucumber	5
99	Blue chromis	3	Slender seahorse	5
100	Blue mouth	3	Sucker mouthed catfish	5

Table 5. The 100 most commonly displayed taxa kept in UK public aquaria during the period 2000-2002 (column two and three) and spring 2004 (column four and five). Their rank (first column) has been estimated by counting the number of taxa found to be displayed in exhibit signs. A taxon display, then, roughly equates to an exhibit, so it could be that the same aquarium has more than one entry per taxon. Due to the common disagreement on which English names correspond to which seahorse scientific name, all taxa have been expressed in English terms except seahorses (genus *Hippocampus*).

It is possible that taxa in public aquaria changes all the time, so no trend can be deduced from the two sets of data. However, due to the fact that changing taxa often implies changing the display itself (which may be costly), and that taxa that does better in captivity should be the obvious choice for any aquarium, in just two years you would not expect too much change. A more detailed analysis of the lists, though, shows a possible explanation for the results, because a change towards a particular direction that could justify the hypothesis of a trend was identified.

If we compared both periods regarding the existence of exotic taxa (taxa not normally found in UK territory/waters) in the top ranks of occurrence, we can see that in 2000-2002 only 10% of the first 100 most common taxa displayed in UK public aquaria were exotic taxa, whilst in 2004 the value has tripled to 33%. Indeed, the first exotic in the rank list for 2000-2002 appears in the rank number 63 (tropical cleaner wrasse), while in 2004 is already in the rank number 14 (Pot bellied seahorse). Although an exact quantification of this difference is difficult to be obtained due to the slight differences between the methods used, it can be said that there is some evidence that suggests that in the last few years the UK public aquarium industry appears to have been displaying more exotic taxa.

The fact that precisely between the two periods compared the Sealife Centre chain, almost monopolising the big aquaria sector in 2000, sold many of its centres to either other chains or to individual public aquaria (which might have changed the displayed animals after the transfer), can explain why a radical change in the taxa composition of the UK public aquarium industry may have occurred in such a short period of time.

ANIMAL WELFARE IN UK PUBLIC AQUARIA

ABNORMAL BEHAVIOUR

In captivity, animals frequently exhibit behaviours which may be described as abnormal because they are not known to be a feature of the natural/wild behavioural repertoire of the species, or because they appear inappropriate in time or frequency of performance (Dantzel, 1986). The causes of such behaviours may vary considerably, from stress due to their housing conditions –or the nature of captivity itself– to a physical disease such as infections.

Despite the fact that anglers, fishermen and other groups whose livelihood/hobby depends on the exploitation of fish tend to dispute these facts, a wealth of scientific research suggests that fish suffer both stress and pain, confirming what has been suspected by observant aquarists for decades (Bailey & Burges, 1999).

Evidence that the term pain is applicable to fish comes from anatomical, physiological and behavioural studies whose results are very similar to those of studies on birds and mammals (Anonymous, 1996; Sneddon, 2003; Sneddon et al. 2003).

There are also many studies addressing the issue of stress in fish (Barton, 1997; Bathesda, 1998; Pickering, 1981; Shreck et al, 1997). Practices such as handling, transport and poor water quality impose stress on fish, which affects individual fish and fish populations at all levels of organisation raging from biological perturbations to changes in community structure (Barton, 1997). Overcrowding or being kept with the wrong species or individuals may be another stressor. There are publications with in depth chapters on disorders associated with general 'stress factors' in fish, which correspond fairly closely with those that affect mammals (McGregor and West, 2000).

Stressed or ill fish can manifest their health problems in many ways, but changes in their normal behaviour tend to be the first sign that something is not quite right. The following is a list of some of the common behavioural patterns displayed by stressed or diseased fish in aquaria (based on Anonymous, 2003c and Shreck et al, 1997).

Aggression
Fish showing repetitive hostile or violent behaviour towards another individual/s, expressed either by 'chasing' (rapid movement of one fish in close pursuit of another) or fin-nipping (which can be detected by damage of the fins of other fish). Some territorial fish or breeding fish may show this aggression naturally, but its intensity and frequency may be modified (increased or reduced) if the fish is stressed or ill.

Abnormal predator avoidance
A reduction of the reaction and escape distances from predators.

Abnormal feeding
Overfeeding or underfeeding, the latter being more common as a consequence of physical disease.

Shelter seeking
Seeking shelter more often than usual.

Bottom-sitting
In the case of non-sedentary species or normally active species, staying put at the bottom of the aquarium for unusually long periods of times.

Colour change
Changes of body colour that do not match the expected changes due to maturity, courtship or reproduction. This may involve a fish becoming pale or decreased intensity of the entire body.

Drifting
Aimless, un-propelled motion through the water.

Head-standing
Fish assuming a vertical position in the water with its head down.

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Hovering
Fish swimming staying relatively in one place in the aquarium, for species where this behaviour is atypical.

Piping
Gulping of air at the surface of the water for species where this behaviour is atypical.

Tail-walking
Fish swimming assuming an oblique position with the head directed toward the surface.

Stereotypic behaviour
Morphologically similar patterns or sequences of behaviour, performed repetitively, and having no obvious function. See chapter below.

The causes of these behaviours may vary, but some of them are symptoms of specific diseases in specific species. For example, 'Head-standing' is common in catfish infected with *Edwardsiella tarda*, 'Tail-walking' is very characteristic in tetras infected with the microsporidian *Pleistiphora,* and 'Piping' is indicative of severe hypoxia except for air breathers such as lungfish, some eels and some sharks (Anonymous, 2003c).

Most of these behaviours, however, are difficult to assess in the context of an investigation based on a quick glimpse of the individual fish through a single visit to a public aquarium. It is difficult to recognise a change in colour of a fish if one has not seen its usual colour, or it is difficult to identify a case of bottom-sitting without knowing the activity pattern of that particular individual in that particular aquarium. Also, some fish may dislodge equipment such as heaters and filter pipes, sometimes pulling them free from their holdings which may be part of site clearance prior to breeding but may also be due to boredom (Bailey & Burges, 1999). However, it would not be possible for an investigator to detect those cases without knowing the original configuration of the aquarium features, or the breeding status of the animals involved. Most of these behaviours may be quite subtle, and only the accustomed eye of the aquarium keeper can detect them.

Moreover, fish showing such behaviours, because they may be infected with diseases that may spread among the tank population, are normally taken out of the tank as soon as the behaviour is detected (often in the morning before the aquarium is open to the public) and kept in separate tanks out of the public view for treatment.

There is, however, one exception to all this. Stereotypic behaviour, although sometimes seen as a response to a physical disease, tends to be the expression of stress or neurological dysfunction. These are not normally life threatening, are not 'infectious' to other fish, and removing the affected fish placing it in isolation in the quarantine section of the aquarium would normally make the problem worse. For these reasons stereotypic animals are not normally removed from public display. Also, contrary to the other types of abnormal behaviour, stereotypies are relatively easy to identify, even to an observer that only has seen the fish for a few minutes and has no knowledge of its history. These factors make stereotypies a good indicator of welfare problems for a study such as this, and this is why it was especially observed and analysed.

Stereotypic behaviour, also known as 'stereotypy', is one of the most important indicators of long-term welfare problems. Odberg (1978) defines stereotypy as "morphologically similar patterns or sequences of behaviour, performed repetitively, and having no obvious function". The most well known examples are the pacing to and fro of caged zoo animals, or the rocking or head bobbing of captive animals like primates or elephants. These behaviours are not only observed in non-human animals, but in people as well, like prisoners or children with autism or other psychiatric disorders (Levy, 1944. Hutt and Hutt, 1970). In fact, the range of species in which such behaviours have been described is quite wide, and covers both captive wild and domestic animals (Brion,1964; Fraser,1975; Odberg ,1978; Broom,1981,1983; Dantzer,1986; Fraser & Broom,1990; and Mason, 1991a).

One of the key elements to be able to identify a stereotypy is to determine whether or not a behaviour has a function, but this is usually quite easy because whilst a single movement may be part of a normal functional system, frequent repetitions of movements are necessary only for certain limited purposes, like locomotion to a particular place, repeated feeding, respiration, cleaning or repeated display movements. A brief period of observation is usually sufficient to distinguish stereotypies from such movements (Broom & Johnson, 2000).

However, it is true that in some cases distinguishing between stereotypies and other forms of behaviour can be problematic (Mason, 1991b), and for this reason it is always important to observe the animal and define with precision the criteria that has been used. As discussed by Dantzer (1986) and Mason (1991a), in most cases we do not know whether a stereotypy is helping the individual to cope with its life conditions, has helped in the past but is no longer doing so, or has never helped and has always been a behavioural pathology. But in all cases the stereotypy indicates that the individual has some difficulty in coping with its conditions or situation and is an indicator of poor welfare (Broom, 1991;Broom & Johnson, 1993, 2000).

A recent study (Mason & Latham, 2004) has concluded that preventing an animal from performing stereotypies by simply making a few husbandry changes that make it more difficult for the animal to show such behaviour (as opposed to changing the captive conditions that generated the behaviour in the first place) does not necessarily constitute an animal welfare improvement. As stated in the UFAW press statement (which funded such study) this research suggests that "abnormal behaviour in captive animals is bad, but physically preventing it is even worse".

Some mild cases of stereotypy might only be in their initial stages of development, as with some forms of displacement or vacuum behaviour, while others might be well stabilised and could even be considered as signs of severe neurosis. Some stereotypes can also constitute behavioural scars that stay with the animal even if the housing conditions that caused them have changed. In this investigation it was considered that, as long as the animals performing stereotypy remain in captivity and under unnatural circumstances, it is impossible to rule out the possibility that their present captive conditions, however improved, contribute in one way or another to the maintaining of such stereotypy.

Compared with other vertebrates there are very few studies of stereotypic behaviour in fish, although this does not necessarily mean that the behaviour is less common. There have been some descriptions of fish stereotypic behaviour associated with particular diseases (like enteric septicemia in catfish, Ruth Francis-Floyd ,1996), or to development (like in Zebrafish, Saint Amant & Drapeau, 1998), but it is quite possible that the relationship between such behaviours and captivity is fundamentally the same in all vertebrates, despite some authors may only accept stereotypies in mammals or birds. An investigation on Scottish pet shops in 2003 found that fish stereotypic behaviour was observed in 50% of the shops that sell fish (Casamitjana, 2003), and an earlier survey of UK zoological collections that included aquaria also observed stereotypic behaviour in public aquarium fish (Casamitjana & Turner, 2001).

Despite the fact that an individual's or population's degree of stereotypy does not necessarily correspond to the degree to which its welfare is impaired (Mason, 1991a), measuring the occurrence of stereotypy, regardless of whether this is just a displacement or vacuum behaviour or a severe neurological dysfunction, is a good indication of the existence of welfare problems, even if the degree of these problems cannot be measured, or the genesis of the behaviour investigated cannot be determined.

The only common quantifiable behavioural aspect of all stereotypes using Odberg's definition is the concept of repetition. Authors differ as to just how rigid or repetitive a behaviour pattern has to be before they will call it a stereotypy (Forrester, 1980; Broom, 1983; Fraser and Broom, 1990), but some studies using informational redundancy to quantify the repetition within behavioural sequences (Stolba et al. 1983) concluded that repetitions of three or more times in a 30 seconds assessment period agreed with the results of information-redundancy analysis. Other work on stereotypy in mink also used three successive repetitions of a movement or sequence of movements as a criteria to identity stereotypies (Mason, 1994).

In this investigation the criteria of 'at least three repetitions in half a minute' to categorise a behaviour as possibly stereotypic was also used. However, that was only the criteria used to identify a 'possible' case of stereotypy that would require further observation before confirmation. Therefore, if during the aquarium visit an animal was seen performing any sort of repetitive behaviour with no apparent function at least three times in a row, the animal was identified as 'possible stereotypic animal', and its behaviour was then video recorded for a sufficient period of time to allow confirmation of stereotypy –which often implied returning to the exhibit several times during the visit.

Once all possible cases of stereotypic behaviour were recorded, they were classified in the following categories:

∉ **Pacing:** Continuous walking/swimming to and fro, following the same path (or several similar paths), from one point of the exhibit to another, when performed with no apparent special response to a transparent boundary (i.e. glass). See figure 6.

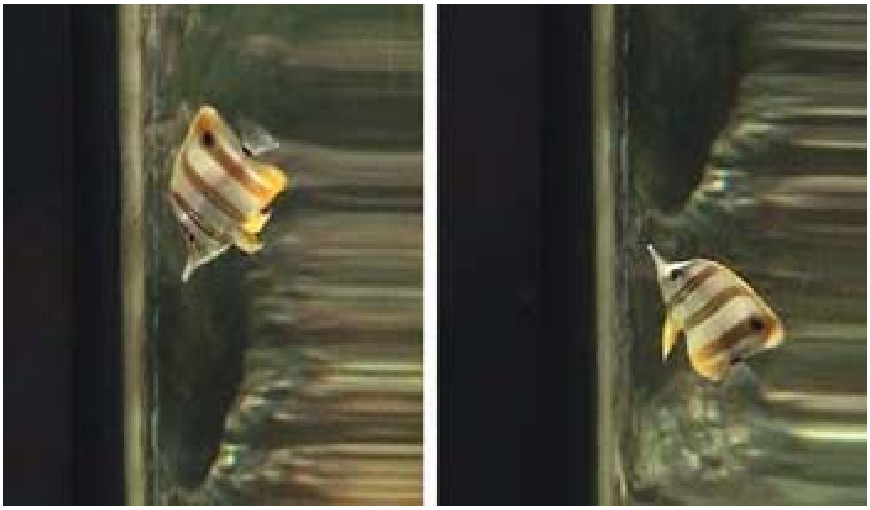

Figure 6. Butterflyfish pacing in a UK public aquarium

∉ **Circling:** A form of pacing where the animal continues around a circular path with no points easily singled out of where it ends or begins. See figure 7.

∉ **Head bobbing & swinging:** Staying stationary in one place and continuously moving the head up and down, or swinging it left and right, when performed with no apparent special response to a transparent boundary (i.e. glass).

Figure 7. Regal tang circling in a UK public aquarium exhibit featuring examples of the characters of the film ‘Finding Nemo’.

- **Interaction with Transparent Boundaries (ITB)**: Continuously walking/swimming onto the glass or reflecting walls of an enclosure either attempting to climb on them, go through them, or responding to a reflection from them. See figure 8.

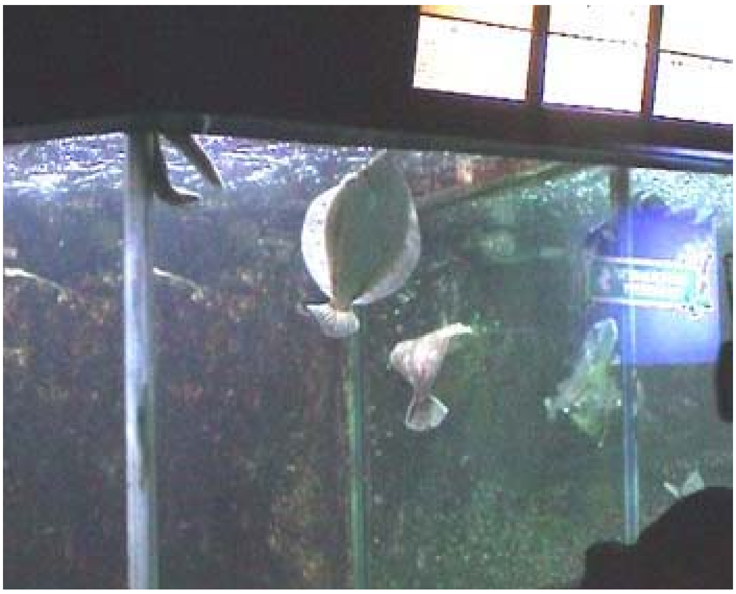

Figure 8. Several plaice performing ITB behaviour (see text) in a UK public aquarium.

- **Surface Breaking Behaviour (SBB)**: Whilst swimming repeatedly lifting the front of the body so that the snout or front of the head is raised above the level of the water, when performed with no apparent special response to a transparent boundary (i.e. glass). See figure 9.

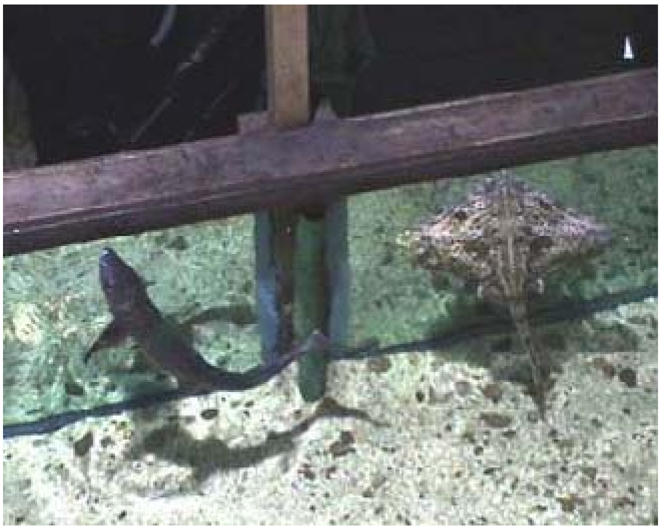

Figure 9. A smooth hound and a thornback ray performing 'surface breaking behaviour ' behaviour in a UK public aquarium

∉ **Spiralling**: continuously spinning through the water either around a central point or around an imaginary axis moving in a spiral course. See figure 10.

Figure 10. Ray performing 'spiralling' behaviour in a UK public aquarium

∉ **Stereotypic flashing:** Repeatedly turning on one side and rubbing one flank on the substrate or on any other surface. See figure 11.

Figure 11. Coris wrasse flashing in one UK public aquarium

These categories have been defined based on previous similar research undertaken by the author (Casamitjana & Turner, 2001; Casamitjana, 2003) but also on other studies where these types have been identified in both terrestrial and aquatic animals. For example, the 'stereotypic circling' has been described in research of zoo seals (Hoden, 2003), 'ITB' has been normally described in captive reptiles (Warwick, 1990; Warwick et al.1995), 'SBB' has been studied in rays displayed in public aquaria (Scott et al. 1999a, 199b), 'head bobbing' is one of the stereotypic behaviours commonly found in elephants (Clubb & Mason, 2002), 'pacing' is probably the most common stereotypy in zoo carnivores (Clubb and Mason, 2003), 'spiralling' has been described in ill catfish (Ruth Francis-Floyd ,1996) and flashing, although not normally described as stereotypy, is a well know phenomenon, especially in sea bass (Pickett, & Pawson, 1994). On a very few occasions rare cases of stereotypic behaviour that could not be falling ubder any definition of any known type of stereotypy were found (they will be discussed below). These cases were included in this study because of their consistency with the definition of stereotypic behaviour.

Occurrence of stereotypy in UK public aquaria

Table 6 shows that stereotypic behaviour is not absent in modern UK public aquaria. On the contrary, the study shows that at least 90% of the UK public aquaria (n=31) keep animals that show this abnormal behaviour. If we do not count 'flashing' as stereotypy, the percentage remains 90%. More than one third (39%) of the UK public aquaria showed more than 10 cases, and 16% showed more than 20 cases. Hundreds (at least 320, without counting 'flashing' 264) of individual animals showing stereotypic behaviour were identified.

All these values only represent the minimum occurrence, since the method used could easily miss cases not detected because the fish was not performing stereotypic behaviour when seen initially. It is important to point out that although once a possible stereotypic animal was detected it was recorded on several occasions during the visit to confirm the stereotypy, if on first seeing an animal it was not showing such behaviour, the investigator promptly moved to the next individual or exhibit, which would effectively make him miss the behaviour if it was performed later on. Also, many aquarium species are active during the night, or are hidden from the general public in either shelters or in sections of the aquarium away from the viewing windows. Also, as mentioned above, stereotypy is only one type of abnormal behaviour. This reinforces further still the notion that the occurrence of abnormal behaviour found is only the minimum observed, and it is very likely that there are more cases than the ones detected.

It is possible to estimate roughly the minimum percentage of animals in UK public aquaria that show stereotypic behaviour. As seen in table 6, from the 13,530 fish and aquatic invertebrates that were seen in this study (with the exception of micro and planktonic fauna), 320 were showing this abnormal behaviour, which represents a percentage of about 2.3% (1.9% without counting 'flashing'). Incidentally, this percentage is about the same found for all UK zoological collections with a similar study undertaken in the year 2000 (Casamitjana & Turner, 2001), which is not surprising if we consider 'captivity' as the main cause of the behaviour.

We have to consider, though, that to determine whether or not an animal was a possible stereotypic case in need of further observation each individual was only initially observed for a very short period of time, and therefore we know that the 2% is a gross underestimation of the real value. Only individuals that had been observed for most of their active hours, and no abnormal behaviour would have been detected during that time, could confidently be classed as 'non-stereotypic'. However, the average time used to decide that an animal not showing abnormal behaviour was not stereotypic was 30 seconds, and nevertheless 320 cases were found. This means that had each fish been observed for half of its active time (perhaps an average of 6 hours per fish) almost certainly a value many more times higher than 2 % would have been found. Wiepkema (1983) suggested that if stereotypies occur in more than 5% of a population, its animal welfare status should be considered 'unacceptable'. We have found 2% with a strong probability that the real number is many times this value, and therefore it is perfectly possible that Wiepkema would have considered that the animal welfare status in UK public aquaria is 'unacceptable'.

To put this value into perspective, it could be useful to compare it with other values in which the concept of 'welfare' –although not in relation to animals– is also used. The Official British National Statistics shows that for the year 2000 the prevalence of psychotic disorder in the general British population was about 0.5%. If the performance of stereotypic behaviour is taken as an indicator of psychological distress (as is often done in the case of humans) and some hypothetical psychiatry doctors, after having been asked to evaluate the British population as a whole, had already found four times more cases than in 2000 by just having a few minutes talk with a sample of people, that certainly would be a matter of concern for those who consider psychological well-being as a paradigm of civilisation.

There is another way with which further assessment can be made. As can be seen in table 6, if we try to calculate the percentage of occurrence of abnormal behaviour per public aquarium, we can see that 16% of the aquaria show a percentage of animals showing abnormal behaviour higher than 5% (with two cases 8%), about half higher than 2%, and about a fifth less than 1%. Even for those who may consider 2.3% as not such a high value (disregarding the fact that the method used underestimates the actual occurrence) it would be difficult not to recognise that around 20% of the public aquaria approaching or crossing the 5% 'benchmark is certainly a cause of concern.

type	CODE	Individuals	cases AB	%
BIPA	A-STA49	411	33	8.0%
SIPA	A-OCE56	75	6	8.0%
APA	A-BRI02	17	1	5.9%
SIPA	A-MAR50	98	5	5.1%
CHPA	A-SEA33	551	28	5.1%
SIPA	A-MAT10	193	9	4.7%
APA	A-FOR25	134	6	4.5%
SIPA	A-SEA32	90	4	4.4%
CHPA	A-SEA53	326	13	4.0%
CHPA	A-SEA27	884	33	3.7%
BIPA	A-SEA20	631	23	3.6%
CHPA	A-SCO45	399	13	3.3%
SIPA	A-FOW04	256	8	3.1%
CHPA	A-SEA01	719	21	2.9%
APA	A-NAT47	40	1	2.5%
CHPA	A-DEE48	768	16	2.1%
BIPA	A-MAC44	602	12	2.0%
APA	A-ISL24	55	1	1.8%
CHPA	A-NAT41	855	14	1.6%
CHPA	A-BLU03	1193	18	1.5%
CHPA	A-SEA17	474	7	1.5%
BIPA	A-THE23	679	9	1.3%
BIPA	A-AQU08	456	6	1.3%
CHPA	A-UND18	1233	16	1.3%
APA	A-BLA26	491	6	1.2%
CHPA	A-BLU06	1398	9	0.6%
SIPA	A-ABE52	210	1	0.5%
SIPA	A-LYM16	210	1	0.5%

Table 6. Cases of animals showing abnormal behaviour (in particular stereotypic behaviour) in UK public aquaria during 2004, per public aquarium. The first column shows the type of public aquarium, the second column shows the code of each aquarium, the third column shows the number of individual animals seen in each particular public aquarium, the fourth column shows the number of individual animals seen performing such behaviours, and the last column the percentage of individual animals showing such behaviours respect the individual animals seen. AB= abnormal behaviour, CHPA= Chain Public Aquarium, BIPA= Big Independent Aquarium, SIPA= Small Independent Public Aquarium, APA= Auxilliary Aquarium

However, because not all the animals in aquaria have the same percentage of stereotypy detectable in relation to time, and there is no basis for considering Wiepkema's 5% as the only acceptable cut-off value to judge the welfare status of a population, the only conclusion that can be deduced with absolute certainty with the results of this study about the UK public aquaria population as a whole is that the occurrence of abnormal behaviour in UK public aquaria is by no means negligible, and it could well be very high.

Stereotypic animals per type of public aquarium

Regarding types of public aquaria showing cases of abnormal behaviour, table 7 shows that the majority of each type show animals performing it. The highest percentages for the big aquaria can be explained by the fact this type of aquarium holds more animals than the others, and therefore there is a higher chance to observe individuals showing abnormal behaviour when visited.

	PA with AB cases	PA sampled	%
Chain PA	11	11	100%
Big Independent PA	5	5	100%
Auxiliary PA	5	6	83%
Small Independent PA	7	9	78%

Table 7. Number of UK public aquaria keeping animals showing abnormal behaviour (in particular stereotypic behaviour) during 2004. The second column shows the number of public aquaria showing cases of abnormal behaviour, the third column shows the number of public aquaria per type, and the fourth column shows the percentage of public aquaria keeping animals showing abnormal behaviour with respect to the number of public aquaria sampled of each kind. PA= Public Aquaria, AB= abnormal behaviour.

Another more precise way to assess if there is any difference between types of aquaria in respect of the occurrence of abnormal behaviour is to calculate the percentage of occurrence per number of animals seen in each type. Table 8 shows that although there are small differences that suggest that independent aquaria have relatively more cases than the other two types, these differences are not significant.

	AB cases	individuals seen	%
Chain PA	188	8687	1.9%
Big Independent PA	83	2792	3.0%
Small Independent PA	34	1213	2.8%
Auxiliary PA	15	978	1.5%
TOTAL	320	13670	2.2%

Table 8. Cases of animals showing abnormal behaviour (in particular stereotypic behaviour) in UK public aquaria during 2004, per type of public aquarium. The second column shows the number of individual animals seen showing such behaviours, the third column shows the total number of individual animals seen in each type of public aquarium, and the fourth column shows the percentage of individual animals seen showing abnormal behaviour with respect to the total number of individual animals seen in each type of public aquarium. AB= abnormal behaviour. Microscopic or semi-microscopic invertebrates, like jellyfish , coral polyps and small crustaceans have not been included as individuals seen.

Table 6 also shows that all types of public aquaria are found among the worst performing public aquaria in terms of occurrence of animals showing stereotypic behaviour.

Types of stereotypic behaviour in UK public aquaria

Figure 12 shows the relative frequency of types of stereotypic behaviours that can be seen in UK public aquaria. The types described only correspond to the types witnessed during the visits to the selected aquaria, and therefore it is likely that more types are present in other individuals of other collections.

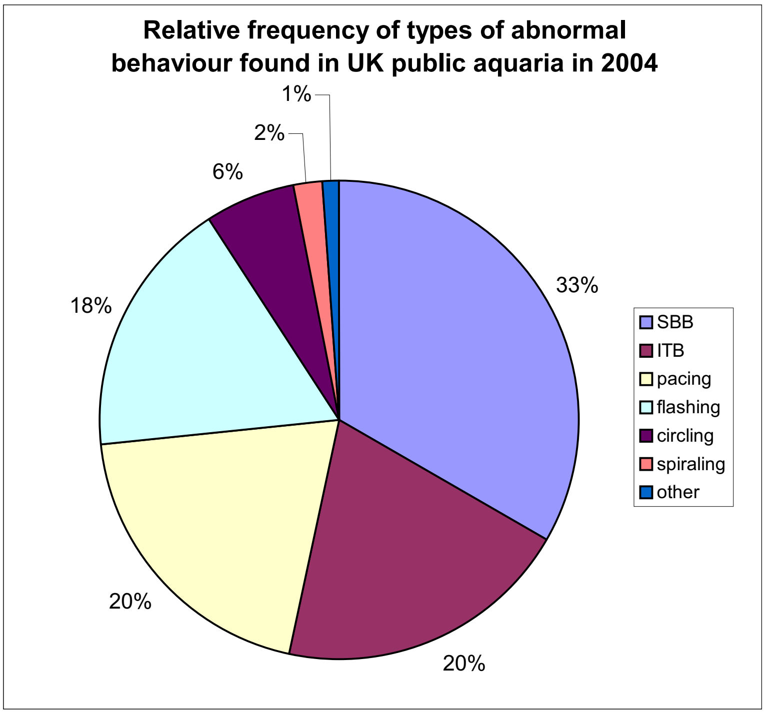

Figure 12. Relative frequency of types of abnormal behaviour (in particular stereotypic behaviour) found in UK public aquaria during 2004. SBB= Surface Breaking Behaviour, ITB= Interaction with Transparent Boundaries. N=320.

In 16% of the UK public aquaria 'spiralling', arguably one of the most severe forms of stereotypic behaviour in fish, was observed. "Surface Breaking Behaviour" was observed in almost three-quarters of the UK public aquaria, and it is the most common abnormal behaviour, mainly seen in rays and sharks.

The category 'other' in figure 12 (which only represents less than 1% and therefore would not affect the conclusions had any of its cases been contested) include 'handling' (an otter repeatedly handled small stones and rubbed them against objects; this behaviour had been observed for years in this particular individual, and the context and frequency of its appearance is consistent with a stereotypy), 'head bobbing' found on two occasions in clownish (clownfish have a particular way of swimming in which sometimes it appears that their head is moving up and down, but the two cases in which this was considered stereotypy were cases when this particular motion was exaggerated and repeated very frequently while the fish remained particularly stationary; although these cases are open to interpretation, their addition in the study has not affected any of the conclusions), and a unique case that could be called 'scratching' since a damselfish was repeatedly scratching its ventral area against a substrate in a way that could not be classed as 'flashing' (there is a possibility of parasitic infection, or even ovipository behaviour, although the behaviour was very fixed in its appearance and frequency).

Although definitions of types of stereotypic behaviour vary from author to author, some attempts have been made to group several behaviours into main types. When the stereotypy occurs because of physical limitations of the captive environment, they have been classed as 'cage stereotypes' (Draper & Bernstein. 1963; Berkson 1967, Ridley & Baker, 1982). They are usually of a locomotor nature, and are typical of small/barren enclosures, although they can be altered by changes in the environment enrichment. 'Pacing' and 'circling' are purely locomotor categories, but most ITB, SBB and 'flashing' have a strong locomotion component in them. It is then safe to say that the majority of the stereotypies found in UK public aquaria are 'cage stereotypies', and therefore the main cause of their occurrence may be the physical limitations of the aquaria, as opposed to social factors. The two cases of 'head-bobbing' found in clownfish and the case of 'handling' in otter mentioned earlier could be, on the other hand, cases of 'social stereotypy', in which the lack of stimulation –and not the physical limitations of the enclosure– may be the underlying cause. In the two clownfish cases the individuals were kept without a sea anemone with which they could establish a symbiotic relationship (as they do in the wild), and although its is commonly said that clownfish do not 'need' an anemone when kept in aquaria, perhaps they may feel 'exposed' and therefore stressed if they do not have them. It has to be said, though, that the existence of all these 'lumped' categories of stereotypy has been considered a little too simplistic by some authors (Mason, 1991).

Nevertheless, during this study on several occasions an animal was seen performing a combination of different stereotypic behaviours (although because of the exclusive nature of the definitions used they were registered as one type). It was not unusual to observe SBB with ITB, pacing with ITB or spiralling with SBB. In fact, it is possible that all stereotypies in fish are just different expressions of very similar problems, perhaps expressed differently by different species, or perhaps expressed differently depending on the severity of the problem (or both).

The information obtained during this study does suggest that an interesting avenue for further research on stereotypic behaviour could be trying to test a 'unified theory of fish stereotypy'. There is the possibility that similarities in housing conditions (after all, the public aquarium trade is fairly standardised in practices) plus the theoretical similarity of the psychological makeup of some fish groups could lead to similar "experiences" of captivity that could produce similar behaviours.

For instance, as already said most stereotypic behaviours described in this report are up to an extent locomotory. If we consider locomotion as the natural behaviour from which the basic stereotypy could have arisen, then 'pacing' could be the most 'primordial' stereotypic behaviour generated from a constant frustrated attempt to leave the somehow 'wrong' environment. Particular aquarium designs, or perhaps the natural patrolling tendencies of territorial fish, could transform such 'pacing' into 'circling'. If, on the other hand, a pacing fish often encounters a transparent boundary could then transform its pacing into ITB, perhaps either as a reinforced response of its own reflection, the smooth surface of the glass, or the fact that the fish can see what is on the other side but cannot reach it (or a combination of the three). Alternatively, if the fish pacing or circling go too often near the surface (or this is reinforced with 'human' feeding from 'the top'), SBB could be the next stereotypy developing. The longer the fish is exposed to the conditions that originated the initial pacing, the more intense and frequent the cycles of its stereotypy become. Finally, when the circling becomes ever so tighter, the SBB ever so vertical, or additional stressors are added, 'spiralling' could be the result. In fact, spiralling is the behaviour in fish that seems more alien to the normal behavioural repertoire of the species observed performing it, especially if it takes place near the surface. Indeed, this obviously pointless behaviour would most likely leave any observer, experienced or otherwise, with the distinctive impression that the fish is 'losing its mind'. It is also a common behaviour seen in the last stages of many lethal physical diseases, as can be seen below in the chapter on health.

This admittedly speculative unified view of fish stereotypy is not incompatible with the same type of behaviour seen in terrestrial animals. Indeed, the concepts of 'pacing' and 'circling' have been borrowed from them, and the equivalent of 'spiralling' in a terrestrial animal could be the stereotypy named 'looping' –where a tight circling becomes a loop. Alternatively, a stereotypic over-grooming may become so extreme that develops into self-mutilation. The respective analogous (or perhaps homologous) case for fish could well be 'stereotypic flashing' (or the case of 'scratching' mentioned earlier). Indeed, as it will be seen below, in the same way that over-preening parrots are sometimes also seen pacing and head-bobbing, or over-grooming monkeys are sometimes seen rocking and neck-twisting, during this study a severe case of an over-flashing fish was in fact seen combining its flashing with strong ITB (figure 15).

Although further research is needed to assess the validity of such unified theory of stereotypy, this study may have produced tantalising information to encourage it. This view of stereotypic behaviour also suggests that 'captivity' in general could be the underlying cause of the problem. The nature of a captive environment, regardless of how modern, how enriched, or how in tune with accepted high standard husbandry techniques is, is the restriction of space, the limitation of stimulation, and the reduction of choice. These three factors could well be what would trigger, in any animal, the chain of events that would eventually lead in some of them to the expression of their difficulties in coping with their environment with a behaviour we can detect and recognise. Some animals may express it sooner than others, some animals may express it with some behaviours more often than with others, and some animals may 'take it all in'. If from captive fish to captive humans psychological well-being is certainly an issue, perhaps a more basic research on 'captivity' is needed, and perhaps the question of whether or not it is really possible to create a suffering-free captive environment should be seriously explored.

Types of animals showing stereotypic behaviour in UK public aquaria

The data of table 9 shows the most common animals (which account for 95% of all the stereotypy observed) that were seen performing stereotypic behaviour in UK public aquaria. Note that elasmobranchs leads the list.

types of animals	individuals	Percentage
Rays	76	24%
Sharks	48	15%
Bass	28	9%
Wrasses	20	6%
Pufferfish	17	5%
Flatfish	17	5%
Freshwater tropical	13	4%
Gadiforms	11	3%
Triggerfish	10	3%
Catfish	7	2%
Blennids	7	2%
Breams	5	2%
Butterflyfish	5	2%
Trunkfish	5	2%
Cavefish	4	1%
Grey mullets	4	1%
Lumpsuckers	4	1%
Porcupinefish	4	1%
Trevallies	4	1%
Tangs	4	1%
Damselfish	3	1%
Reptiles	3	1%
Gurnards	3	1%
Seascorpions	3	1%
TOTAL	305	95%

Table 9. Most common types of animals seen performing abnormal behaviour (in particular stereotypic behaviour) in UK public aquaria during 2004. Some taxa have been grouped in taxonomic groups. The second column shows the number of individual animals of each type seen performing such behaviour, and the third column shows the percentage from all individuals seen performing it (n=320)

Pufferfish (including porcupinefish) are the type of fish most commonly observed performing pacing or ITB.

All cases of abnormal behaviour observed except five were seen in fish. The five exceptions are one case of ITB found in horseshoe crab, three ITB cases in terrapins, and a peculiar case of stereotypy that could be called 'handling' in one otter (mentioned above). The overwhelming majority of fish kept with respect to other vertebrates kept in UK public aquaria explains why no more cases on non-fish stereotypy were found.

'Stereotypic flashing' behaviour

'Flashing' should be considered as a special case because of the possibility that the behaviour observed may not always be abnormal.

A study by Pickett, & Pawson (1994) described that when wild bass are resting as a shoal near the bottom, every now and then an individual will slowly sink towards the bottom and then suddenly move forward, turning on one side and appearing to rub one flank on a substrate The authors called this behaviour "flashing" (or "grattage du flank") and they pointed out that it can be also seen in grey mullet. Pickett, & Pawson hypothesise that there are two possible explanations for such behaviour: to disturb small crustaceans in order to eat them, or to get rid of ectoparasites. Other authors consider it a sign of "itchy" fish where ectoparasite infestation is the most common cause (Anonymous, 2003c).

