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# Harbouring nature: port development and dynamic birds provide clues for conservation

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## Abstract

During the twentieth century, many coastal areas in Europe changed dramatically due to coastal protection works, human expansion drift and booming beach tourism. As a result the natural area of suitable nesting habitat of many coastal birds has decreased enormously and a large number of species are now listed as threatened. Some species were able to exploit new opportunities offered by human activities, but most coastal birds are now confined to islands, protected areas or artificial sites (nature development projects, restored coastal habitats and even floating rafts). Protection of local resources, as well as further development and management of breeding sites is considered vital in maintaining the populations of threatened coastal breeders. The rationale behind nature restoration and development is often solely based on offering suitable habitat to the birds, while its success is mainly judged from the evolution in the number of birds present. As more and more information becomes available on the reproductive performance of coastal birds, it becomes clear that in some protected areas long-term reproductive success is below self-sustaining levels. Apparently humans are able to create artificial nesting habitats that are highly attractive from the birds' perspective but are in fact pitfalls for the population in the long term. In contrast, the port of Zeebrugge, Belgium, is an excellent example of an artificial nesting habitat of high quality in terms of attraction as well as reproduction. Here, vast sandy areas were raised in a former marine habitat in the 1980s. The works mimicked natural dynamic processes and coastal breeding birds instantly reacted. Within 20 years, the area has developed from open sea to a breeding site of major international importance. Peak population figures by far exceed the 1% of the total biogeographical population. At present, Zeebrugge harbours more than 4% of the total north-west European Common Tern population, thus making it the largest colony in Europe. It is a highly productive population and acts as a major source of recruits for the biogeographical population as a whole. Until recently, the success of the bird populations was based on the ongoing creation of suitable nesting habitats and management measures, like removal of the vegetation and covering areas with shell fragments. Further development of the harbour, the arrival of the fox and competition for nesting habitat with large gulls are major threats for the bird population. Therefore part of the colony was allocated to a peninsula and further steps are now being considered to preserve this valuable population. Apparently feeding conditions are very good and the harbour itself and its direct surroundings function as a major source of small prey fish of which the availability is facilitated by the heavy shipping traffic and the sheltered conditions of the feeding areas.

Keywords: Zeebrugge; Nature development; Coastal breeders.

## Introduction

During the twentieth century, increased anthropogenic pressure and the tendency of mankind to protect coastal sites against the unpredictable character of the sea has lead to a decreasing area of dynamic coastal habitats. Throughout Europe, coastal breeders that depend on areas that *a*re subject to processes of erosion and accretion and naturally shifted their location over time are now restricted to remnants of their natural breeding habitat. Only the more opportunistic species were able to adapt to the loss of their original breeding habitat and the increasing pressure of beach tourism. The European populations of many larger European gull species, for example, showed a strong increase during the second half of the twentieth century as their breeding areas were better protected and they learned to exploit new food resources such as fish offal and organic waste on refuse dumps (Del Hoyo *et al.,* 1996; Spaans, 1998; Mitchell *et al.,* 2004). Being true opportunists, they also showed a great plasticity in their habitat choice. In the beginning of the twentieth century Herring and Lesser Black-backed Gulls were restricted to natural coastal habitats, but nowadays they are found breeding far inland and often in the proximity of humans (Del Hoyo *et al.,* 1996; Spaans,1998; Mitchell *et al.,* 2004). Many urban areas as well as harbours and industrial areas are now harbouring gulls. However, the populations of more specialised coastal birds as well as species that require undisturbed areas for breeding were put under great pressure and many of those species are now listed as threatened on many national Red Lists. At present, they are mainly confined to islands, protected coastal areas or artificial sites (such as nature development projects, restored coastal habitats and even floating rafts). During the twentieth century, it has become a generally accepted principle that threatened birds of dynamic habitats can be helped by managing already established breeding sites or by attracting them to new suitable breeding grounds. This has without any doubt improved the conservation of the species. Here we report on the conservation of a population of coastal breeders in the outer port of Zeebrugge, Belgium.

