Monitoring growth and energy utilisation of the harbour porpoise (*Phocoena phocoena*) in human care

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ABSTRACT

Two harbour porpoises of an estimated age of 1-2 years were held in captivity from April 1997 and were still alive in April 2002, after rescue from pound nets set in inner Danish waters. They are presently housed in an outdoor penned-off area of Kerteminde fjord. Their growth (total body length, girth, body weight and blubber thickness) and daily dietary intake (weight of fish, dietary composition and energy value) have been monitored since capture. The general activity of the animals was regularly monitored, including two 24-hour long observation periods.

Initial body weights were 37.5 kg for Eigil (male) and 40.5 kg for Freja (female). Both porpoises lost 4 to 5 kg in the first few days because of their initial refusal to feed from the hand. Then body weight increased steadily reaching a peak of 44.75 kg for Eigil and 51.6 kg for Freja in early February 1998. A fluctuation in body weight with peaks of 44 to 45 kg for the male and 51to 56 kg for the female in winter followed by lows of 41 to 44 kg and 47 to 48 kg respectively in summer, established a clear pattern of seasonal fluctuation, mirrored by girth and blubber thickness variation. Length increased steadily from 130.5 cm to 139cm in Eigil, and from 127.5 cm to 150 cm in Freja. Food intake also fluctuated seasonally, and increases in food intake preceded weight gains. Daily food consumption in Eigil and Freja represented about 7 to 9.5% of body weight.

The growth of the animals resembles that of wild porpoises in the region. The sudden initial weight losses suggested that the energy reserves of the animals may only be short-term. The large weight increase in the winter months with colder water, correlating with the increase in girth and blubber thickness, suggest that energy reserves and blubber fat may be important for insulation.

During the two 24-hour observations, the animals spent most of their time cruising around, although slow swimming and logging at the surface increased at night. Breathing rates were lower in the early morning hours, consistent with diminished activity. Both animals' movements were influenced by external activities at poolside.

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INTRODUCTION

Two harbour porpoises (*Phocoena phocoena*) Eigil (male) and Freja (female) were taken into human care on 7th April 1997, after rescue from a pound net set in inner Danish waters. These types of net are commonly set from the shore in shallow coastal waters, and porpoises that become entrapped are normally alive and in good condition when discovered within a few days. The 2 rescued animals are presently housed at the Fjord&Bælt, Kerteminde, in a semi-natural outdoor pool, which is a penned-off area of Kerteminde fjord (Fig. 1). This pool is approximately 15 m by 36 m and 3.5 m deep with both rock and sandy bottoms, and the open system allows entry of local fauna and flora, including smaller sized fish. The system is also exposed to normal fluctuations in the climate, tidal flow and sea (fjord) temperatures.

The porpoises' growth has been monitored regularly since capture through regular measurements of total body length, body weight and blubber thickness as well as dietary intake by weight and dietary composition. The general activity of the animals has been recorded in relation to gradual release on 3rd June 1997 from an initial indoor/covered holding tank to the outside holding pool and finally the entire pool area on 5 July 1997. The water temperature has also been recorded. The aim of the monitoring, apart from health checks, has been to assess growth and feeding rates and energetics in the harbour porpoise, and to learn more about this species' physiology. Information derived in this way will help to understand the growth and feeding dynamics of wild porpoises.

METHODS

Monitoring growth

Total body length, body weight and blubber thickness were measured at least every second week for both harbour porpoises. However, the newly acquired porpoises were weighed more frequently. The animals were removed from the water by means of a special stretcher, and brought to an examination table for measuring and weighing (±0.01 kg) on a large platform balance (Fig. 2). Length (taken in a straight line from jaw tip to tail fluke notch, parallel to the body) and 6 girths (Lockyer 1995a) (Fig. 3) were measured manually by means of a soft tape measure. The measurements were found to be variable and sometimes difficult to take because even small movements by the animals

Fig. 1. Plan of the porpoise pool and general drawing of the Fjord&Bælt and the Research Centre for Aquatic Biology, Odense University. Numbered / coded sectors in the pool refer to the behavioural observations.

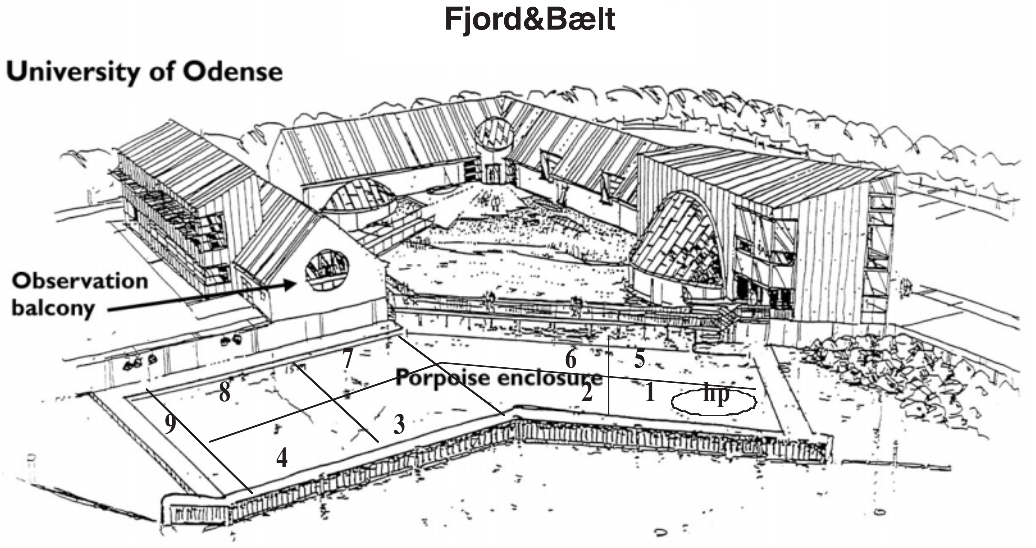

Fig. 2. *Taking girth measurements of a captive harbour porpoise, Fjord&Bælt, Kerteminde, Denmark. (Photo: Fjord&Bælt)*

(*e.g.* breathing) could alter girths and body flexing could alter length by as much as 3 cm at any one time. Measurements were attempted when the animal appeared to be calmest. Girths were always measured after a full expiration/inspiration sequence by the animals. The blubber thicknesses were measured dorsally, laterally and ventrally in 3 positions along the body (positions along girth lines behind the pectoral flippers, in front of the dorsal fin and posterior to the dorsal fin, see Fig. 3) by means of a portable ultra-sonic sub-dermal fat scanner. We use the Lean Meater by Renco, designed for use in pig husbandry.