Despite the fact this behaviour has been seen in the wild, still it could be considered as an abnormal behaviour if it is caused by disease, and the frequency of the disease is higher than normal. Parasitic infestations are diseases, and therefore if flashing is a response to ectoparasites that are more likely to infect captive animals it could be argued that it should still be counted as an abnormal behaviour. However, if parasites are very common in the wild (as they are), and such behaviour as a consequence can be seen very often in the wild, it is more difficult to accept the behaviour as abnormal. For the other side, if the behaviour is entirely a feeding strategy, it should not be considered abnormal at all. Should we, then, count this behaviour as abnormal in this study?

Taking into account that, for those who remain unconvinced of the inclusion of 'flashing' in this analysis, separate calculations were made including or not flashing as abnormal behaviour, it was decided to consider flashing as an abnormal behaviour for the following reasons:

- The observations conducted during this research show that from the 56 fish that were clearly identified performing this behaviour, none of the fish was ever seen turning towards the substrate where the flashing took place in order to seek for possible food items having been 'freed' with the behaviour. This, in our opinion, makes the 'feeding' hypothesis a very unlikely explanation for the flashing cases we observed (although it could still be an explanation for wild cases).

- During the study it was observed that the majority of the flashing fish were flashing repetitively as opposed to just once (61% seen flashing repeatedly, but the fact that only one flash was seen for the rest does not mean that they did not flash more). Although you would expect that a fish with ectoparasites would flash repeatedly in order to get rid of then, the fact that a repetition of a behaviour takes place makes it a candidate to be considered as a stereotypy. It is possible that there is a 'parasitic flashing' and a 'stereotypic flashing', the first caused by parasites while the second caused by stress. It is also possible that both types are intimately interrelated. A similar case would be the commonly accepted over-grooming in primates or over-preening in birds as a sign of stress. Moreover, there are people that are 'nervous' or stressed who may scratch themselves as a kind of 'tick', but it is also known that stress itself can produce an 'itchy' skin. These phenomena could also occur in fish. After all, pacing, a commonly accepted stereotypy, derives from a perfectly natural behaviour –walking– which has lost its original function. It is possible that flashing, which could be in the wild a response to ectoparasites, in captivity can be expressed as a stereotypy (as well as still have the 'cleaning' function because there are also parasites in aquaria).

- There is a third possibility besides the ectoparasite or feeding explanation. It is well know that the wrong water chemistry in a tank can make its inhabitants stressed, but the chemicals themselves, specially suspended matter in the water, low PH or high level of ammonia and nitrates can be the cause of an 'itchy' skin, and in consequence of flashing behaviour (Bailey & Burges, 1999). Indeed, in this study flashing was observed often (but not always) in tanks where the water was noticeably dirty (figure 13). This possibility is consistent with the interpretation of 'abnormal behaviour' as a response of a wrong environment in captivity, regardless of whether the behaviour is stereotypic or not.

Figure 13. Bass flashing in a UK public aquarium in which the tank water was uncharacteristically dirty (hence the green tone)

- On several occasions during the investigation it was possible to 'zoom in' with the video camera on the skin of flashing fish and in the majority of cases no evidence of ectoparasites could be found. Although it is possible that the size of such parasites would be too small to be seen with a normal video camera, some of these type of parasites are big enough to be detected with the naked eye. Although in some cases skin lacerations or loss of scales were seen, on many occasions no evidence of skin problems was found, reinforcing the hypothesis that some flashing could be stereotypic.

- Often flashing fish were seen flashing repeatedly both flanks of their body, which is more consistent with either a stereotypic flashing or a chemically induced one than with a parasitic flashing.

- Often flashing was mostly observed in a particular spot in the exhibit. Although it is possible that such a spot is 'the best' area in the tank to have a scratch due to physical reasons, often locomotory stereotypies are 'fixated' on specific areas of an enclosure, which is consistent with what was observed.

- Even in the cases where flashing is purely ectoparasite, it could be argued that the closed conditions of a captive environment increase the chances of a fish becoming infected with a parasite. Therefore, although the behaviour may be in itself not abnormal in kind, it still may be an indicator of animal welfare problems due to housing conditions, consistent with the way this study interpreted abnormal behaviour in relation to captivity.

- As can be seen in figure 14, despite the fact that many of the cases of flashing observed were performed by sea bass, the majority of the fish (53%) seen flashing belonged to other species (at least 19 different taxa). Although this in itself does not support either the ectoparasite hypothesis or the stereotypy one, together with the fact that there are not many reports of fish other than sea bass seen flashing in the wild may suggest that the occurrence of the behaviour among different species in captivity may be an indicator that the cause of the behaviour is more linked to a captive environment itself than to a normal behaviour commonly seen in the wild.

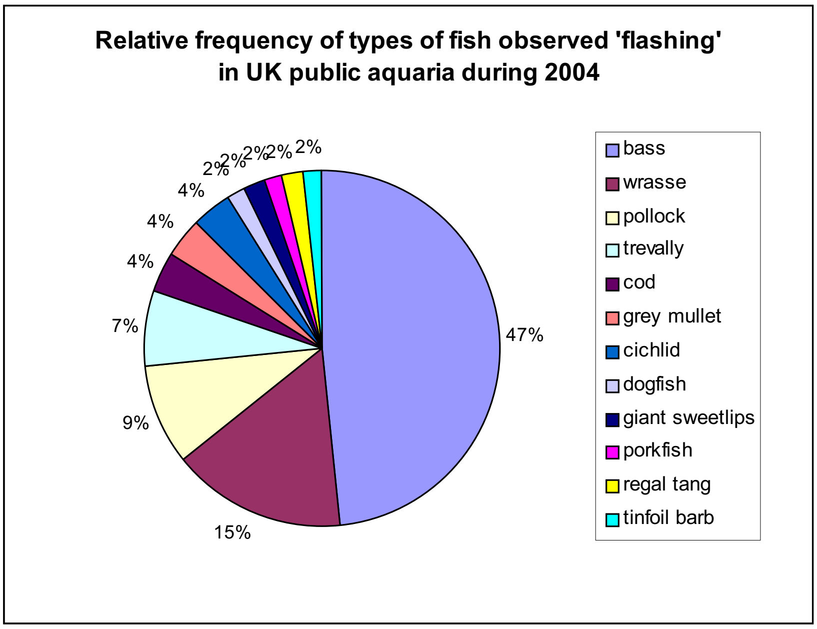

Figure 14. Relative frequency of types of fish observed 'flashing' in UK public aquaria during 2004. N=56

∉ There were particular cases in which the hypothesis of the existence of 'stereotypic flashing' seemed easier to prove. In one case, the flashing behaviour of a sea bass occurred much more frequently than in other cases observed, and it was combined with other stereotypic behaviour such as ITB (figure 15). Stress is a variable that can be suffered with several intensities, and it is not unusual that in the most severe cases several types of stereotypies appear combined. For instance, observation of primates in zoos have shown that often severe stereotypic monkeys perform both 'neck-twisting' and 'pacing' at the same time (Casamitjana & Turner, 2001). The fact that the most clear candidate of stereotypic flashing observed happens to be a sea bass also supports the idea of including the behaviour as abnormal behaviour. It is consistent with the hypothesis that stereotypies may derive from normal behaviours which manifest themselves out of place or out of intensity when the animal is having difficulties in coping with its environment. If sea bass is an animal that tends to flash naturally more than others, it is more likely to find stereotypic flashing in bass more than in other fish.

Figure 15. Case of a bass performing several types of stereotypic behaviour in a UK public aquarium. On the left performing ITB against the tank glass, and on the right performing repeated flashing

All these points lead to the conclusion that it would be worth considering the possibility of the existence of 'stereotypic flashing', and although it is possible that different types of flashing do occur in public aquaria, it is reasonable to consider in general such behaviour as part of the 'abnormal behaviour' repertoire stressed or diseased fish normally show. However, due to the fact that we cannot really tell apart the purely parasite flashing from the rest, it is sensible to make all calculations twice –including or not flashing– to see if the inclusion of purely parasite flashing in our study alters significantly the conclusions taken from the data.

Surface Breaking Behaviour (SBB)

A third of the stereotypic behaviour observed in this study constitutes Surface Breaking Behaviour (SBB), which can be seen in 71% of the UK public aquaria. It would be relevant, then, to study this type of behaviour with a little more detail.

Captive rays (mainly of the genus *Raja,* like thornback, painted, undulated, cuckoo or spotted rays) commonly exhibit this behaviour in captivity (figure 16), and in this study it was observed in 83% (n=22) of the public aquaria that keep rays. Scott & Rollison (1999), in a study on captive *Raja* rays, defines the behaviour as following: *"whilst swimming the SBB performing animal lifts the front of its body so that the snout, eyes and sometimes the respiratory spiracles are raised about the level of water (...) it is often repeated several times by an individual in a single bout of behaviour".* It is this repetitive nature that makes it fall into the definition of stereotypy used in this study (in addition of the repetitive swimming motion that is required to maintain a single bout with the snout out of the water).

Table 10 shows that almost one third of individual rays of the genus *Raja* were seen performing SBB, and above a quarter of all rays were seen showing it. These are very high values indeed, which indicates that the problem is serious (no public aquarium that showed this behaviour in *Raja* rays had less than 9% of the rays showing it) and widespread (at least 87% of the public aquaria keeping *Raja* rays showed this behaviour). Almost a quarter (22%, n=23) of the UK public aquaria with *Raja* rays had half or more of their population showing SBB, and in one public aquarium the percentage was as high as 83% (n=6).

Type	CODE	SBB	%	SBB rays	%	Visible rays	% rays	SBB *Raja* rays	%	visible *Raja* rays	% *Raja* rays
CHPA	A-SEA27	15	14%	6	9%	20	30%	4	6%	13	31%
CHPA	A-SEA33	14	13%	6	9%	16	38%	6	9%	12	50%
BIPA	A-STA49	13	12%	5	7%	6	83%	5	8%	6	83%
CHPA	A-UND18	8	7%	7	10%	22	32%	6	9%	20	30%
CHPA	A-SEA53	7	7%	7	10%	17	41%	7	11%	17	41%
CHPA	A-BLU03	6	6%	6	9%	22	27%	6	9%	12	50%
CHPA	A-SEA17	6	6%	3	4%	16	19%	3	5%	14	21%
BIPA	A-SEA20	6	6%	4	6%	10	40%	4	6%	7	57%
CHPA	A-BLU06	5	5%	5	7%	15	33%	5	8%	10	50%
CHPA	A-SCO45	5	5%	3	4%	14	21%	3	5%	14	21%
CHPA	A-SEA01	4	4%	4	6%	20	20%	4	6%	18	22%
BIPA	A-MAC44	3	3%	2	3%	10	20%	2	3%	10	20%
CHPA	A-NAT41	3	3%	2	3%	11	18%	2	3%	9	22%
SIPA	A-OCE56	3	3%	2	3%	5	40%	2	3%	5	40%
SIPA	A-FOW04	2	2%	1	1%	9	11%	1	2%	9	11%
BIPA	A-AQU08	1	1%	1	1%	8	13%	1	2%	7	14%
CHPA	A-DEE48	1	1%	1	1%	14	7%	1	2%	11	9%
APA	A-FOR25	1	1%	1	1%	9	11%	1	2%	9	11%
APA	A-ISL24	1	1%	0	0%	0	0%	0	0%	0	0%
SIPA	A-LYM16	1	1%	0	0%	0	0%	0	0%	0	0%
SIPA	A-MAR50	1	1%	1	1%	2	50%	1	2%	2	50%
SIPA	A-SEA32	1	1%	1	1%	9	11%	1	2%	9	11%
TOTAL	22	107		68		255	**27%**	65		214	**30%**

Table 10. Number of individual animals seen performing Surface Breaking Behaviour (SBB) in UK public aquaria in 2004. The first column shows the type of public aquarium, the second column shows the code of each aquarium, the third column shows the number of individual animals seen in each particular public aquarium showing SBB, the fourth column shows the percentage of individual animals showing such behaviour in each particular public aquarium with respect to the total of individuals seen showing the behaviour, the fifth column shows the number of individual rays seen in each particular public aquarium showing SBB, the sixth

column shows the percentage of individual rays showing such behaviour in each particular public aquarium with respect to the total of individuals rays showing the behaviour, the seventh column shows the number of visible rays for each public aquarium, the eighth column shows the percentage of rays showing SBB with respect to the number of rays seen in each aquarium, and the remaining columns the same than columns five to eight but for rays of the genus *Raja*. The last row shows the values for all public aquaria put together.

Figure 16. Ray of the genus *Raja* performing 'Surface Breaking Behaviour' behaviour in a UK public aquarium.

Several reasons have been given to explain the existence of SBB: the animals 'curiosity' made them 'look' outside the water often, they are smelling the visitors that come along to see them, they are 'asking' for a physical interaction with visitors because of their 'sociability', or they are expecting the next feeding time with impatience. Most of these explanations are given by public aquarium keepers when visitors ask but they are rarely based on any research made on the subject.

The exception is the study of Scott & Rollison (1999) observing 17 Raja rays of four different species in a UK public aquaria testing the hypothesis that the fact the rays were fed by keepers from 'the top' of the enclosure was the cause of the behaviour (figure 17). Indeed, they found that rays when fed exhibited higher levels of SBB that those which did not, and therefore they concluded that SBB could be thought as an appetitive behaviour appearing in a particular artificial environment with a particular feeding procedure. However, when modifications on the feeding method were made by scattering the food across the aquarium floor using a net (Scott & Rollison, 1999b), although the behaviour was reduced in frequency it did not eliminate it.

It is true that increased performance of behaviour associated with feeding food is often an indication that captive animals have a deficient diet in terms of quantity or quality (Broom & Jhonson, 1993; Appleby & Lawrence, 1987), but as any shortcoming of a captive environment this could be the initial trigger that developed the behaviour, which later on it becomes fixated as stereotypy almost becoming independent of the initial cause. The reason that we encountered this behaviour mainly in rays and sharks could be because the ventral position of the mouth, which makes the animal raise itself out of the water to take the food when fed from above, but when the feeding stops the continuous array of visitors approaching the tanks could make the animals believe that more food is coming, so the behaviour continues. When these visitors interact with the rays and sharks by touching the water or the animals themselves (very common practice in public aquaria holding these species, as will be seen below) they keep reinforcing the behaviour which eventually becomes fixated.

Figure 17. Surfacing ray being fed 'from the top' by a member of staff of a UK public aquarium.

In this study the cases of 'surface breaking behaviour' observed took place mainly during non-feeding sessions, although SBB was seen to increase around feeding time in the cases that feeding occurred from 'the top', as you would expect in any case. Farmed minks, for instance, and some zoo animals increase their stereotypic pacing (de Jonge & Carlstead, 1987; Odberg, 1984) and pigs increase their rooting behaviour (Mason, 1991) prior to scheduled feeding. The link between the behaviour and feeding, however, does not invalidate the interpretation of the behaviour as a stereotypy, nor does it make the behaviour 'normal', because the artificial scheduled feeding regimes of captive environments are one of the characteristics of captivity (as it could be the existence of enclosure walls or the lack of companionship) that may explain the existence of abnormal behaviours.

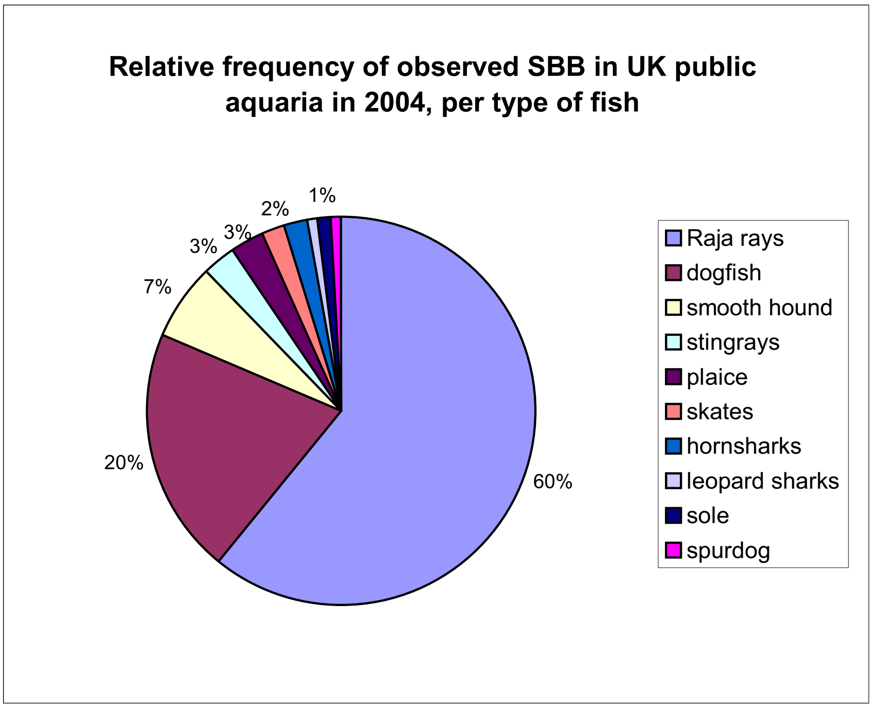

Figure 18. Relative frequency of observed Surface Breaking Behaviour (SBB) in UK public aquaria in 2004, per type of fish. N=107

As can be seen in figure 18, it was observed that some other species, like several types of flatfish, also showed SBB, but in them it often was associated with ITB. In their cases the mouth is not ventral, but their flat body made them take a vertical position when they want to overcome a tall obstacle. If such an obstacle is the glass wall of the tank, the flatfish may end up surfacing while trying to go over it –or while performing ITB. If done very often such behaviour could become fixed. This was also observed in bottom dwelling sharks and stingrays (figure 19). In this case a 'cage stereotypy' may be behind a SBB, reinforcing the notion that all fish stereotypies may be somehow connected (see above).

Figure 19. Dogfish showing 'surface breaking behaviour' behaviour in a UK public aquarium, perhaps originated by the frequent encounter with the tank's walls.

PHYSICAL HEALTH

Despite what public aquarists may say when asked, reproducing in captivity the intricacies of natural aquatic ecosystems is not only a very difficult task, but almost impossible to accomplish with overall success. It is not as simple as to have the water at a particular temperature or salinity. Water chemistry (hardness, nitrates, PH, heavy metals), suspended particles, levels of Oxygen/CO_2, parasites, turbulence, plankton, vegetation, preys and predators, symbionts, light (intensity, cycle, spectrum), water pressure, substrate, electric fields, sound, space, shelter, mates, companions, etc. are all variables that that are either difficult to replicate or are difficult to control in a captive environment. In consequence, they are likely to go wrong –at the very least occasionally– making the captive aquatic animals become chronically or acutely ill.

There are many types of diseases and health problems that fish and aquatic invertebrates can suffer for a variety of causes. Following are examples of the most common:

- Environmental diseases
  - Water chemistry problems
    - Acidosis and Alkalosis
    - Osmosis stress and shock
    - PH shock
  - Poisoning
    - Aflatoxic poisoning
    - Ammonia poisoning
    - Chlorine poisoning
    - Metal poisoning
    - Nitrate poisoning
    - Nitrite poisoning
  - Atmospheric gasses problems
    - CO_2 problems
    - Gas bubble disease
    - Hypoxia
  - Temperature problems
    - Chilling and overheating
    - Temperature shock
  - Stress and shock
  - Trauma
- Diet problems
  - Constipation
  - Fatty liver
  - Obesity
  - Malnutrition
  - Vitamin deficiency
- Pathogenic diseases
  - Viruses
    - *Lymphocystis*
    - Fish pox
  - Bacteria
    - *Aeromonas*
    - Fin rot
    - Fish TB (*Mycobacterium*)
    - *Flexibacter*
    - *Nocardia*
    - *Pseudomonas*
    - *Vibrio*
  - Fungus
    - *Achyla*

- *Branchiomyces*
    - Cotton wool disease
    - Gill rot
    - *Ichthyophonus*
    - *Saprolegnia*
  - Parasites
    - Protozoan
      - *Apiosoma*
      - *Chilodonella*
      - *Costia*
      - *Cyclochaeta*
      - *Epistys*
      - *Heterosporis*
      - *Hexamina*
      - *Ichthyobodo*
      - *Ichthyophthirius*
      - *Octomitus*
      - Velvet disease
      - Whitespot
      - *Cryptocaryon*
      - *Oodium*
    - Metazoan
      - Anchor worm
      - Black spot
      - *Camallanus*
      - *Capillaria*
      - Eye fluke
      - Fish leech
      - Fish louse
      - Gill fluke
      - Nematodes
      - Skin flukes
      - Tapeworms
- Genetic disorders
- Disease with more than one possible cause
  - Anaemia
  - Dropsy
  - Bubble-eye
  - Tumours
  - Sterility

<u>Evidence of physical health problems in UK public aquaria</u>

Uncovering the physical health problems in public aquaria is not an easy task. Many animals obviously ill or injured are normally taken out of display –on most occasions in order to treat the animals in isolation tanks where chemicals can be easily administered, or to give them a 'break' from the presence of other fish. The ones that are not obviously ill or injured, on the other hand, are difficult to detect –by definition– without the knowledge of their history. And the ones that cannot cope at all just die and disappear from any visitors' view forever.

Nevertheless, there are always some cases that can be found with an observant eye and a very basic knowledge of fish healthcare, and in this study an attempt to quantify these cases was made.

The cases that were identified as possibly having health problems (due to the lack of proper diagnostic tools and veterinary experience many of them should be interpreted only as 'possible') were detected through visible clues that work as evidence of ill health. The definition of types of evidence of ill health used in this study follow:

- Laceration:
  a tear or abrasion of flesh/skin beyond the epidermic level that does not show current bleeding (see figure 20)

- Wound:
  an injury of living tissue in which the skin is cut or broken, with evidence of recent bleeding (see figure 20)

- Scar:
  mark on the body indicating an old injury, wound or laceration that seems to be already healed (see figure 20)

- Death:
  animal dying or already dead (see figure 20)

- Eye disease:
  any disease affecting a fish eye, from the absence of an eye to an infection that shows in the eyes appearance (see figure 20)

- Deformity:
  carrying any unusual shaped body (or body parts) involving the animals skeleton (see figure 20)

- Infection:
  disease in which there is visual evidence of a parasitic, bacterial, viral or fungal infection (i.e. swelling of critical body parts, presence of growths, etc). See figure 20.

- Abnormal swimming:
  unusual locomotory movement unlikely to be part of stereotypic behaviour or psychological disorder/distress (see definition in the abnormal behaviour chapter above), such as swimming on one side or upside down. See figure 20.

- Growth:
  Tumour or any other abnormal growth of living tissue.

Throughout the visits made, and taking into account that the investigator could only make a very approximate diagnosis –not equivalent at all to the one a vet specialised on fish could do– some evidence of possible physical health problems in the animals kept was found in 74% (n=31) of the UK public aquaria investigated.

About 150 cases were identified, but because only those cases that left some visual physical evidence (as the presence of wounds or lacerations) could be identified, these types of cases were found to be the majority detected (figure 21).

The majority of the cases of lacerations were seen in sharks and rays, in particular those kept in open tanks were the visible public can touch them. Although we only can assume that many of such lacerations come precisely from such visitor animal contact (see below), on some occasions that assumption was confirmed by the aquarium staff.

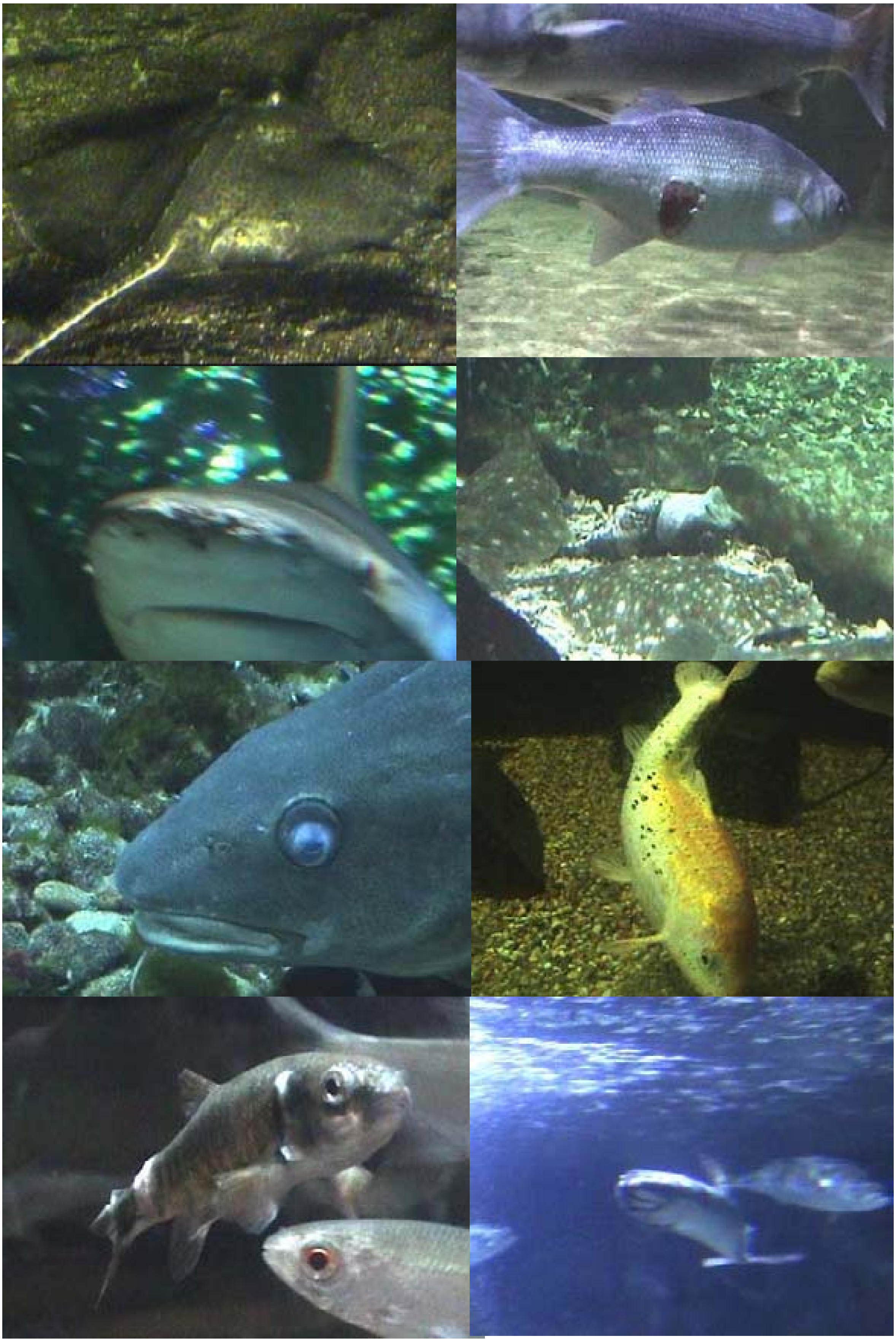

Figure 20. Examples of evidence of health problems in fish found in UK public aquaria during this investigation. From left to right and top to bottom. Laceration on ray's lower wing, wound on sea bass' side, scar on sandbar shark nose, dying blue mouth, clouded eye in cod, deformed goldfish, minnow with an infection, and mackerel swimming sideways (see text for definitions).

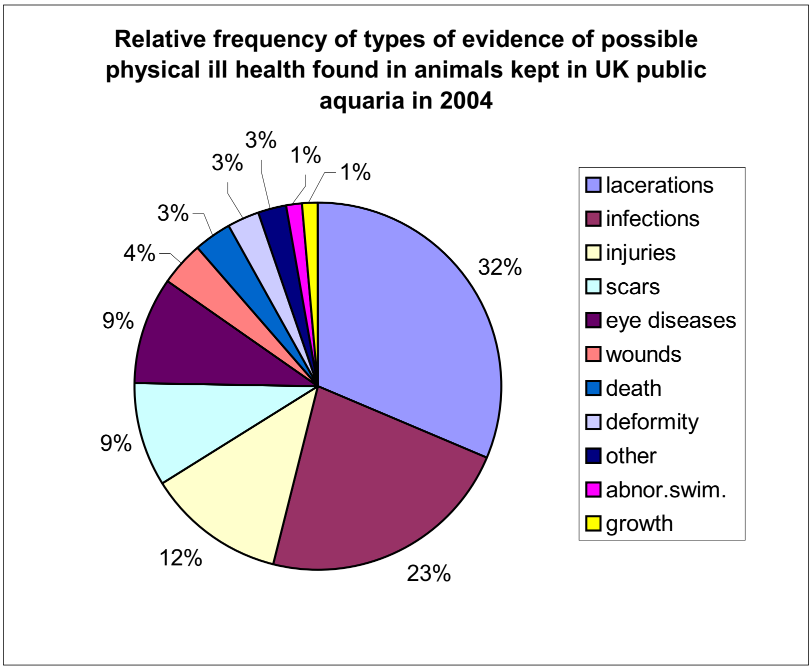

Figure 21. Relative frequency of types of evidence of possible physical ill health found in animals kept in UK public aquaria in 2004. See text for definitions. N= 150

Mortality and Morbidity in UK public aquaria

Contrary to what one finds in some traditional zoos, the majority of the public aquaria deaths may occur unnoticed by the general public. On one hand, the sheer number of fish in the tanks –and their relative 'anonymity'– would prevent them from being missed by visitors if they die, and on the other hand they are easily replaceable without anybody noticing. It would be more difficult to replace a giraffe or even a zebra in a zoo without anybody realising it. Therefore, without the express collaboration of those public aquaria which record all their fish death –collaboration unlikely to happen –it is almost impossible to assess how many fish die (mortality) or get ill (morbidity) in UK public aquaria with a study of this kind.

However, on some occasions internal information about the workings of public aquaria surfaces, which may help to give an insight of the health issues taking place 'behind doors'. The investigator of this study managed to obtain internal reports from chain public aquaria produced six years ago. They were weekly general reports covering a five-month period sent from some of the centres of the chain to the others to inform them of the progress of their collections. Reading these reports, because they represent more than ten UK public aquaria in a relatively recent short –but continuous– period of time, allows us to arrive at conclusions beyond the anecdotal about the mortality and morbidity in UK public aquaria.

Following are extracts (paraphrased) from the reports in which incidents of animal ill health and fatalities were mentioned (in red especially illustrative examples):

Public aquaria	Report	Morbidity	Mortality
Centre 1	Report 1	Three seahorses with gas bubble disease	
Centre 1	Report 2	Zander and Perch ongoing Protozin treatment	
Centre 1	Report 4	One big bellied seahorse on Cuprazin treatment	
Centre 1	Report 4	Zander and pike in bad way	
Centre 1	Report 5	Lice infestation in Freshwater system	
Centre 1	Report 5	Zander problems with eyes	
Centre 1	Report 6	Last tigertail seahorse moved to quarantine for treatment of gas bubble disease	
Centre 1	Report 7	Perch suffering from the same problem as zander	
Centre 1	Report 10	Large blonde ray not feeding and keeps banging	

		its nose opening up the same wound	
Centre 1	Report 10	Many freshwater fish going pale or develop fungus after the five Dipterex treatment	
Centre 1	Report 10	Parasites in dogfish and bull huss are skin flukes, which contribute to juvenile mortality	
Centre 1	Report 12		Common octopus lost because of protozoa in skin
Centre 1	Report 12		More mortalities with freshwater system. Chub showed spiralling swimming behaviour shortly before death
Centre 1	Report 15	Punkinseed got fungus	
Centre 1	Report 15		Lost big male undulate ray. Samples show monogenean trematode
Centre 1	Report 16	Fewer flukes on wave tank dogfish	
Centre 1	Report 16	Treated perch and Zander with Protozin for fluffy fungus	
Centre 2	Report 2	British sharks and rays not eating too well	
Centre 2	Report 17	Archerfish has bacterial infection	
Centre 2	Report 18	Still problems with Archerfish and Mudskippers	
Centre 2	Report 18		Lost a five-foot long conger eel due to reproduction. Had not eaten for several months
Centre 3	Report 2	Picked up a wells catfish that has not settled and still not feeding well	
Centre 3	Report 7	Problems in tropical marine display. Yellow tailed blue damsels with eye infection	
Centre 4	Report 1		Lost a bonnethead shark due to intestinal biting, perhaps by black tip sharks
Centre 4	Report 3	A few tropical sharks show signs of goitre	
Centre 4	Report 8	Leopard shark had bite injuries	
Centre 4	Report 8	Treating rays for *Vibro*	
Centre 4	Report 13		Problem with bass; nitrite levels very high; very stressed, some losses
Centre 5	Report 1	Juvenile tope got bitten by a large angel shark	
Centre 5	Report 1	One brill in quarantine for eye wounds	
Centre 5	Report 1	Treating lumpsuckers with Cuprazin because protozoan infection	
Centre 5	Report 10	Conger in Oxylet following damage to its tail	
Centre 5	Report 16		We lost our large male cuckoo wrasse (jumped from display having shown no sign of stress beforehand) and one large gurnard
Centre 5	Report 17	Bacterial infection of young thornbacks	
Centre 5	Report 17	Conger looking better	
Centre 5	Report 18	Older *H. reidii* looks better after treatment with Myxazin but young group suffered when a dodgy heater overheated	
Centre 5	Report 18	Problems with juvenile cuttlefish floating on surface	
Centre 5	Report 18		We had to euthanise yet another adult tope, the third in two years. Females continuously injure their noses. The public really notices the state of the tope; when they reach a certain size they start deteriorating.
Centre 5	Report 19		Treatment continuing with black bream and goby display. We are loosing less of

			them
Centre 6	Report 10	Another of our tope does not look brilliant	
Centre 6	Report 18		Seal hauled out and later died
Centre 7	Report 12	*H.ramulosus* has developed a large white area	
Centre 7	Report 12	Treating large female bull huss for flesh wounds infected by males	
Centre 7	Report 13	Some improvement in bull huss condition	
Centre 7	Report 13		Seahorses in quarantine. Bacteria like *Pasteurella*. One euthanised (lost buoyancy)
Centre 7	Report 16		Smoothound spiralling. Growth in tail was *Pseudomona pickettii*. It died
Centre 7	Report 17	Treatment continues for two remaining tigertails that had *Vibro*	
Centre 7	Report 18	Tigertails have bacterial infection	
Centre 8	Report 1	John Dory has not eaten in two months	
Centre 8	Report 5	Cuttlefish in quarantine because of bacteria infection	
Centre 8	Report 16		Death of catfish due to gill parasitism
Centre 9	Report 4		All goldsinnies died on Wednesday. Some other mortalities too leading to some impromptu tank retheming
Centre 9	Report 6		Lost a couple of cuttlefish. Upon close examination a copper coin thrown by visitor could be it, but test was negative
Centre 10	Report 2		Lost slender seahorse to an accidental drain
Centre 10	Report 12	We had a shoal of mullets that were getting attacked by some grumpy sea bass and were developing quite a large lesions on their heads	
Centre 10	Report 13	Mullet in quarantine following sea bass attack	
Centre 10	Report 13	The stingray has picked up an infection in her tail from a suspected bite	
Centre 11	Report 2	Spurdog slowly improving	
Centre 11	Report 14	Ocean tank copepode infestation	
Centre 11	Report 18	Freshwater fish develop white spot	
Centre 12	Report 2	Rays had their second Diptrex treatment	
Centre 12	Report 21	Slender and kuda seahorses treated in formaldehyde	
Centre 12	Report 21	Turbot, tub gurnard and conger treated with Zaquilan	
Centre 12	Report 21		Lesser octopus passed away
Centre 12	Report 3		The baby ray shark crashed in quarantine. We lost almost all our babies
Centre 12	Report 11		We lost three slender seahorses due to nutritional problems
Centre 12	Report 13		Lost another slender seahorse. One left
Centre 13	Report 2		Euthanasied our salmon as they were not putting on weight despite feeding well. They suffered from recurrent skin infection/scale lost problems due to them being farmed stock. For this reason we could not release them
Centre 13	Report 20	Problems in getting the large turbot to accept antibiotics	
Centre 13	Report 4	Problems target feeding a smoothound with Oxylet	
Centre 13	Report 4	Two cod with bubble eye moved to quarantine	

Centre 13	Report 10	Parasitic infection	
Centre 13	Report 12		Have developed major problems with the rocklings. Lost three and unsure of reason
Centre 14	Report 2	White growth in mouths of many koi	
Centre 15	Report 6		Common octopus die from bacterial infection
Centre 15	Report 6		Lost large turbot
Centre 15	Report 7	Common octopus in quarantine because of bacterial infection	
Centre 15	Report 9		Lost our remaining cuttlefish. Starved itself
Centre 15	Report 9		Lost one seahorse
Centre 15	Report 10		Euthanised one smooth hound. In post mortem plastic toy lodged in stomach was found. Ammonia shock problem finished it off.
Centre 15	Report 13	Octopus still hardly eating	
Centre 16	Report 1	Problems with cuttlefish	
Centre 16	Report 10		Lost two juvenile spurdogs
Centre 16	Report 10		Mortalities in bass tank
Centre 16	Report 12	Baby spurdogs did not settle well in display. Treatment with Oxytet	
Centre 16	Report 12		Mortality of pipefish
Centre 16	Report 16	Male black top damaged his nose	
Centre 16	Report 16	Male lumpsucker attacked a conger eel biting its eye	
Centre 16	Report 16		two mortalities of new tigertail seahorses. Rest treated with Cuprazin
Centre 16	Report 16		Loosing cuttlefish from unidentified disease. Only three left.
Centre 16	Report 17		Lost one Octopus
Centre 16	Report 17		Lost another cuttlefish from strange disease. Only one left

These reports allow us to see cases of ill health involving hundreds of specimens in the five-month period, even though it seems that not all the centres sent their reports every week, and not all the centres reported on their cases of ill health. Although it is impossible to accurately estimate the number of fatalities and ill fish with the reports, they do give an idea of the range of illnesses, their causes, the types of animals involved and the severity of their outcome. For instance, we can see that both sea and freshwater fish often suffer physical diseases, and this is not confined to the exotic species either. It is noticeable the number of health problems seahorses suffer, although as can be see below in a dedicated chapter changes in seahorse husbandry today may have improved some of them. Fatalities among the cephalopod population seem quite high.