## Evolution of coastal breeders in Zeebrugge

With the development of the outer port of Zeebrugge in the 1980s (Fig. 1) vast areas of sandy, sparsely vegetated and relatively undisturbed land were created. The works mimicked natural dynamic processes in coastal areas and pioneer species instantly reacted to the availability of new suitable nesting habitat. Little Tern *Sterna albifrons* and Kentish Plover *Charadrius alexandrinus* settled in the area in 1985. At first, the vegetation developed slowly and breeding birds reacted reluctantly, but from 1988 onwards the area attracted increasing numbers of plovers, terns and gulls. During the next 16 years the area underwent major changes. Sites of suitable nesting habitats were claimed for the development of buildings, car parks, roads and railways, while ongoing raising of land created new nesting opportunities for coastal birds. In areas that remained more or less undisturbed, Herring Gull *Larus argentatus* and Lesser Black-backed Gull *L. fuscus* displaced pioneer species. To ensure nesting of pioneer species management measures were taken, such as regular removal of the vegetation and covering areas with shell fragments. The radical changes (raising of land, industrial development and nature management) caused strong and sudden fluctuations in the population size of true pioneer species, while slow processes like succession of the vegetation, competition for

nesting habitat and recruitment of young seem to contribute to the population dynamics of gulls and Common Terns *S. hirundo* in a positive (or negative) way. In this paper we will focus on the population development of and future prospective for terns and plovers in the harbour area. The evolution and status of breeding gulls in the Zeebrugge port is described in detail elsewhere (Meininger and Flammant, 1998; Seys *et al.*, 1998; Stienen *et al.*, 2002; Vercruijsse *et al.*, 2002).

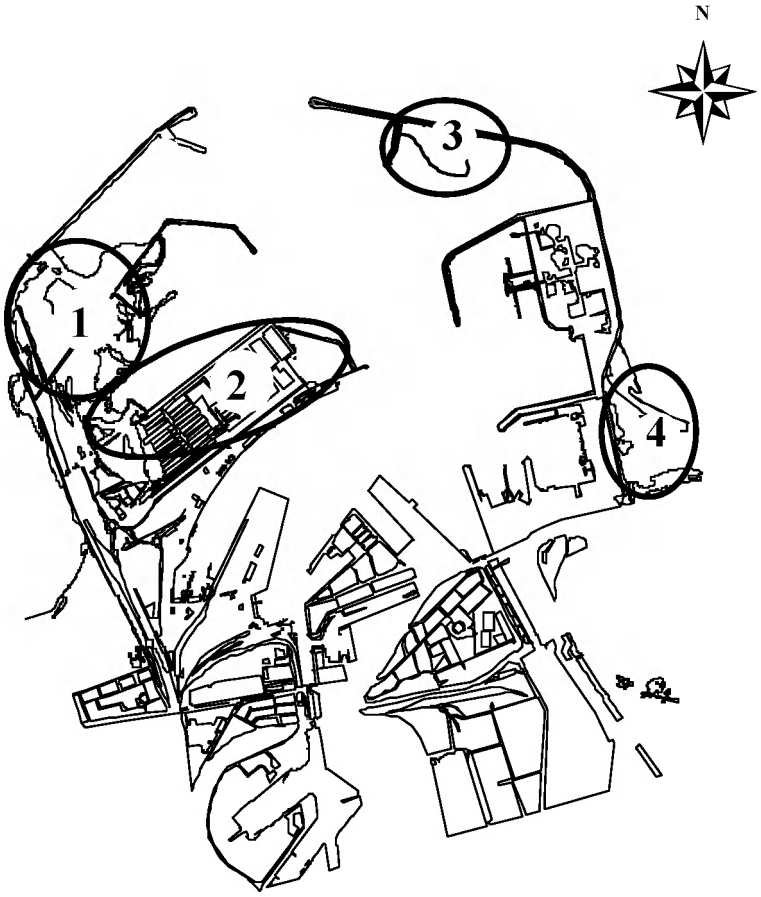


*Fig. 1. Map of the outer harbour of Zeebrugge showing (1) the initial nesting site of plovers and terns that is now largely industrialised or taken over by Herring and Lesser Black-backed Gull, (2) the core of the colonies in 1990s, (3) the newly created 'tern peninsula' and (4) the Flemish nature reserve 'Baai van Heist'.*