Food intake

The main species fed to the harbour porpoises have been herring (*Clupea harengus*), some mackerel (*Scomber scombrus)* and a little cod (*Gadus morhua*), plus a few others such as whit-

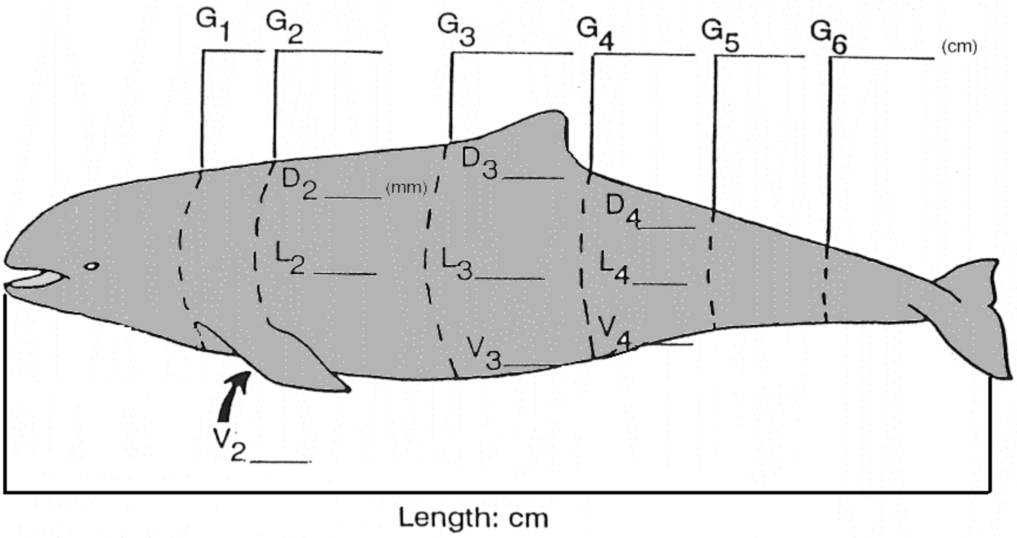

Fig. 3. *Diagram showing the sites of measurement on the porpoise body: total body length from snout tip to tail fluke notch; girths (G_1 – G_6); blubber thickness (D_2 - D_4, L_2 - L_4, V_2 -V_4).*

ing (*Merlangius merlangius*), blue whiting (*Micromesistius poutassou*) and trout (*Salmo sp.*). All food fish were weighed and recorded daily by species. Fish used were freshly thawed from frozen. A sample of fish from each new food batch was retained for biochemical analysis. Fish were offered at regular intervals throughout the daytime; up to 6 feedings per day of roughly equal portions, and although feeding was not *ad libitum*, the animals were encouraged to take their full ration. Daily rations were usually increased when there was any evidence of declining trend in body weight and decreased when weight was observed to be increasing quickly. The possibility that small fish and other small fauna that entered into the pool could be eaten was ever-present. This potential problem of entry of "unscheduled" fish that could be consumed as undocumented supplements was limited by placing additional small mesh nets (mesh size 22 x 22 mm) over the existing ones (mesh size 100 x 100 mm) at each end of the pool during experimental feeding periods of which there were 2: one in February and the other in October, lasting 3 weeks each.

Activity budget

Two 24 hr watches were carried out in October 1998 and February 1999 to coincide with the feeding experiments. All observations were made from a position outside and above on a balcony overlooking the entire holding facility. The pool was arbitrarily divided into sectors and coded as illustrated in Fig. 1. These were 10 sectors in all, 1 to 9 in the pool area plus "hp", the floating but moored holding pen which had a fixed floor and mesh sides. The door to the pen was open during the observation periods. Analysis of pool use required recording which sector the animals were using at any particular time, as well as swim speed, feeding, breathing and other social/interactive behaviours. The watches comprised 4 hr shifts, with 2 observers on each watch, during which activity for one animal was recorded for 10 min, followed by a break for 5 min, and then switched to the other animal for the same period. This alternation continued throughout the 24 hour period, so that each animal was observed for 2 periods (20 min total) in any one hour. To help distinguish the porpoises and facilitate their observations underwater, each animal was individually marked with white zinc oil-based cream on the back. A recording behaviour software programme (Noldus Information Technology) was used to log behavioural records directly. The observations were based on focal sampling (Altmann 1974, Martin and Bateson 1993), and locations were recorded as states and behaviours as events. Swimming speed was recorded as a qualitative measure, harmonised between observers.

RESULTS

Growth parameters

Body length

During the 33 months since capture, the length increased from 130.5 to 139.0 cm for Eigil and from 127.5 to 150 cm for Freja (Fig. 4). The discontinuous appearance of the length data is because of the movements (wriggling) of the animals that occur sometimes during examination, which can cause measurement errors of about ±3 cm. The data have been smoothed with a fitted curve to show the growth pattern. The animals are estimated to be in their fourth (Freja) or fifth (Eigil) year of life on the basis of extrapolating the growth curves back to a birth size of 70 cm, probably in June, the peak birth month for harbour porpoises in the region (Lockyer and Kinze 2003).