Also, the reports show how often drug treatment –such as giving antibiotics– is used, even if only as prophylactic measure, which will have a bearing in the consequences of releasing animals back into the wild (see chapter on reintroductions below). Interesting are the cases where the health problems seem to be caused by husbandry techniques, like the mixing of species in an exhibit, the regulation of the water chemistry or the interactions with visitors. Epidemics, or at least general infections/infestations affecting several –if not all – the individuals of a tank system do not seem uncommon, and mortalities despite available treatments appear to be inevitable. On several occasions during this study the investigator witnessed tanks with clear infestations, which confirms that the events described in the reports are by no means exceptional.

There is no doubt the reports reflect the routine running of large public aquaria of just a few years ago (aquaria that were probably considered state of the art in the UK at the time, and that probably have not significantly changed most of their procedures in the few years that have passed). If something this view of the inner working of public aquaria shows us that there are many animal health problems to encounter when running public aquaria, and death and disease occurs on a regular basis in them. Quite far from the image that visitors can experience when moving slowly under the underwater tunnel at the sound of a relaxing soft tune.

Despite most of the health problems of captive fish going unnoticed by the general public, on some occasions the problems of a high profile aquarium inhabitant do make it to the press. For instance, in the year 2001, ozone problems in the main aquarium tank caused by equipment failure made the National Marine Aquarium in Plymouth lose four of their valuable sandbar sharks (Anonymous, 2001a), which was widely publicised.

Sometimes the health problems do not originate in the public aquarium display, but in any of the other activities the aquarium is involved, such as during fish capture and transport. For instance, a previous batch of another four sandbar shark at the National Marine Aquarium also died in 1998 soon after arrival, probably killed by hypothermia after their flight to the aquarium was delayed (Anonymous, 2001a). This was not only an animal welfare tragedy, but had conservation implications since sandbar sharks in the wild travel from the Atlantic Ocean where they are obliterated by one fishery, to the Gulf of Mexico where they are caught by another. This means that, in addition to the captures for public aquarium displays, these shark populations are being hit twice, and because they grow very slowly (a 17 year old sandbar was found to be still immature, and it is considered that females do not mature until they are nearly 30 years old) their populations are slow to regain numbers and are therefore vulnerable to over-fishing (Bright, 1999). In fact, the survival rate of sharks during transport is often not very impressive. Young et. al (2002) found that for the scalloped hammerhead shark it was 83% for Beijing aquarium, 83% for the Oceanarium of Lisboa and 33% for the Rotterdam Zoo Oceanarium.

The safe capture and transport of sharks present several challenges due to key features of shark anatomy and physiology. Important issues include risk of trauma, overexertion, hypoxia, circulatory compromise/collapse, hypoglycemia, metabolic acidosis, hyperkalemia, and environmental accumulation of toxic metabolites leading to declining water quality. In addition to capture techniques, some of the factors contribute directly to a fatal exertional rhabdomyolysis syndrome or 'capture myopathy' (Greenwell, 2003), also known as "over standing disease" for terrestrial animals (one of the most important causes of death in wild ungulates that are captured for translocation).

Once in the aquarium many sharks do not survive for long, since they are very susceptible to bacteria and fungi infections (Bright, 1999; Grimes et al, 1884). For instance, 69% of the sharks kept at the National Aquarium of Baltimore between 1981 and 1988 died within a year, which was attributed to their inability to acclimatise. 103 mortalities occurred, and from the 71 sharks with a definite cause of death, 51% died due to infections, 31% to trauma and 18% were euthanised (Hecker et al.1989).

In other cases disease suffered in public aquaria may contribute to the extinction of threatened species. An example of this is the captive breeding programme to save the Charco Palma pupfish *Cyprinodon longidorsalis*, which was discovered in the early 1980's and it is considered extinct in the wild since 1991. A captive population exists in one US institution, London zoo and in the London aquarium. However, fish tuberculosis (*Mycobacterium*) was discovered in the British captive population which led to the euthanasia of all the symptomatic fish, which in turn threatened the success of the captive breeding programme (Spinks, 2003). This is not an isolated case, because the presence of *Mycobacterium* infection in marine and freshwater fish kept in aquaria has been a continual problem for zoological collections (Nyaoke et al., 2000).

Some species are more susceptible than others to the shortcomings of captive life, and therefore are more prone to illness and death. Cephalopods (octopuses, squid, cuttlefish and nautiluses), as seen in the reports above, seem to be a group of animals particularly affected by captivity. Octopuses are very sensitive to water quality and the tropical ones cannot survive without reef-quality water conditions (Haywood & Wells, 1989). Most are nocturnal and prefer subdued lighting, not always available in public aquaria for the visitors' sake. Elevated concentrations of heavy metals, especially copper, are especially deadly to invertebrates. Octopuses are also extremely sensitive to low concentrations of dissolved oxygen. The common octopus will die if the concentrations of oxygen drops to 2.5 mg/l, and get ill if lower than 5 mg/l (Toonen, 2003). They are also extremely intelligent predators, and spending their life in a completely predictable and unchanging glass box is not only boring for them, but it has also an impact on both their health and behaviour (Wood & Wood, 1993). Cuttlefish are also intolerant to copper and heavy metals and may be sensitive to ozonation. Their life span in captivity is only six to 16 months (Anonymous, 2004c).

Another species that seem to suffer particularly when kept in captivity is the tope, one of the British sharks. Most of the tope seen during this study either showed signs of abnormal behaviour or had wounds or scars that were probably caused by continuously crashing against objects or the tanks walls (figure 20). Information in the mentioned internal reports suggests that the UK public aquarium industry acknowledges the difficulties of keeping tope in captivity, which may explain why it appears that there are less tope kept in the UK now than in the past.

Husbandry methods in UK public aquaria as cause of animal health problems

It is not uncommon that public aquarists get used to the everyday encounters with death and disease, and they may not even see anymore how much of their practices and procedures may be partially responsible for those health problems. As in any profession, it is sometimes difficult to have enough perspective 'from the inside', and sometimes something that can be regarded as unethical –or at the very least perfectly avoidable –by an independent observer is accepted as an un-mutable part of 'the trade'. A good example of this can be seen by reading some of the articles of R. C. Anderson (1995, 1996), a public aquarist from Seattle Aquarium that explains the kind of management techniques he used to keep captive Giant Pacific octopuses (*Octopus dofleini*). The following extracts from his writings give an interesting insight of the approach to life and death some aquarists may take, but when one tries to read his comments from the octopus point of view it allows one to have an idea of what really represents a life time in captivity, and what kind of ordeal the octopus have to endure during it:

> *"Assuming the resource is not affected or depleted, collecting animals from the wild is usually the preferable and most satisfactory method, as the condition, size, and species of the animal can be chosen."*
>
> "If the animal is in a den it can be forced out by squirting a noxious chemical inside the den. We currently use a legal fish anesthetic, although it is somewhat less effective than bleach."
>
> *"Prior to shipping, the animal is not fed for two days to allow any food to be totally digested (faeces in the shipping water harms the water quality)."*
>
> *"We have shipped four O. dofleini from Seattle to Sweden with good success (one animal died due to a transit time of more than 36 hours caused by a flight delay)."*
>
> *"Before a tight-fitting backdrop was installed, the O. dofleini was able to pull the gravel out from the bottom, squeeze under the backdrop, and hide behind it, thus avoiding the tank lights and exposure to people. One particularly retiring female octopus that continually pulled this stunt was named "Emily," for Emily Dickinson, who was notoriously shy. I had a very difficult time keeping this animal out in the open. I used a bristly stick, bright lights, prickly sea stars, and Astroturf, all to no avail. A weak electrical prod, using a 9 volt transistor battery, was finally successful."*
>
> *"O. dofleini lives longer than most species of octopus, but only four to five years from egg to adult"*
>
> *"Contrary to popular belief, most male octopuses do not die directly after mating (…) but they may live several months before dying. Like the females, they may not eat during this period,*

known as "senescence." They usually come out of their dens and become very active, even during the day. It has been hypothesised that this frees up den space for females to lay their eggs in. Such senescent males are usually good display animals; they're active and require little care since they're not eating. But because they're not eating their tissues soon start to decay and they usually develop "ulcers" on their mantles as part of the ageing process. Once the ulcers appear such animals are not display quality and could be put down."

"Octopuses in captivity generally do not heal from wounds as well as those in the wild, especially those in closed systems. It may be necessary to euthanize an animal that has injured itself severely."

"Roper and Sweeney (1983) list five methods of anesthetizing cephalopods, several of which are also suitable for euthanization. Their first listed agent is ethanol (…) second method is cold water. (…) other methods are the use of fresh water, magnesium chloride, or urethane (ethyl carbamate). I have not found fresh water or MgCl2 to work very well as anesthetizing agents for the octopuses I have available (<u>O. dofleini</u> and <u>O. rubescens</u>). My experience showed the addition of fresh water seems to agitate the animals and cause peculiar arm contractions. (…) I have tried the fish anesthetic quinaldine in an alcohol solution on octopuses. This does not sedate them at all, but rather irritates them tremendously.(…) The fish anesthetic MS222 likewise agitates octopuses and also causes arm contractions similar to those caused by the use of fresh water."

Many aquarists would say that disease and death are all natural things and public aquaria only do their best to deal with them in the most clinical way. Not only would many aquarists deny that the captive conditions may worsen the animal's quality of life, but many would not accept any responsibility for their suffering.

An argument that is often given to justify the existence of so many health problems in public aquaria is that they would also occur in the wild. Although it is true that injuries and parasites are a common feature of living in the wild, the enclosed nature of the captive conditions may make them worse both in intensity and frequency. For instance, some of the injuries found in sharks may be as a result of sexual behaviour in which males bite females during copulation, both in the wild and in captivity. However, while many of intra- and inter-sexual behaviours function well for wild conspecifics, captive animals are confined to the limited space provided by the aquarium system, and a full spectrum of behaviours are almost always modified or attenuated. Consequently, captive sharks, skates or rays may be subject to persistent chasing and biting by members of the same or different sex. In addition, wounds inflicted during pre-copulatory or copulatory behaviours in captive elasmobranchs may act as entry sites for pathogens such as bacteria and fungus, which may have more dire effects than in the wild (Henningsen et al, 2003).

Even such common and widespread practices as traditional aquarium feeding methods can be a direct or an indirect cause of the public aquaria health problems. As Caine & Howarth (2004) say, *"from the very beginning of the captive care of marine animals within home, public and research aquariums to the present day, aquarists have been feeding the animals contained in such systems incorrectly. This method of feeding results in many problems associated with the long term care of animals within a marine aquarium (…) The effects of this feeding are vast. Animals that have evolved to have a low concentration of food but continuously supplied are suddenly subjected to a gorge, starvation, gorge, starvation-feeding regime".*

This sporadic introduction of relatively large amounts of food causes many problems. Some of them, extracted from Caine & Howarth (2004), follow:

1. Fish gorge themselves to collect as much nutrition as possible in a short time span, filling the gut with large unnatural amounts of food (figure 22).

2. Large amounts of food remains partially or undigested within the fish gut and is passed as faeces, only a small proportion of food is assimilated through the gut wall. This represents a huge loss in the animal's potential energy budget and an increase in contamination to the aquariums water body.

3. The animals are then starved with only natural food to eat existing at a very low concentration. Over time the fish's health can suffer as they begin long term malnutrition. This results in a loss of vitality, high rate of disease, infection, and a high mortality rate.

4. Fish behaviour is altered as they become unnaturally aggressive to species they would ignore in their natural environment.

5. Large amounts of microscopic particulate food is lost to the system, most will reside in the boundary layer existing over the solid/ liquid interface of the rockwork within the aquarium. If not eaten by scavengers this then can rot down causing pollution and possible algal problems.

6. Filter feeding foods are often added in too small amounts once per day, resulting in rapid increase and rapid decrease in food concentration to the animals.

7. Corals and other Cnidarians suffer as their food source is sporadic. A surge in amino acids stimulate their feeding responses but is often too late as the main bulk of particulate food has been taken out of the system by filtration, or eaten by other animals, by the time the corals have extended their polyps to feed.

8. No food is added during the night, many animals including corals and other filter feeders are active during the night. They rely on the capture of natural nocturnal zooplankton within the aquarium, whose populations remain low due to low food source and predation. Nocturnal feeders are slowly starved.

9. For Cnidarians less food is assimilated, resulting in less waste production, this waste is food for the symbiotic algal population within the gut wall, this results in a lower algal population within the coral, resulting in low algal waste such as sugars required by the coral as food.

10. Lower algal activity results in lower growth rates of the corals, and lower calcification in the growth of hard corals.

11. Denitrifying bacteria populations and activity fall and rise to the availability of their food source, this source again has high peaks and low troughs due to the feeding. As a surge in toxins appears the bacteria are slow to respond, this results in a high residence time of toxins in the system. Even at low concentrations the toxins are acting on the metabolic processes of the fish.

Figure 22. 'Feeding frenzy' in a tropical tank in a UK public aquarium in which a diver feeds the fish population during a talk/show.

Some public aquaria are experimenting with new feeding methods to compensate for at least some of the problems above, but the feeding methods seen during this investigation were consistent with the traditional ones. For example, the 'feeding from the top' with rays and sharks that induces 'surface breaking behaviour' (figure 17) or the supply of large amounts of food only few times a day (figure 22).

An example of one extreme of wrong diet was seen when the investigator talked to one of the public aquarium staff members that admitted that all the young seahorses they have every year – because of breeding– die of starvation due to the fact the aquarium does not have any system to produce the small crustaceans they need to eat. However, this problem did not prevent the aquarium from obtaining other seahorses from other sources to continue exhibiting them. In general, this 'death by starvation' may be more common in public aquaria that one might think if considering the offspring of spawning fish and reproducing invertebrates, which may develop into small fry or larvae and not only find themselves in a closed space surrounded by predators but also without any of the microscopic plankton they need to survive. No wonder that the majority of the taxa kept in public aquaria do not breed successfully in captivity and have to be taken from the wild.

Using animals in talks, shows and touchpools is also a source of health problems. Despite all the precautions that members of staff say they take when they handle animals for visitors to touch, it is sometimes quite obvious that many animals do not like being touched or handled. Often they try to escape or they adopt defensive positions as if they had been attacked by a predator (figure 23).

Figure 23. Spider crab being held upside-down by a member of a UK public aquarium staff for up to six minutes to show to visitors. The crab adopted a defensive position with its legs flexed during all the time, as did all the other crabs that went through the same process.

Sometimes the sheer number of visitors touching the animals have an effect on their health, despite the fact that they might have been touched under supervision. In one public aquarium visited a sign indicating that the touchpool had no starfish was displayed above the touchpool (figure 24). Later on a member of staff explained why, saying that *"we had to move starfish from the touchpool because people kept poking them and they just died"*.

Figure 24. Sign displayed at a UK public aquarium touchpool indicating the absence of starfish. A member of the staff explained later that this was because they ended up dying due to visitors touching them

Evidence of one starfish having lost its arm after been touched by many visitors was found in another public aquarium (figure 25), and crabs loosing their claws for similar reasons were witnessed in another public aquarium –in which visitors really gave very rough treatments to the touchpool inhabitants (figure 67). In fact, a comment on the aquarists reports quoted in the previous chapter does summarise the fate of many touchpool creatures: *"touchpool with a few more hidden places for the crabs, mainly so they survive longer than last year".*

Figure 25. Starfish having lost one of its arms after being handled by visitors of a UK public aquarium

The extreme case of what could be labelled as 'contempt' for a touchpool creature witnessed by the investigator during this study consisted of a terminally ill crab infected with parasites that still had 'to perform' to the public by being taken out of the water by aquarium staff and being shown around despite the obvious swelling of its abdominal area (figure 26). Not only was the staff member aware of its disease and its fatal consequences (she told the visitors about it), but she did not show any particular concern for the crab's wellbeing treating it as any other crab.

Figure 26. Crab infected with parasites taken out of the water by a UK public aquarium staff member to show to visitors despite its terminal illness.

In the other extreme some cases of 'proper animal care' do seem to take place in some public aquaria, such as the rehabilitation and release back to the sea of rescued wild born seals (although only a few centres do this), but sometimes even if the intentions may be good the circumstances of a captive environment do not allow the aquarium to look after the animals properly. For instance, in most cases oral administration of drugs is not suitable as diseased animals loose their appetite, or the calculation of adequate doses is also difficult as the real biomass is frequently unknown (Blanch et al., 1999). Because of the sizes of some exhibits and the number of animals kept it is often difficult to track individuals or to prevent infections from spreading uncontrollably. The truth is that, even with the best of intentions, public aquaria are such complex systems that proper health care may not be possible, which casts doubts on their justification of existence.

However, it seems that such good intentions are not always there. In one case the investigator witnessed a couple of horseshoe crabs that were seen upside-down in a tank trying, unsuccessfully, to turn themselves over –the lack of vegetation in the tank to help the crabs to hold and turn over may have played some role in the unfortunate situation (figure 27). This was witnessed by concerned members of the public who then informed the aquarium staff, who in turn said that somebody would go and promptly help the crabs up. However, they did not do anything, and time passed while the crabs struggled in vain to turn themselves over in what was an obviously distressing situation. By the time the investigator left the centre, two hours and twenty minutes later, nobody had helped the crabs yet, despite the aquarium being aware of the problem and the visitor reactions to it. Either if it was a real disregard for the crabs situation or a genuine memory slip of the keeper that received the visitors' concern, this example does show at least one of the extremes in which 'proper animal care' does not seem applicable to the way some public aquaria operate.

Figure 27. Horseshoe crab upside-down unable to turn itself over struggling for over two hours without any member of the UK public aquarium where it was kept helping it, despite the voiced concerns of visitors that had informed the staff hours earlier.

CONSERVATION IN UK PUBLIC AQUARIA

Many modern zoological collections use the 'conservation' concept to justify their existence. This justification has not only become a common feature in zoos literature, but it also has recently become a legal requirement in the whole of the European Union. The European Zoo Directive (Council Directive 1999/22/EC) states that by April 2002 all member states should have had legislation enacted that ensured that all zoos "*participate in research from which conservation benefits accrue to the species, and/or training in relevant conservation skills, and/or the exchange of information relating to species conservation and/or, when appropriate, captive breeding, repopulation or reintroduction of species into the wild."*

This 'conservation requirement' was incorporated into the UK domestic legislation in 2003 with the enactment of the respective Zoo Licensing Act 1981 (Amendment) Regulations for each of the UK countries, but it already had some legal form in the *Secretary of State's Standards of Modern Zoo Practice*, which were mandatory from the year 2000 –but which had less power than the Act.

Public aquaria, for being officially classed as 'zoos' in the UK, are under this legislation, and therefore they are required by law to perform conservation work. Are there, though, conservation issues regarding fish or aquatic invertebrates, or it is all about giant pandas and sphinx macaws?

Indeed there are, the two most well known being the decimation of the ocean fish species by over-fishing, and the devastation of coral reefs by the aquarium and curio trade.

Fish stocks around the world are being too intensively exploited, and most major fisheries are fully to overexploited. Of the total of 20,000 known species of fish, around 9,000 are routinely fished. Only 22 are taken in amounts over 100,000 tons while five groups make up 50% of global fisheries. These are the herring, cod, jack, redfish and mackerel species (Lean & Hinrichsen 1992).

In 1997, 44% of fisheries were already fully to heavily exploited, 16% were overexploited and 6% were depleted. Only 9% were regarded as under exploited (Botsford *et al.* 1997). Estimates suggest that the global fishing fleet has 30-50% more capacity than needed to sustainably harvest the worlds stocks (Johnson et al., 1998). And the efficiency of fishing methods gives a lot to be desired. It is estimated that 23% of the global fisheries catch is thrown back into the sea dead or wasted (Ross & Isaac, 2004).

Baum et al. (2003) stated that all populations of sharks in the world had declined in the last 8-15 years, some by up to 86%. A staggering 100 million sharks are killed each year. Tuna fisheries, which in the past had high dolphin bycatch levels, are still responsible for the deaths of 1 million sharks. The fisheries with the highest levels of bycatch are shrimp fisheries, in which often over 80% of a catch comprises marine species other than shrimp (Anonymous, 2004i).

The public aquarium industry is not totally detached from the over-fishing of the world's oceans. Some UK public aquaria are run by fishermen that keep some of their bycatch in the aquarium for public display. Some of the most heavily fished species can indeed be found in UK public aquaria, and as seen below most of the public aquaria fish are still wild-caught. Although obviously in terms of numbers the fisheries industry has a much greater impact on the depletion of the population of the commercially harvested ocean species than the public aquarium industry, the latter certainly shares its part of responsibility, and at the very least it should acknowledge the conservation concerns arising from over-fishing. Many do indeed acknowledge these problems (some even seem to support campaigns on them), but surprisingly not all the UK public aquaria investigated seem to.

The other well known conservation issue concerning fish is the devastation of coral reefs around the world because of the private aquarium/curio industry and the public aquarium trade, which tend to be associated with each other in the minds of the general public (Matland, 1995). Currently, 15-30 million tropical marine fish and hundreds of thousands of invertebrates are collected from at least 45 countries around the world (Wood & Dakin, 2003). The proportion of the world's reefs at different levels of risk is estimated to be 27% at high risk, 31% medium risk and 42% at low risk (Bryant et al., 1998). A report on the state of Hawaii reefs published in 1998 concludes that a substantial decline in aquarium key targeted species is taking place. It specified that the decline at the time was of 43% for yellow tangs, 54% for longnose butterflyfish, 48% for Potter's angelfish, 63% for Achilles tangs and 36% for Moorish idols (Clark & Gulko, 1998). The authors blamed such decline mainly on the aquarium trade.

It is estimated that over 95% of marine species for the aquarium trade are collected from the wild. From the 1,000 or so fish species used by marine hobbyists, only about 25 are cultured in sufficient quantities for commercial purposes (Wood & Dakin, 2003). Also, a fast growing section of the aquarium trade caters to the demand for 'minireefs' of living corals, not only for individual collections, but also for commercial and public aquaria (Wells & Hanna, 1992).

About 2,500 fishermen in the Philippines collect fish using the poison *cyanide*, using as much as 150 tones of it annually. The use of *cyanide* began in Philippines in the 1960s, in Indonesia in the 1990s, and in Vietnam and Thailand recently. There is heavy unintentional mortality with this practice (Wood & Dakin, 2003), not only on the species targeted, but on the rest of the inhabitants of the coral reef. Other poisons are also used elsewhere: *Quinacidine* is a chemical used by collectors in Florida, but it is banned elsewhere (Wood & Dakin, 2003).

A considerable amount of wild-caught fish are lost along the line that goes from swimming free in the sea to being kept in a probably small aquarium tank somewhere else in the world. A recent study in Indonesia showed losses between 49-80% in the long journey from the collector to the exporter (Wood & Dakin, 2003). 70% of all reef fish imported into the UK are dead within a year from stress and disease, and 10% die in transit before even reaching their destination. For instance, over half of all butterflyfish die within two months (Wells & Hanna, 1992). There are also animal welfare issues besides death. Most fish are not fed for at least 48 hours prior to packing for export, so their guts are empty and they do not pollute the water in transit (Wood & Dakin, 2003), which must cause unnecessary suffering.

Some may say that all this coral reef devastation has nothing to do with the public aquarium industry, and only with the hobby of keeping fish by private individuals. Although it is probably true that the hobby part of the coral reef fish trade is much bigger than the trade solely for public aquaria, it is certainly not true that public aquaria do not contribute to the decimation of coral reef population at all. As seen above there might be a trend within the UK public aquarium industry to display more exotic animals than in the past (table 5), and as seen below the majority of these are wild-caught coral reef species (table 14). Also, the number of public aquaria in the UK –and probably in Europe– seems to be growing, and in consequence the pressure on wild populations may grow with it.

Not to mention that public aquaria play a role in inducing the general public to acquire their own tanks and join the hobby that is the main cause of the problem. Indirectly, public aquaria are a major promotion for keeping fish as pets and thus there may be an implied mandate for public education on public aquaria about issues related to this (Marliave et al, 1995). However, during this investigation hardly ever any comment was seen to discourage the hobby of keeping fish, nor even the most difficult species to keep in captivity. It has been initiatives in some public aquaria in the world to display advisory logos for pet trade fish in public aquaria (Marliave et al, 1995b), but they do not seem to have caught on, in particular in the UK. Also, even the advances on fish husbandry that may take place through public aquaria 'research' may benefit the aquarium hobby, which will use those advances to grow in its scope and size.

It is not only the fact that both hobby and public aquaria often keep the same animals. Marine souvenirs are still being sold in gift shops of European zoos and aquaria, including corals, shells, dried starfish and seahorses. Ironically, it seems that as a direct response to these increased concerns about the trade, dealers are beginning to promote 'eco-friendliness' of their stock by putting on labels, many of which may be misleading (Hall, 2002)

If the husbandry techniques are similar, the types of animals kept are similar, the sources of the animals are similar, the approach to captive fish and its animal welfare and conservation implications is similar, and the promotion of each other's businesses is mutual, it is not surprising that in many people's minds there is no distinction between the private aquarium industry and the public aquarium industry. Although there are obvious differences in scope and impact, both industries do contribute to pressure on the wild populations of tropical fish in the world, and therefore they both have a responsibility to get involved in serious marine conservation. How seriously UK public aquaria take conservation is something this study set out to discover. The outcome of this assessment will be revealed throughout this chapter.

Threatened taxa kept in UK public aquaria

The most common way zoological collections get involved with conservation is by claiming they breed endangered species with the potential intention to reintroduce them into their natural habitat some time in the future (which is known as *ex situ* conservation). Although previous studies have shown that for the majority of UK zoological collections this is more of a claim than a reality (Casamitjana & Turner, 2001), *ex situ* conservation remains the most common way zoological collections choose to justify their work –and up to a point their existence.

The World Conservation Union (IUCN) is the international organisation that determines the degree of threat each of the worlds species is under. It produces regular 'red lists' (these days updated online) in which species are classed in the following categories (Anonymous, 2004b):

EXTINCT (EX)
A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW)
A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range.

CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an **extremely high risk** of extinction in the wild.

ENDANGERED (EN)
A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a **very high risk** of extinction in the wild.

VULNERABLE (VU)
A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a **high risk** of extinction in the wild.

NEAR THREATENED (NT)
A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN/LOWER RISK (LC/LR)
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

As can be seen in figure 28, only 1.8% of the individuals kept in UK public aquaria belong to taxa threatened with extinction according the IUCN classification system (Threatened = CR or EN or VU). This means that a staggering 98.2% (n=16,283) of the animals kept in UK public aquaria are not classed as threatened at all (92% are not even listed in the IUCN red list in any way). Looking at specific categories only 0.2% of the taxa are classified as Endangered or Critically Endangered, and only 0.006% as Critically Endangered. There are no cases of Extinct in the wild taxa in the sample of UK public aquaria investigated (although there are claims that some other UK public aquaria may be keeping some of these).

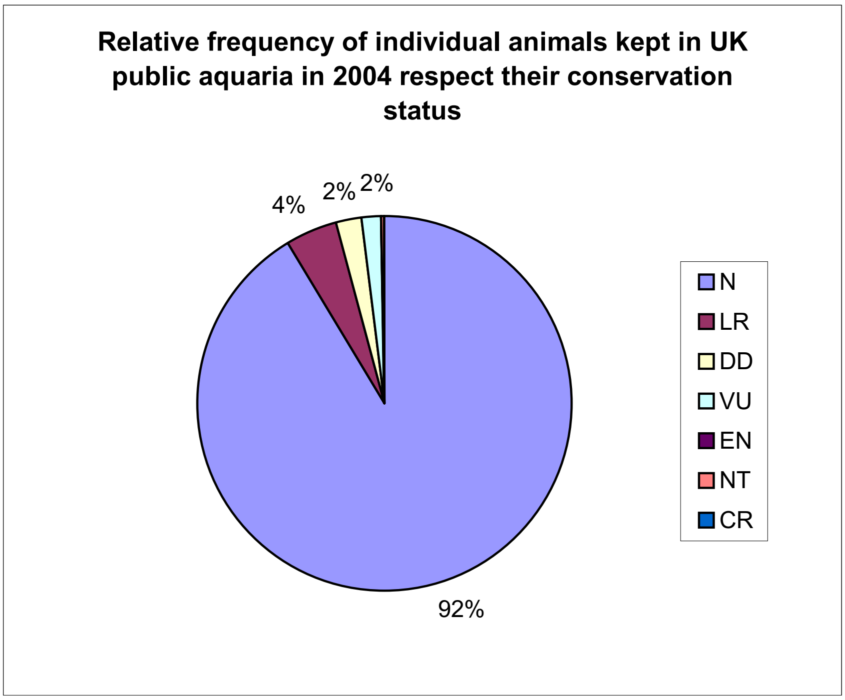

Figure 28. Relative frequency of individual animals estimated to be kept in UK public aquaria in 2004 respect their conservation status. N= not listed in the IUCN red list, LR= Lower risk, DD= Deficient data, VU= Vulnerable, EN= Endangered, NT= Near threatened, CR= Critically endangered). N=16,283.

61% (n=31) of the UK public aquaria do not keep any Endangered or Critically Endangered taxa, and none of the Auxiliary aquaria do (as expected).

This data confirms the lack of role of UK public aquaria in *ex situ* conservation through captive breeding of threatened species (regardless of whether or not such a role is a valid conservation strategy). If we only look at taxa (not individual animals), then the percentage of threatened taxa in UK public aquaria is 3.2% (n=781). In comparison with a similar study made in 2000 (Casamitjana & Turner, 2001) this value for all types of UK zoological collections was 5%. In this respect, then UK public aquaria perform worse than the average UK zoological collection.

It could be said, though, that one of the reasons that there are not many threatened taxa in UK public aquaria is that in fact there are not many threatened taxa of fish and aquatic invertebrates in the world in general, or in Europe in particular. This does not seem to be the case, since the most current (IUCN) red list of threatened taxa (Anonymous, 2004b) shows 1,532 fish taxa listed, 750 of which are threatened with extinction (table 11). Regarding taxa naturally found in UK territory, there are 18 taxa of fish listed as threatened in the IUCN red list, eight freshwater taxa (allis shad, twaite shad, vendance, lavaret, hounting, river lamprey, smelt and common sturgeon, the latter being the only critically endangered) and 10 marine (Atlantic cod, haddock, red porgy, Atlantic halibut, deep water spiny dogfish, basking shark, common skate, school shark, devil fish and angel shark). Therefore, that data shows that 97.2% (n=750) of the all recognised threatened fish in the world (excluding all threatened species still to discovered or evaluated), are not displayed in any of the UK public aquaria, and 72% of the taxa of fish threatened in UK territory are not displayed in any UK public aquaria.

Class	**EX**	**EW**	**Subtotal**	**CR**	**EN**	**VU**	**Subtotal**	**LR**	**NT**	**DD**	**LC**	**Total**
CEPHALASPIDOMORPHI	1	0	**1**	0	1	2	**3**	0	5	3	1	**13**
ELASMOBRANCHII	0	0	**0**	8	17	32	**57**	1	64	63	74	**259**
HOLOCEPHALI	0	0	**0**	0	0	0	**0**	0	0	1	3	**4**
ACTINOPTERYGII	79	11	**90**	153	126	410	**689**	12	96	270	98	**1255**
SARCOPTERYGII	0	0	**0**	1	0	0	**1**	0	0	0	0	**1**

Table 11. Number of fish taxa threatened with extinction per IUCN red list categories, and divided per the major taxonomic groups of fish (rows). LR/LC= Lower risk, DD= Deficient data, VU= Vulnerable, EN= Endangered, NT= Near threatened, CR= Critically endangered, EW= Extinct in the wild, EX= Extinct.

Animals in UK public aquaria as part of co-ordinated captive breeding programmes

If an endangered species is kept in a public aquarium but does not breed, or is bred in an uncontrolled way that may generate genetically inadequate/unnatural individuals, it is difficult to justify their presence in the collection in the name of conservation. A collection of breeding individuals is not a breeding programme itself. A 'programme' has to have a purpose beyond the perpetuation of the captive stock. Nobody uses the term 'sheep breeding programme' or 'budgerigar breeding programme' to describe the activities of farmers or commercial pet breeders. Also, the explanation that such 'programmes' are genuine conservation initiatives because they help public aquaria to take less fish from the wild, and therefore they help to reduce the pressure they themselves inflict upon wild populations (public aquaria do not 'have to' keep those species, so the sensible way to stop the pressure is to stop keeping them altogether) is such a ridiculously circular argument as claiming that growing your own vegetables is a form of law enforcement because it prevents people from stealing food.

Despite all this, the word 'programme' does tend to be added to any breeding taking place within zoological collections, and this is because this word has been borrowed –or should we say stolen –from internationally co-ordinated conservation breeding programmes that have as a main aim to prevent threatened species from going extinct.

In Europe there are two ways to participate in official co-ordinated conservation captive breeding programmes: to be part of an 'European Endangered Species Programme' (EEP) or to be part of the 'European StudBook' (ESB). Regional collection plans of the Taxon Advisory Group (TAG) of a particular taxon (which are a group of experts that discuss issues specifically related to particular taxa), identify which type of programme should be assigned to which species. The European Association of Zoos and Aquaria (EAZA) is the zoo umbrella organisation that organises all these groups and programmes, and at present runs programmes for 250 species.

The EEP is the most intensive type of population management for a species kept in a zoo or aquarium. Each EEP has a co-ordinator, who among other tasks produces a studbook and, together with the Species Committee, recommends which animals should breed or not breed, or which individual animals should go from one collection to another (Anonymous, 2003a).

The ESB is less intensive than the EEP programme, and the studbook keeper responsible for a certain ESB collects all the data on births, deaths, transfers etc. from all the collections of the programme that keep the species in question. By collecting and analysing all the relevant information on the species, the studbook keeper can judge if a more rigid management is needed to maintain a healthy population over the long term.

At the time of publication there are not any taxon of fish or aquatic invertebrate that belong to either a EEP or a ESB because the European Fish and Aquatic Invertebrate TAG has not established any yet (Anonymous, 2003a).

As seen in table 12, from all taxa found in the sample of 31 aquaria (779), only one belongs to an EEP or ESB (Humboldt penguin belonging to an EEP). This means that a staggering 99.9% of the taxa kept in UK public aquaria are not part of any co-ordinated conservation European captive breeding programme, although some public aquaria may be involved in breeding some of their stock with conservation ideas in mind.

Participation in European Captive Breeding Programmes (ECBP)	taxa	%
EEP	1	0.1%
ESB	0	0.0%
Not part of any ECBP	778	99.9%

Table 12. Percentage of taxa kept in UK public aquaria that are part or not of European Captive Breeding Programmes (ECBP). See text for definitions.

It could be said, though, that for some unlikely reason the fish in UK public aquaria are not part of European captive breeding programmes, but of American ones, but this does not seem to be the case because the American Zoo and Aquarium Association's (AZA's) Species Survival Plan Program (SSP), which would be the equivalent of the EEP, does not have any programme for fish or aquatic invertebrates either (Anonymous, 2004e).

The fact that none of the UK public aquaria studied displayed any fish taxa that is part of European Captive Breeding Programmes does not seem to be because of a general lack of interest by the conservation community as a whole (as opposed to only public aquarists) on the problems of fish populations. The conservation of fish has been taken seriously –at least recently– by IUCN, which has created several fish specialists groups (Caribbean Fish SG, Coral Reef SG, Grouper & Wrasse SG, Salmon SG, Shark SG and Sturgeon SG). Also, both in Europe and in the UK Fish and Aquatic Invertebrates Taxon Advisory Groups (FAITAG) have been created and overseen by the European Union of Aquarium Curators (EUAC, reporting to the European Association of Zoos and Aquaria, EAZA) and the Federation of Zoological Gardens of Great Britain and Ireland respectively. The existence of other groups like the Mexican Livebearers Conservation Group, the British Killifish Association, the British Cichlid Association or the Project Seahorse indicate that concerns have been raised and initiatives have been taken in relation to fish conservation in the UK. However, these initiatives do not seem to have conduced to the creation of official EEPs or ESBs, and do not seem to have been lead by the public aquarium industry itself, but by individual zoos or private keepers/breeders instead.

Nevertheless, in UK public aquaria in recent years a particular group of fish has emerged which seems to capitalise the conservation efforts of the industry, or at the very least the perception of it. Seahorses are regularly seen in modern UK public aquaria in the context of captive breeding and conservation. Their case deserves special attention and it will be dealt at the end of the chapter below.

Reintroduction of animals into the wild by UK public aquaria

As said above, typical zoos claim they conserve species by breeding them and increasing their numbers in captivity, in the hope that one day the animals or their descendants will be reintroduced into the wild and restock depleted wild populations. Have UK public aquaria ever reintroduced threatened taxa into the wild as part of a captive-breeding programme? As seen above, there is only one taxon (Humbolt penguin) kept in the sampled UK public aquaria that is classed as threatened and part of a European co-ordinated captive breeding programme (ECBP). However, Humbolt penguins never seem to have been reintroduced into the wild. Although it is possible that other taxa part of ECBP are present in the remaining half of the UK public aquaria population, in any event the actual percentage of conservation re-introductions is bound to be still very close to nil.