Until 2000, the breeding sites in the harbour were maintained by ad hoc nature management such as mowing of the vegetation, ploughing up the soil and deposition of shell material. Each year, warning signs were put up and the major sites were fenced of

with wire. By the end of the 1990s, a more permanent solution for a part of the ation and in 2000 was sought. A small peninsula (2-3ha) was created along the eastern breakwater of the port of Zeebrugge (Fig. 1). This was the first of a series of measures to compensate for the loss of nesting habitat in the western part of the harbour. During the next five years, the peninsula was further enlarged in four steps and during the breeding season in 2005 it reached about 10ha. The peninsula was intended to attract terns and was therefore named the "tern peninsula". In order to offer suitable nesting habitats to the different tern species, it had to meet several preset ecological conditions that were extracted from literature (Veen *et al.,* 1997). The lower parts of the peninsula were covered with a 5cm layer of shell material to make them suitable for Little Terns. In order to minimise erosion and to support quick colonisation by Black-headed Gulls *L. ridibundus* the elevated areas were planted with salt-resistant grasses. Most parts of the peninsula, however, were not planted because earlier experience in raised terrain showed that the area would become suitable for Common Terns within a few years anyway. No specific measures were taken to attract plovers because it was determined that the parts developed for Little Terns were also suitable for those species. At about the same time the adjacent Flemish Nature Reserve "Baai van Heist" (Fig. 1) was established and closed for the public during the breeding season from 1998 onwards. This area also attracted coastal breeders for some years.

The different species of coastal breeders that settled in Zeebrugge can be subdivided into four groups that all have different life-history traits and show very specific development of their populations (Fig. 2). The Little Tern and Kentish Plover are true pioneers that require highly dynamic, open habitats. Common Tern and Black-headed Gull are species of the first stage of vegetation succession, whereas the Sandwich Tern *S. sandvicensis* is a more erratic species that depends on the presence of Black-headed Gulls. Finally, there are the larger gull species that show a large overlap in breeding habitat with the Common Tern and Black-headed Gull, but are in fact less critical species. The two pioneer species showed peak numbers during the second half of the 1990s, mainly because the area of sparsely vegetated habitat was then at a maximum. These species instantly reacted whenever new terrains were raised in the harbour or when sandy habitats became available through disturbance of existing terrains. This was also the case when shell material was laid out as a management measure. Similarly, they colonised the new breeding habitat at the "Baai van Heist" in 1989 and they settled on the "tern peninsula" in 2000, the year that the first part of the peninsula was realized. In the following years, they always used the most disturbed soils at the peninsula for their nesting activities. These were either newly raised terrains, parts where the vegetation was removed or parts that were most impacted by the winter storms. In the "Baai van Heist" no specific measures were taken to keep the soil disturbed in order to keep it suitable for pioneer birds. This may very well have contributed to the fact that breeding at the "Baai van Heist" was abandoned after three years.

As representatives of a more evolved habitat, the populations of Common Tern and Black-headed Gull showed a more or less gradual increase and peak numbers were counted in 2004 and 2003. This is directly correlated to the development of the vegetation in the western part of the harbour. For the Black-Headed Gull the increase in numbers was disrupted in 2004 due to disturbance (by human activity or terrestrial predators) in an early stage of egg-laying. Following the abandonment of the western