Body weight

Weight has fluctuated seasonally, with weight increasing from October, peaking in January, remaining stable throughout the winter and then declining rapidly in around April. This pattern has continued through nearly 3 annual cycles (Fig. 5). From April 1997 to early January 2000, body weights fluctuated between 31 and 45 kg for Eigil and 35 and 57 kg for Freja. The initial period in captivity resulted in major weight losses, especially in the dorsal thoracic and trunk regions because of refusal to feed from the hand, stress and reduced swimming activity that may have resulted in muscle atrophy. Weight loss gave the porpoises a characteristic appearance featuring a concavity behind the head, and abnormal definition of the dorsal ridge as blubber and possibly underlying muscle were dissipated. Such losses were sudden and dramatic in just the first few days, with 5 kg being lost

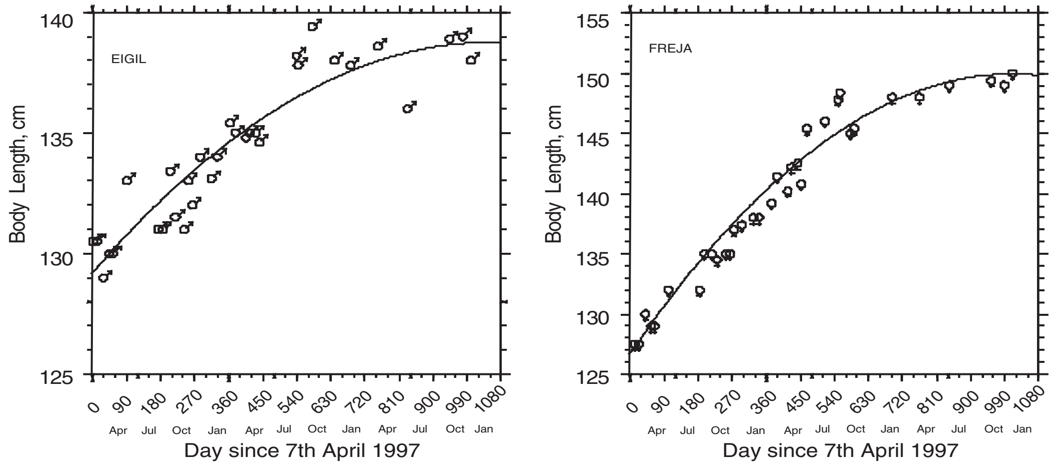

Fig. 4. *Growth in body length for Eigil and Freja.*

by Freja (female), and about 4 kg by Eigil (male) who continued to lose a further 2.5 kg until about day 60 when the animals were first transferred from the initial indoor holding pool to the outside holding pool. In the first month the animals were force-fed, but once voluntary feeding was established weight became more stable after about 60 days. Movements were restricted in both these small facilities, which also had a shallow depth. A noticeable weight increase did not take place until after about 90 days, when they were finally freed into the entire pool space. At this point it is most likely that some small fish within the pool area were also consumed by both animals as supplement to the diet provided.

Body weight fluctuated but nevertheless increased up to about 180 days (about 6 months) after capture, and then increased steadily over the next few months during winter, reaching a peak of 44.75 kg for Eigil and 51.6 kg for Freja in late January/early February 1998. Body weight then diminished to 43.55 kg for Eigil and 47.2 kg for Freja in April / May 1998 with further weight losses to 37.5 kg in Eigil and 41 kg in Freja during the summer. There then followed a regular pattern of increase and loss of weight according to season.

Body weight fluctuated seasonally by as much as 7 to 8 kg, and yet the animals remained healthy. The periods of maximum weight (winter) coincided with the coldest months of the year when water temperature dropped to about 3° C, although the time of onset of increasing weight in October occurred while the water temperature was still warm (Fig. 6). The maximum summer temperature was 18° C. There appeared to be a difference between the male and the

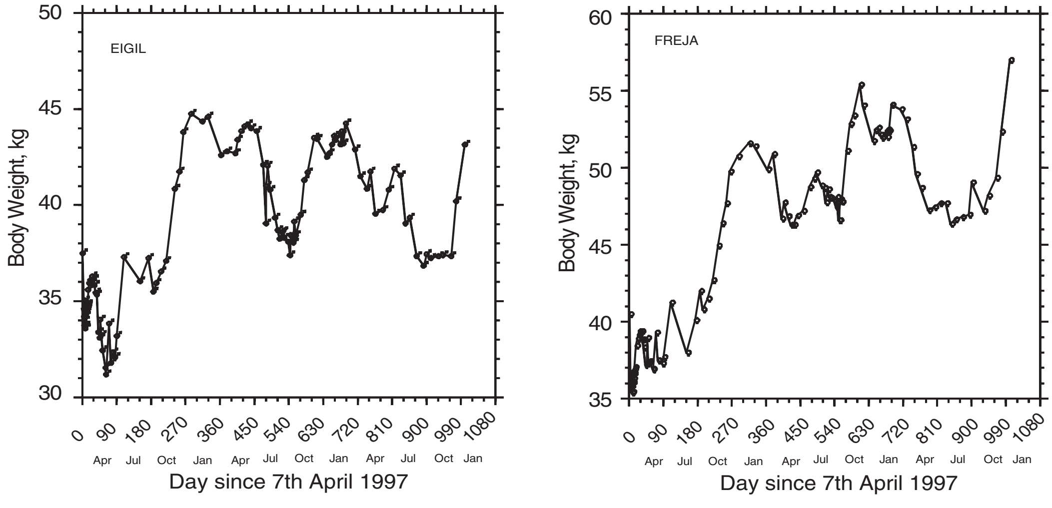

Fig. 5. *Growth and seasonal variations in body weight for Eigil and Freja.*

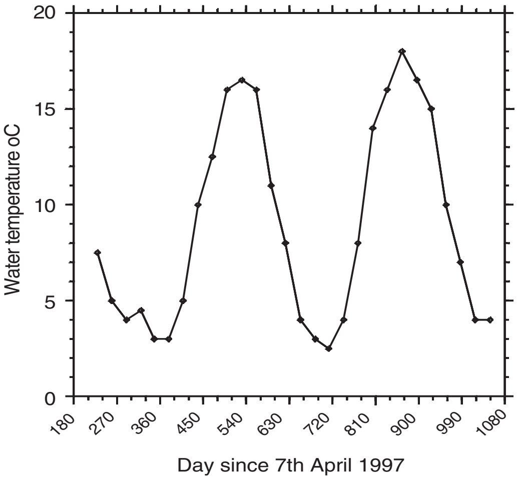

Fig. 6. *Water temperature in the Kerteminde fjord between winter 1997/1998 and winter 1999/2000.*

female in that the successive winter peaks of weight increased over time for the female but remained at a similar level in the male. We do not know if this is a normal sex difference or an individual characteristic.