The term' saving' is not uncommonly heard in zoological collections in relation to threatened species. In fact, 'saving' a threatened species means permanently preventing its extinction by properly protecting the wild individuals of such species on a long term basis and, if there is a captive population breeding in a conservation minded way, successfully releasing all its individuals into the wild (with no risk to wild populations or ecosystems) where they breed and carry out a natural existence. With this as the understanding, it would appear that describing UK public aquaria as institutions that regularly 'save' threatened species is totally wrong.

However, the term 'reintroduction' has a different connotation from an attempt to save a species from extinction. When a captive animal is 'returned' to the wild, if it ends up in a wild area where there never has been natural occurrences of the population the animal belongs to, the process is know as 'introduction', whilst if the wild area contained individuals of the same population in the past but not at the time when the release occurs, then the process is also known as 'reintroduction'. The latter only can be considered 'conservation reintroduction' if it has been performed under conservation criteria and co-ordinated/monitored under strict guidelines. Otherwise, these release cases, together with the 'introduction' ones, are more akin to the concept 'dumping' than 'releasing/reintroducing', since often the motivation and methods behind them are very similar to the ones of people who dispose of rubbish or unwanted objects/substances.

The IUCN guidelines for reintroduction clearly state that the availability of surplus stock is not a reason to release animals into the wild. Many of the common species of shark kept in aquaria, for instance, have been released into the wild, including Caribbean reef, lemon, nurse, sandbar, sand tiger, silky and sevengill sharks and dogfish. The reason behind the release may be that the animal has outgrown a facility, or is surplus to requirements (Hall, 2003). There is only one documented report of shark release (sandbar shark, in captivity for a year at the National aquarium in Baltimore) as part of a co-ordinated conservation programme (Hennings et al, 1996), although other authors would not recognise this case as looking to improve the state of the species in the wild.

A particular account of the release of 'Ursula', a pacific giant octopus kept in Seattle Aquarium for 22 months, illustrates the approach of some of these types of releases. One of the representatives of the aquarium wrote:

> *"Although animals up to 29 Kg in weight have been kept in the tank with no indication of ill health, if an octopus larger than about 18 Kg is kept there the public begins to see it as ' a large animal in a small tank', and we may get letters of complaint (…) Ursula was released on 12 May 1993 because her large size."* (Anderson, 1995).

Some recent examples made public of UK public aquaria releasing animals to the wild are a large turbot kept for four/five years which was 'evicted' from a public aquarium after attacking the aquarium divers, the case of 16 rays released into the sea in which one had to be returned to the public aquarium because 'it kept coming back', the case when a common frog returned to breed at the public aquarium where it was born almost a year after being released into a pond a quarter of a mile away, or the very recent case of the release of a large conger eel for having begun its reproductive phase after five years in captivity.

There are many reasons for considering that non-conservation releases not only are not recommended, but indeed can be very bad for the environment and/or the individuals involved. For instance, the animals may have lost the ability to look after themselves in the wild and soon perish after release, they can expose the wild community to exotic parasites or exotic genetic material, reintroduced individuals that had antibiotic treatment may be carriers of resistant strains of pathogens, or any reintroduced animal that is recaptured for human consumption may represent a health risk if it was given a chemico-therapeutic agent when in captivity (Smith & Crow, 2000) – which is a very common practice as can be seen in the animal health chapter above.

Because in the UK there is no specific legislation controlling release of native species (although the release of non-native animals is banned by section 14 of the Wildlife and Countryside Act 1981) some may say that public aquaria that regularly release fish back to the sea may be damaging the environment and its inhabitants in complete impunity. However, since public aquaria in the UK require a zoo licence, they have to follow the regulations stipulated in the *Secretary of State's Standards of Modern Zoo Practice* (SSSMZP, mandatory since the year 2001) which do address animal releases with the following points in its Appendix 5:

4.7 The guidelines of the Reintroduction Specialist Group of the Species Survival Commission of the World Conservation Union (IUCN) should be followed when considering or undertaking the release of animals into the wild. Consideration should also be given to using other recognised guidelines such as those of the British Wildlife Rehabilitation Council.

4.8 Animals intended for release present special challenges in comparison with those staying in the zoo. For example, health care may need to be different and exposure to stressors may be necessary, as care and facilities in recipient country may fall below standard in the UK. Zoos involved in release programmes should make every effort to conform as closely as possible to the IUCN standards and reconcile these as far as possible with the legitimate needs of the project. Particular attention should be paid to the suitability of any temporary care facilities.

Therefore, a UK public aquarium that releases animals back to the wild for non conservation reasons and not following the IUCN guidelines (which only authorise releases for conservation reasons) is effectively in breach of the *Secretary of State Standard's of Modern Zoo Practice*, and in consequence should loose its zoo licence and close to the public. It would be a matter for the local authority to enforce this.

Despite having already established that there are no current 'conservation reintroductions' in UK public aquaria, it is possible that 'introductions' or otherwise other non-conservation 'releases' take place regularly throughout the UK. During this investigation the question of whether or not each public aquarium ever releases animals back to the wild was asked to aquarium staff every time that opportunity arose. The answer of this question was also sometimes available in either the collection signs/literature or in news articles (figure 29). From all the 31 collections investigated an answer to the question was found for the majority (61%), and it was video recorded when given by an aquarium staff member. The remaining cases were mainly collections where no available staff was found to ask the questions at the time of the visit and no information about it was found elsewhere. The results of the analysis of the answers show that the majority of the public aquaria asked (74%, n=19) responded that they do indeed release animals back to the wild (mostly back to the sea). In two of the answers the keepers said that no releases take place, but that was in contradiction to published articles or the aquarium literature that indicated otherwise, so in those particular cases it was considered that releases took place despite the keepers' answer. As far as the remaining cases are concerned, the staff answers were taken at face value (since there was not any particular reason they would lie on that particular subject to a visitor).

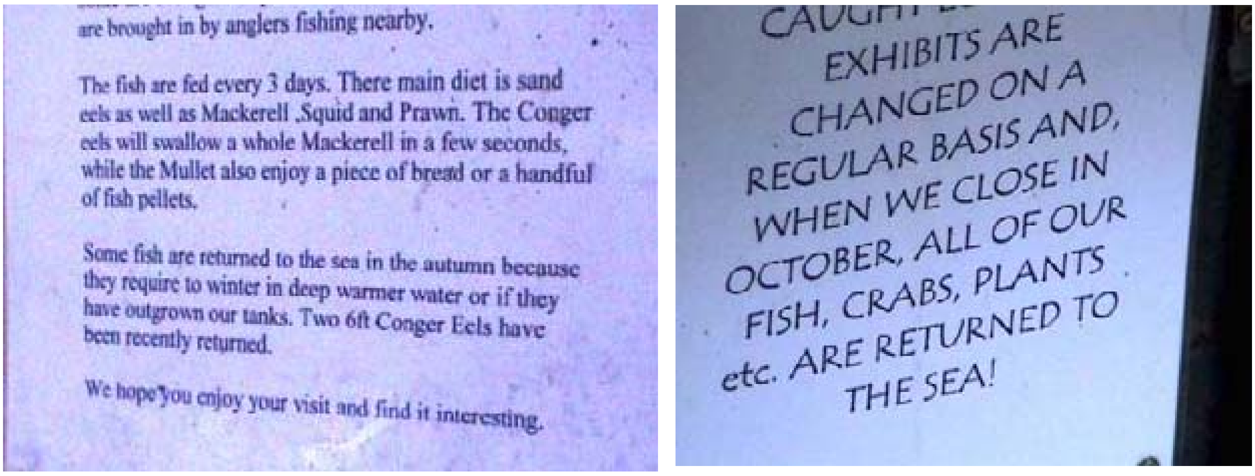

Figure 29. Two signs displayed in two different UK public aquaria indicating that non-conservation releases of animals back to the wild take place regularly.

Analysing the answers per type of public aquarium, table 13 shows the 'release' problem seems to take place in all types of public aquaria except 'Auxiliary', although the most cases where staff members denied that sea 'releases' take place –and no evidence was found to contradict them– were in 'Chain' public aquaria asked.

Type PA	Release back to wild	%	DO NOT Release back to wild	%
CHPA	6	60%	4	40%
BIPA	4	100%	0	0%
SIPA	4	100%	0	0%
APA	0	0%	1	100%
Total PA asked	13		6	

Table 13. Frequency of UK public aquaria that release or do not release animals back to the wild per type of public aquarium. Columns two and four have the number of cases in which this was known from the ones the issues was asked to members of the aquarium staff. PA= Public aquaria, CHIPA= Chain Public Aquaria, BIPA= Big Independent Public Aquaria, SIPA= Small Independent Public Aquaria, APA= Auxiliary Public Aquaria.

It is interesting to notice that several public aquarium staff that said they did not release fish to the sea gave as a reason that it was an 'illegal' practice in the UK (showing their awareness of the SSSMZP), while a few hundred miles down the road other public aquarium staff member in other centres would said they would release back to the sea most of their fish at the end of the tourist season –and as seen above on some occasions, this information was even available in the signs (figure 29).

These results mean that, at the very least, 45% of the UK public aquaria release animals back into the wild for reasons other than conservation (some on a regular basis), and in consequence it can be said that the UK public aquarium industry may be damaging the environment and its inhabitants considerably due to this irresponsible practice –and may be doing it against the law.

Wild-caught animals in UK public aquaria

One of the characteristics of modern zoological collections is the claim that they do not contribute to the decimation of wild populations anymore because they now mostly keep captive-born animals. Zoos tend to sell the image of institutions that return animals back into the wild (or somehow save them from extinction so someone in the future can return them back into the wild), as opposed to taking animals from the wild. Public aquaria, then, by being officially defined as a zoological collection operating under the same laws and regulations as any zoo, and for being part of the scope of zoo umbrella organisations and their rules, should also have a 'captive born' policy. For instance, the European Federation of Zoos and Aquaria (EAZA) Code of Practice states:

"All members will endeavour to ensure that animals acquired are born in captivity. This is best achieved by direct zoo to zoo contact, but does not preclude the receipt of animals resulting from confiscation or rescues."

However, this does not happen in public aquaria, where many still tend to acquire their stock from the wild or purchase it from dealers (Wetzer & O'Brian, 1995), which perhaps explains why none of the UK public aquaria belongs to either EAZA or the Federation of Zoological Gardens of Great Britain and Ireland.

In order to estimate the percentage of individuals kept in UK public aquaria that are wild-caught two different kinds of estimations were made. Firstly, estimating the number of individuals of each taxon present in each public aquarium. The amount of individual animals present, as opposed to the animals seen during the investigation, was estimated by assuming that there was at least one individual per each taxon not seen which had a public sign on display (unless it was an starfish, sea urchin or anemone in which 10 individuals were assumed). Also, when the number of individuals in one tank or the whole collection was known through other sources (printed material, website or information from keepers) the estimated number of individual animals values were adjusted accordingly from the visible animals. The amount of total animals estimated to be present was 16,283. It is likely that this method underestimates the number of individuals present, in particular in big aquaria where many individuals can hide and adding only one individual per taxon seems likely to fall short, but this should not affect the results since both captive born and wild born individuals should in theory be as likely to be missed (although in practice, due to the fact that many big tanks contained tropical reef fish, most of which have never been bred in captivity, more wild-caught animals could be missed, which would reinforce any result that concludes that the percentage of wild-caught animals is high).

The second estimation to be made was, for each individual estimated to be present in each public aquarium, its wild-caught or captive-bred origin. This estimation was made through the following procedure:

- Asking questions of aquarium keepers about the origin of the animals or reading the collection signs or literature (which sometimes do mention it)

- If no information about the origin of all individuals in a particular collection was obtained with the method described in the point above, for the animals where the origin is not yet known make the following assumptions:

  - Animals that, through bibliographic research, belong to taxa not known to ever being successfully bred in captivity were assumed wild-caught

  - Animals that, through bibliographic research, belong to taxa which on very few occasions it has been reported successful breeding in captivity were assumed wild-caught if no information of their breeding was found in the collection literature (zoological collections tend to publicise the fact they have managed to breed a species almost impossible to breed).

  - Animals that were considered to be easily obtainable as normal by-catch of the local fishery industry, difficult to breed when kept on display (i.e. fry predation due to the keeping of other fish), and that no evidence of organised breeding of any member of their taxon was seen in any public aquarium, were assumed wild-caught.

  - Animals that were considered older than the first time that members of their taxon were reported successfully bred in captivity were assumed wild-caught.

  - Animals from taxa that were seen in nurseries of breeding sections of some chain public aquaria were assumed captive-born for all the public aquaria of the same chain

  - Animals that, through bibliographic research, belong to taxa which are reported to be usually bred either in the public aquarium industry or the pet trade industry were assumed captive-born

  - Animals that, through bibliographic research, their breeding appears to be possible although not common were assumed captive-born if evidence of members of their taxa have been ever bred in any UK public aquaria had been found

  - Animals that belong to taxa that are bred in UK aquaculture farms were assumed captive-born

  - Animals that belong to taxa which is commercially bred in the UK for the pet/garden trade were assumed captive-born

  - All animals belonging to all seahorse, Cichlid, and Cyprinodont taxa were assumed captive-born if no specific information of their wild-caught origin was found

  - All animals belonging to terrestrial taxa were assumed captive-born if no specific information of their wild-caught origin was found

Using the method above, it is estimated that the majority of animals kept in UK public aquaria are wild-caught. Indeed, the analysis of the data shows that 79% of the estimated animals present in UK public aquaria in spring 2004 were wild-caught in origin (n= 16,283).

Table 14 shows an estimation of the origin of animals kept in UK public aquaria in 2004, per public aquarium. It is estimated that in 45% (n=31) of the UK public aquaria 90% or more of their individual animals are of wild-caught origin, while in 87% of the UK public aquaria half or more of their animals are wild-caught. In fact, no collection keeps less than 20% wild-caught animals, and 16% of the public aquaria has only wild-caught animals. Only one public aquarium (3%) from the sample was seen keeping more than 200 fish and having the majority of them captive born. This is clearly in contrast with the common 'zoo' claim that most of the animals of modern zoological collections are captive born, setting public aquaria clearly apart from other collections in this respect, which could explain why they do not belong to any zoo federation.

CODE	captive bred	wild-caught	total	% wild caught
A-FOW04	0	261	261	100%
A-LYM16	0	212	212	100%
A-OCE56	0	152	152	100%
A-SEA32	0	94	94	100%
A-BRI02	0	17	17	100%
A-ABE52	3	217	220	99%
A-ISL24	2	63	65	97%
A-THE23	27	692	719	96%
A-MAR50	5	110	115	96%
A-FOR25	10	167	177	94%
A-SEA11	6	89	95	94%
A-BLU06	145	1696	1841	92%
A-MAC44	75	733	808	91%
A-BLA26	52	448	500	90%
A-SCO45	112	639	751	85%
A-SEA20	102	534	636	84%
A-AQU08	170	878	1048	84%
A-UND18	253	1271	1524	83%
A-SEA53	73	338	411	82%
A-SEA33	134	421	555	76%
A-NAT41	224	697	921	76%
A-BLU03	412	1009	1421	71%
A-SEA01	126	290	416	70%
A-STA49	148	291	439	66%
A-DEE48	274	534	808	66%
A-SEA17	159	308	467	66%
A-SEA27	462	642	1104	58%
A-MAT58	9	8	17	47%
A-NAT47	31	12	43	28%
A-MAT10	142	52	194	27%
A-BOL21	193	59	252	23%

Table 14. Frequency of wild-caught and captive-bred individual animals estimated to be kept in each of the UK public aquaria investigated (first column). Last column shows the relative frequency of wild-caught individuals

Wood & Dakin (2003) stated that well over 95% of marine aquarium specimens are collected from the wild for the marine hobbyist trade, and this was a cause of concern. The percentage of marine UK public aquarium specimens estimated to be wild born is 89% (n= 13,601), only 6% better than the commercial marine aquarium pet trade, while in theory, as any modern zoological collection, they should only keep captive born specimens. However, counting both marine and freshwater species 29% of the UK public aquaria perform worse than the marine pet trade with respect to this issue with higher percentages than 95%. Other studies have reported that 98% of marine fishes and invertebrates exhibited in the world's public aquaria are removed from the wild (Thoney et al., 2003). With these figures it is difficult to believe that the UK public aquaria does not contribute in any way to the decimation of species from the wild.

It is interesting to notice the fact that although no UK public aquarium belongs to UK or European zoo federations, and therefore they do not need to adhere to their code of practices and regulations, UK public aquaria are not considered in any way different from a zoo from the legal point of view. The Zoo *Licensing Act 1981* and the *Secretary of State's Standards of Modern Zoo Practice* are applicable to any public aquarium as well as to any traditional zoo, and most UK public aquaria are indeed licensed under such legislation. However, this legislation, and the European Zoo Directive behind it, is very much based on the standards of 'zoos', among them the conservation and 'captive born' policy. How can UK public aquaria not adhere to such standards, and the local authorities still keep giving them zoo licences? Perhaps because up to now there was no knowledge about the extent to which public aquaria are not adhering to those standards.

Why, then, do public aquaria operate mainly with wild-caught individuals? A likely explanation is that public aquaria are profit-making businesses, not conservation charities, and therefore they would choose the most profitable option. In this case, capturing animals from the sea, especially if they are animals from local seas, is a much cheaper method than having to buy captive born individuals and transport them to the aquarium (which are more expensive since the rearing costs have to be added). Also, it is more convenient taking animals from the sea every time that replacements are needed rather than finding the suitable offer in the 'aquarium fish market', since the Wildlife & Countryside Act 1981 does not prohibit the taking of fish from the wild (with the exception of the most endangered species).

A survey on US accredited public aquaria in 1996 gave an insight to some of the sources used to acquire animals. In the study 74% of the surveyed public aquaria stated that they collected specimens from the wild themselves, and the most common method of acquiring animals was through 'cash and carry' sources (like local wholesales or retail pet stores). Regarding the use of dealers, over 70% of the responding aquaria indicated that not only did they not use a formal dealer review process but that they were not planning doing so in the future (Hemdal, 1998).

Many wild-caught individuals, also, are donated free of charge to aquaria because they are by-catches of the fishing industry. Many tropical fish that are 'crowd-pullers', such as reef fish and sharks, have not been bred successfully in captivity yet (the spiny larva forms of tangs, for example, spend a long time in the plankton, and this is why they probably will never be raised in captivity), so if the public aquarium industry wants to keep displaying them they have no other choice other than to take them from the wild. For such cases, public aquaria have developed 'systems' that prevent them from being outright accused of contributing to the decimation of wild populations, such as the Marine Aquaria Council Certification System which is supposed to show that the wild caught individuals come from sustainable sources. The truth is that there is not such a thing as a sustainable reef, since all tropical reefs are threatened.

Regardless of whether or not a taxa is threatened or coming from a supposedly 'sustainable' source, taking animals from the wild is bound to have a negative effect on the wild populations, even if it is very localised and small –independent of the animal welfare damage that the capture and loss of life in the wild would inevitably produce to the individuals involved. In some cases, though, the effect could be quite noticeable. For instance, in 2002 there were about 30 sand tiger (=Grey Nurse) Sharks in commercial aquaria in Australia, and despite being part of a so called 'captive breeding programme' only six pups had been born in captivity. However, the Australian Environment Protection and Biodiversity Conservation Act 1999 listed this shark as Critically Endangered on the East Coast of Australia and as Vulnerable on the West Coast. As a consequence there were serious concerns that with the sand tiger shark populations at such low numbers it was going to be unsustainable for the species to be taken from the wild for public aquaria anymore, which lead the Department of Environment to recommend the end of any capture for exhibition in public aquaria (Anonymous, 2002c).

Close to home we only have to look at the data of this study to notice that among the specimens estimated to be wild-caught are threatened taxa such as cod, haddock, skate and halibut. Certainly their removal from the wild to be exhibited in UK public aquaria would not help their conservation status.

Some may say that removing fish from the wild to supply public aquaria is more accidental than intentional these days, since the recognition of conservation issues has made the public aquarium industry move away from those days when 'the competitive edge' was catching at any cost the rarest or biggest fish before the competition did it first. However, this ruthless 'freak show' mentality is still very present in public aquaria today. For instance, despite the outrage of animal protection groups and shark conservation organisations, at present there is a world race to see which public aquarium first manages to catch and keep successfully a Great White Shark, the infamous 'Jaws'. From 1955 to today there have been 19 attempts to keep great whites, all ending tragically. From 1968 to 1994, 15 attempts took place, but the maximum any shark survived in captivity was 16 days. From 1976 to 1980 Sea World in San Diego (USA) tried to get some but none survive the trip to the aquarium. In 2000 a great white captured by fishermen was released after three days, and in 2003 another great white accidentally caught almost ended up in Monterey Bay Aquarium, although it was released after five or six days (Hewitt, 1984; Ellis & McCosker, 1991; Reidarson & McBain, 1994; Powell, 2001; Mullet, 2003).

Another example is the keeping of whale sharks –the biggest fish in the world– in a Japanese public aquarium, which prompted American aquaria to try to get some for themselves. Recently, when Georgia Aquarium, to open in 2005, offered to capture and 'buy' a wild whale shark from the Belize Whale Shark Sanctuary, it was received with indignation by the international community –among them the Shark Research Institute– which apparently lead to the withdrawal of the offer. The numbers of whale sharks are diminishing world-wide, and at a very rapid pace (83% within an eight-year period along the east African coast alone). Nevertheless, between 1980 and 1998, the Okinawa Churaumi Aquarium kept 16 whale sharks in captivity (all were captured locally) with survival times from three days to 6 years, despite the lifespan of a whale shark in the wild being in excess of a century. Thirteen of the sharks died in captivity, and of those, seven were damaged during capture and survived less than two months (Anonymous, 2004f).

This 'thirst' for rarities is not confined to public aquaria abroad. UK public aquaria that publicise their 'rarities' are not difficult to find, and almost inevitably such unusual species were all wild-caught. For instance, sawfish, green turtles, arapaima fish, sea dragons or ocean sun fish are all unusual and uncommon species kept in UK public aquaria whose exceptionality is used to attract visitors.

***In situ* conservation in UK public aquaria**

In terms of fish conservation, captive breeding (also known as *ex situ* conservation) can only be regarded as a short-term emergency measure because various genetic and behavioural problems are likely to arise if small numbers of animals are kept in captivity over several generations or more. For this reason it has been said that it should ideally be restricted to just one generation from wild stock (Matland, 1995), although it is perfectly arguable that for animal welfare reasons it should not be attempted at all.

The conservation of fish species is often much more difficult than that of many other groups of animals. In the long term, habitat restoration, management and protection are the principal means through which successful fish conservation will be achieved (Mailand, 1995). All these strategies constitute what is known as *in situ* conservation, since they take place in the same area where the species involved naturally live.

Legal protection of species and/or ecosystems is an integral part of *in situ* conservation. International legislation like CITES deals with the world trade of endangered species, and the Berne Convention in 1979 and the Bonn Convention in 1983 set up the basis for the conservation of European fauna and migratory species respectively. In Europe the EC Habitats & Species Directive (92/43/EEC) gives protection to natural habitats and wild fauna and flora. In the UK the Wildlife & Countryside Act 1981 gives protection to British wildlife present in the UK mainland and out to 12 nautical miles. Although it gives protection to all birds and cetaceans, in its schedule five it gives special protection to several fish, such as burbot, vendace and whipefish (since 1981), twaid shad, giant goby, couch's goby and basking sharks (since 1998). The Act also gives provision to designate Sites of Scientific Interest (SSSI) or National Marine Reserves, in compliance with the European Directive that defines the creation of Special Areas of Conservation.

The Biodiversity Strategy Group of the UK Biodiversity Partnership (which replaced the UK Biodiversity Group in 2002) has designed the strategies –which are called Biodiversity Action Plans ,BAP– to protect the most endangered taxa in the UK, including fish. None of the BAP for any fish or aquatic invertebrate have captive breeding as part of their strategy. Instead, one of the most common strategies is the protection of specific habitats –such as tidal rapids, deep water coral reefs or sublitoral sands and gravels –or the careful controlled translocations of stock from one place to another (Matland & Lyle, 1991, 1992).

During this study no evidence of *in situ* conservation activities run by the public aquaria visited aimed directly to protect threatened species of British fish and aquatic invertebrates was found, although information about these species, their conservation status and actions from other organisations was sometimes available. Despite this, 61% of the UK public aquaria use the 'conservation' term in their publicity and/or displays, and in 35% 'conservation' features predominantly (mainly *ex situ* conservation).

However, another way to participate indirectly in *in situ* conservation is by supporting other organisations that do this sort of work. Although it is difficult to ascertain to what extent UK public aquaria help other organisations, on many occasions some sort of collaboration with other organisations, whatever minimal, seems to exist. One of the most common ways the UK public aquaria seem to collaborate with conservation organisations is by having leaflets, posters or displays of such organisations available for the public aquarium visitors (5% of the UK public aquaria have special displays from conservation organisations, 19% have leaflets from them, and 26% have posters). These often include petitions for several campaigns the visiting public can sign.

The conservation/environment organisations that have been found advertised in one way or another (regardless of whether these organisations are aware of it) in the sample of UK public aquaria investigated are (in bold the most common):

British Divers Marine Life Rescue
Campaign Whale
Dorset Wildlife Trust
Environment Agency
Galapagos Conservation Trust
Greenpeace
Hebridean Whale and Dolphin Trust
International Fund for Animal Welfare
Lake District Tourism and Conservation Partnership
Marine Conservation Society (MCS)
Project Seahorse
Sea Turtle Protection Society
The Shark Trust
The Wildlife Trust
Wateraid
Whale and Dolphin Conservation Society (WDCS)

The Sealife Centre chain, the biggest chain public aquarium in the UK, has a conservation sister organisation called *Sealife S.O.S. Conservation & Rescue Programmes* that seems to regularly participate in annual campaigns on a variety of subjects (from whale conservation to protection of sharks or turtles), and also seems to collaborate with projects of other groups in the UK and abroad. However, it is difficult to ascertain whether the relationships are ongoing, involve only economic support and how much, which is the most beneficiary of the relationship, or whether the collaboration only took place on specific events already in the past and it was very symbolic. Also, the fact that the same organisation works for conservation and animal welfare issues ('rescuing') makes it more difficult to assess its purely *in situ* conservation contribution.

The lack of publicity on joint projects between public aquaria and the organisations that they seem to have some sort of relationship with, and the absence of current press news that would reflect on a full ongoing relationship had that been the case, may be indicative that such relationships could be quite minimal and/or superficial, and perhaps have been initiated with the intention of a perceived involvement in conservation, as opposed to undertaking committed *in situ* conservation work.

Threatened animals in UK public aquarium restaurants' menus

In 2000, the European Association of Zoos and Aquaria (EAZA) launched its first conservation campaign: the Bushmeat Campaign. The term 'bushmeat' applies to all wildlife species, including threatened and endangered, used for meat. It is normally associated with African rainforest animals, but there is no reason for restricting the concept to that continent and habitat only. With habitat loss 'bushmeat' is often cited as the primary threat to wildlife. Commercial hunting for the meat of wild animals has become the most significant immediate threat to the future of wildlife in Africa and around the world; it has already resulted in widespread local extinctions in Asia and West Africa (Anonymous, 2004a).

As stated in the 'Bushmeat Crisis Task Force' website, "*Wildlife has been hunted for food ever since humans first evolved, and wildlife is still viewed as a resource 'free' for the taking in many areas. Today in Africa, bushmeat continues to be an economically important food and trade item for thousands of poor rural and urban families (…) The scale of the commercial bushmeat trade now occurring in Africa, however, is driven by markets with large, rapidly growing populations of consumers".*

In the previous quote, if we substitute 'hunting' for 'fishing', and 'Africa' for 'Atlantic Ocean', the statement continues to be correct. In this case we would be talking about cod or haddock (which are threatened species in Europe), instead of gorillas or chimpanzees. The same threat of extinction, the same reasons for the threat, and the same socio-economic obstacles to conservation initiatives intended to sort out the same sort of crisis. If, however, we would have discovered an African zoo that would have joined the EAZA campaign but still serve in its restaurant 'chimps & chips', not many people would fail to spot the hypocrisy. However, if instead of that sole hypothetical zoo, the majority of the zoos of a hypothetical African country did the same, the eyebrow raising would quickly develop into serious concern.

This is precisely what could be happening in the UK in the not-hypothetical UK zoo community. While displaying signs criticising other countries hunger for their endangered wildlife the zoo's cafeterias could be serving portions of British endangered wildlife. This interpretation of the bushmeat problem is not an opportunistic spin of a zoo campaign devised by the zoo's opponents. Bristol Zoo itself, in its own 'Fish n' chimps' campaign answers to the question *"would you eat an endangered species?"* with *"it is quite possible that many of you have eaten an endangered species –cod . While it is not endangered in all its range, it is now seriously threatened in the North Sea, due to over-fishing"* (Hughes & Woolard, 2002). In fact a Marine Stewardship Council questionnaire showed that 90% of people knew that gorillas are endangered species, while only 61% said that cod was endangered.

Bushmeat (i.e. fish) may be eaten right now in some UK zoos, but would a zoo serve on their menu the very animals that it is displaying in its exhibits? Perhaps a zoo would not, but a public aquarium would.

During this study the menus of restaurants or cafés in the public aquaria investigated were checked to see if any fish or aquatic invertebrate normally displayed in public aquaria was part of the food offered to visitors. Only those catering services that were an integrate part of the public aquaria (as opposed to those that could be used by people not visiting the aquarium, or that were not an obvious part of the visit by being situated immediately after the aquarium displays) were checked for this purpose.

Half (52%, n=31) of the public aquaria investigated had a restaurant, café or a food kiosk from which a menu could be checked, although circumstances in particular visits did not allow the checking of three of them. From all the 13 public aquaria where the menu was checked 85% of them offered as food to visitors fish and/or aquatic invertebrates that are commonly seen in public aquarium displays (figure 30), and in 62% of the public aquaria these animals belonged to threatened taxa. The aquarium animals found in the menus were: cod, haddock, common prawn, Norway lobster, pink salmon, common mussel, edible crab, and unidentified fish part of fish & chips or fish fingers dishes (likely to be pollack, dogfish, cod or haddock).

Figure 30. Several menu signs of the cafeterias/restaurants of three different UK public aquaria showing that fish displayed in UK public aquaria is served for food, including the endangered cod and haddock.

Even assuming that the three public aquaria offering food to visitors whose menus could not been checked would not have any fish and/or aquatic invertebrate on offer, still the majority (69%) of UK public aquaria would be offering them. Food for thought, is it not?

<u>The Seahorses 'conservation' flagship</u>

Seahorses are a group of fish regularly seen in modern public aquaria, probably more than ever. The reason is not their unusual shape or rearing habits –these have not change since they were first exhibited –but the fact that their name is hardly ever far from the term 'conservation'. Indeed, it appears that seahorses have taken the flag of public aquaria conservation, and the centres that keep them are waving this flag vigorously. But is seahorse conservation really the paradigm of the type of conservation public aquaria do? Perhaps it is, but not for the expected reasons.

Nine of the 21 seahorse species are listed as Vulnerable in the IUCN red list, with one as Endangered and the remaining 11 as Data Deficient. It is obvious that seahorses as a group do require conservation strategies.

However, there are several problems in the way of preserving seahorse populations. Firstly, there is a considerably confusion on the taxonomy and nomenclature of the seahorse group. Many authors and organisations still use two particular species names, *Hippocampus histrix* and *H. kuda* to describe what now seems to be 11 different species recently accepted (although this could still be changing further). The same common name also has been applied to different species, and for this reason throughout this report only scientific names have been used. Taxonomic instability is always a problem in conservation because often conservation measures are taxon based, and if there is no agreement about which seahorse belongs to which taxon it is difficult to implement conservation steps 'on the ground'.

The second obstacle, perhaps the biggest, is a thriving industry of seahorse capture destined for the aquarium trade, the curio trade and for traditional medicine. This exploitation of seahorse populations has been the main cause of their decimation in the wild, and since their extinction is threatening the trade itself, the term 'over-exploitation' has now begun to be happily used among traders with foreseeing insight. It has been said that the majority of landed seahorses go to traditional Chinese medicine (TCM) and its derivatives (e.g., Japanese and Korean traditional medicines). At least 77 nations and territories around the world are involved in buying and selling seahorses. The largest known net importers are China, Hong Kong, and Taiwan, and the largest known exporters are Thailand, Vietnam, India, and the Philippines. In 2001 the total global consumption of seahorses was at least 25 million specimens (Anonymous, 2004g).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) added seahorses to its Appendix II, which means that the international trade in seahorses began being regulated since May 2004, when the listing took effect. However, four nations (Indonesia, Japan, Norway, and South Korea) have taken out reservations to the listing, effectively withdrawing from CITES for the purposes of seahorses. This means that in real terms, despite the fact seahorses are threatened with extinction, their exploitation for commercial reasons continue, and in some countries it still takes place without regulation.

Despite the fact the conservation organisations with strong links with the public or private aquarium industry like to emphasise that the seahorse trade is mainly for traditional medicine, a considerable proportion of the trade goes to the aquarium industry itself. As seen in the introduction above, there is a significant effect of the hobbyist trade on the demise of coral reef fish populations. It is the same hobby that keeps butterflyfish and regal tangs that also keeps seahorses for the same reasons. The pet trade takes an estimated one million seahorses annually from the wild, and less than 1,000 survive more than six months, very often suffering a slow and possibly painful death (Anonymous, 2004g). Downplaying the role of the private aquarium industry in the demise of seahorse populations may be very convenient for those who collaborate, directly or indirectly, with the industry. This is the case of the public aquarium industry, which until very recently was obtaining its seahorses from the wild, as did everyone else.

As recent as 1999 neither home aquarists nor public aquaria seemed to have yet managed to develop consistently reliable protocols for sea horse husbandry. Effectively all captive seahorses were wild-caught, most coming from Indonesia or the Philippines and sent to North America, Europe and Japan (Lourie et al., 1999). For many years, institutions and hobbyists alike tried to sustain seahorses with brine shrimps (*Artemia salina*), but these were nutritionally deficient. The seahorses would slowly lose weight, show signs of stress, develop diseases and eventually die. What the public may have perceived as a thriving seahorse exhibit was, in reality, an exhibit in which the seahorses were constantly replaced (Weissenfluh, 2004). It was not until the 1990s, with the incorporation of wild mysid shrimps in the seahorse diet, that they began surviving for years. Today a species of mysid shrimp has been commercially harvested and frozen, which is the main reason that you can see seahorses in most aquaria, and you can see them breeding (Wood & Valentino-Fiamma, 2003).

This very recent husbandry 'break through' seemed to coincide with the strengthening of zoological collections regulations, especially in Europe with the so-called 'Zoo Directive' (Council Directive 1999/22/EC), which first introduced conservation as a criteria for allowing 21st century zoological collections to be open to the public. Before the directive many European countries did not even have a licensing system for public aquaria, and the ones that did have it, like the UK, allowed many public aquaria the 'slip through the net'. Indeed, studies on UK zoological collections during the 2000-2001 period indicated that about a quarter of the UK collections appeared to be operating without a zoo licence –among them many public aquaria (Casamitjana & Turner, 2001). The Directive, and the subsequent new domestic legislation that generated it (in England, Wales and Scotland, the respective Zoo Licensing Act 1981 Amendment Regulations 2002 and 2003) made it clear that proper conservation had to take place in zoological collections if it had to be licensed, and therefore any public aquarium that had no conservation activity whatsoever (which were many) had to do something about it.

As the captive breeding of threatened taxa is the 'traditional' conservation activity of many modern zoos, the possibility of breeding seahorses (which are both threatened species and popular among visitors) due to the new husbandry advances was perfectly timed. Also, because of the size of seahorses, incorporating them into a collection would not require many infrastructure changes. In other words, they seem to be the perfect candidates for public aquarium 'conservation flag'.

Indeed, since the beginning of this new century many aquaria have acquired seahorses (52% of the UK public aquaria keep some now), many so-called 'captive breeding programmes' have been initiated and 'publicised' (figure 31), and many seahorse conservation projects and organisations have been created, some of them in close relationship with zoos or public aquaria.

Save the seahorses

Over 20 million seahorses are caught each year in Far East waters and exported to Hong Kong and China for use in jewellery or medicine. There is also a relatively small demand from the aquarium trade. The World Conservation Union (IUCN) estimates that seahorse numbers in the wild have halved in some areas in just five years, and some species are close to extinction.

But the wild seahorse has good friends in British scientist Amanda Vincent and the Exeter

Cute seahorses now have friends in high places...

Figure 31. One of the many articles that can be seen pinned up in UK public aquarium's displays emphasising the need to 'save' the seahorses, mainly through captive breeding programmes.

One of them, perhaps the oldest and most well known, is 'Project Seahorse', a non-governmental international organisation that defines itself to be composed of "biologists, development specialists and other professionals committed to conserving and managing seahorses, their relatives and habitats, while respecting human needs" (Anonymous, 2004d). It appears that it was first founded by collaboration between the University of British Colombia (working in the Philippines) and the Zoological Society of London (London Zoo), and later on it developed partnerships with public aquaria, perhaps some from the UK because displays on this project have been seen during visits part of this study. Some of the project activities are research, managing fisheries and adjusting supply, influencing and adjusting consumption, monitoring seahorse fisheries and trades, seeking sustainability in the aquarium trade, education and policy development (claiming to have been instrumental in the incorporation of seahorses in CITES Appendix II). Therefore, Project Seahorse in itself does not seem to be seeking a total cessation of the seahorse trade.

Another organisation is The Seahorse Trust, which is planning to open a new public aquarium specialising in seahorses (combined with a seahorse research facility) to be named the National Seahorse Centre (NSC). The aims of this organisation are to research into seahorses, to educate into seahorse and marine education, and to enjoy seahorses and other species. It does not appear that this organisation is campaigning for the total cessation of the seahorse trade either.