Girth and blubber thickness

The measurements of girth and blubber thickness correlate well with observations on weight. The measurements taken in mid-girth, G_3, (anterior to the dorsal fin) demonstrate the fluctuations in fat deposition that are reflected in body weight changes throughout the captive period (Fig. 7). Mid-girth, G_3, (anterior to the dorsal fin) has been taken as the representative girth for monitoring body fat condition because girth is generally maximal at this position and the animal is rather circular in section. The remaining girths, post-pectoral insertion, G_2, and posterior to the dorsal fin, G_4, also reflect similar changes in fatness. The other measurements, G_1, G_5 and G_6 have not been found so useful for monitoring fatness, and tend to remain more stable, possibly the latter 2 because of their association with the structure of the caudal peduncle, which causes the girth to become more elliptical in section in the dorso-ventral plane with less musculature, thin blubber and more tendons.

Blubber thickness taken at the mid-dorsal position, D_3, also mirrors the changes in girth and body weight observed (Fig. 8). Other dorsal blubber thicknesses, D_2 and D_4, lateral and ventral blubber thicknesses also provide indications of fatness, but the ventral measurements especially have been difficult to obtain consistently. The animals do not particularly like being turned slightly whilst out of the water in order to facilitate these measurements being taken, and consequently the data for these are fewer.

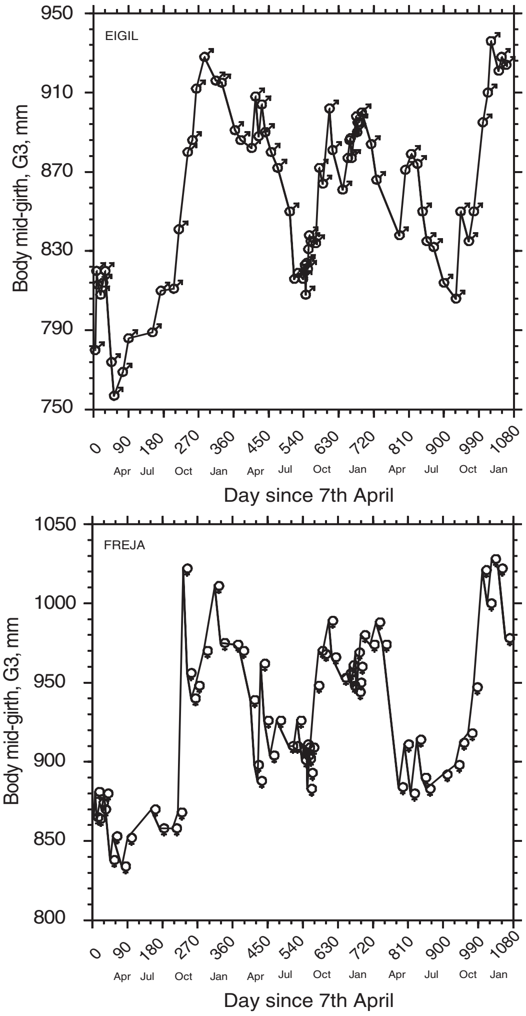

Fig. 7. *Seasonal variations in mid body girth G_3, for Eigil and Freja.*

Food intake

Food intake by prey species was recorded daily. A sample of fish from each new food batch was retained for biochemical analysis and energy density as shown in Table 1. The diet was comprised mainly of herring with some mackerel. The energy density of these fish species is high,

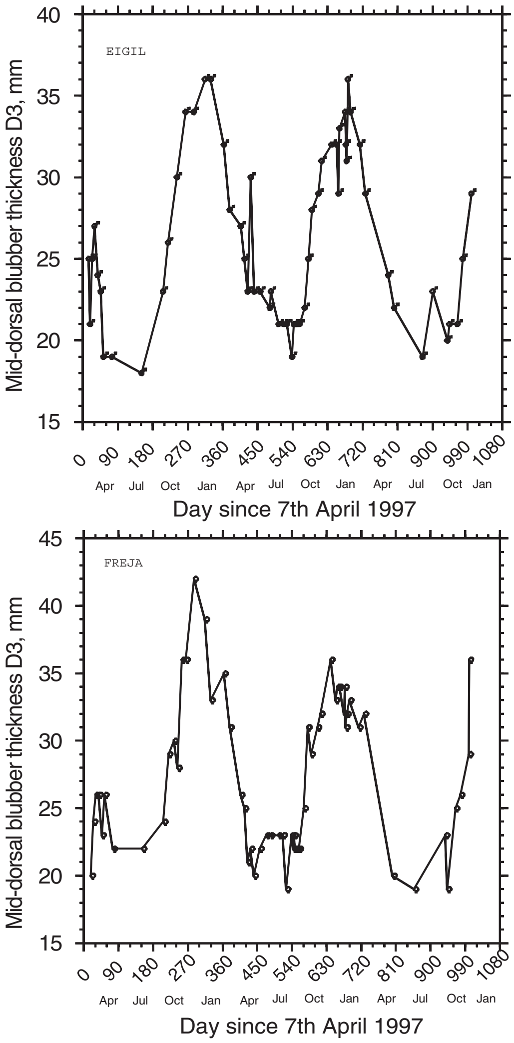

Fig. 8. *Seasonal variations in mid-dorsal blubber thickness D_3, for Eigil and Freja.*