Sealife Centres, the biggest chain of public aquaria in the UK, has not been left behind because in 2003 it created the National Seahorse Breeding and Conservation Centre, which despite having a very similar name to the project of NSC is a completely different centre. For the information displayed about it, it seems the centre is mainly aimed at breeding and supplying seahorses to the other centres, mainly from its own chain. It does not appear that such centre aspires to become a campaigning group within the Sealife centre organisation, and so far Sealife S.O.S. (the actual campaigning side of Sealife Centres) does not appear to be campaigning for the abolition of the seahorse trade.

The way seahorses are displayed to the public has also changed. Not only are they now placed in dedicated areas of the public aquarium often under a 'centre' title (with many more tanks and different species than in the past), but they are housed in 'breeding' tanks, which often are empty and barren to facilitate all the breeding management (figure 32). In some respects this change may produce in some the same perception of seeing battery farmed animals after having seen free ranged ones, although it is difficult to know how much the adding of naturalistic tank 'furniture' improves the well-being of captive seahorses. It would be worrying, though, if public aquarium visitors get used to empty and small tanks if they are under a 'conservation' or 'breeding' banner, because there is then the risk that they would 'spread' to other species.

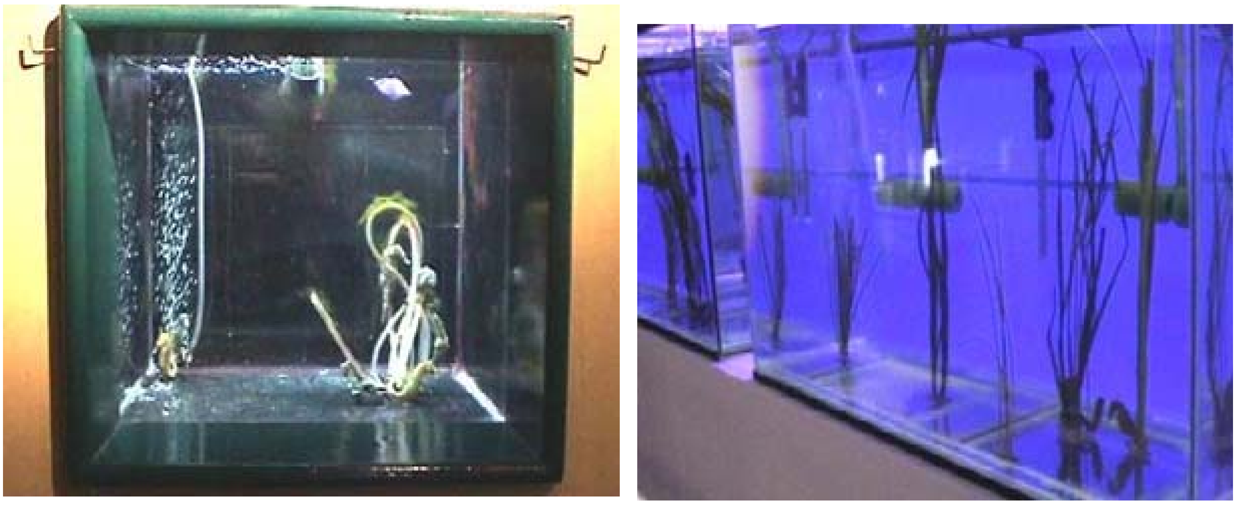

Figure 32. Two examples of the tanks where seahorses are bred and displayed to the public in UK public aquaria

In reality, though, the majority of these seahorse conservation 'centres' and so-called 'seahorse captive breeding programmes' (which are not part of official EEPs or ESBs, as seen earlier) have a higher impact on perpetuating the population of captive seahorses in public aquaria than on solving the problems of wild seahorse populations. For starters, these 'breeding programmes' will supply seahorses to public aquaria that otherwise would find it increasingly difficult to obtain due to the recent incorporation of seahorses in CITES Appendix II. Secondly, as suggested earlier, these projects help the public aquaria to justify their legitimacy in terms of the recent conservation criteria incorporated in domestic zoo legislation. Thirdly, and perhaps most importantly, neither the public aquaria nor the conservation organisations created seem to advocate the cessation of the commercial trade in seahorses. They merely seem to be involved in 'regulatory' or 'reformist' initiatives that although do make the trade more difficult –which hopefully would reduce its size and impact – also help to legitimise the very practice that is decimating the seahorse wild populations.

For example, there are no cetacean conservation organisations that campaign for the stopping of the whale hunting moratorium in order to resume sustainable whale hunting; or bird conservation organisations which advocate sustainable hunting of endangered birds. On the contrary, supporting these 'harvesting methods' strategies is the role of the organisations that represent the 'exploiting' industries/hobbies, which do 'battle' with conservation organisations that seem to interfere with their business. Stopping exploitation for the sake of the species exploited, not reducing it for the future benefit of the exploiting industry, is what non-governmental conservation organisations should be aiming for. Otherwise, their use of the term 'conservation' could be misleading and should probably be substituted by 'sustained harvesting'. In the case of the seahorse conservation organisations involved with UK public aquaria this type of misleading seems to take place, since none of them seem to work to stop the seahorse trade as a whole, probably only to regulate it so that both traders and public aquaria have some benefit from it (probably at the expenses of the seahorses involved).

Some may say this is a cynical view of what otherwise seem well-intentioned initiatives, but looking at them from the purely practical point of view does not seem to improve the perception. For example, the total reliance on captive breeding to solve the problem of over-exploitation of wild seahorses may be quite naïve. To protect the wild populations it may be necessary to avoid even captive-bred exports where these cannot be distinguished from animals taken from the wild. Tagging is meant to be a solution for this problem, but this system may not be as practical as it may seem on paper, and it may be easily abused. Besides, as seen above, captive breeding that it is not carefully co-ordinated with no real intention to reintroduce the animals back to the wild (as stated in some of the seahorse captive breeding programmes seen in public aquaria, see figure 33) is hardly a conservation strategy at all. The lack of a seahorse studbook that would allow the management of the captive population genetically, the fact that it appears that each public aquarium runs its own 'mini' captive breeding programme in an uncoordinated way with the others, and the fact that each of these can hardly maintain their own captive populations, does not point towards the conclusion that public aquaria are indeed conserving seahorses. On top of that, the reality of breeding seahorses is that it remains a very difficult process with a high rate of mortality and failure, very far from the image of an efficient breeding machine that will one day make redundant the need to take seahorses from the wild. Indeed, despite all the claims and husbandry advances, we still found public aquaria in the UK that confessed they failed in their seahorse breeding efforts and that they still keep seahorses taken from the wild.

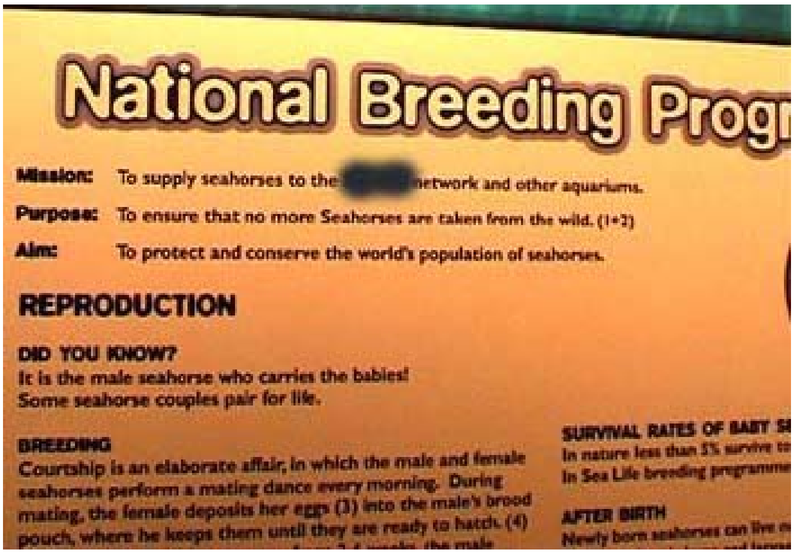

Figure 33. Sign of one of the so-called 'seahorse captive breeding programmes' undertaken in a UK public aquarium. No mention of reintroduction back into the wild as a main aim, but supplying other aquaria seems to be the main mission. The name of the particular public aquarium involved has been masked.

Also, the continuation of the trade with captive-bred individuals perpetuates the demand for seahorses, and therefore indirectly contributes to the threat of wild populations. Not to mention the fact that visitors seeing captive bred seahorses in public aquaria may be induced to get their own seahorses for their own private aquaria (a hobby that these 'conservation' initiatives do not oppose), which could well come from the wild.

Therefore, if the public aquaria 'conservation flag' is not really proper conservation education because it does not educate who collect seahorses from the wild (on the contrary, it tries to educate the aquarium visitors that do not fish seahorses anyway, but for the other side perhaps indirectly encourages visitors to buy seahorses from the pet trade after having 'fallen in love' with them during the visit), it is not really conservation breeding either because it is not properly co-ordinated and it is not aimed to reintroduce seahorses back to the wild, and it falls short in its *in situ* conservation initiatives because it supports the seahorse trade industry based on removing seahorses from the wild, then which kind of conservation flag is it? Perhaps it is a powerful public relations flag, which allows to perpetuate the public aquarium industry despite the recent tightening of legislation, and that eases the responsible visitors' conscience that may begin to see aquaria as just another 'wet zoo'. After all, the seahorse case may be indeed paradigmatic of public aquaria conservation.

EDUCATION IN UK PUBLIC AQUARIA

Conservation, education and research. These are the three pillars that seem to sustain most modern zoological collections that have survived the growing concerns the general public has been showing in the lasts decades about the keeping of animals in captivity for entertainment. Entertainment, so the zoo community today would say, is not the primary reasons for the zoos' existence anymore; those three pillars are.

We already have seen that the conservation pillar is not very solid as far as UK public aquaria are concerned. What about the claim that UK public aquaria play an important role in education? Although this is quite a difficult issue to asses through an investigation of this kind, this study did make some steps in order to get closer to answer this question.

Reading exhibit signs in UK public aquaria

There is no easier thing to do for a zoological collection that wants to justify its education role than write some signs with the names of the species it keeps and stick them by its exhibits. It does not take much more effort to add a few facts about each species natural history, regardless of the accuracy of such facts. A few pictures, some posters and even some buttons to push in displays may seem enough to comply with all the education requirements one could ask from a public aquarium. The reality is, though, that it takes much more than signage and interactive displays to be able to claim an education value.

For starters, it does not matter how fancy the signs may be, if they are not read by the visiting public their education value is next to nil. Most UK public aquaria have plenty of signage around their displays, but do visitors read them? During this study a particular interest was taken to answer this question.

The obvious sensible intuitive answer to the question is 'it depends'. It depends on the aquarium, the sign, the species displayed and the visitor. In order to overcome all this 'relativity', during the public aquarium visits undertaken to the random sample of collections, a random sample of signs, species displayed and visitors was also taken to assess how often visitors read exhibit signs. The result was 540 randomly selected visitors looking at 54 randomly selected signs in 20 randomly selected public aquaria

The procedure used to obtain all this sampling follows.

∉ Selecting public aquaria.

We already began with a sample of 31 randomly selected aquaria, so all those that had enough visitors during the visit were chosen. To determine whether the number of visitors was enough, some random signs were selected as well as a particular starting time for the survey (see below). If in half an hour from the starting time less than 10 visitors had watched the exhibit of the first sign, it was considered that the session had not enough visitors to do the 'sign study'. The majority of the UK public aquaria investigated (20 of them, 65%) did show enough visitors for the study in at least one sign.

∉ Selecting exhibits

When the investigator first entered the aquarium his task was to record all exhibits, signs and visible animals kept in the order that any visitor would encounter them during a normal visit. If, before all this was recorded, a special event or talk would take place, the investigator attended the event and resumed the 'survey' after it finished. When all the displays were recorded the investigator walked his way back to the beginning counting the number of live exhibits on display (separate tanks with their own signs of the same themed exhibit were considered separate exhibits). He then divided the total number of exhibits by four, and identified the exhibit that corresponded to that number from the entrance to the aquarium (named exhibit 'a'), the one corresponding to twice that number (exhibit 'b') and the one that corresponded to three times that number (exhibit 'c'). If public aquaria had less than four exhibits, only the third exhibit was chosen. However, in order to prevent any bias the order in which the exhibits were counted from the entrance had to be pre-determined by the following rules:

- If exhibits were numbered, or the 'itinerary' the visitor had to follow was clearly indicated, this was the order used

  - If there was not a clear itinerary established and different routes could be taken that would lead to a different order of rooms visited, any option on the right was chosen first (either a right path or a right room) and then if several options (sub-options) were found within an option, the right option was always chosen first, then the right sub-option, then the left sub-option and then the left-option.

  - Within a room, if it was a long room (corridor type) the order of exhibit chosen was the first exhibit on the right, then the one opposite to it (first on the left), then second on the right, then opposite to it, and so on. If it was not a long room the order chosen was starting with the first exhibit on the right and then continuing going around the room anti-clock wise to end in the same spot where started, to continuing counting any exhibit that was in the middle of the room (if any) and not by its walls (also choosing right first if more than one exhibit was in the middle of the room). Using this method the exhibits were chosen without bias because they depended on the particular design of the aquaria, and not on any choice of the investigator. This method, however, did not allow choosing exhibits at the very beginning and end of the centre, but this was convenient for the purpose of the study because the behaviour of visitors both at the beginning and end of a visit are not representative of the average visitor behaviour (due to the initial 'excitement' or the final 'tiredness'), and therefore it was appropriate to choose only exhibits 'in the middle'.

If any of the three chosen exhibits had no specific sign referring to the animals displayed in it, the next exhibit with a specific sign was chosen following the order mentioned above. Because not all the 20 collections had more than four exhibits, the total number of exhibits selected was only 54.

- Selecting signs

Only signs referring to and naming displayed animals in exhibits by them (or near them so there is no doubt that they refer to a particular exhibit) were considered (see example in figure 34). Any sign that introduced the contents of a room, describing animal groups as opposed to specific species (unless this was the only sign referring a particular exhibit), were not associated with particular exhibits, or that were educational displays supplementing the species description signs of the species displayed, were ignored. This was decided because the purpose of this study was to ascertain whether the exhibit sign was read, rather than any other type of sign or interactive display that were relatively 'free' from live animal exhibits that would distract the visitor away from them.

If the selected exhibit had only one sign referring to the specific animals displayed in it, that sign was the one chosen. If there was more than one sign (each describing different species displayed in the same exhibit), but all could be read from the same spot, the group of signs was chosen as a unit considering it a single 'composite' sign. If, however, the exhibit had different signs that would require the visitor to move in order to read them, the first sign the visitor would encounter (or the first on the right if visitors could choose different routes after first finding the exhibit) was chosen if the sign reading observations would begin at an o'clock hour, the second sign was chosen if it would begin at 15 minutes past the hour, the third if it would begin at 30 minutes past the hour, and the fourth at 45 minutes (see below). Therefore, only the first four signs for a particular tank/exhibit were considered, but it was extremely rare to find more than four signs for exhibits that would require the visitor to move between them in order to read them.

The total number of signs selected was therefore 54.

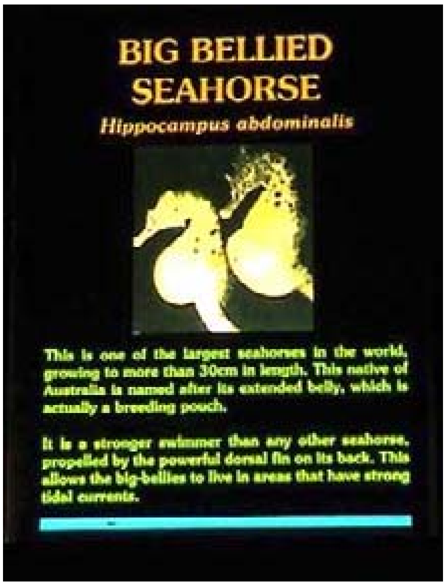

Figure 34. Example of the type of exhibit sign in UK public aquaria used for the 'reading signs study' (see text)

- Selecting visitors

  Once the investigator had determined which was the exhibit 'a' he had to choose the time when to begin the observations on visitors reading the selected sign. This time was either at the next hour, 15 minutes past the hour, 30 minutes past the hour, or 45 minutes past the hour, whichever was the closer after immediately identifying exhibit 'a'. The time chosen was the time when the observation began unless there was an event such as a talk programmed for such time, in which case the investigator attended the event and then began the observations at the hour, 15 minutes past or so on immediately after the event finished. From the first second of the exact moment of the starting observation time the investigator paid attention to all visitors coming (not already watching the exhibit) that were capable of reading the chosen sign (either because they were old enough or because they lacked a disability/handicap that would prevent them from reading them) and that clearly had encountered the exhibit for the first time during the visit. Because the investigator had observed all the visitors during his visit it was possible to identify the visitors that were 'going backwards' watching the exhibits again, or that were repeating the 'circuit'. The investigator took a mental note of whether the 10 first suitable visitors (using the criteria set above) that were indeed watching the exhibit animals (the ones that passed by the exhibit not paying attention to it were not counted either) read the chosen sign for three seconds or more, read the totality of the sign contents, or did not look at the sign for more than three seconds. When the tenth suitable visitor left the exhibit, the investigator (who had video recorded all the observations to help him confirm whether the ten visitors read the sign long enough to read them in their entirety) would state on tape how many out of ten read more than three seconds the chosen sign, and how many of those read the sign long enough so they could have read all its contents (assuming everyone was as fast reader one could be)

  It was considered that a glance of less than three seconds to a sign does not constitute reading it. Even if during two seconds the name of the animal on the sign could be read it is likely no other information about it could, so checking the name of the animal the visitor is watching without learning anything else was not considered educational enough for the purpose of this study.

  If after 30 minutes of starting observations the tenth suitable visitor to watch the exhibit had not arrived, the sign study was cancelled.

  If between the beginning of the observation time and the end of the tenth visitor an event like a talk took place, the investigator interrupted the observations to attend the event, and resumed them when it finished. After having done the 10 visitors for exhibit 'a', the time was checked so to begin exhibit 'b' at the next hour, 15 minutes past, 30 minutes past or 45 minutes past, whichever was sooner. The process would be repeated for exhibit 'c'.

Using this method the investigator did not choose which visitor to survey, and the cases where visitors did not read the signs because they had already read them could be avoided. As a result, a random sample of 540 suitable visitors of all genders, age and backgrounds was obtained.

The results of the analyses of the data show that 83% of the visitors did not read the contents of live exhibit signs besides perhaps the animals names (n=540), and 95% of the visitors did not read all the contents of exhibit signs. Table 15 shows which exhibits were observed in each public aquarium, and the averages of percentages of visitors reading part of the signs or all of them. As can be seen no public aquarium reached an average of half the visitors reading the exhibit sign, and no public aquarium reached a third of the visitors reading the exhibit signs in their entirety. It is important to remember that even if an exhibit sign was read in its entirety this does not mean that the other signs close to the exhibit sign, and that probably complement it with other information, were also read. Thus, it should not be interpreted that in some public aquaria almost a third of visitors read all available signs.

Looking at the data from the signs point of view, 72% of the signs (n=54) were not completely read by any of the ten visitors, and 33% of the signs were not read for more than two seconds by any of the 10 visitors. Only one of the 54 signs was read more than three seconds by more than half of the ten visitors observed.

Code	**Type**	**Exhibit 'a'**	**Exhibit 'b'**	**Exhibit 'c'**	**Aver. % visitors reading the sign**	**Aver. % visitors reading ALL the sign**
A-AQU08	BIPA	Common carp/mirror carp/tench	Minnow/grass carp	Bass/grey mullet/dogfish	20.0%	3.3%
A-BLA26	APA	Pacu	Sailfin tang/wimplefish	Clownfish	16.7%	16.7%
A-BLU03	CHPA	Splasing tetra	French guyana dart frog	Lobster/dahlia anemone	13.3%	0.0%
A-BLU06	CHPA	Cuttlefish	Nautilus	Soft coral	23.3%	6.7%
A-BRI02	APA	Tench	N/a	N/a	0.0%	0.0%
A-DEE48	CHPA	Clown cucumber	Whites tree frog	Green and black poison frog	20.0%	3.3%
A-FOW04	SIPA	Thornback ray/plaice/flounder	Conger eel	Mermaid purses	40.0%	30.0%
A-MAC44	BIPA	Butterflyfish/seascorpion	Dogfish	Sea whip/cuttlefish	13.3%	0.0%
A-MAR50	SIPA	Octopus/turbot/dogfish	N/a	N/a	30.0%	20.0%
A-NAT41	CHPA	Goldsinny/snakelocks anemone	*Hippocampus erectus*	Freshwater European fish	16.7%	3.3%
A-NAT47	APA	White catfish	N/a	N/a	0.0%	0.0%
A-SCO45	CHPA	Cuttlefish	Bib/red mullet/crawfish/goldsinny	Big bellied seahorse	13.3%	10.0%
A-SEA01	CHPA	Trout	Moray eel/queen angel/clown trigger	Lake Malawi Cichlid	30.0%	0.0%
A-SEA17	CHPA	Lumpsucker	Broad nosed pipefish	Otter	10.0%	6.7%
A-SEA20	BIPA	Pipefish	Common sea urchin	Pipefish (juv)	13.3%	3.3%
A-SEA27	CHPA	Dogfish	*Hippocampus reidi*	Tucan fish/tetra	10.0%	0.0%
A-SEA33	CHPA	Wolf fish	Ballan wrasse/dogfish	Big tropical tank	20.0%	0.0%
A-STA49	BIPA	Lobster/lumpsucker/spiny spider crab	Triggerfish	Seahorses	33.3%	0.0%
A-THE23	BIPA	Wimplefish/yellow tailed chromis, stripped eel catfish/regal tang	Harlekin tuskfish/coral wreckfish/Valentinni's puffer/saddled butterflyfish/bicolour angelfish/yellow tang	Day octopus	10.0%	3.3%
A-UND18	CHPA	*Hippocampus abdominalis*	Jewell anemone	Lobster	0.0%	0.0%

Table 15. Exhibit signs used in the 'read sign study' (see text) in each of the public aquaria investigated (column one), with the average percentage of visitors reading the three public aquaria signs (Exhibit a, b and c) more than three seconds (column six) or in their entirety (column seven). Type = type of public aquarium, CHIPA= Chain Public Aquaria, BIPA= Big Independent Public Aquaria, SIPA= Small Independent Public Aquaria, APA= Auxiliary Public Aquaria

Figure 35 shows the averages of percentages of visitors reading exhibits signs per type of public aquarium. The difference between sample of each type can explain some of the differences observed in the table. For instance, SIPA show higher values than the other types, but the majority of small independent aquaria did not have enough visitors for the sign study, so the sample only contains three signs, one of them registering the highest reading value of the whole study. Therefore, their higher value for SIPA is not really indicative that this type of public aquarium has a more attractive signage than the other types. Similar situation occurs in APA, which explains their smaller values. The values in figure 35 should be interpreted, then, as very similar across all types.

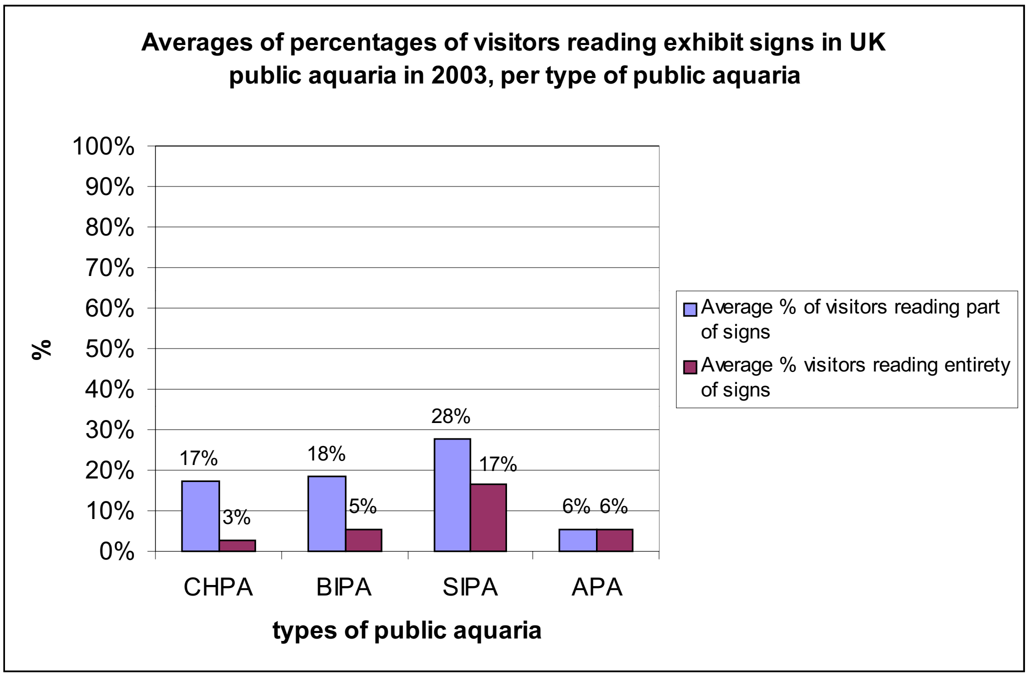

Figure 35. Averages of percentages of visitors reading exhibit signs in UK public aquaria in 2004, per type of public aquarium (see text). CHIPA= Chain Public Aquaria, BIPA= Big Independent Public Aquaria, SIPA= Small Independent Public Aquaria, APA= Auxiliary Public Aquaria

The results do show that by and large visitors in public aquaria do not tend to read exhibit signs, which is not a surprising conclusion also found by other authors (Glendron, 2003). One possible explanation is that the live exhibit draws their attention away from the signs. However, the need to watch an exhibit and quickly move on to the next could also prevent visitors from reading all the signs. In fact, if we analyse the relationship between the number of visitors present in the public aquaria before the 'signs study' began (which can be obtained from the videotapes, since the investigator recorded all present visitors while he was counting all exhibits) and the percentage of visitors per public aquarium that read the entirety of the selected signs, we can see that it appears that there is a slight co-relation (figure 36).

It seems that the higher the number of visitors present the less likely it is to find visitors reading the entirety of the signs. The flux of visitors from exhibit to exhibit may reduce the time visitors spend on any of them, which in turn reduces the chances of the signs being entirely read. This means that during Summer, which is the full high season with more visitors on average than in the studied period, the number of visitors reading signs is likely to be lower than found in this study. Because the majority of public aquarium visitors visit the aquaria in the holiday period, it would be fair to say that that the majority of the information written in UK public aquaria exhibit signs goes unread among the visiting public. Also, as will be seen below, other types of signs in public aquaria, such as the ones that instruct visitors what they are allowed or not to do, are also commonly ignored, adding to this perception that visitors do not come to the aquarium 'to read'.

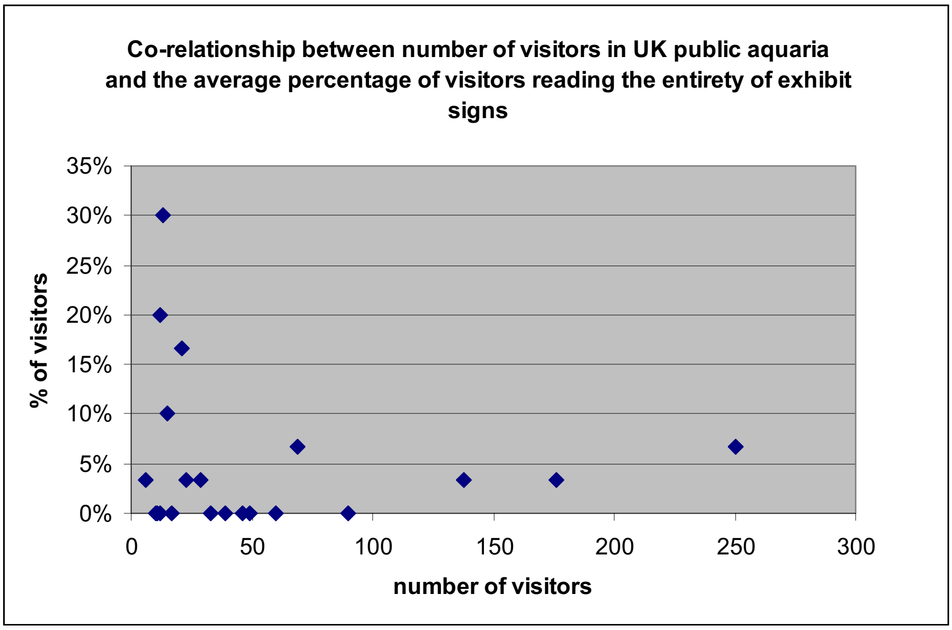

Figure 36. Co-relationship between number of visitors in UK public aquaria and the average percentage of visitors reading the entirety of exhibit signs (see text).

Lack of exhibit signs in UK public aquaria

In the section above we concluded that most exhibit signs are not read in UK public aquaria. Should public aquaria not bother to have any signs at all? Perhaps this is the approach some may take, but it would be quite difficult to maintain the claim that public aquaria have good education value if visitors do not even know which animals they are watching, let alone anything about their natural history or biology. Besides, the UK zoo regulations do not allow animals to be exhibited to the public without signs containing a minimum of information about them. Point 7.7 of the *Secretary of State's Standards of Modern Zoo Practice* states the following:

> *7.7 Accurate information about the species exhibited must be available. This should include, as a minimum, the species name (both scientific and common), its natural habitat, some of its biological characteristics and details of its conservation status.*

During this investigation the number of animals kept in UK public aquaria without the minimum information signs mentioned in the *Standards* could be assessed, because each sign was recorded, and so were all visible animals displayed. The analysis of the tapes allowed the identification of most of the taxa without signs.

Taking into consideration that some individuals or taxa without signs could have been missed by the investigator (especially in the big tropical tunnel tanks) but no signs were missed, the analysis of the data shows that 41% of the individual animals seen in UK public aquaria had no signs identifying which taxa they belong to (n= 13,530). Considering that some existing signs may provide the name but not the rest of the minimum information mentioned in the *Standards*, the total number of individuals without the minimum information required may approach half of the population kept in UK public aquaria.

The most common taxa displayed without identifying signs can be seen in table 16.

Rank	Taxa	individuals seen
1	Golden trevally	589
2	Yellow tang	229
3	Wimplefish	212
4	Brittlestar	212
5	Blue chromis	162
6	Grey mullet	152

7	Beadlet anemone	145
8	Lesser spotted dogfish	143
9	Mono	142
10	Trevally	120
11	Common starfish	111
12	Cichlid	107
13	Cardinal tetra	100
14	Bass	91
15	Shore crab	84
16	Foxface	73
17	Yellow tailed chromis	65
18	Sea squirt	65
19	Snakelocks anemone	63
20	Spider crab	61
21	Pollack	59
22	Sailfin tang	54
23	Killifish	54
24	Dahlia anemone	51
25	Smooth tailed trevally	50
26	Pulmose anemone	44
27	Blue and green chromis	43
28	Ballan wrasse	43
29	Brown trout	42
30	Greater spotted dogfish	40
31	Tetra	39
32	Plaice	39
33	Tropical anemone spp.	38
34	Regal tang	38
35	Porkfish	38
36	Humbug damsel	38
37	Common clownfish	38
38	Thornback ray	37
39	Lookdown	37
40	Mimic surgeonfish	34
41	Common sea urchin	32
42	3-spined sitckleback	32
43	Batfish	31
44	Dace	30
45	Edible crab	29
46	Shanny	27
47	Long nosed butterflyfish	27
48	Domino damselfish	27
49	Zebra danio	26
50	Common prawn	24

Table 16. The 50 most common taxa displayed without identifying signs in UK public aquaria in 2004.

If almost half the animals kept in UK public aquaria had no identifying signs at all, and for the ones that do have them most of the visitors do not read the information in them, it is difficult to avoid the overall conclusion that the educational value for visitors of the UK public aquaria signage as a whole is very poor.

The education message of UK public aquaria

Some may say that if the visiting public does not want to read the signs in public aquaria this is not the aquarium's fault. Ignoring the fact that it is difficult to see whose fault it is if that is true, one should not forget that the main issue is not whether indeed some visitors learn in public aquaria, but whether the claim that public aquaria play an important education role can be used to justify their existence.

It is true that besides exhibit signs many public aquaria do provide other education resources: talks, videos, education packs, guided tours, non-live animals displays, websites, guide books, etc. It may equally be true, though, that in the same way the visiting public tend to ignore exhibit signs it would tend to ignore other types of education material, although this study does not allow assessing that. It does appear that attending talks is something many visitors do, although on more than one occasion the investigator was the only visitor attending some talks in public aquaria that had many visitors in them at the time.

However, how much education all these other activities provide is open to question. It very much depends on how common they are, and how educational they are. Regarding quantity, for instance, less than half (45%, n=31) of the UK public aquaria offered talks or special events to the visiting public of spring 2004, less than half (45%) offered education packs, and almost a quarter (23%) of the UK public aquaria did not even have a website.

Regarding quality, the contents of the education message delivered by some public aquaria leaves something to be desired. The mixing of species displayed in a tank not representing communities that could be found together in the wild, for instance, was often found. This problem is not exclusive to UK public aquaria. J. Charles Delbeek, an American Aquarium Biologist, wrote in 1999:

"In the last eight years I have visited approximately eighteen non-profit and for-profit aquaria in North America, and ten in Asia and Europe. During these travels one thing that struck me was that just about all of them went to great pains to make it clear that one of their primary mission goals was education. I think all of us hold this as one of the main justifications for the displays we construct and maintain, to educate the general public about the habitats, ecosystems and organisms of a particular area. That is why one prevalent trend I noticed left me rather puzzled; the collection of fish and invertebrates presented as "representative" of a particular biotope or geographical area were often inaccurate. In some cases the inaccuracies were minor but in far too many they were significant."

On several occasions wrong information was given to the investigator who asked general questions to the aquarium staff. For instance, on two separate occasions members of staff gave the completely wrong identity when repeatedly asked about what was the name of the fish the investigator was watching, and on two other occasions the staff simply replied that they did not know. On several occasions the animals displayed in one exhibit had signs of animals displayed in another exhibit (figure 37) or simply the wrong sign, and in others the signs were placed in such a way that it was almost impossible to read them (figure 38).

Figure 37. Example of wrong signage in UK public aquaria. In this case two exhibits with each other's signs regarding the anemones displayed

Figure 38. Example of a sign that is difficult to read displayed in a UK public aquarium. In this case only visitors that crouched could read the sign, although the small print made this task still quite difficult

Poor education is not the only type of 'bad' education. Mis-education, or 'teaching the opposite from what should be taught' is not absent in UK public aquaria. One could say that deciding what is the 'right' or 'wrong' message is not an issue for either public aquaria or their critics, but there are obvious cases that most people would agree can easily be interpreted as mis-education. For instance, in either talks or displays some of the information not only did not help to dissipate myths about some animals, but they reinforced them instead. An example of this is the case of piranha exhibits. Despite the fact that it is now quite well known that the reputation of piranhas as being ferocious man-eating fish is grossly exaggerated, this is one statement seen in one public aquarium literature:

> *"Marvel at the frenzy piranha feeds (…) piranhas are deadly and a school of them can reduce a wounded crocodile to skeleton in seconds. Those on display in [aquarium name] are man eating red bellied piranhas".*

In another public aquarium the piranha exhibit was complemented with a video clearly exploiting the man-eating myth. In another the aquarium leaflet had as a main picture a close up of a piranha showing its teeth, and in another the exhibit was preceded by signs portraying the fish as 'criminals' (figure 39). Some of the talks seem almost exclusively dedicated to the exploitation of this myth. For instance, among all possible dedicated feeding talks that could be offered in public aquaria, often the 'piranha feeding talk' is one of the few available, probably in the expectation that the gruesome image of flesh eating animals may attract visitors to it. Some of these talks are advertised as 'feeding frenzy'. The clash between reality and myth was evident in one of these piranhas feeding talks in which no piranha ate anything. The reason given by the staff member was that they were too wary of visitors around the tank to eat.

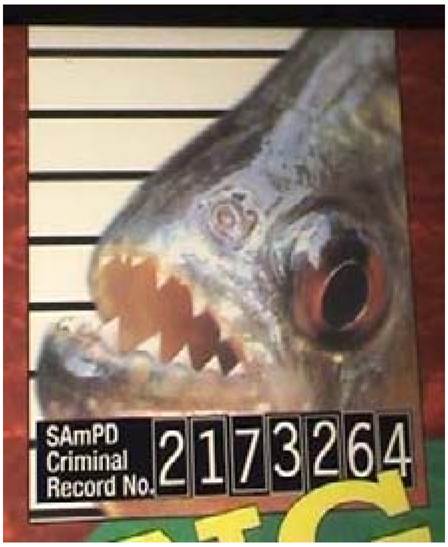

Figure 39. Sign by a piranha exhibit in a UK public aquarium jokingly portraying a piranha as a 'criminal' and so perpetuating the myth of their fearsome man-eating habits

A similar perpetuation of a myth takes place in the case of sharks and their reputation to be ferocious man-eating animals. Glendron (2003*)* states that one of the modern roles for modern aquaria is to inform the public on the conservation issues that face the waters of the world and their inhabitants, and that debunking the many myths that surround sharks and their relatives is a critical part of this role. However, the spread of such myths can be seen throughout UK public aquaria publicity or displays, with statements such as the following:

> *"Beware! Ferocious creatures"*
> *"Look fear in the eye. Shark dives at…"*
> *"Send us more tourists, the last ones were delicious"*

In some public aquaria where divers are part of 'the show' it was clear that both their behaviour and the 'script' was intended to exaggerate the threat that the swimming with sharks was posing to them (figure 40),which goes along to support the myth (apart from giving an exciting 'edge' to the performance).