ranging from 5.24 to 7.89 kJ•g^{-1} wet weight of fish. The herring and mackerel were generally fed whole and size ranged from an average 15.4 to 24 .0 cm in length. A variety of fish *e.g.* cod, has been introduced into the diet in order to conduct experimental feeding of different fish species to determine the likely effect on growth efficiency. Cod has a lower energy density at 3.44 to 5.59 kJ•g^{-1} wet weight, and because their size was larger (19 to 34 cm average length), the fish were cut into pieces (including all parts). The introduction of different fish species has been met with limited success until recently in March 1999 when up to 50% mackerel has been fed on a regular basis. Other species have also been offered and consumed in smaller quantities. During feeding trials, body weights, girth and blubber thickness were measured on alternate days.

The first scheduled dietary trials started mid-October 1998 (around day 545 in all of Figs 4, 5, 7, 8, 9), but the animals would not accept a sufficiently varied fish diet at that time. In the trial, the food intake (herring) was therefore reduced by >20% of average food intake during the previous week for Freja, resulting in an actual average reduction from about 5.5 kg per day to 4.2 kg per day, but maintained at previous levels for Eigil. In this situation, Eigil was used as a kind of control against which to measure any effects of dietary change on Freja. The trial lasted two weeks, but no significant change was observed in the body weight of either animal. During a similar trial in February 1999 (around day 655 in all Figs), the same criteria were again applied with an actual reduction in food intake from about 4.7 kg to 3.4 kg per day for Freja. This represented nearly a 30% reduction in food consumption, yet again neither animal showed loss or gain in body weight. At this time it is not possible to predict how quickly the effects of a new diet may be manifested in terms of body mass, and we must consider the possibility of an increased efficiency of energy utilisation when energy intake is reduced or a change in pattern of behaviour to conserve energy.

The introduction of up to 50% fish other than herring in the diet at present will help to facilitate future feeding trials. All 3 porpoises will now readily consume herring and mackerel, and will also take some cod, blue whiting and live trout (in current live-feeding experiments).

Feeding records have been analysed to investigate possible correlation between food intake and weight gains. Apart from the initial period of 60 days when feeding problems were encountered (see above), the data indicate interesting patterns of food intake relative to weight gain. It is apparent that there are cyclical seasonal trends in food consumption (Fig. 9). In both 1997 and 1998, food consumption increased rapidly in July and then declined significantly after January, although there were secondary drops in food intake in November/December for both Freja and Eigil. With reference to the seasonal body weight increases during the year (Fig. 5), the main increases commence after October and weights fall again in April. There is thus a time lag (about 2 to 3 months) between the increasing food intake and weight gain, and in the decline in consumption and weight loss. Reproductive activities, monitored hormonally and behaviourally (Desportes *et al.* 2003), increase greatly during the spring and summer months and this may influence both the weight loss in April and the rapid increase in food consumption in July once energy reserves have gone, especially in the male. The diet has until very recently comprised almost exclusively herring, so that we cannot assess the possible implications of varying the calorific content of the diet.

The average daily food consumption generally varies between 3 to 4 kg for Eigil and 3.5 to 4.5 kg for Freja. This currently represents about 7.1 to 9.5% body weight for Eigil and 7.3 to 9.4% body weight for Freja. Energetically the calorie intake is likely to be large because both herring and mackerel are fatty fish. The content of whole herring may also vary both according to size and season from 5.45 to 7.89 kJ•g^{-1} (Table 1) so that a daily feed could represent extremes of 16,350 to 31,560 kJ for Eigil and 19,075 to 35,505 kJ for Freja.

Both Freja and Eigil are now of virtually adult size and less energy will be directed to developmental growth with less increase in length and overall average body weight.

Activity budget

The 24 hr watch data in October 1998 and February 1999 have been analysed for each individual by blocks of time throughout each 24 hr period, and breathing rate, type of activity and area of the pool favoured have been examined. Throughout each 24 hr period, the schedule of the Fjord&Bælt dictates certain activities, such as feeding and training sessions (normally up to 5 times daily) between 10:00 and 17:00 hr and thus the favoured pool area occupied at these times is influenced by the human activities around the pool. However, outside the public opening times, the animals are completely free to choose their activities and movements within the pool.

Table 1. Energy content of food fish between 1997 and 1999 inclusive.

Batch no	Fish species in diet	Collection datea	Fish length average (cm)	Fish weight average (g)	Energy density (kJ/g) Wet weight		Energy content per fish (kJ)
					Wet weight	SD	
X-1	cod	Apr. 1997	34.0	497.0	3.44	0.04	1707.39
X-2	herring	Dec. 1997	18.8	79.5	6.15	0.03	488.79
1	cod	May 1998	19.0	59.5	5.59	0.05	332.60
2A	herring	Oct. 1999	15.4	37.9	5.45	0.06	206.53
2B	herring	Oct. 1999	18.7	74.4	7.54	0.04	561.41
2C	herring	Oct. 1999	20.7	91.4	5.99	0.02	547.75
3	herring	May 1999	18.8	65.0	7.09	0.08	460.86
4A	herring	Aug. 1999	20.3	82.0	7.46	0.03	611.89
4B	mackerel	Aug. 1999	24.0	134.5	5.24	0.23	704.71
5	herring	Sept. 1999	16.8	53.5	7.89	0.01	421.91