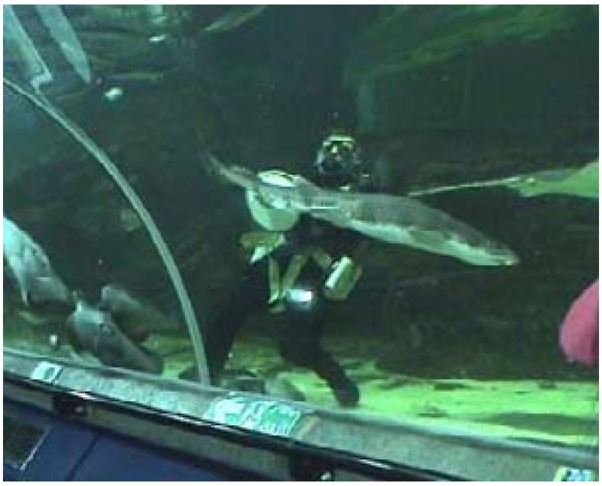

Figure 40. Diver feeding fish in a UK public aquarium tank as part of a talk/show in which often the threat of shark attacks is exaggerated to add drama to the performance.

On some other occasions, although part of the displays or talks tried to correct the shark's bad reputation (sometimes quite convincingly, it must be said), other parts or displays in the same aquarium contradicted that message. The most extreme example of this is the 'Jaws-like' photo opportunity with an attacking great white shark model that a particular chain public aquarium offer at the entrance of their centre, in which the visitor's picture is taken and then sold to them when they leave (figure 41). It is difficult to imagine in what way the man-eater myth can be better supported.

Figure 41. Model of an attacking great white shark emulating the film 'Jaws' used by a UK public aquarium as a photo opportunity for visitors

Finding a close up face of a 'fearsome' shark is not uncommon among public aquarium leaflets and posters. In fact, one of the reasons public aquaria choose to keep some species of sharks over others is how fearsome they look. Sand tiger sharks (the ones that often appear in posters and leaflets, and that indeed look quite fearsome) have been described by public aquarists as *"possessing all the desirable appearance traits"* to be displayed to the public (Sabalones, 1995). However, several UK public aquaria have stated, even in their own leaflets and guide books, that sand tiger sharks should not be kept in captivity, whilst others few miles on the road not only keep them but publicise them on a big scale (figure 42).

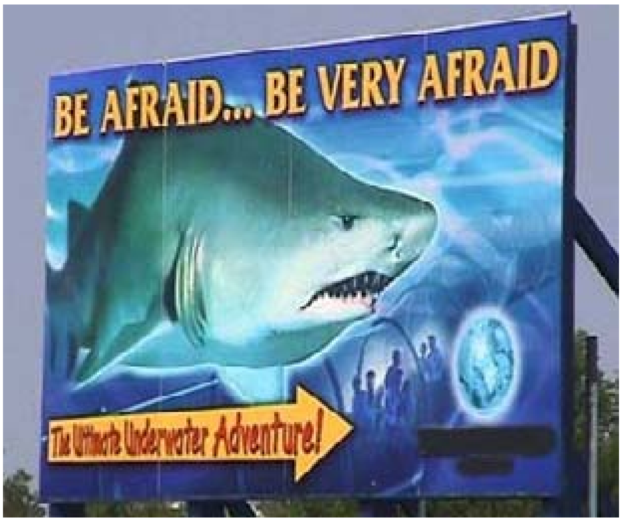

Figure 42. Road publicity sign advertising a UK public aquarium using the 'fearsome' sight of a sand tiger shark with comments that fuel the myths of sharks being man-eating creatures. The name of the public aquarium has been masked.

It is obvious that from the 'freak show' value point of view, it is better to portray sharks and piranhas as deathly than otherwise. The exaggerated use of language to exploit what is exceptional is another calling card of the 'freak show' concept. When we think of freak shows we all have a clear image in our mind of some presenter at the entrance shouting how exceptionally superlative the world's wonders to be witnessed are waiting for us inside the tent. This use of superlatives as a way to attract visitors is a very common language found in UK public aquaria. Apart from the obvious lack of educational value, and often misleading use of these 'facts', it is a reminder that public aquaria belong more to the show business world than to the education one. Some examples of these superlatives found in the publicity of UK public aquaria –some of them almost bordering on the ludicrous– can be seen in figure 43 and in the following statements:

- *"The world's most poisonous fish"*
- *"The world's only Submarium"*
- *"The only place in the UK to see grey reef sharks"*
- *"One of the world's largest underwater viewing"*
- *"The largest freshwater fish in the world –and we've got the biggest in the UK!"*
- *"The most northerly of Scotland's aquaria"*
- *"Golden dart frog, the world's most poisonous creature"*
- *"Britain's bigger sharks are waiting for you"*
- *"The biggest sea aquarium in West Wales"*
- *"Purpose built large scale sea water aquarium"*
- *"Lethal reef. From stonefish to lethal lionfish, they don't come much deadlier than this"*
- *"Europe's largest collection of sharks"*
- *"Britain's biggest freshwater aquarium"*
- *"The world's largest group of aquaria"*
- *"Deadly creatures of the ocean together in one 'highly toxic' exhibition."*
- *"Probably the largest shoal of piranhas in the world"*

Figure 43. Two examples of signs advertising small independent UK public aquaria with misleading superlatives more akin to 'freak show' scenarios than to educational centres. The name of one of the public aquaria has been masked.

Another example of mis-education taking place in UK public aquaria is the use of the 'Atlantis' myth almost as if it was part of history (figure 44). Although this may be appropriate in a theme park attraction, you would expect that in a public aquarium that is supposed to educate, at the very least an explanation that any reference of the lost city of Atlantis is part of Greek mythology, not part of Greek history, would be given. However, no such explanation was to be found, which surely could be classed as mis-education. From all the interesting facts about animals' natural history a talk could be composed of, it is almost ludicrous to see all that 'talk time' lost on the Atlantis myth. This is just another example where the 'theme park' approach has overridden any serious education intention.

Figure 44. A whitetip reef shark in a UK public aquarium exhibit featuring the myth of the lost city of Atlantis almost as if it was part of history.

The final example of mis-education is more general and widespread than the ones mentioned so far. Public aquaria, or any zoo for that matter, teach 'by default' that the humanity 'dominion' over Nature, which allows people to remove at their will any animal from any habitat in the world and keep it away from the wild 'by force' until it dies, is an ethically acceptable state of affairs. Zoos and public aquaria regularly 'hide' from visitors all the problems and shortcomings caused to their captive animals and exaggerate the appearance of their cages/enclosures (euphemistically re-named 'habitats') so they look closer to what the wild habitats look like in the visitors minds. In doing so they mislead the visitors into thinking that indeed Nature can be replicated anywhere (even in the tiniest room of the tiniest village) and any wild animal can be taken captive by anyone with enough will to do so. It is not surprising, then, that conservation problems arise everywhere, that the number of people keeping exotic pets is also increasing, and, more relevantly, that the hobby of keeping a tropical fish tank as a piece of furniture is still very popular among the British general public. Of course many would disagree with this, but the fact remains that 'educating' is something more than laying out information. It is also 'teaching' what is right and what is wrong, and nobody can deny that keeping wild animals in captivity for exhibition is a subject charged with ethical connotations. This ethical 'debate' is absent in UK public aquaria, which portray a greatly one-sided view of the concept of captivity.

As Taylor (1995) put it *"One cannot superficially don an ethical cloak and go on to rationalise the 'education value' of the aquatic equivalent of albino tigers jumping through flaming hoops. The exhibition of animals for other primary ends* [other than conservation] *will result in dishonest displays and poorly maintained animals, a situation that visitors will sense sooner or later; the magic of the aquarium will diminish and the gold will turn into lead."*

One of the arguments that is likely to be given to defend the role of public aquaria in education is that without them many people would not learn anything about aquatic creatures. Disregarding the selfish attitude of people refusing to learn by any other means than having 'the real thing' at the touch of their fingers (an attitude that justifies the old fashion colonial idea that it is perfectly acceptable to go around the world stealing archaeological, artistic, economical and, of course, zoological resources to supply your imperial museums or zoos), the truth is that there are many more efficient ways to learn about aquatic animals than visiting a public aquarium. Although natural history museums do provide a very good platform to teach about fish and other aquatic invertebrates without the distraction of the living animal that lure away the attention of the observer from signs and displays, ethical objections to either taxidermy displays or indeed the imperialistic attitude mentioned earlier may put some people off. However, natural history documentaries do provide a perfect alternative to the public aquarium, not just because they tend to be animal-cruelty-free (although not all of them may be), or because in the long run they are cheaper than keeping fish in captivity (once they are produced they last forever at no extra cost), or because they cover a larger audience than public aquaria, or because they provide a one-channel story telling platform that allows more efficient teaching; not only because all of this, but especially because in them you actually can see the proper 'real thing', with the animals doing what they do, where they do it, when they do it, and how they do it.

As an example of the difference in educational value between public aquaria and natural history documentaries we can take the BBC series 'The Blue Planet' (Anonymous,2001c), broadcasted everywhere in the world, and available on video, DVD, and any other format of audio-visual display in existence. This series alone features about 300 different animal species in their natural aquatic habitats. The public aquaria surveyed in this study that displayed the highest number of exhibits only showed about 130 species, none of them in their natural habitat, most of them not doing what they normally do in the wild, and some of them doing what certainly they never would do 'in real life'. UK public aquaria exhibit as an average about 25 taxa, less than ten times the taxa featured in the series. One single documentary features more aquatic animals than any public aquarium in the UK, and in it you can find all the education messages (conservation, environment, ecology, biology, history, etc) that you would expect. Eight hours of real education versus three or four hours of rushed mis-education; and this is just one example.

In summary, the results of this study show that, although the educational value of public aquaria clearly differs from one centre to another (in one exceptional case education appears to be the most important activity of one particular public aquarium, which seems miles away from the others in this respect) it is difficult not to conclude that the UK public aquaria 'education pillar' is not very solid at all.

SCIENTIFIC RESEARCH IN UK PUBLIC AQUARIA

The European Zoo Directive (Council Directive 1999/22/EC) aimed to standardise legislation regarding zoological collections by not only creating a licensing system in all the countries that do not have one, but also by setting up the criteria that each member state should use to assess whether a collection should receive a license or not. The Directive requires Member States to ensure that <u>all</u> zoos "*participate in research from which conservation benefits accrue to the species, and/or training in relevant conservation skills, and/or the exchange of information relating to species conservation and/or, when appropriate, captive breeding, repopulation or reintroduction of species into the wild".* Although the use of the 'and/or' means that zoological collection do not need to do research if they do the other conditions, if no captive breeding or reintroduction takes place, and no conservation training or exchange of conservation information takes place (not any type of information), research may be the only alternative.

In the UK we have had a zoo licensing system since the early 1980s (Zoo Licensing Act 1981), which is backed up, following section 9 of the Act, by the *Secretary of State's Standards of Modern Zoo Practice*. Recently, though, a new law was passed, the Zoo Licensing Act 1981 (Amendment) Regulations 2002, which effectively embraces the points raised by the European Zoo directive, including the ones mentioning research.

Because many zoological collections cannot claim they do conservation activities, modern zoological collections, including public aquaria, often claim that they do research instead. The presence of exotic species in public aquaria might be of interest to researchers looking for subjects to investigate, but it is likely that the conditions in which those species are kept do not facilitate the researchers' work. Abnormal behaviour or visitor presence might make public aquaria less attractive to researchers, many tanks do not offer a complete unobstructed view to those who want to make detailed observations, or public aquaria may not be well suited to experimental replication where more than one tank is required (Smale, 2003).

If researchers do not go to public aquaria, perhaps the aquarium staff, or otherwise students on training, can do the research instead. However, investigations carried out by non formally qualified researchers might not contribute to scientific knowledge if they are not published or made available for peer review. Therefore, although any investigation of any kind could be considered research in its widest sense of the word, only scientific research that is made available to the scientific community for scrutiny is what the Zoo Directive probably means when using the 'research' criteria.

In a previous study (Casamitjana & Turner 2001) evidence that UK zoological collections publish very little scientific research at least by the usual channels was unearthed. In this study the same methods were used to investigate UK public aquaria only.

The method used to quantify the contribution of public aquaria to scientific research was based on analysing the final stage of any research investigation: the publication of papers in scientific books or journals.

There are reference publications available to aid bibliographic research, which compile records of references of all published scientific material on a whole range of topics. Three of these databases were used for the assessment: *Zoological Records*, *Biological Abstracts* (both published by BIOSIS), and *ESTAR* , the Electronic Storage and Retrieval System of the British Library.

In order to investigate the research that has been undertaken on wild animals the best publication to use is the *Zoological Records*, which exists in both hard copy and as an electronic database. This is a well-known and widely used reference work published since 1864. The database provides powerful searching features for quick retrieval of references from over 6,500 international journals, review annuals, monographs, meeting proceedings, books, and reports, from over 100 countries. The database has an international coverage and has no geographical or linguistic restrictions.

The criteria to include entries of publications in the *Zoological Record* stated by BIOSIS in its website follows:

"*Zoological Record Coverage* and *Subject Criteria*

> *Zoological Record* products cover publications on all aspects of zoology.
> BIOSIS aims to comprehensively cover traditional areas of zoology, such as ecology, physiology, taxonomy, evolution, life history, morphology, and nomenclature. More experimental applied topics, such as applied biology, biochemistry, immunology, toxicology and veterinary medicine are covered selectively. An item is relevant for coverage if it contains material on the biology of an animal, but particular emphasis is given to natural biology and systematics. BIOSIS attempts to be exhaustive in its coverage of systematic zoological literature.
>
> Papers dealing with commercial activities such as fishing or fisheries, farming or agriculture etc., are included in *Zoological Record* only if some aspect of the biology of the animal is discussed, or if historical or conservation aspects of such activities are covered.
> Source documents dealing with experimental or domestic animals usually are not indexed in *Zoological Record* unless the systematics, evolution, distribution, or biology of the animal in the wild is discussed in some detail. Purely experimental papers are not included. However, source documents which deal with unusual animals used in laboratory experiments are indexed.
>
> *Zoological Record* coverage normally excludes *Homo sapiens*, but papers which discuss humans and animals will be covered for the animals provided that they are within general scope. Papers discussing extinct relatives of man (eg., *Homo erectus*, *Homo neanderthalensis*) will be included.
>
> Parasitology studies are included in *Zoological Record* provided that some zoological aspect (eg., taxonomy or physiology) of either the parasite or the host is discussed. Both the parasite and host receive index entries in the appropriate sections.
> Papers discussing techniques or methods used in areas which are not covered, but having definite implications for use by zoologists are indexed in *Zoological Record*. For example, a paper discussing a new method of determining basal metabolic rate could be considered important to an animal physiologist. Therefore, the paper would generally be included, as long as the technique is performed on an animal. If the technique discussed in the paper is performed on a human, it would not be included."

The second database, *Biological Abstracts*, is the world's largest abstract publication for life sciences journals published world-wide. According to its web-page:

> "Total Journal Coverage: *BA* indexes articles from over 4,000 serials each year. This publication also offers: Over 360,000 new citations each year, nearly 90% of citations include an abstract by the author, and almost 5.8 million archival records are available back to 1980. *BA* articles originate from journals all around the world, and cover topics in every life sciences discipline".

The third database is the Electronic Storage and Retrieval System (ESTAR) of the British library, only accessible from the computer workstations of the library itself. The ESTAR system provides electronic access to the full text of over 4000 major journals held by the British Library, mainly in the fields of science, technology and medicine (at the time of writing 4,049 journals and 2,384,960 articles were accessible, all searchable with a full text search engine –not only searching for keywords).

The three databases can be accessed electronically from the British library, covering the period from 1978 to today as far as *Zoological Records* is concerned, from 1985 to today as far as *Biological Abstracts* is concerned, and from the early 1990s as far as *ESTAR* is concerned. They cover all journals and books where articles about public aquaria research may be published, including the journals *Ichthyologica, Aquarium Sciences and Conservation, Aquarium Digest International, Freshwater & Marine Aquarium, Aquarium News, International Zoo Yearbook, Ratel* and many more.

Using the search engines available on the British Library computers for the three databases, entries that contained the names of the 31 public aquaria investigated were sought. In order to find any possible scientific article mentioning the public aquaria in any capacity (even if the article was not a study undertaken in the aquarium or by the aquarium researchers, but just a reference to it) different combinations of names, new or old versions, hyphenated or not, or the name of the town where the public aquarium is located together with the word 'aquarium', were used through the searching process involving all the entry fields. As a result of using this method it was hoped that no article mentioning any of the UK public aquaria investigated would 'slip the net'.

From the millions of article entries that were sought covering a period of 25 years only seven references involving the public aquaria investigated were found. These references represent 23% of the UK public aquaria. Taking into account the time scope of the databases and the size of the aquaria sample, this means that the UK public aquarium industry as a whole publish an average of one scientific article every 30 years. No entries since 2002 were found, and the 2002 entry corresponded to an acknowledgement of one researcher thanking one of the public aquarium for having provided him with some anemones for some stress-inducing experimentation (which raises the whole different issue of ethically acceptable research). The next entry was 1999, so in total only one article mentioning half the UK public aquarium population in the last four years.

In order to check that the databases were covering all articles involving aquaria, a search for the keywords 'aquaria' or 'aquarium' was performed. The result showed 5,187 full articles from *ESTAR*, and 18,708 from *Zoological Records* and *Biological Abstracts* together. Using the words 'fish', for instance, produced 66,932 entries for *ESTAR* and 374,105 entries for the other two databases. Therefore, the databases do cover fish and aquarium research, and nonetheless only seven entries were found for the public aquaria studied.

These results clearly show that scientific research is not, by any means, an integral part of the UK public aquaria work, despite some public aquaria claiming otherwise. Indeed, two or three public aquaria seem to be involved, according to their own literature, with some Universities in some scientific research, but either this is a fairly recent development that has not produced many scientific papers yet, or this is not 'scientific' research *per se* because it is not providing scientific papers available to the scientific community (perhaps only internal 'husbandry' papers for the trade, which could be found in any profession without any claim that scientific research is in the making).

Perhaps the 'research' claim comes from the fact that some students may have used public aquaria as the site of any of their pre-graduate dissertations/assignments –or similar 'training' activities– which do not produce scientific articles or theses. If that is the case maybe an 'education' claim could be more appropriate, although providing a site for someone to develop their own project hardly qualifies as 'teaching'. Or perhaps the public aquaria attempts –successful or not– to breed, feed or transport aquarium stock are interpreted as scientific research, although this would be as misleading as describing rare-breed pet breeders or professional gardeners as scientists. Most likely, though, is that public aquaria, as any other zoological collection, are responding to the conservation/education/research criteria imposed by the European zoo regulations, as well as executing PR and marketing strategies first developed by the World Zoo Organisation (WZO) a few years ago through its International Zoo Marketing Conferences.

EXHIBIT DESIGN IN UK PUBLIC AQUARIA

The fact that exhibits in zoological collections can be designed in many different ways is something that does not normally enter the mind of a normal visitor. It is almost as if there is a general acceptance that all zoological collections follow the best –and perhaps the only –designs created by the 'experts' to accommodate perfectly well each of the animals displayed. It is assumed, then, that if an exhibit has a particular size or feature it is because the ones that 'know best' have agreed that this is both fine for the animals and safe for the visitors. The reality is, though, that each zoological collection is free to choose any design they feel is adequate for them, and they do not always have to put the animals' needs first.

Public aquaria are not an exception to this, and therefore it is possible to find aquaria with worse designs than others, with worse exhibits than others, or with worse tanks than others.

Small, dirty and barren tanks –perhaps the classic image of an old-fashion Victorian public aquarium –are not totally absent from UK public aquaria, but these are only the obvious cases that even the people that never have seen an aquarium before can identify. The remaining cases may be much more difficult to detect, since life underwater is so different to ours that we are not equipped to recognise instinctively physical environments that would not be appropriate for aquatic creatures.

A good example of this can be found in captive sharks. When one sees a shark swimming in a public aquarium tank one would assume that if it swims about in an apparently relaxed manner it must be because it is happy with its environment. In fact many sharks have to be continuously swimming in order to breathe because they do not have gills able to pump water when they are stationary. One shark may be what we could classify in anthropomorphic terms as 'depressed' but still be swimming about in order to breath, instead of remaining motionless as we would.

There are even more subtle factors. For instance, the primary limiting factor in deciding the tank size to keep many of the sharks that have a typical shark appearance is the 'swim-glide' index (Klay, 1977). These sharks swim a certain distance and then glide a certain distance, and the ratio between these two distances is idiosyncratic for each species. Examples of these sharks are sandbar sharks, exhibited in some UK public aquaria (figure 45) , and which need long uninterrupted runs –fully grown individuals need more than 23 metre long runs (Sabalones, 1995). Thus, the size of a shark tank should be designed taking into account the swim-glide index of the species the tank is going to keep. Interior tank decoration should also be also configured so as not to protrude into the glide path. However, a shark, having adapted relatively well to one exhibit, may be unable to make the transition to another, because sharks are capable of lasting for some time in captivity with unseen health problems, and when faced with the stress of capture and transport, these problems manifest themselves (Sabalones, 1995). Thus, what on paper seemed a perfectly fine tank for a shark in reality results in sharks getting ill and dying when first introduced into it.

Figure 45. Sandbar sharks kept in a UK public aquarium. These sharks need to be in continuous motion, and require tanks that allow a natural 'swim-glide' index (see text) to be uninterrupted

Sometimes it is not how big the tank is, but what is in it. For instance, a captive octopus housed in a tank without sufficient hiding places and without sufficient stimulation can develop a number of stress behaviours, including white colour patterns, inking, frequent deimetic displays ('startle flashing' in which false eye spots or brilliant colours are suddenly displayed in an attempt to startle a predator), autophagy (eating its own limbs), hiding all the time, rapid jetting into the side of a tank, etc. (Wood and Wood, 1999).

Octopuses can distinguish between different-shaped targets; they can learn to run simple mazes; they can open jars; they can navigate by using landmarks; they can use tools; they have different temperaments that can loosely be called 'personalities'; and they have even demonstrated play behaviour (Wood and Wood, 1999). The presence or absence of play behaviour in captive animals should be used to determine the quality of their captive environment, which should lead to providing stimulating enclosures with sophisticated behavioural enrichment programmes as an integral part of their design. However, the development of 'prey-puzzles' sometimes seen in octopus exhibits around the world, although they have significantly improved the activity level of the housed specimens they do not appear to have increased longevity (Rehling, 2001), putting a question mark on the real efficiency of behavioural enrichment devices. These devices have, however, dramatically increased visitor interest in the exhibit that contain them. Although the occasional behavioural enrichment device has been seen in octopus exhibits in the UK public aquaria investigated (which indeed seemed to attract many visitors to the talk designed to draw attention to them, figure 46), by and large most captive octopus in the UK do not seem to have efficient enrichment programmes as part of their housing.

Figure 46. Giant pacific octopus kept in a UK public aquarium negotiating a transparent 'prey-puzzle' box attached to the tank glass in which a live crab had been placed. Many visitors watched how the crab was finally devoured by the octopus, which signalled the end of the behavioural enriched activity for the day.

Another design factor is the number and types of animals to be kept in exhibits. It is not only that some fish may eat others if kept together, but also that excessive aggressive behaviour may be triggered by the type or number of fish in a mixed exhibit, and this could lead to stress and disease. Whether or not fishes defend territories at all is influenced dramatically by intruder pressure, resource density and resource dispersion. Fish defend spawning sites, mates or offspring more often than food, but feeding territories are more common among coral reef fish than in other types. Territory radius is positively correlated with the threat the intruder poses to the resources being defended (Godin, 1997), and therefore an overcrowded exhibit with many fish looking for their own 'patch' is bound to produce more aggressive territorial behaviour than may happen in the wild, where more space is available.

Sometimes some species may be housed with others because they either look similar, or in the visitor's mind they might be living together in the wild, when in reality they never would find each other in their respective natural habitats. For instance, most Banggai cardinalfish in public and private aquaria (figure 47) are commonly kept with coral reef species, despite the fact that they live in seagrass beds miles away from coral reefs (Delbeck, 1999). Although this does not necessarily mean that these fish may suffer from the presence of its unusual companions, it does not help public aquaria to fulfil their self-imposed education role, which should have being considered when designing their exhibits.

Figure 47. Banggai cardinal fish kept in a UK public aquarium tank together with tropical reef fish species that it never would encounter it in the wild.

Although it may seem impossible, sometimes the design of exhibits does not prevent animals in aquaria from escaping their tanks. In one UK public aquaria in the year 2000 a shark leapt out of its tank twice and landed among visitors (Anonymous, 2000), and the low walls of the tanks were blamed for the event.

The materials used in the exhibits or even the chemical procedures to treat the water may also be chosen wrongly as part of a public aquarium design. Aluminium is acutely toxic to fish and invertebrates, so it should not be used in the design of tanks. Synthetic salts that may be used in public aquaria are notorious for containing elevated levels of this element due to impurities (Poléo, 1995).

In fact, metals should not be part of the submerged portion of a tank when species sensitive to electric fields are housed. In Steinhart aquarium (San Francisco) a young great white shark that was held in a doughnut-shape tank kept crashing into the wall at the exact spot, and it turned out that some corroded metal was generating a weak electric current (Bright, 1999).

Ozone is commonly used to disinfect the water of public aquarium systems but it is a powerful oxidant and can elevate 'Oxidation Reduction Potential' (ORP) values to unsafe levels. Several sharks deaths in UK public aquaria have been blamed on this, not only in published cases (Anonymous, 2001a), but also in unpublished ones.

Although it is very difficult to measure the actual free volume a shark may have in an aquarium without having exact measures of its tank (visual references are not good enough to assess size in aquaria due to the distortion water refraction produces), or to know the actual composition of the aquarium artificial salt, some display designs can indeed be assessed through a simple visit to the aquarium. In this chapter we will pay attention to some of them.

Modernity in UK public aquaria exhibits

A few years ago, advances in aquarium materials (mainly the use of acrylics instead of traditional glass) and techniques (more efficient filtration systems and the use of ozone as a disinfectant) allowed aquarium exhibits to depart from their traditional shapes and sizes. Many of the modern UK public aquaria have adopted all these technological advances, but some more than others. In order to assess how 'modern' the UK public aquaria tanks are the frequency of distinctive tank features indicative of these advances was calculated.

Following are the types of special tanks used to assess the modernity of UK public aquaria exhibits.

- Big (no tunnel): Tank bigger than 200 cubic metres of volume, more than three metres deep but without any underwater tunnel for the visitors to walk through (see figure 48).
- Big shallow: Relatively big tank much bigger in surface than in height (less than one metre deep), without a pentagonal or similar shape, and not designed to allow visitors or staff easy physical access to animals normally living in rockpool habitats (see figure 48).
- Cylindrical: Tank with its main glass in a cylindrical shape (see figure 48)
- Tunnel: Tank with an underwater tunnel for the visitors to walk through (see figure 48)
- Quarantine: Tank with no glass walls, normally located in the quarantine or holding area of the public aquarium although still in public view (see figure 48)
- Ray pool: Relatively big tank (bigger in surface than in height), less than two metres deep and with a pentagonal or similar shape normally used to display rays and/or small sharks (see figure 48)
- Spherical: Tank with its main glass in half spherical or quasi-half-spherical shape (see figure 48)
- Semi-spherical: Tank with its main glass in the shape of (or close to) a quarter of a sphere (see figure 48)
- Touchpool: Open tank designed to allow visitors or staff easy physical access to animals normally living in rockpool habitats (see figure 48)
- Wave: Tank with a mechanical device that produces artificial waves (see figure 48)

All tanks that did not conform to any of the above definitions were considered 'traditional' tanks. The category 'big tanks' was defined as the sum of the 'Big (no tunnel)', 'Tunnel', 'Ray tank' and 'Big shallow' categories.

The results in figure 49 show that 80% (n=804) of the tanks in UK public aquaria could be considered 'traditional', and about 5% could be considered 'big'. Touchpools represent 3% of the exhibits, and 'ray pools' 2%. Only 1% of the tanks have underwater tunnels for visitors to walk through, and these represent about 30% of the 'big' tanks.

Regarding the presence of modern tanks per public aquarium, 97% (n=31) of the UK public aquaria have one or more of the non-traditional tanks described. If we do not count 'touchpool' tanks (which in some respect could be considered traditional) the percentage remains at 97%. More than a third (39%) of the UK public aquaria have underwater tunnels, half (52%) of the UK public aquaria have tanks with concave or convex glass/acrylic walls, touchpools and 'ray tanks', and almost three quarters (74%) have big tanks. In general, then, we can conclude that the UK public aquaria show aquatic exhibits that can be considered quite 'modern' in terms of design and materials, and therefore we should conclude that in general the shortcoming of public aquaria performance discovered in this study should not be attributed to the use of outdated exhibits.

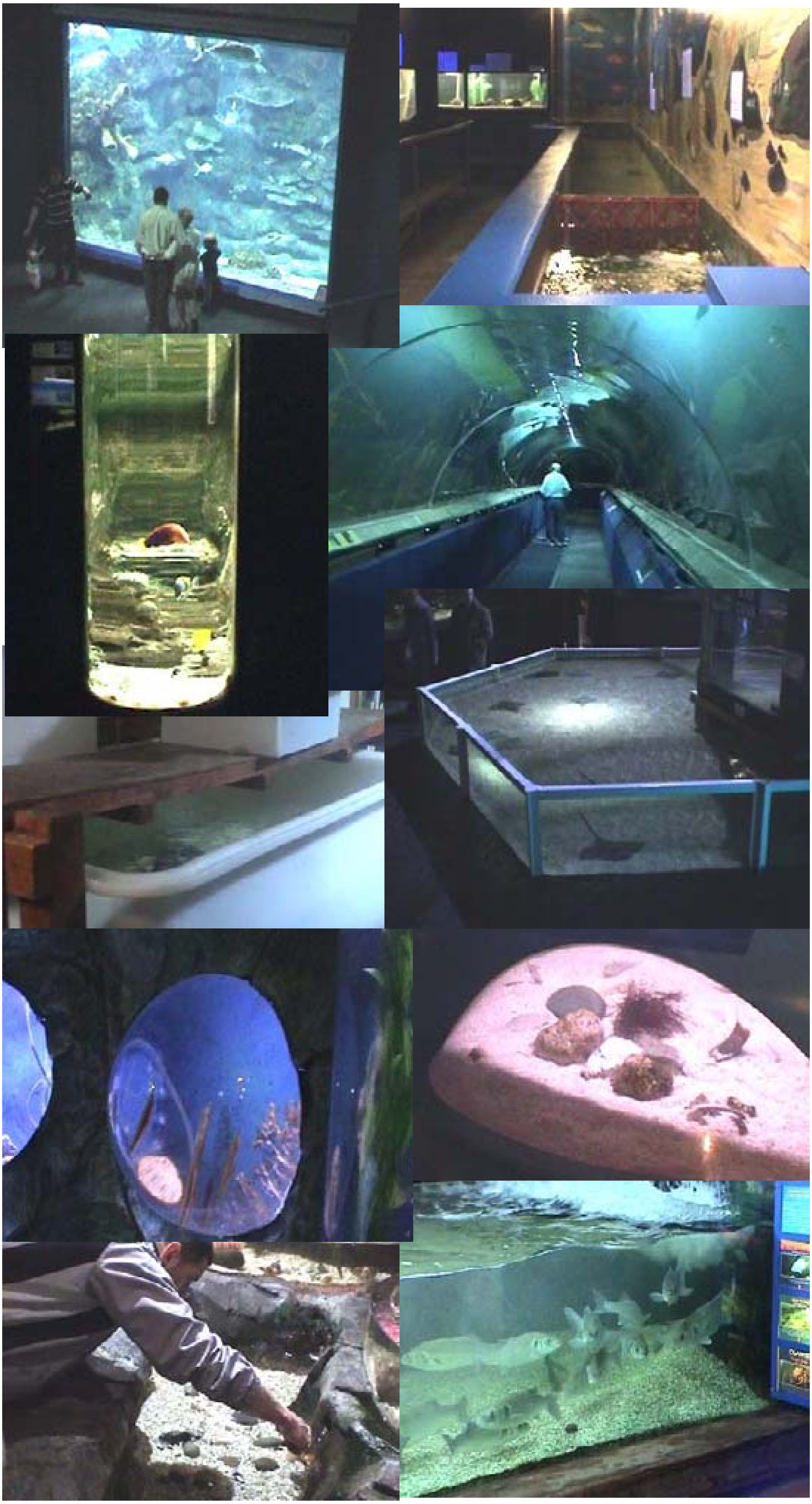

Figure 48 (previous page). Types of special tanks characteristic of modern aquaria found in UK public aquaria. From left to right and top to bottom, big tank (no tunnel), big shallow, cylindrical, tunnel, quarantine, ray pool, spherical, semi-spherical, touchpool and wave (see text for definitions)

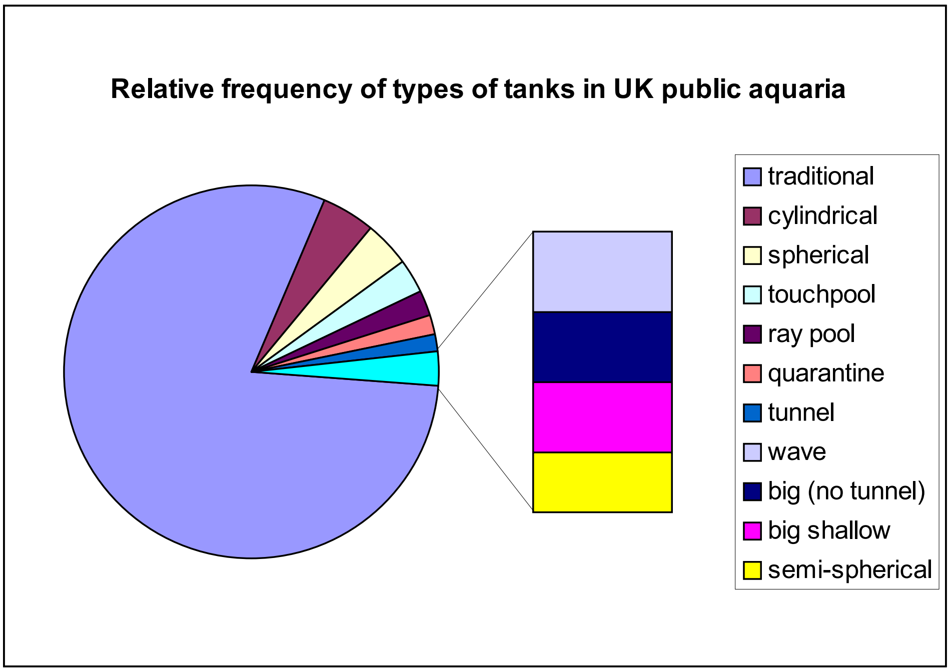

Figure 49. Relative frequency of types of tanks found in UK public aquaria (see text for definitions). N=804

Exhibit substrates in UK public aquaria

When one designs an aquarium exhibit one not only has to choose its size, types of fish to be kept or decoration. The substrate on which all non-floating tank elements would be resting is also an important feature to choose, since it may play an important role in the behaviour of the animals (which may use the substrate as a hiding or breeding place) but also in the chemistry of the system (since it can become a valuable bacterial filter bed, or may contribute to regulate the water PH).

There are several types of substrate that can be chosen for several reasons. For instance, gravel or sand have the advantage of being PH inert and not having any nutrients nor CEC (Cation Exchange Capacity) value. Zeolite, on the other hand, contains sodium or calcium, and therefore can act as ion-exchanger with a high CEC. Peat has a high organic content which makes the water more acid, convenient when the 'hardness' of the water is too high, while coral sand or other calcareous substrates can increase the hardness and raise PH if needed.

It is possible, then, to choose the wrong substrate, and for this reason some assessment of the type of substrate used in UK public aquaria was made during this study.

One of the substrates that can be considered 'wrong' in most exhibits is 'crushed cockleshell'. These are sharp pieces of crushed seashells often seen lining the bottom of the tanks (figure 50), but because they have not being crushed by the natural erosion of the sea they are much sharper that the portions of shells that are present in the wild. It is their artificial sharpness that makes them unsuitable for most public aquarium displays, since combined with stress, overcrowding and human interactions this material may bring out sores and lacerations on the undersides of fish such as rays or any type of flatfish (figure 51). These animals would normally lie buried in sand in the wild, but in the public aquaria where they are kept in a cockleshell substrate they are forced to either use such abrasive substitute, or not to be buried at all. In either case, the result may be unnecessary suffering or stress.

Figure 50. Close up of a 'Crushed Cockleshell' substrate often seen in UK public aquarium exhibits.

Figure 51. Ray kept in a UK public aquarium that shows lesions in its ventral area that might have been caused or worsened by scratching with crushed cockleshell substrate.

The reason that this substrate is used is because it acts as a good filter bed to catch suspended detritus in the water, and it holds well many welcomed de-nitrifying bacteria due to their large surface area. Also, perhaps, its sharpness may prevent fish from burying themselves under it, not only upsetting the carefully laid bed of the exhibit, but also disappearing from the visitor's sight.

The presence of cockleshell substrate in UK public aquaria was investigated. Figure 52 shows that it is the third most common substrate seen in UK public aquaria exhibits, with 16% of the exhibits containing cockleshell (n=804).