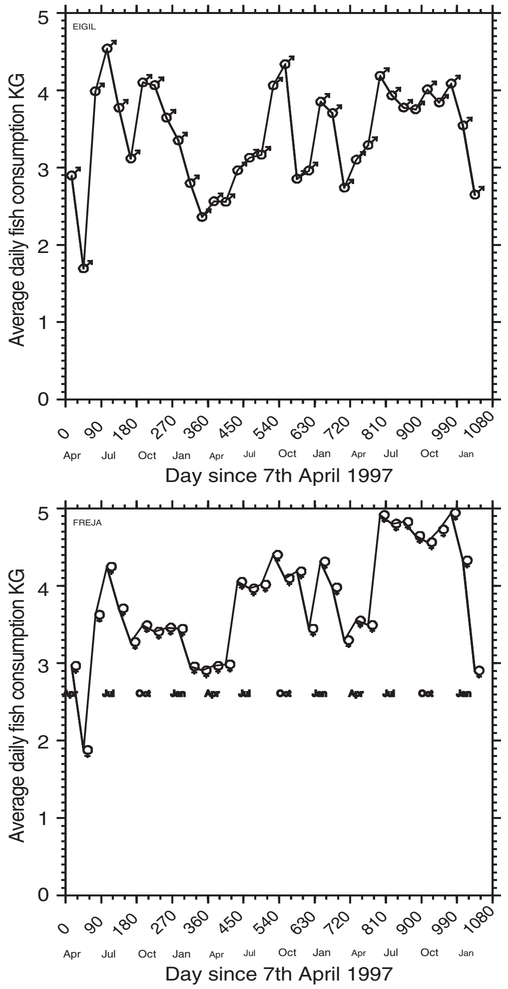

Fig.9. *Average daily food consumption by month for Eigil and Freja since 7th April 1997.*

Respiration

Respiration rate usually reflects activity status and metabolic rate (Reed *et al.* 2000), becoming more frequent at higher activity levels. The average breathing (blowing) interval has been calculated for each observation period. These periods are not of equal duration, but continue throughout the day and night. The data show that, comparing the two 24 hr sessions (October 1998 and February 1999) for each animal (Fig. 10), the average blow interval and S.E. range is less in October 1998: 16 to 34 sec for Eigil and 17 to 31 sec for Freja compared with February 1999: 19 to 54 sec for Eigil and 22 to 52 sec for Freja; see also Table 2. Furthermore, there also appear to be diurnal changes in respiratory interval for both animals. There was no clear pattern, but in general, the most rapid respiration occurred during the hours of daylight when there was general external activity at the poolside, but this was not so obvious in 1999, except that the longest intervals occurred in the middle of the night when the animals might be expected to rest more.

Frequency of different behaviours

Behaviours have been expressed as percentage of observation time spent in each category in 24 hours in Table 2 by session and individual animal. It is clear that cruising around was the most frequent activity for both animals, followed by slow swimming. Fast swimming was not very frequent and may be influenced by external stimulation because this generally occurred during daytime. Both animals were observed logging and being immobile at the surface more often in February 1999 than in the previous October period. This was certainly reflected in the longer average blowing interval in February 1999 (Table 2). The animals were not observed very often bottom grubbing and socialising (includes here both swimming together and contact).

Examination of diurnal patterns of activity revealed that activities changed throughout the day (Table 3). Bottom grubbing was more frequent during the early hours of the morning (03:00 to 08:00 hr) and cruising diminished during the late evening hours until 08:00 hr., whilst slow swimming and logging tended to increase during the night and early morning hours. This pattern was similar in both October and February.

Use of pool areas

All areas of the pool were used at some point during the 24 hours. However, it became evident that although there were some preferred areas for specific activities, the area changed in association with external activities at the pool (*e.g.* daytime public opening hours when feeding and training were taking place). Table 3 records the most used area during each time period. In October 1998, the animals tended to remain at the end of the pool nearest the pontoon by the fish kitchen (mainly Area 8) during daytime hours (where activity was centred), but removed themselves to the other end nearest the

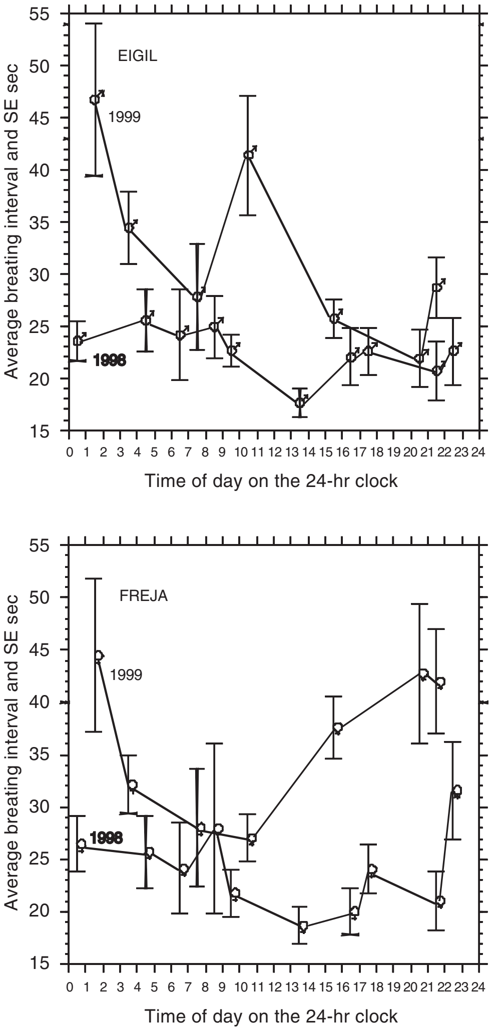

Fig. 10. *Average breathing interval for Eigil and Freja, 20-21October 1998 and 9-10 February 1999.*

main buildings at night-time (Area 5), and closest to the outer pontoon adjacent to the fjord wall (Areas 2, 3 and 4). This movement was not so marked in February 1999, when the animals clearly preferred the pool end nearer the main buildings (Areas 2, 6 and 5), although movements towards the inner pontoon (Areas 5 and 6) in daytime and outer (fjord wall) pontoon opposite (Areas 2 and 3) at night were occurring. Clearly the animals' movements within the pool were influenced by external activities (or lack of them), which generally may change from day to day according to training and experimental procedures.