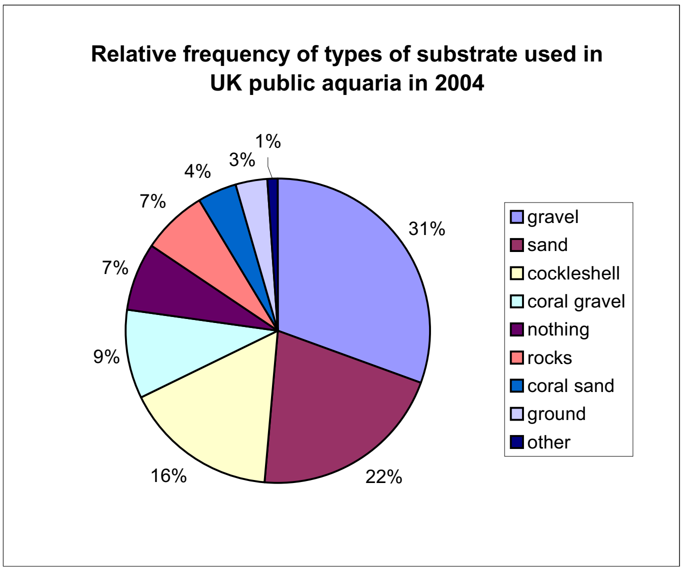

Figure 52. Relative frequency of types of substrate used in UK public aquaria in 2004. N=804

Almost half of the public aquaria (48%, n=31) have exhibits with this substrate, and it could be found in all types of public aquarium, although most commonly in chain public aquaria, where it was seen in 82% of the centres (n=11). The absence of this substrate in about half of the public aquaria, and the fact that the majority of exhibits show different types of substrate, are proof that this is not a substrate 'needed' to exhibit fish, and alternatives are available. However, a considerable number of public aquaria have chosen to ignore such alternatives (which perhaps may turn out to be more expensive), perhaps at the expense of their animals wellbeing.

Open/closed tank design in UK public aquaria

One of the features of modern public aquaria –and modern zoological collections as well –is the 'hands on activities', in which visitors can physically interact with the animals. Although in zoos this tends to be the 'children's farms' or the 'meet the snake' sessions (also present in aquaria), in public aquaria more 'passive' interactions take place. These are the ones that are not organised as aquarium events, but that take place at any time by any visitor in the form of exhibits designed to allow physical contact.

Because of the nature of the aquatic environment, there are two types of physical interactions that could occur between visitors and public aquarium animals: the direct touching of the animals or the touching of the water surrounding them. Both, as will be seen below in the interactions chapter, can be detrimental for the animals or visitors involved, and both can take place with supervision of aquarium staff, or unsupervised (a practice not only forbidden by zoo regulations but often not recommended by the public aquaria themselves, at least in theory). The latter only can occur if the design of the exhibits allow it because they are 'open' from above and easily reachable by visitors. In this study an assessment of how widespread are exhibits that allow unsupervised physical contact between visitors and animals/water was made.

Three exhibit categories were used:

- Open (not touchable): Exhibits where visitors can see the surface of the water from above but they cannot easily touch it without either climbing on barriers or other exhibit structures, or by making a clear effort in order to reach it (see figure 53)

- Open touchable: Exhibits where visitors can easily touch either the water or the animals in it without either having to climb anywhere nor making too much of an effort trying to reach it (see figure 53).

- Closed: Exhibits where visitors cannot see the surface of the water from above

Figure 53. Two examples of 'open' tank found in UK public aquaria. On the left an 'open touchable' where most people can easily reach the water, while on the right an 'Open (not touchable)' where the level of the water and the size of the wall between the visitors and the tank edge would make it quite difficult for most people to touch the water.

Using these categories 20% (n=804) of the UK public aquaria exhibits are 'open' from the top so visitors can see the surface of the water, but 14% of the UK public aquaria exhibits are 'touchable' so visitors could easily touch the water and/or fish if they were allowed to (figure 54).

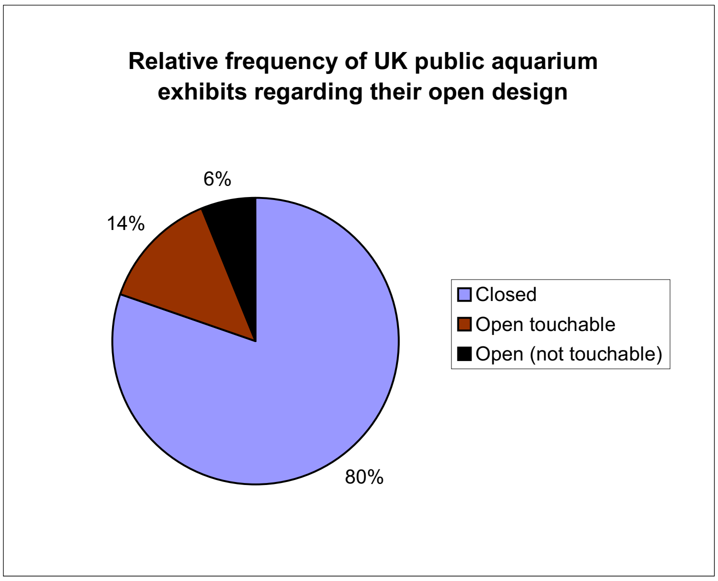

Figure 54. Relative frequency of UK public aquarium exhibits regarding their exposed 'open' design (see text). N=804

The analysis per aquarium shows that the majority of the UK public aquaria (77%, n=31) have exhibits where the visitors can physically touch either the water or the animals in them easily, regardless of whether or not they are allowed to do it. As will be seen below, many visitors disregard signs telling them not to touch the fish or the water, so 'touchable' exhibits almost equate to 'touching' exhibits.

As seen in figure 55, there are 'touchable' exhibits in all types of UK public aquarium, but the 'Auxiliary' aquaria, predictably, are the type with a lower proportion of 'touchable' exhibits.

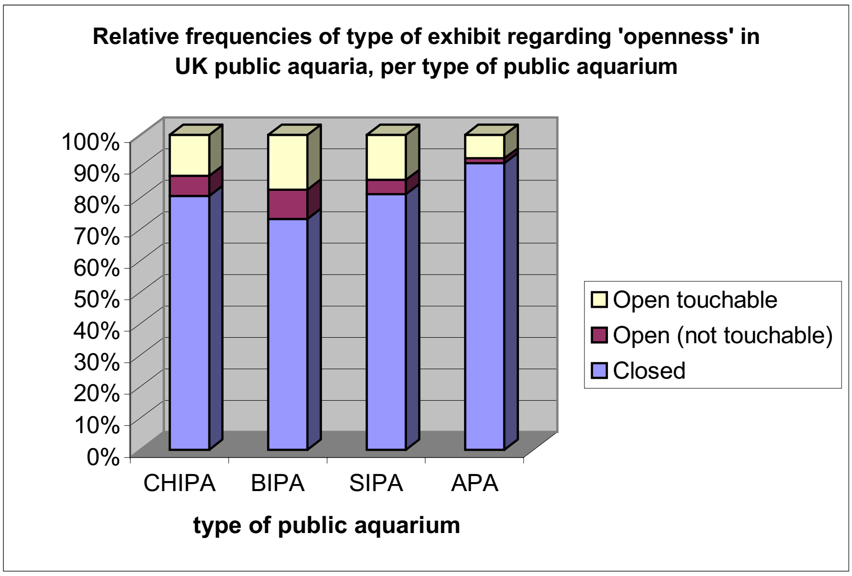

Figure 55. Relative frequency of type of exhibit regarding 'openness' in UK public aquaria, per type of public aquarium (see text). CHIPA= Chain Public Aquaria, BIPA= Big Independent Public Aquaria, SIPA= Small Independent Public Aquaria, APA= Auxiliary Public Aquaria.

The fact that in the majority of UK public aquaria visitors can physically touch the water and their animals and, as will be seen below, actually do touch them most of the times they can, is in clear contradiction with the claims that unauthorised physical contact is not encouraged in public aquaria. It is true that signs asking visitors not to touch the water or the animals are very commonly seen in many public aquaria, but equally common are visitors ignoring these signs. Surely public aquaria must be aware of that, and therefore they should design their exhibits in such a way that the contact is physically impossible.

Some aquaria may say that the nature of some of the exhibits, for being shallow or very big, made them impossible to be 'open', but as the results of this study show several open exhibits (6% of them all) can be closed but still designed so no visitors can reach the water. This can easily be achieved by either making the tank walls taller or by adding stand off barriers –a relatively inexpensive infrastructure modification. The existence of 6% open enclosures with non visitor access proves that such designs are possible, but the fact that totally unprotected open exhibits are double this amount can be interpreted as public aquaria, despite all the signs, not having a real intention to prevent visitors/animals interactions. In fact, it is perfectly arguable that an aquarium where visitors can freely touch what they want has a greater 'visitor appeal' than one that is all 'look and not touch'. The increasing number of 'hands on' activities in all zoological collections shows that this is one of the latest marketing strategies to attract more visitors –who do seem to enjoy such activities. Why would public aquaria, then, not want to profit from this public demand? For one side zoo regulations –and the common sense often appealed to by organisations or individuals that express their concerns for the animals' wellbeing– do not actually recommend such interactions, but 'marketing' pressure does. A possible way to overcome such conflict could be by designing the exhibits so the interactions can take place, and at the same time displaying a few signs asking visitors not to interact –without ever acting against visitors that disregard them. Some evidence that UK public aquaria may indeed be attempting to overcome such conflict in this way could be found in the fact that the vast majority of unauthorised physical contact between visitors and animals/water observed during this study went unchallenged by the aquarium staff (even when the staff witnessed such interactions), with only one case witnessed where a keeper told off a misbehaving visitor.

These 'double standards' are clearly exposed when one analyses some of the specific designs of some of the exhibits, such as the case of ray tanks (figure 56). In ray tank exhibits (see definition above) the main function of their design seems precisely to encourage physical interaction despite any signs that may be displayed stating otherwise. The height of many of such tanks walls not only facilitates people to 'reach over', but make it difficult for people to watch the animals through the glass without having to crouch. Because the surface of the water tends to be turbulent in such tanks visitors cannot see clearly what is in the water by watching from above, and therefore the design is not aiming for visitors to 'see', but for visitors to 'touch' –since 'surface breaking behaviour' (see chapter on abnormal behaviour above) is common for rays and small sharks normally displayed in such tanks.

Figure 56. 'Ray tank' in one UK public aquarium, exhibit clearly designed so visitors have physical access to the surfacing rays or small sharks.

Public aquaria may defend these designs by saying that indeed they were created to encourage physical interaction but that was many years ago before such interactions were identified as detrimental for either animals or visitors (although some public aquaria still do not accept that). Therefore they may say they have inherited such tanks from the past and the only thing they can do now is to display the signs asking people not to interact anymore. In reality, though, public aquaria can do much more than that. They can increase the height of the walls, they can install stand off barriers, they can have permanent staff 'on watch' actively telling off visitors that disregard the signs, or if all the above is deemed impossible, they can close those particular exhibits on the grounds of animal welfare or even compliance with zoo regulations. Most public aquaria choose not to do any of that, which should be an indication of their real intentions on this issue.

Another example of this is the design of touchpools. According to zoo regulations, only when there is staff supervising the touchpool should visitors be allowed to touch and pick up animals. However, this hardly ever happens because most of the time touchpools in most public aquaria have no keepers supervising anyone. Despite the occasional sign explaining about the supervision, most visitors would not hesitate to touch the animals on their own when the exhibit is so obviously designed for that. If the public aquarium does not have enough staff to man the exhibit, the solution is simple: to cover it as one of the public aquaria does (figure 57). However, none of the others opted for such solution, which effectively leaves the touchpool animals unprotected most of the time. As will be seen in the chapter on human interactions below, this can have serious consequences for the animals.

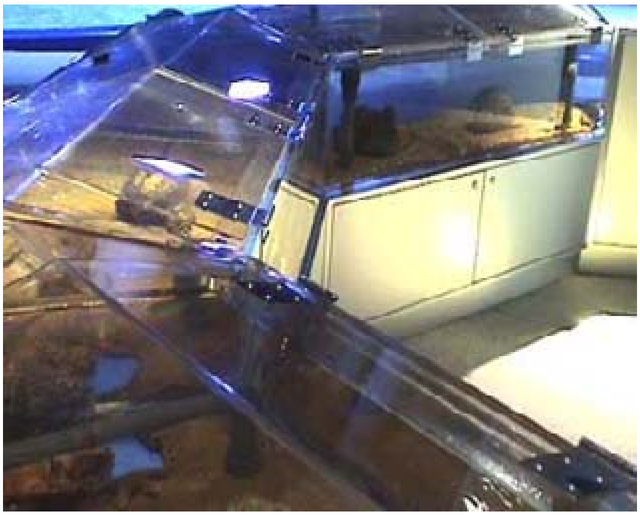

Figure 57. Touchpool in one UK public aquarium in which the open tops are covered with a transparent cover when the exhibit is not supervised.

Mixed exhibits in UK public aquaria

Perhaps more commonly than in other types of zoological collections public aquaria tend to have exhibits in which more than one taxon is displayed together. There are pros and cons of having mixed exhibits. The main pro is that it provides a more stimulating life to the animals kept in the exhibit, but the main con is that it may be a cause of stress –and even death –for those animals that cannot escape from members of other taxa with which they share a space. When predators and prey, for instance, are housed together, this 'con' is obvious. In the case of aquatic animals, though, it is often both the aesthetic value of mixed exhibits together with the economic value of having less tank systems that is likely to be the main criteria in deciding which species go where.

In this study how often different taxa were housed together in UK public aquaria was assessed. Figure 58 shows that over one third of the exhibits (36%, n=804) showed only one visible taxon, about a fifth (20%) showed two taxa and a bit more than a tenth (12%) three taxa. 7% of the exhibits housed 10 or more taxa, and 1.3% more than 20. The majority of exhibits in UK public aquaria, then, are mixed exhibits, with an average of 3.6 taxa per exhibit, and a maximum of 41 taxa per exhibit.

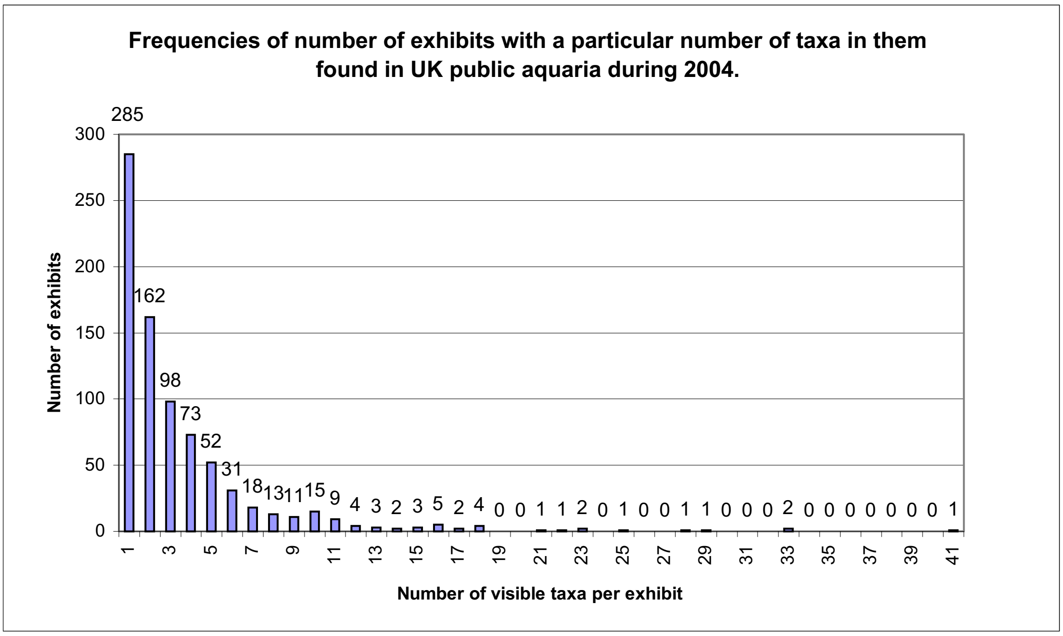

Figure 58. Frequencies of number of exhibits with a particular number of taxa in them found in UK public aquaria during 2004.

The *Secretary of State's Standards of Modern Zoo Practice* state:

> *PROVISION OF ANIMAL HEALTHCARE*
> *7. Injury: The provision of an enclosure designed to minimise the risk of injury is required. The design should allow animals to get away from each other. In mixed species' exhibits, care should be taken that one species cannot injure another. Enclosures should be designed to minimise the risk of predators entering the exhibit.*
>
> *PROVISION OF PROTECTION FROM FEAR AND DISTRESS*
> *12. Animals often benefit from mixed species environments. However, inter-species conflict can cause stress and this needs to be monitored, recorded and reviewed, including safety from potential predators.*

Despite the compulsory status of the *Standards*, UK public aquaria are one of the few types of zoological collections where predators and prey are still housed together. Aquarists often say that these fish are no longer predators nor prey because the husbandry techniques can control their feeding behaviour. Although it is true that captive animals have lost the ability to behave normally in most situations, and that indeed feeding behaviour can be altered to a great extent in captivity, it is also true that one thing captivity cannot do to wild animals (although it can to domestic animals, or animals in the process of domestication) is to eliminate their instincts. Predatory behaviour is a highly instinctive behaviour, so it would be almost impossible to ensure that a potential prey housed with its predator will never succumb to it.

Large sharks such as lemon sharks or sand tiger sharks tend to eat smaller fish in captivity (Sabalones, 1995). In fact, sand tigers –which are present in UK public aquaria in mixed exhibits despite some aquaria having publicly stated they should not be kept at all– are said to attempt to eat everything smaller than themselves, and even if they are not successful they may cause greater stress among the fish kept with them. Most staff in public aquaria will reassure visitors that constantly ask if sharks eat other fish by saying that they never do it because they are overfed, but in truth it does seem that large sandbar, sand tiger or even nurse sharks occasionally supplement their daily diet with other residents of the tank, including remoras, jacks, giltheads, bass and lookdowns (Anderson et al., 1995). Some of the staff of the public aquaria investigated indeed admitted sharks eating other fish does sometimes happen.

Some may say that this is acceptable because prey do succumb to predators in the wild, but the reality is that in the wild both prey and predator have a 'fair' arena in which to express their natural predatory and defensive skills, whilst in captivity the predator is given all the advantage. Because the enclosed environment puts predators in a position to strike at their prey more frequently, the situation is quite different than in the wild. It does not really matter that the public aquarium feeding regime manages to keep predators with their stomachs full most of the time, because for those occasions that this does not work, even if they may be rare, the aquarist has failed to provide the proper animal welfare care to the smaller fish that has unfairly become someone else's dinner.

It is not always sharks who are the predators housed together with prey in public aquaria. On one occasion the investigator witnessed a tropical moray eel being introduced for the first time into a tank after a long trip from the tropical fish supplier. Instead of keeping the moray eel for a while in an out-of-sight isolated tank for acclimatisation, it was put directly into a display in an exhibit that contained other fish. As a consequence not only did the eel show great signs of distress (confirmed by the keeper overseeing the introduction), but one of the fish that was already in the tank, a small triggerfish, showed strong stereotypic pacing/ITB, clearly as a reaction of the sight of one of its potential predators (figure 59). The exhibit was not much bigger than 1.5 cubic metres of volume, so the likelihood of prey and predator finding each other was high. Hours later, although the moray eel showed signs of settling, the triggerfish was still stereotyping in the opposite end of the tank (which most people would easily interpret as a frustrated attempt to escape).

Figure 59. A Picasso triggerfish (left) housed together with a moray eel (right), soon after the eel was first introduced into the tank in one UK public aquarium. Both prey and predator showed signs of distress, but the triggerfish showed strong stereotypic behaviour for hours clearly as a response of the introduction of the potential predator.

Sometimes predators are not the problem in mixed species exhibits. A public aquarium staff member told the investigator that a giant Queensland Grouper (a very large tropical fish) they kept in a big mixed tropical tank holding many fish eventually died a few months ago *because "it was getting distressed by many small fish picking on it".*

<u>Obvious bad exhibits in UK public aquaria</u>

As said earlier, some aquarium exhibits may be so inappropriate that even someone with no experience of keeping aquatic animals may realise it at first glance. It is normally the small size, the general lack of hygiene, or the absence of any decoration or shelter whatsoever that may set this exhibit apart from the standard (which as said so far may also be inappropriate, but in a less obvious way).

In some public aquaria visited not a single exhibit appeared to be properly maintained, with a huge amount of algae growing everywhere, and many signs of ill health among the fish population (figure 60).

Figure 60. Examples of dirty and un-mantained tanks found in one UK public aquarium. The two pictures above show the same tank, while the two below show different tanks. All tanks featured contained fish. This particular public aquarium, in which many examples of unhealthy fish were found, had signs claiming to be one of the best aquariums in the area.

In others the barrenness was particularly shocking when found in cephalopods tanks (figure 61), due to the highly intelligent nature of octopuses and cuttlefish already mentioned above.

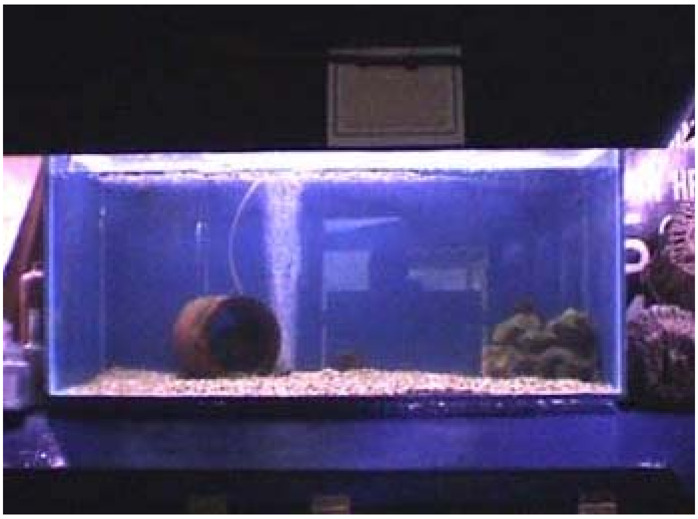

Figure 61. Octopus tank found in a UK public aquaria, in which only some rocks and an exposed tube are available for shelter. The octopus is in the tube.

In others it was the traditional tiny 'fish bowl' that made one think that this was perhaps not a 'public' aquarium, and in others the only vegetation available was painted on the tank walls (figure 62).

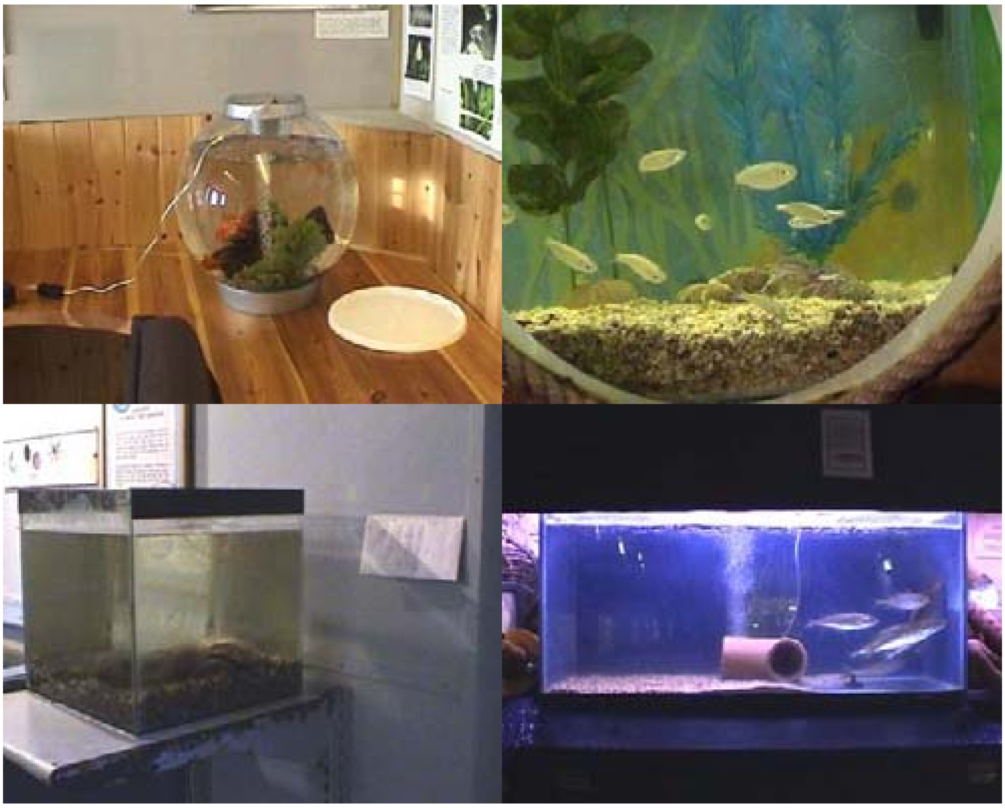

Figure 62. Four examples of very small exhibits found in UK public aquaria. Top left, a goldfish bowl; top right, a bass small tank with vegetation painted on the background; bottom left, a tank with an oyster; bottom right, a featureless tank with several medium size bib.

Sometimes it is not the 'old and dirty' concept that awakes 'bad feelings' about an exhibit when first seing it. Sometimes it is just the opposite, the 'modern and clean' that may produce the same reaction. An example of how the 'modern and clean' can be as bad as the opposite was seen in a UK public aquarium which displayed a 'new' section in which most exhibits were 'futuristic looking' with unusual shapes and designs. More substrates had been replaced by glass or plastic beans/balls, most naturalistic environments had been replaced by 'futuristic' minimalist ones, and the shapes of the exhibits were also very unconventional, clearly aimed to please the visitors eye, not the animals'. The fish kept in them, however, did not seem happy at all. With an unusually high incidence of stereotypic behaviour in that aquarium section, it was obvious that such 'clinical' design had been a mistake.

A good example of this is a triangular exhibit in this public aquarium section that played with light and reflection to give the optical illusion that the tank was bigger than it actually was (figure 63). Two on the walls acted as mirrors reflecting each other, but they also reflected the group of fish inside, and as a consequence they were showing severe ITB (Interaction with Transparent Boundaries) behaviour (see abnormal behaviour chapter below), which is an indicator of animal welfare problems. Another exhibit of the same section a few metres on showed a completely barren ray tank with two rays showing clear pacing/circling/surfacing behaviour, probably as a reaction to the lack of stimulation, or the lack of proper shelter to get away from visitors (figure 64). Another example of 'clinically' barren tanks can be found in the so-called seahorse breeding centres, already mentioned in another chapter (figure 32).

Figure 63. One of the 'futuristic' exhibits found in a UK public aquarium in 2004. On the left, two mirrors in a triangle ending with a vertical red light at the centre of the image reflecting each other's images. On the right, the foxface housed in this exhibit reacting to their own reflected images with clear ITB stereotypic behaviour(see text).

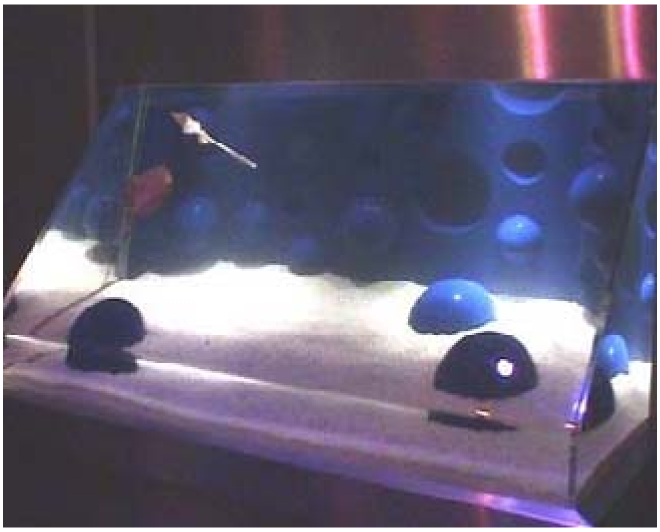

Figure 64. Another 'futuristic' exhibit at one UK public aquarium in which two exposed severely stereotypic rays are kept without any real shelter, besides a substrate that they do not seem to use much.

Overall, in more than half of the UK public aquaria (58%) one could find exhibits that would be easily identified as 'bad' by most people due to their small size, dirtiness, barrenness or poor maintenance, which is a very high percentage.

Although many aquarists would probably agree that the obviously bad enclosures should not be allowed, it is easy to blame irresponsible aquarists for all the bad things of the public aquarium industry. However, the evidence unearthed in this study so far does not free of guilt any of the 'reputable' aquarists who might have managed to avoid criticism for long, because as has been seen not all the problems found in public aquaria are limited to small tanks or poorly maintained exhibits. After visiting all these public aquaria, from the smallest dirty one to the modern big tunnel 'reefs', one cannot help to remember the famous marine explorer Jaques Cousteau, who once said "*no aquarium, no tank in a marine park, no matter how spacious it may be, can begin to replicate the conditions of the sea".*

ANIMAL/VISITOR INTERACTIONS IN UK PUBLIC AQUARIA

Zoological collections are a combination of four main elements: exhibits, captive animals, visitors and staff. So far we have dealt with the first two, but visitors play an important role, not only because zoos are dependant on visitors for the running of their businesses, but also because animal welfare matters derive from the interactions between the visitors and the animals kept. This chapter will address these interactions taking place in UK public aquaria.

Visitors touching animals in UK public aquaria

As said earlier, 'hands-on activities' is a familiar expression that is commonly heard these days when referring to zoological collections. Touching, not just watching, is certainly part of the modern 'zoo experience', and this is not necessarily a good thing for everyone. There is no doubt that these activities are somehow invasive for the animals involved, but they also change the expectation of zoo visitors that want to get closer and closer to them, pushing forward the boundaries of how far the interaction can go. We are led to believe by zoo operators that these activities are safe for the public and do not represent any problems to the animals, but the reality is that this may not be true.

The hands-on 'fever' has also reached the world of public aquaria, and this study can confirm it. In 41% (n=31) of the UK public aquaria authorised physical contact between animals and visitors was witnessed, but since 51% of the UK public aquaria have touchpool exhibits the proportion of aquaria with authorised interaction should be at least half of them. Authorised contact normally takes the form of organised touchpool talks, although ray pools talks with authorised contact occur in some public aquaria, and the occasional 'meet the snake' can also be seen. However, unauthorised physical contact (see section below) is very common indeed, so in the majority (at least 61%) of the UK public aquaria there is physical contact between animals and visitors, regardless of whether that contact is allowed or not. A similar survey produced with a random selection of UK pubic aquaria during the period 2000-2002 (part of it in Casamitjana & Turner, 2001) showed a similar percentage (57% of public aquaria, n=33).

The zoo regulations authorise some of the supervised contacts under certain circumstances. The *Secretary of State's Standards of Modern Zoo Practice* state:

> *5.1 Animals must be handled and managed only by, or under the supervision of, appropriately qualified or experienced staff. Handling must be done with care, in order to protect the animals well-being, and avoid unnecessary discomfort, stress or physical harm.*
>
> *5.2 Any direct physical contact between animals and the visiting public must only be for restricted periods of time and under conditions consistent with animals' welfare, and not likely to lead to their discomfort.*
>
> *5.3 Animals must not be provoked for the benefit of the viewing public.*
>
> *5.4 Animals which may interact in an excessively stressful way must not be maintained in close proximity.*
>
> *6.9 The zoo must have adequate hand-washing and sanitising facilities, close to the contact point and obviously signposted. These should provide with running water, soap and disposable towels or hot air blowers.*
>
> *8.44 Suitable and, where appropriate multi-lingual, warnings and information should be provided where animals and visitors may come into contact.*
>
> *Appendix 6, 6.10 Supervisors should ensure that, following contact with animals, children wash their hands. Prominent signs should remind parents or accompanying adults of this.*

Appendix 6, 6.11 There must be adequate staff supervision in all contact areas. This should be commensurate with the type of animal and degree of risk, and to ensure the welfare of the animal. At all times whilst the public have access to the contact area there must be an appropriate number of staff on hand to ensure the welfare of the animals is not compromised by excessive handling.

It is obvious that, for the number and type of conditions stipulated in the *Standards*, there are reasons for considering that physical contact is something that should not be encouraged, even with fish.

In fact, there are various reasons for actively avoiding physical contact with fish. One of them is the risk of zoonoses, which are defined as diseases the agents of which are transmitted between vertebrate animals and humans (Hubbert et al. 1975; Schwabe, 1984). There are more than 230 known species of organism that are zoonotic agents, but it is probable that this represents a very small proportion of the agents that really can infect both human and other vertebrates. Zoonoses can be transmitted by faeces, urine, saliva, blood or milk, via aerosol, oral, contact with bedding or animals, direct blood to blood contact, or animal vectors. The transmission can happen from humans to animals or vice versa.

Some diseases caused by infection with zoonotic agents have been recognised clinically since early history whereas others are only being recognised recently (Huge-Johnes et al. 1995). Any place where humans and vertebrate animals are in direct or indirect contact with one another is susceptible in having a zoonoses risk, and although zoonoses are not often reported in the case of public places with live fish, this does not mean that there is less of a risk.

Large, dense populations of susceptible species have the potential of acting as sources of novel or previously unnoticed infections, especially if the multiplying host is relatively unaffected (Hugh-Jones at al, 1995). Public aquaria, due to the mixing of species from several parts of the world and the high frequency of mixed exhibits, may constitute a potential 'growing soup' for these new pathogens. Exogenous pathogens could enter and survive in such complex systems because aquaria are supplied from livestock of rivers and seas. Wild species usually reach the aquarium under stress, which increases the chances of disease. In this situation unknown diseases or emergent pathogens are more likely to appear (Blanch et al. 1999).

Despite the fact that most well-known zoonoses are normally reported in cases where humans get ill from contact with terrestrial animals, as opposed to animals being the ones getting a disease from a human, or humans getting infected from aquatic animals, there are many studies that confirm zoonotic cases involving fish, such as cases of *Comamonas* (Smith & Cradon, 2003), *Mycobacterium marinum* (Lewis et al., 2003; Kiesh, 2000, Lawler, 2004; Lahane & Rawlin, 2001), *Vibrio alginolyticus, V. damsela, V. parahaemolyticus, V. vulnificus*, (Lawler, 2004), *Aeromonas hydrophyla, Edwardsiella tarda Streptocoiccus iniae* (mad fish disease), *Erysipecothrix rhusiopathiae* (Lahane & Rawlin, 2001; Lawler, 2004), or other bacteria (Le Hane & Rawlin, 2000; Nemetz & Emmet, 1993). In some of these cases the disease produced can be systematic and rapidly fatal.

There have been cases where humans have been infected without direct physical contact with fish, just through dermal contact with water (i.e. cases of *Mycobacterium*, *Vibro, Aeromonas, Pseudomonas* and *Edwardsiella*, Nemetz & Emmet, 1993). In fact, there are many ways in which fish or aquatic animals kept in public aquaria can pass a zoonotic disease to a human that enters into contact with them, especially members of the aquarium staff: spine punctures, scratches caused on a fish tank, injured bare feet on wet surface (i.e. in an aquarium parking lot close to a beach), mouth-siphoning and splashing into mouth in fish tanks, bites from tank fish, diving with infected fish, splinters from fish net handles, unhygienically handling fish food, etc. (figure 65).

Figure 65. Example of a UK public aquarium in which fish food is handled by the visitors (who then can throw it to the fish, or allow them to pick it). Although there may be signs suggesting to wash hands afterwards, many visitors disregard them. The surfaces where the food is placed constitute a potential health hazard for the visitors that may touch them afterwards.

Fish can indeed bite visitors (as many signs in public aquaria indicate, figure 66) and do bite, as in a recent case where a toddler had to have surgery after being bitten by a piranha during a visit to a butterfly farm in Scotland. The girl was visiting Edinburgh's Butterfly World with her mother when the incident happened, after it is thought she dangled her hand in a pond. The owners of the centre admitted the child may not have been supervised at the time of the attack (Anonymous, 2004h).

Figure 66. One of the signs in a UK public aquarium advising visitors not to touch the fish because of the risk of biting

Some of the pathogens that have been found in UK public aquaria in the last few years may be zoonotic agents. The six-year-old internal weekly reports from a UK chain public aquarium quoted in the health chapter above describe an infection by *Psedomonas picketti* (an infection the general public was likely unaware of at the time)*.* In 1985 there was a human outbreak of pseudobacteremia in a hospital caused by *P. picketti*, and in 1991 some patients in a South African paediatric unit developed *P. picketti* septicaemia (Lacey & Want, 1991). Although this does not mean that these people caught the disease from fish, it does show that the same bacteria that may affect fish can also affect humans. Those people with weakened immune systems are at greater risk from getting zoonotic infections. So people with AIDS, diabetes, liver dysfunction, kidney problems, or undergoing cancer treatment, etc. should be especially careful around animals (Hubbert et al., 1975), including fish in public aquaria. On no occasion a warning of this sort was seen in any UK public aquarium during this study.

Sometimes the risk of infection the visitors to public aquaria take does not come from the animals in the tanks, but from the tanks filtering and cooling systems. In April 2000 in Australia 107 people were affected by a legionnaires disease outbreak originated in the water-cooling towers of Melbourne Aquarium. As a result 77% of the affected were hospitalised and four people died directly from the disease (Graham et al, 2000). Legionnaires' disease enters the body through inhaled water droplets. Multiple types of water systems have been implicated as sources for the disease –including domestic hot water, showers, hot tubs, and cooling towers, like the ones present in public aquaria that require reducing the ambient temperature. Bacteria are part of the filtering system of public aquaria, which contains *Nitrosomonas* and *Nitrobacter* that together transform the toxic Ammonia produced by the fish waste into the innocuous Nitrate. Therefore, conditions for the growing of large bacteria colonies are an integrate part of the aquarium system, and if pathological bacteria use them, and any part of the system to prevent that from happening goes wrong, the result can be catastrophic.