DISCUSSION AND CONCLUSIONS

The estimated ages at first capture were about 1 to 2 years for Freja and Eigil in April 1997 based on the fitting of growth curves and reference to wild animals of similar size. The lengths of the animals in January 2000 were similar to wild animals of the same sex from the eastern North Atlantic region, and correspond to an age of about 4 to 5 years (Lockyer 1995b, c). At this age it is anticipated that for this species in this region the animals will be sexually mature because average age at first maturation is about 3 to 4 years (Sørensen and Kinze 1994, Lockyer 1995b, Lockyer and Kinze 2003). Maturation has been confirmed for Eigil, and Freja has participated in mating since summer 1998 (Desportes *et al.* 2003). The body weights are also similar to expected weights determined from bycaught porpoises in this region. The initial weight losses were not unexpected because of the lack of feeding at first and other stresses mentioned. However, the losses were not expected to be so sudden in Freja and Eigil. This suggests that the energy reserves of the animals may only be short term.

The large weight increase in the 1997-98 and subsequent 1998-99 and 1999-2000 winter months were associated with the cold water temperatures, which suggests that energy reserves and blubber fat in terms of insulation may be important. Studies on body weight composition of wild porpoises have shown that immature animals have the thickest and relatively largest amount of blubber reserves (Lockyer 1995a, c; Read 1990). The peak of fatness in terms of blubber thickness in winter may be interpreted as providing extra insulation for the animals. However, the thickness is such that extra insulation is probably not necessary (see Lockyer 1995a, c for a discussion of this point), and it is more likely that the extra lipid represents energy depots that can be mobilised to supplement food intake if needed. The subsequent loss of weight for Freja and Eigil in the spring supports the possible role of blubber fat as insulation, but also occurs at a time when reproduction may demand energy reserves.

Table 2. Mean breathing interval, and percentage frequencies of different behaviours in different seasons by animal.

Animal and time period	Average breathing interval (sec)	Frequency (as percentage of all recorded activities) of behaviour throughout 24-hr day							
		Cruising	Fast swim	Slow swim	Logging	Bottom grubbing	Social interaction	Jumping	Other
Eigil 20-21 October 1998	23.4	64.4	4.5	20.3	1.4	4.8	4.4	-	0.2
Freja 20-21 October 1998	24.1	64.9	0.9	20.6	1.5	6.8	4.8	0.4	1.0
Eigil 9-10 February 1999	32.4	51.0	2.0	20.9	17.9	4.8	3.3	-	0.1
Freja 9-10 February 1999	36.3	64.4	7.0	14.2	10.4	1.0	3.0	-	-

Key to behaviours listed:
Cruising – swimming around at an average speed, purposefully without any stops
Fast swim – brief burst of fast swimming with often rapid blowing, sometimes triggered by excitement
Slow swim – slow swimming sometimes with erratic direction
Logging – near-immobility laying horizontal at the surface between breathing
Bottom grubbing– foraging head down either vertically or at an angle (near-vertically) on the bottom
Social interaction – close tandem swimming, touching, sexual display
Jumping – leaping from the water (unusual activity)
Other – coughing – short noisy explosive blows, tail/flipper splashing at the surface, etc.

Table 3. Percentage time spent in different activities throughout the 24-hour day.

Time period (24-hr)	Blow interval, sec		Pool Area (1-9+hp see Fig. 1)		Cruising		Fast Swim		Slow Swim		Logging		Bottom Grubbing		Social Interaction		Jumping and Other	
20-21st Oct 1998	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja
17.33-	22.6	24.0	5	5	57.1	68.9	4.3	1.7	23.6	19.8	2.4	1.6	8.4	3.9	2.6	4.1	1.6	0
21.03-	20.7	21.0	5	5	56.1	77.5	2.2	0	25.1	14.0	2.4	0.9	0.7	7.3	4.5	0.3	0	0
22.45-	22.6	31.6	5/6	2	45.4	39.3	6.30	0	33.3	57.9	3.0	2.2	6.1	0.3	5.9	0.3	0	0
00.49-	23.6	26.5	2	2	52.9	67.2	5.9	1.2	27.7	24.2	3.8	0	7.3	4.8	2.4	2.6	0	0
04.58-	25.6	25.7	3	2/4	40.5	48.9	4.0	0	41.8	29.3	0	0	8.6	17.2	5.1	4.6	0	0
06.57-	28.4	24.1	2/5	3/4	65.5	62.3	0	0	19.3	18.4	0	0	7.3	15.8	7.8	3.5	0.1	0
08.05-	27.8	27.9	5	5	93.9	58.7	0	0	3.6	6.7	0	0	0	17.1	2.5	17.5	0	0
08.38-	23.5	-	3/6	-	77.2	-	11.7	-	8.1	-	0	-	3.0	-	0	-	0	-
09.40-	22.6	21.8	7/8	8	70.0	75.9	2.8	3.2	17.9	7.1	1.5	4.8	0	0	6.9	4.2	0	4.8
13.24-	17.6	18.7	-	8	74.2	80.1	8.5	2.9	7.6	5.9	1.8	5.7	2.0	2.4	5.9	3.0	0	0
16.02-	22.0	20.0	8	8	76.7	69.9	3.5	0	15.1	22.3	0	0	0	0	4.7	7.8	0	0
9-10th Feb. 1999	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja	Eigil	Freja
15.50-	25.7	37.6	3	2	59.6	65.1	2.2	1.2	16.5	12.5	16.8	17.1	1.4	1.3	2.4	2.8	1.2	0
20.07-	21.9	42.8	6	6	67.5	79.2	5.0	10.4	10.0	12.4	16.2	0	0	0	1.3	0	0	0
21.37-	28.7	42.0	6	2	59.9	42.6	0.2	37.3	29.9	13.5	8.7	13.5	0.2	0.4	1.0	6.2	0	0
01.14-	46.8	44.5	2	2	37.5	63.8	1.9	0.7	31.3	17.8	25.4	14.9	2.9	0.7	1.0	2.0	0	0
03.08-	34.4	32.1	5	2	43.1	69.8	1.1	0.6	16.4	13.1	24.3	10.8	13.1	3.3	2.1	2.4	0	0
07.30-	27.8	28.1	2	5	36.0	59.5	1.4	0	35.0	23.7	9.1	7.8	17.0	1.6	15.0	7.4	0	0
10.54-	41.4	27.1	3	2	60.6	74.9	3.4	0.9	9.2	9.8	26.0	12.4	0	0	0.8	1.9	0	0

The area denoted is the one most used during that time period. A */* denotes equal useage of two areas.