Apart from the zoonoses issues, there are other reasons to prevent animals and visitors contact. In the case of fish and aquatic invertebrates, this contact can be very detrimental for the animals' health. For instance, often in unsupervised touchpools, many visitors not only touch and handle animals that show clear signs of not wanting to be touched (as hiding or trying to run/swim away) many times a day, but also they do it in a very rough manner. Sometimes animals fall from peoples' hands by accident but sometimes they are deliberately and violently thrown in some sort of sadistic game, both cases being capable of producing injuries and certainly always causing distress. The investigator witnessed several examples of this. In one chain public aquarium, for example, an obviously apprehensive visitor was encouraged to pick up and hold a crab by members of the staff, and when the crab moved, the visitor, startled, let it go, which made the crab fall provoking laughter from visitors and staff alike. In another even more disturbing case a group of young visitors enjoyed themselves throwing crabs into the touchpool – which caused the loss of some of the crabs' limbs – or turning them over for fun, all under the impassive sight of the aquarium staff (figure 67). On another occasion the continuous rough handling of starfish in a touchpool made some lose their limbs (figure 25).

Figure 67. Visitors in a UK public aquarium touchpool deliberately letting crabs drop from a considerable height onto the exhibit, which in some cases produced the lost of claws (image below). This behaviour took place repeatedly involving several visitors and crabs, all under the impassive presence of aquarium staff.

Sometimes it is not the handling of the animals, but the objects thrown into the tanks, which can cause animal welfare problems. The classic case of this is the throwing of coins into enclosures, ponds or pools, which must have some cultural roots –such as 'wishing'. Metal coins, in particular the ones made of copper –which are the most often thrown – poison the water with metallic ions that are toxic to many aquatic animals, especially invertebrates. This is a practice that should be strictly forbidden, but although some public aquaria do not encourage it, others condone it. In one particular UK public aquarium 155 coins were counted in two exhibits (figure 68), most of them nicely piled up in the middle of the tank by aquarium staff. Also, as can be seen above in the health chapter when quoting the internal reports of a UK chain public aquaria, sometimes fish die after swallowing objects thrown into the tank by visitors.

Figure 68. View from above of a UK public aquarium exhibit in which a catfish can be seen swimming by a pile of coins (on the left). These are coins thrown by the general public, activity condoned by the aquarium staff

Perhaps, though, the most widespread case of animal health problem caused by visitor physical interaction takes place in the ray pools, which will be dealt in the following chapter.

Visitors touching rays and small sharks in UK public aquaria

As can be seen above in the chapter about exhibits, one of the common features of modern public aquaria in the UK is the existence of ray pools, which are relatively shallow open tanks where rays, small sharks, and other fish (normally flatfish, bass or grey mullet) are kept. The majority (52%, n=31) of the UK public aquaria have them. As explained in that chapter there are reasons for believing that the design of such exhibits is based on allowing visitors to physically interact with the fish, especially the rays, which, as can be seen in the abnormal behaviour chapter, are prone to display a stereotypic behaviour called 'surface breaking behaviour'.

However, in recent years, signs asking visitors not to touch the rays or the water have begun to appear around those exhibits, in many cases in clear contradiction to the exhibit design. Recent changes in the zoo regulations with respect to what is allowed or not in terms of contact have been mentioned to explain this contradiction (although there has not been any specific change in the regulations in this respect), but if that was the case you would expect that such changes would have taken place in all public aquaria under such regulations (figure 69). This does not seem to be the case, because although 52% of the UK public aquaria have 'ray pools', only in 35% of the public aquaria is the touching of the animals/water explicitly forbidden through signs or talks (although unauthorised touching still occurs, and on many occasions aquarium staff seemed to give the blind eye to it), whilst in 16% of the public aquaria is, surprisingly, explicitly allowed.

Figure 69. Sign advising not to touch the animals seen by a ray pool in a UK public aquarium in 2004

When the investigator asked members of the aquarium staff of those public aquaria that explicitly prohibited the contact why rays could not be touched anymore (or when the reasons were written, figure 70), the reasons given were:

- Visitors touching rays cause burning on the rays' skin
- Visitors touching rays make them lose the infection-protecting mucus they have around their body
- The conditions of the zoo licence do not allow such touching to take place
- The rays did not like the touching very much
- Rays and other fish can bite visitors
- Rays' eyes and noses are delicate
- Visitors touching rays without cooling their hands by dipping them into the water beforehand cause burning on the rays' skin
- Some rays in the tank have stings
- The new zoo legislation does not allow visitors touching rays anymore
- Soap particles or other chemicals on people hands upset the chemistry of the water and ray's skin

By far, the most common explanation given was the one referring to 'burning'. The temperature of human skin, apparently, it is too high for a cold-blooded animal that lives in very cold water, such as British rays and sharks, so touching actually burns the animal's skin producing lacerations. This theory is not only plausible and commonly accepted, but plenty of evidence of sharks and rays lacerations were found in the exhibits where visitors touch them, regardless of whether they were allowed to touch them or not (see below). On some occasions the aquarium staff pointed to specific lacerations caused by human contact, but in the majority of lacerations seen the cause could only be guessed (figure 71).

Figure 70. Sign in a UK public aquarium explaining the reasons of not being allowed to touch the fish.

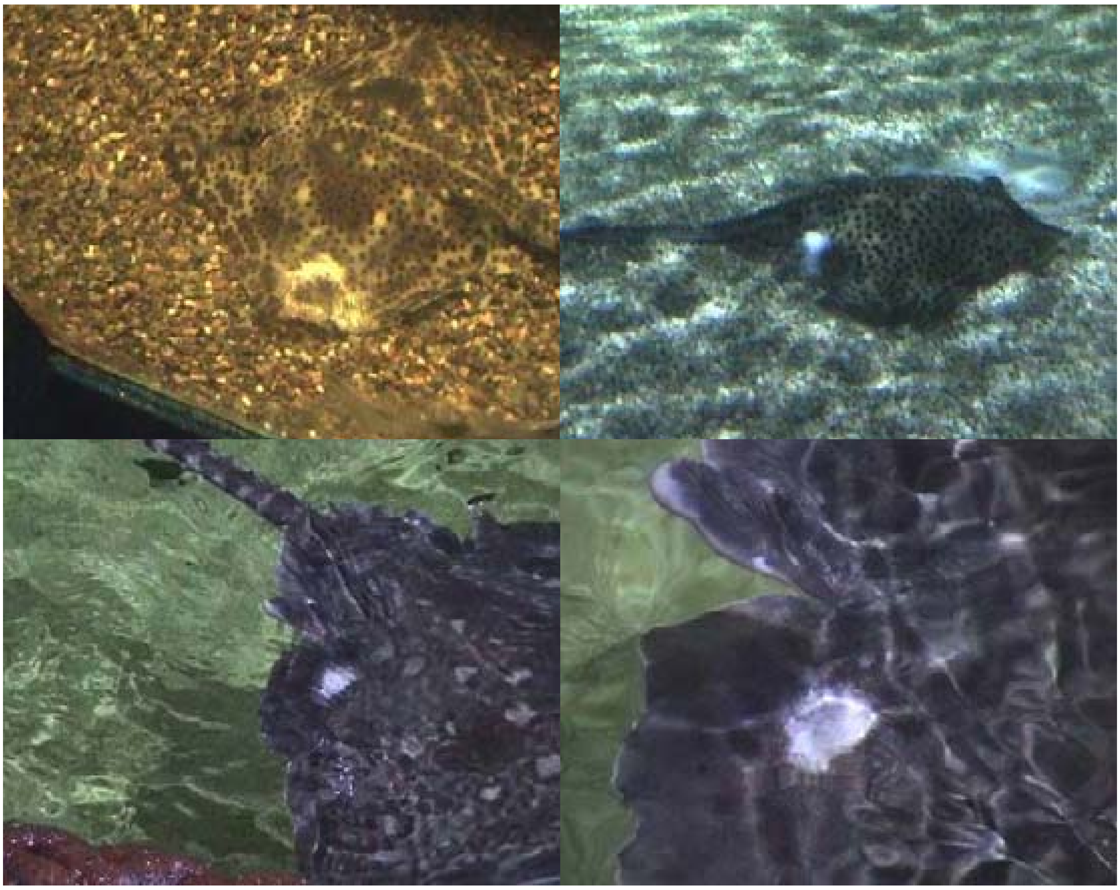

Figure 71. Examples of lacerations (the white patches on the rays' wings) found on rays that are in physical contact with visitors in UK public aquaria. The two images below belong to the same ray in one public aquarium in which members of the staff confirmed the laceration was caused by visitors touching the ray.

In 55% of the UK public aquaria that keep rays, lacerations were found on them, and the only public aquarium where the majority (67%, n=12) of its visible *Raja* rays (the common British rays) showed lacerations was in fact one of the public aquaria that authorises physical contact.

If, as it appears, there are plenty of reasons and evidence for sharks and rays not to be touched by visitors, why in 16% of UK public aquaria is such contact not only authorised, but encouraged? In one of these public aquaria the contact goes as far as members of staff literally lifting up rays and sharks at the very edge of the water and passing them around so that all surrounding visitors can have a feel. In such aquarium the rays are even pressed against the glass so that visitors can have a better view of their ventral body features. All this with obvious signs of the rays involved not being happy with the whole process (figure 72) –although probably the aquarium staff would not accept that the continuous tail wagging and wing flapping mean anything.


Figure 72. Extreme of authorised ray touching in one UK public aquarium, in which rays are held and passed around to be touched (left), and even pressed against the tank walls to show visitors their mouths (right).

Surely if there are animal welfare reasons for not allowing such contacts, even if they were only hypothesis –which because of the abundance of lacerations found it does not seem they are only that– the sensible thing to do would be to stop the contacts altogether. Under these circumstances there is only one reason for continuing such practices: visitors want to do it, and more visitors means more money. Hardly the attitude of responsible education/conservation centres, but perfectly in line with the 'freak show' mentality already alluded in this report.

Visitor misconduct in UK public aquaria

Captive life in zoological collections deprives animals of freedom of movement and often forces them to share a space against their will, but another of its problems is the exposure to visitors, who more often than not have little regard for the animals' wellbeing. Zoo regulations emphatically compel zoo operators to ensure that visitors are not distressing the animals, and zoo operators address this issue by establishing, often through public signs, some 'rules of conduct' that all visitors have to obey. However, 'disobeying' those rules is something not uncommon in UK zoological collections, with millions of incidents of visitor misconduct a year (Casamitjana & Turner, 2001). Public aquaria are not an exception, and in this study an assessment of the frequency of visitor misconduct was made.

The types of behaviour considered 'visitor misconduct' in this investigation follow:

- Touching water: Putting fingers or hands into water where animals swim, when doing so is prohibited or when there is no direct public aquarium staff supervision (see figure 73).
- Touching animal: Touching an animal, without involving holding it, when doing so is prohibited or when there is no direct public aquarium staff supervision (see figure 73).
- Holding animal: holding or trying to hold an animal in or out the water, when doing so is prohibited or when there is no direct public aquarium staff supervision (see figure 73).
- Stepping on barrier: Actively reducing the effective height of a fence or stand- off barrier by having both feet on any part of a fence/barrier, by sitting on it, or by leaning over it (see figure 73)
- Using flash photography: Making a photo using flash when prohibited to do so, or when done very close to an animals' eyes (see figure 73)
- Tapping the tank glass: Hitting the glass of an exhibit in order to draw the attention of the animal(s) inside.
- Throwing/dipping objects in the water: Throwing any object into an exhibit tank, dipping it into it, or place it in such a way that is likely to fall into it (see figure 73)

It was considered 'unauthorised contact' when a visitor either touched, with his/her hands or with an object, an animal or the water where an animal was swimming, if such contact was not allowed in the public aquarium according to its signage, or if it was performed unsupervised by any of the aquarium staff.

Figure 73. Examples of visitor misconduct found in UK public aquaria (see text). From left to right and top to bottom, touching water, touching a ray, holding a starfish by its arm when unsupervised, stepping on an exhibit to lean over a tank, using flash very close to animals face (note the keeper passing by behind unconcerned), and dipping a watch in the water to tease a shark.

What visitors are allowed to do or not do in UK public aquaria varies depending on the centre. Some public aquaria fully take on the zoo regulations and do not allow any physical interaction (at least on paper), while others allow such interactions under supervision of qualified staff (which is allowed by the zoo regulations, although not encouraged). Because *the Secretary of State's Standards of Modern Zoo Practice* clearly state that unsupervised contacts should not be allowed, it was assumed that any unsupervised contact that took place in a public aquarium that authorises supervised contact with some species in some tanks was in fact an unauthorised contact.

Any incident that was witnessed but could not be recorded was not counted, since the analysis was made by viewing the tapes only.

As can be seen in table 17, 277 cases of visitors behaving in a way contrary to the official rules of the public aquaria visited were recorded during this investigation. From those, over 200 cases were of 'unauthorised contact' with animals. In more than half of the public aquaria investigated (55%, n=21) 'unauthorised contact' was recorded, and in at least 68% of the UK public aquaria visitors behaved in a way contrary to rules set by the public aquarium they are visiting, which could put themselves and the animals in the aquarium at risk. However, in some public aquaria there were not many visitors during the visit, and therefore in those cases the chances to witness visitor misconduct ware radically reduced. If we only count public aquaria that had ten or more visitors at the time of counting the exhibits for the study of signs (see above), then 90% of the public aquaria with ten or more visitors showed visitors 'misconduct' (n=20) at one point. 75% of the these public aquaria showed two or more incidents of visitor misconduct per every ten visitors, and 30% showed more than five incidents for every ten visitors (n=20). From all the 277 incidents witnessed in only one did the investigator witness the public aquarium staff challenging the misbehaving visitor.

Code	type	Number of visitors	incidents of visitor misconduct recorded	Misconduct Incidents per every 10 visitors
A-MAC44	BIPA	10	13	13.0
A-SCO45	CHPA	15	16	10.7
A-FOW04	SIPA	13	10	7.7
A-DEE48	CHPA	23	17	7.4
A-STA49	BIPA	17	12	7.1
A-BOL21	APA	5	3	6.0
A-BLU06	CHPA	69	30	4.3
A-SEA27	CHPA	49	19	3.9
A-SEA33	CHPA	39	15	3.8
A-SEA20	BIPA	29	11	3.8
A-AQU08	BIPA	6	2	3.3
A-SEA17	CHPA	250	74	3.0
A-UND18	CHPA	46	13	2.8
A-MAR50	SIPA	12	3	2.5
A-LYM16	SIPA	4	1	2.5
A-BLU03	CHPA	90	14	1.6
A-SEA01	CHPA	33	4	1.2
A-BLA26	APA	21	2	1.0
A-NAT41	CHPA	176	12	0.7
A-NAT47	APA	60	4	0.7
A-THE23	BIPA	138	2	0.1
A-BRI02	APA	12	0	0.0
A-SEA53	CHPA	11	0	0.0
A-MAT58	SIPA	5	0	0.0
A-OCE56	SIPA	5	0	0.0
A-MAT10	SIPA	2	0	0.0
A-ABE52	SIPA	1	0	0.0
A-FOR25	APA	1	0	0.0
A-ISL24	APA	1	0	0.0
A-SEA11	SIPA	1	0	0.0
A-SEA32	SIPA	1	0	0.0

Table 17. Cases of visitor misconduct identified during this study per public aquarium investigated (first column). The third column shows the number of visitors present at the time the investigator had recorded all exhibits, the fourth column shows the number of incidents of visitor misconduct recorded, and the fifth column the number of incidents recorded per every 10 visitors present. CHIPA= Chain Public Aquaria, BIPA= Big Independent Public Aquaria, SIPA= Small Independent Public Aquaria, APA= Auxiliary Public Aquaria.

Considering that the investigator could not be everywhere witnessing all incidents, and only the ones that were recorded on tape have been counted, the occurrence of incidents of visitor misconduct is bound to be much higher than the level deduced from these figures. Figure 74 shows the relative frequency of types of behaviours witnessed classed as 'misconduct', and it can be seen that physical interactions with the animals were the most common type.

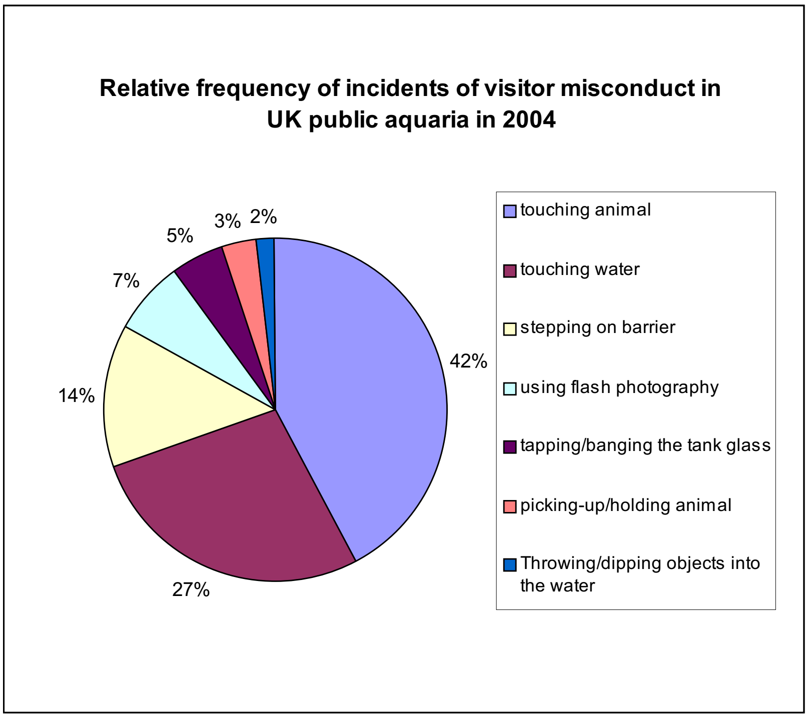

Figure 74. Relative frequency of incidents of visitor misconduct in UK public aquaria during 2004. N=277.

These results indicate that there seems to be a 'public aquarium culture' (akin to what could be called a 'zoo culture') of disregarding signs that direct visitors actions, which because of its scope (at least 90% of the aquaria) and intensity (at least a third of the aquaria with more than five incidents for every ten visitors) it could not be sustained without the public aquaria 'acceptance', reluctantly or not. Either the public aquarium industry finds itself powerless to stop or correct this 'culture', or the industry itself is in agreement with those who consider the signs as 'symbolic' and not really meaning what they say. The second option seems more likely, because it is in the public aquaria interest not to be seen policing its visitors, allow them to behave in a way in which they enjoy their visit more than if they had 'followed the rules', and often such rules have been imposed by 'outsiders', such as the local authorities or the zoo regulations (and therefore may be considered 'unnecessary'). This may be in the public aquaria interest, but certainly not in the interest of the animals they keep.

An example of this was witnessed during this investigation. An octopus which was kept in a very exposed enclosure with not enough shelter and too much light was so distressed by some members of the public tapping its glass that it inked as a response (figure 75). This behaviour is a natural defence mechanism which often happens when octopus are captured (for example 50% of *Octopus rubescens* captured by a Seattle Aquarium are reported to have inked while being packed, Anderson, 1995) but it never should take place in the closed system of an aquarium because the ink may end up suffocating the octopus, apart from radically increasing the amount of suspended organic matter –which the filtration system could be unable to handle without the help of a protein skimmer (Toonen, 2003).

Figure 75. Case of an octopus (left) kept in a UK public aquarium that inked (right) as a defence mechanism after some visitors had tapped its tanks.

It is not only that visitors may disregard signs on purpose, perhaps because they do not take them seriously or nobody has ever asked them to, but they often act under ignorance and harm the animals unintentionally. For instance, it is not unusual to see people wrongly handling animals in touchpools when there is no member of staff to supervise. A common example of this is the picking up of starfish by their arms, which is likely to cause the arm to be separated from the starfish body (figure 25 and 73). Although starfish can sometimes grow their arms back, this does not mean that the event has not been distressing for the animal.

Perhaps the most recent well-known case of how far visitor misconduct can go, and how tragic its consequences may be, was the incident that took place in the Brighton Sealife Centre in 2003, when the comedian Guy Venables who was visiting the aquarium, without telling anyone, suddenly dived naked into the shark tank as a £1 bet and to promote a comedy evening he was running at the time. Two days later a 12-year-old smooth hound shark died of a sudden haemorrhage, which officials at the centre said could had been the result of Mr Venables' stunt. A spokeswoman for the centre said: *"The sight of someone swimming around would have caused a lot of stress because they are in an enclosed area and would have been frightened."* (Anonymous, 2003b).

Visitors diving with fish in UK public aquaria

In recent years several projects which involve visitors diving with captive sharks have been planned in the UK. In the year 2001 the company Subsea Explorer Ltd made public its plans to open one such centre in Milton Keynes, and the company Reef Live made public its plans to open many more, the first one to be in Manchester (Saville & Turner, 2001). These projects were mainly aimed at divers rather than the traditional public aquarium visitors, and concerns about them were raised by animal welfare and conservation groups, among them the Marine Conservation Society. Their stage of development is uncertain (it had been reported that Subsea Explorer Ltd might have changed their mind and decided against having live fish in their diving tank, although it is not clear what is the current status of the project) but some other centres began following suit. One of these is the Ocean Frontier in Scotland, which opened in 2003, and although it does not have sharks yet (just a few dogfish) and it does not aim to keep tropical fish, it does have many local fish already swimming with visiting divers. This centre perhaps is not aimed so much at qualified divers as the other two projects, but diving, as opposed to aquatic life, remains its main focus.

Established UK public aquaria also acted on that idea and Deep Sea World and The Blue Planet (which since August 2002 belong to *Aspro Ocio*, an international group based in Spain with many leisure centres that include at least three dolphinaria, Anonymous, 2002b) are now also organising 'dive with sharks' experiences for selected members of the public.

These activities often send mixed-messages to the public because at the same time the aquaria involved claim that there is no risk for the visitors, they also sell the idea that diving with sharks is 'dangerous', and this is why it is an exciting experience to attempt. For instance, in the promotional leaflets for such an activity one aquarium states "*you can achieve your ambition and test your nerve eyeballing monster sharks. At 10ft long and weighing in at 26 stone, don't let them out of your sight for a second*", and the other states "*prepare to be petrified. Take a Shark Dive and you'll be swimming with nature's most feared predator"*. As seen above in the education chapter, this attitude contributes to perpetuate myths about sharks that are inconsistent with the public aquaria's education claim.

Despite what the aquaria may say (among other things that they follow the guidelines set by the Professional Association of Diving Instructors), these activities may be indeed dangerous, not only because any shark can be unpredictable up to a point, but because diving is an activity dangerous in itself that should not be attempted by unqualified people. These 'diving with sharks' experiences are not aimed, however, at experienced divers, as can be read in the aquaria publicity with statements such as *"give someone a present they'll never forget. Anyone can do it, even if they've never dived before"* or *"No qualifications or experience are required to experience the adrenaline rush of shark diving –just* *sheer guts and a touch of madness– so it's open to just about everyone. Full training is given on the day".*

Also, these events take place precisely with some of the aquaria that keep sand tiger sharks, which are widely regarded to be unsuitable for captive live, even among aquarists –as has been already said above (figure 76).

Figure 76. Sand tiger shark in one UK public aquarium. This is one of the sharks some public aquaria allow visitors to dive with.

It is obvious that the developing of these initiatives is driven by profit. At up to £150 per person (£175 at weekends and bank holidays) this is certainly not any of the conservation, education or research activities public aquaria claim they do.

This trend is certainly worrying because these types of activities are clearly aimed to satisfy the public desire to get closer and more involved, as opposed to improving the animal's captive life, and the more activities of this type take place the less guarantees of a proper care the animals in these aquaria will have. It is obvious that, if for any reason, a visitor diving with sharks is in some sort of trouble while in the tank (either because of a technical problem, panic caused by inexperience, or any shark attacking or looking as if it is doing so), the staff would disregard the animals welfare and would concentrate on the visitor safety, which could be to the detriment of the animals involved that never should have been put in such a position.

CONCLUSIONS

SPECIFIC CONCLUSIONS

Following are the specific conclusions extracted from each of the chapters above (most conclusions, unless stated otherwise, are only relative to the year 2004).

UK PUBLIC AQUARIA PROFILE

- All types of UK public aquaria are more or less equally represented, with a slight majority for 'Small Independent Public Aquaria' (SIPA) and 'Chain Public Aquaria' (CHPA) which together total 59% of the public aquaria.
- It is estimated that there are over 40,000 animals kept in UK public aquaria (over 20,000 of which are vertebrates). As expected, the vast majority of animals kept in UK public aquaria are fish and aquatic invertebrates, representing together 99% of the type of animals (n=11,623)
- The average number of live exhibits per UK public aquarium is 26.8 (n=31, STD= 16.29).
- UK public aquaria keep mainly marine species. There are aquaria specialised only in freshwater animals, but they only represent 19% of the public aquaria, and 13% of public aquaria keep only marine taxa.
- The UK public aquarium industry keep almost as many exotic individual animals as local ones (an 18% majority for 'locals'), although more public aquaria are specialised in local taxa than exotic taxa (45% of public aquaria specialised in local fauna).
- More than half of the 30 most common taxa kept in UK public aquaria in the period 2000-2002 have changed if compared with the 30 most common taxa of 2004. In 2000-2002 only 10% of the first 100 most common taxa displayed in UK public aquaria were exotic taxa whilst in 2004 the value has tripled to 33%. Therefore, it can be said that there is some evidence that suggests that in the last few years the UK public aquarium industry appears to have been displaying more exotic taxa.

ANIMAL WELFARE IN UK PUBLIC AQUARIA

- ABNORMAL BEHAVIOUR
    - At least 90% of the UK public aquaria (n=31) keep animals that show stereotypic behaviour.
    - The majority of each type of public aquarium exhibits animals performing stereotypic behaviour.
    - In at least 16% of the UK public aquaria 'spiralling', arguably one of the most severe forms of stereotypic behaviour in fish, can be observed.
    - A third of the stereotypic behaviour observed in this study constitutes 'Surface Breaking Behaviour' (SBB), which can be seen in 71% of the UK public aquaria, mainly in rays and sharks.
    - Almost one third of individual rays of the genus *Raja* seen in this study were observed performing 'Surface Breaking Behaviour' (SBB).

- PHYSICAL HEALTH

  - Through the visits made some evidence of possible physical health problems in animals was found in 74% (n=31) of the UK public aquaria investigated. The majority of the cases of lacerations were seen in sharks and rays, in particular those kept in open tanks where the public can touch them.

  - In many UK public aquaria, both sea and freshwater fish suffer physical diseases, and this is not confined to the exotic species either.

  - In many UK public aquaria seahorses suffer a noticeable number of health problems, and fatalities among the cephalopod population seem quite high.

  - Cases where the health problems seem to be caused by husbandry techniques, like the mixing of species in an exhibit, feeding methods, the regulation of the water chemistry or the interactions with visitors, do occur in many UK public aquaria.

  - Epidemics, or at least general infections/infestations affecting several –if not all – of the individuals of a tank system do not seem uncommon in many UK public aquaria, and mortalities despite available treatments appear to be inevitable.

CONSERVATION IN UK PUBLIC AQUARIA

- A staggering 98.2% (n=16,283) of the animals kept in UK public aquaria do not belong to taxa classed as threatened by the IUCN.

- 96.8% (n=781) of the taxa kept in UK public aquaria are not classed as threatened by the IUCN.

- 99.9% of the taxa kept in UK public aquaria are not part of any co-ordinated conservation European Captive Breeding Programme (although some public aquaria may be involved in breeding some of their stock with conservation ideas in mind).

- UK public aquaria are not involved with conservation reintroductions of animals into the wild.

- At the very least, 45% of the UK public aquaria release animals back to the wild for reasons other than conservation (some on a regular basis), which could be considered illegal

- 79% of the estimated animals present in UK public aquaria are wild-caught in origin (n= 16,283).

- 89% of the estimated marine animals present in UK public aquaria are wild-caught in origin (n= 13,601).

- In 45% (n=31) of the UK public aquaria 90% or more of their individual animals are of wild-caught origin, while in 87% of the UK public aquaria half or more of their animals are wild-caught.

- From all the 13 public aquaria where the restaurant/café menu was checked 85% of them offered as food to visitors fish and/or aquatic invertebrates that are commonly seen in public aquarium displays, and in 62% of these public aquaria these animals belonged to threatened taxa.

- No evidence of *in situ* conservation activities run by the UK public aquaria visited aimed directly to protect threatened species of British fish and aquatic invertebrates was found. Despite this, 61% of the UK public aquaria use the 'conservation' term in their publicity and/or displays, and in 35% 'conservation' features predominantly (mainly *ex situ* conservation).

- Keeping and breeding seahorses in UK public aquaria, arguably their main 'conservation flag', does not really seem to be proper conservation education because it does not directly educate those who collect seahorses from the wild, it does not really seem conservation breeding either because it is not properly co-ordinated or it is not aimed to reintroduce seahorses back to the wild, and it falls short in its *in situ* conservation initiatives because it supports the seahorse trade industry based on removing seahorses from the wild.

EDUCATION IN UK PUBLIC AQUARIA

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- 83% of the UK public aquarium visitors do not read the contents of live exhibit signs except perhaps the animals names (n=540), and 95% of the visitors do not read the entirety of exhibit signs.

- 41% of the individual animals seen in UK public aquaria have no signs identifying which taxa they belong to (n= 13,530).

- If almost half the animals kept in UK public aquaria had no identifying signs at all, and for the ones that do have them most of the visitors do not read the information in them, it is difficult to avoid the overall conclusion that the educational value for visitors of the UK public aquaria signage as a whole is very poor.

- Less than half (45%, n=31) of the UK public aquaria offered talks or special events to the visiting public of spring 2004, less than half (45%) offered education packs, and almost a quarter (23%) of the UK public aquaria did not even have a website.

- The mixing of species displayed in a tank not representing communities that could be found together in the wild, wrong information given to visitors when they ask general questions to members of the aquarium staff, animals displayed in one exhibit with signs of animals displayed in another exhibit, and signs placed in such a way that it is almost impossible to read them, are all problems found in the education work delivered by UK public aquaria.

- In either talks or displays some of the information delivered by UK public aquaria not only do not help to dissipate myths about animals –such as sharks and piranhas – but they often reinforced them instead.

- A recent single TV documentary series on aquatic animals alone features about 300 different animal species behaving in their natural aquatic habitats. The public aquaria surveyed in this study that displayed the highest number of exhibits only showed about 130 species, none of them in their natural habitat, most of them not doing what they normally do in the wild, and many of them doing what certainly they never would do 'in real life'.

SCIENTIFIC RESEARCH IN UK PUBLIC AQUARIA

- The UK public aquarium industry as a whole publish an average of one scientific paper every 30 years, which clearly shows that scientific research is not, by any means, an integral part of the UK public aquaria work.

EXHIBIT DESIGN IN UK PUBLIC AQUARIA

- Crushed Cockleshell substrate, arguably detrimental to the health of many fish, is the third most common substrate seen in UK public aquaria exhibits, with 16% of the exhibits containing cockleshell (n=804). Almost half of the public aquaria (48%, n=31) have exhibits with this substrate.

- ∉ 20% (n=804) of the UK public aquarium exhibits are 'open' from the top so visitors can see the surface of the water, but 14% of the UK public aquarium exhibits are 'touchable' so visitors could easily touch the water and/or fish if they were allowed to.
- ∉ The majority of the UK public aquaria (77%, n=31) have exhibits where the visitors can physically touch either the water or the animals in them easily, regardless of whether or not they are allowed to do it.
- ∉ The majority of exhibits in UK public aquaria are mixed exhibits, with an average of 3.6 taxa per exhibit
- ∉ In more than half of the UK public aquaria (58%, n=31) exhibits that would be easily identified as 'bad' by most people due to their small size, dirtiness, barrenness or poor maintenance can be found.

<u>ANIMAL/VISITOR INTERACTIONS IN UK PUBLIC AQUARIA</u>

- ∉ In the majority (at least 61%, n=31) of the UK public aquaria there is physical contact between animals and visitors, regardless of whether that contact is authorised or not.
- ∉ Although 52% (n=31) of the UK public aquaria have 'ray pools', only in 35% of the public aquaria was the touching of the animals/water explicitly forbidden through signs or talks, whilst in 16% of the public aquaria it was, surprisingly, explicitly allowed.
- ∉ In 55% of the UK public aquaria that keep rays, lacerations were found on them, and the only public aquarium where the majority (67%, n=12) of its visible rays of the genus *Raja* (the common British rays) showed lacerations was in fact one of the public aquaria that authorises visitor physical contact with rays.
- ∉ 90% of the UK public aquaria with ten or more visitors during the investigation visits showed incidents of visitor 'misconduct' (n=20) at one point during the visits.
- ∉ The ratio of incidents of visitor misconduct in UK public aquaria that go unchallenged by staff members is at least 277 to 1.
- ∉ Visitors being allowed to dive with sharks is a growing trend in the UK public aquarium industry.

GENERAL CONCLUSIONS

This investigation has provided much information from which to draw a general conclusion on the performance and existence of public aquaria in the UK. Although the information can be interpreted in different ways, and sometimes is much easier to judge on the specifics than on the general, it is difficult not to conclude that there are many reasons for questioning whether or not there is still room for public aquaria in the society we aspire to become.

On almost every front public aquaria seem to fail. Many animals suffer in public aquaria, both physically and mentally, and no conservation, education or research work can compensate for this. However, in UK public aquaria, there seem to be minimal conservation activities, the education value is very poor and scientific research is almost non existent, so even the aquaria's own claims that could possibly justify the animals 'sacrifice' are totally unfounded. Further more, in the context of the new UK zoo legislation, it appears that many of UK public aquaria no longer meet the new zoo licensing criteria that would allow them to stay open to the public.

Despite all the pleasing superficial images and the general acceptance that having fish in tanks is a perfectly legitimate practice, a sense of a voyeuristic and abusive culture, not unlike the one associated with 'freak shows', can be felt around the world of public aquaria, from the exhibit design to the visitors' behaviour. However, it is very likely that many people that would not enjoy visiting a zoo, or that would have moral objections to the keeping of elephants in chains or tigers in cages, would not see anything wrong with public aquaria. This is probably because the general public is not yet tuned to the problems of captive fish, and it is easily blinded by the aesthetic beauty of both aquatic animals and aquatic environments. This investigation may begin to open peoples' eyes towards another reality beyond the dashing colours, the elegant movements, and the pleasing sounds of the aquarium experience, so people can realise that public aquaria are just 'aquatic zoos'.

This study was, though, a 'critical' study, and therefore a critical conclusion should be expected. It was critical because emphasis was given to the negative aspects over any positive one. Public aquaria themselves, for over a century now, have spent a lot of effort giving emphasis to 'the positive', so there was a need for criticism, which in an honest society is a healthy way to examine any practice that needs continuous reviewing.

It must be said, though, that there have been some 'positive' aspects identified in the UK public aquaria activities: the apparent successful rehabilitation of rescued wild seals back to the wild, the occasional good educational message being delivered, the good intentions of some aquarium staff, the occasional support to genuine conservation initiatives, the relaxed and aesthetically pleasing atmosphere created by some of the exhibits, and the relatively 'good' entertainment value for the average family looking for somewhere to take the children. All of this, however, is merely incidental and does not represent the work of the public aquarium industry in general. All these 'positive' aspects can easily be achieved, often through more efficient and better ways, with other methods besides the exhibition of live captive animals. None of these aspects, also, individually or collectively, compensate for the negative ones that have been unearthed during this investigation. Some of these have been widely used arguments of the 'anti-captivity' lobby –one group of which has commissioned this study –whilst others have probably been first studied with this investigation, or first addressed in this report. After having analysed them all in detail, it is very difficult not to come to the conclusion that the abolition of keeping aquatic animals for exhibition in public aquaria is not only a genuine campaigning goal, but also one that seems to be firmly supported by facts.

Although every practice, even the most barbaric one, has room for improvement, recognising that tradition and liberty need sometimes to be overshadowed by respect and compassion leads sometimes to an abolitionist political stand. Courageous people in the past took this stand, and now we regard them as heroes responsible for bringing to us the best values of the societies we live in. It always has been the overall picture, not the specific good or bad practice or activity, which lead those people to transform their abolitionist approach into policy, and thanks to them now women can vote, slaves can walk free, prisoners can live, and peoples' opinions can be heard. It has to be the overall picture of public aquaria, then, that would allow us to judge whether or not their role has become obsolete, and although the results of this investigation can be used to improve the performance of UK public aquaria on many issues, it can equally be used to support the abolition of what many would see as a relic from old colonial times.

Even if conservation, education or research had been indeed the main activities of UK public aquaria, this only would have meant that the animals they keep would be, in fact, slaves of the education, conservation and research industries. Anyone who would imprison innocent people to teach others some good lessons, to save some oppressed culture, to preserve a 'special' race, or to experiment upon them in the name of science, would rightly and inevitably be branded, at the very least, the label of 'undesirable'. Why, then, do we accept all the above when it is inflicted on others we do not consider 'us'? Because we have been told for generations that we are allowed to be selfish. It is precisely this selfishness that enabled us to conquer the world, to step over whoever was in our way, and to progress until the point of becoming able to destroy everything with not much effort. Is that the way we want to preserve this planet? Is that what we want to teach to our children? Is that how we want to become wiser? Is that, ultimately, how we want to spend our free time?

Public aquaria embody the essence of all these questions, from the theoretical to the practical, from the general to the specific, and this report provides information so that these issues can be discussed and these questions can ultimately be answered.

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AQUATIC ZOOS:
A critical study of UK public aquaria
in the year 2004

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