What is noticeable now that the 2 porpoises have reached the age of maturity, is that despite seasonal variations in girth and blubber thickness, the overall mean girth and blubber thickness (see Figs 7 and 8) do not now appear to increase with overall mean body size and weight. This is also anticipated from studies on wild porpoises (Lockyer 1995a, c) where the blubber thickness actually decreases in relation to body size, the blubber mass perhaps becoming more of a problem for the animal in terms of over-insulation and thermoregulation. Also muscle mass increases proportionately in adulthood (Lockyer 1995a).

Food intake studies indicate a clear seasonal variation that is correlated with body weight changes and other fatness indicators, but precedes them by about 2 months.

The results so far indicate that while the animals are growing as predicted for wild bycaught porpoises in the region of inner Danish waters (Lockyer and Kinze 2003), the intense monitoring undertaken during this study period in semi-natural conditions indicates a marked seasonal pattern in both body weight and fatness, and food intake, hitherto unreported. Comparison with data for free-living porpoises in Danish waters predicts mean body weights (ignoring seasonal changes) of about 43 kg for Eigil and 51 kg for Freja at their current lengths (length-weight relationship in Lockyer and Kinze 2003). Thus their current weights fall close to those normally observed.

During the two 24 hour watches, the animals spent most of their time cruising around, but on a daily basis, they were less frequently seen cruising at night, and the frequency of slow swimming and logging at the surface increased then. Breathing rates were lower in the early morning hours, consistent with diminished activity. The differences in respiration between February and October could be explained either by intrinsic physiological responses to the environment; *e.g.* temperature, and behavioural changes; or simply that the animals in February are larger than in October - 44 kg from 37.5 kg (Eigil) and 52 kg from 46.5 kg (Freja). The respiration rate, thus correspondingly reduced in February, and reflecting a relative decrease in metabolic rate, could be associated with both maturation and increased volume:surface area ratio. However, both animals were observed logging and being immobile at the surface more often in February 1999 than in the previous October period (Table 2) thus suggesting that increased body size may not be the only factor connected with the observed differences in blowing interval in the 2 time periods. Both animals' movements appeared to be influenced by human and external activities at the poolside, with a preference for proximity to the pontoon by the fish kitchen in day time, *i.e.*, the pontoon by which the trainers enter the pool. Heukers (MS 1998), however, showed the influence of tidal currents on the animals' movements in this semi-open pool system, with the animals staying preferentially at the Fjord&Bælt end with strong incoming currents, *i.e.* the side by which the tidal flow enters the pool, and dispersing over the whole pool with weak currents (which may be weak incoming currents or outgoing currents which are never strong in the pool). Tidal currents may also have influenced the placements of the animals in the present observations. Both sets of data, however, point to the necessity of monitoring these factors in experiments using the placement of the animals in the pool as a control parameter. These aspects, as well as the importance of seasonal water temperature changes will be further investigated in the future.

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REFERENCES

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49:227-267.

Desportes, G., Kristensen, J.H., Benham, D., Wilson, S., Jepson, T., Siebert, U., Korsgaard, B., Driver, J., Amundin, M., Hansen, K. and Shephard, G. 2003. Multiple insights into the reproductive function of harbour porpoises (*Phocoena phocoena*): An ongoing study. *NAMMCO Sci. Publ.* 5:91-106.

Heukers, W. (MS) 1998. Training and research on two harbour porpoises (*Phocoena phocoena*). Four months internship for graduating in Animal Management B.Sc., Van Hall Institute, Leeuwarden, the Netherlands, December 1998.

Lockyer, C. 1995a. Aspects of the morphology, body fat condition and biology of the harbour porpoise, *Phocoena phocoena*, in British waters. *Rep. int. Whal. Commn* (Special Issue 16):199-209.

Lockyer, C. 1995b. Investigation of aspects of the life history of the harbour porpoise, *Phocoena phocoena*, in British waters. *Rep. int. Whal. Commn* (Special Issue 16):190-197.

Lockyer, C. 1995c. Aspects of the biology of harbour porpoise, *Phocoena phocoena*, from British waters. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds.); *Whales, seals, fish and man*. Elsevier Science B.V., Amsterdam, 443-457.

Lockyer, C. and Kinze, C. 2003. Status, ecology and life history of the harbour porpoise (*Phocoena phocoena*) in Danish waters. *NAMMCO Sci. Publ.* 5:143-176.

Martin, P. and Bateson, P. 1993. *Measuring behaviour: an introductory guide.* - Second edition. Cambridge University Press. Cambridge.

Read, A.J. 1990. Estimation of body condition in harbour porpoises, *Phocoena phocoena*. *Can. J. Zool.* 68:1962-1966.

Reed, J.Z., Chambers, C., Hunter, C.J., Lockyer, C., Kastelein, R., Fedak, M.A. and Boutilier, R.G. 2000. Gas exchange and heart rate in the harbour porpoise, *Phocoena phocoena*. *J. Comp. Physiol.* B 170:1-10.

Sørensen, T.B. and Kinze, C.C. 1994. Reproduction and reproductive seasonality in Danish harbour porpoises, *Phocoena phocoena*. *Ophelia* 39:159-76.