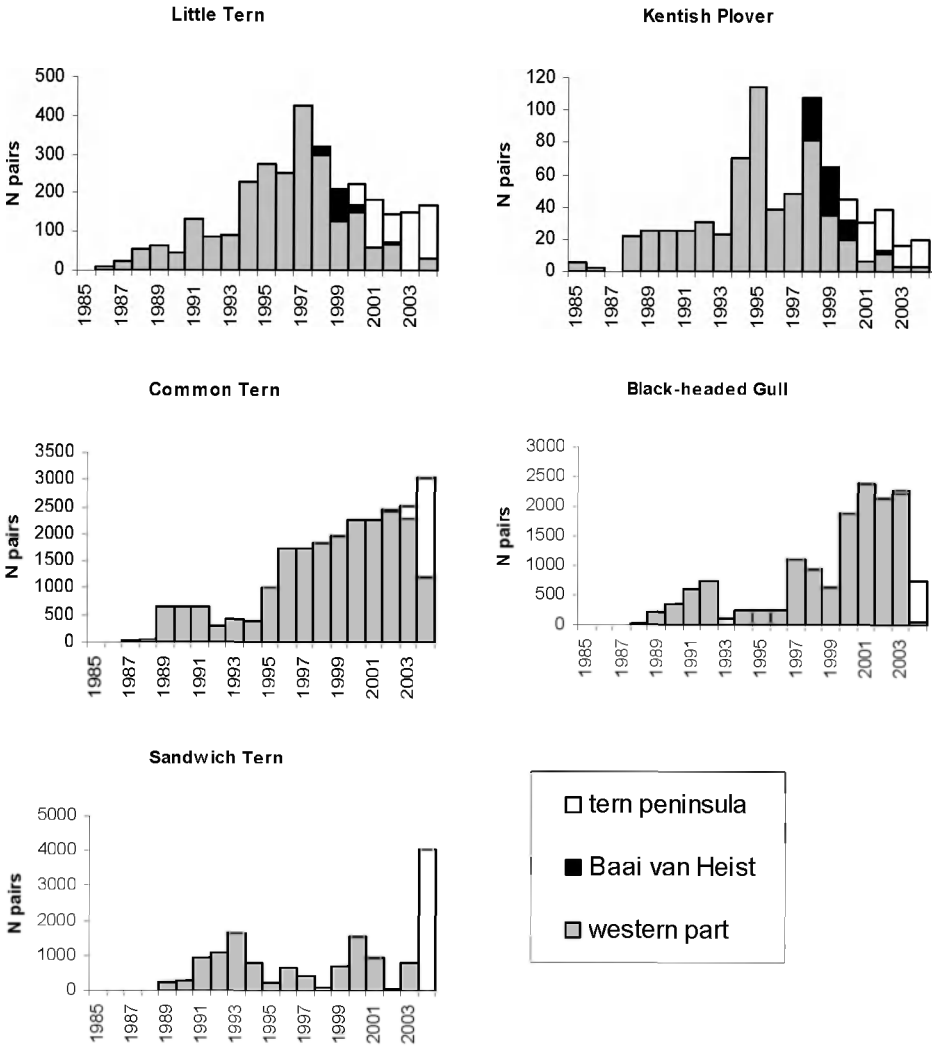


*Fig. 2. Evolution of coastal breeders in the outer harbour of Zeebrugge and at the adjacent nature reserve "Baai van Heist" during the period 1985-2004.*

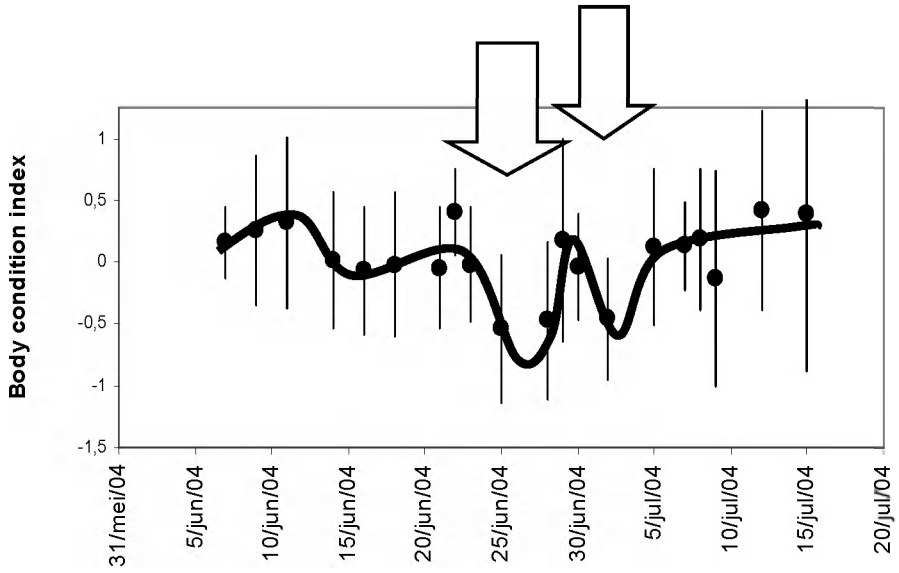


*Fig. 3. The development of the body condition (average values ± standard deviation) of Common Tern chicks in the harbour of Zeebrugge in 2004. The arrows indicate two periods of heavy storm. The drawn line is a visualisation of the development of the chicks' body condition and is drawn by hand.*

part of the harbour, a small part of the gull population found a refuge at the "tern peninsula". Common Tern and Black-headed Gull reacted somewhat later to nature management measures than the pioneer species. This is perfectly illustrated by the fact that they only started breeding in Zeebrugge 2-3 years after the first Little Terns and plovers had settled in the harbour. They also occupied the "tern peninsula" two years later than the first pioneers. Judging from the ongoing increase in numbers, at present, there are no signs that Common Tern population of Zeebrugge is reaching its upper limit. Conversely, the Black-headed Gull population fluctuated around a stable number of slightly more than 2000 pairs after 2001 (with the exception of 2004 when only approximately 600 pairs are found).

Sandwich Terns exclusively breed in association with other species and in Europe these are mainly Black-headed Gulls and sometimes Common Terns (Veen, 1977). Since Sandwich Terns are not very aggressive against intruders, they depend on the neighbouring gulls to chase away predators. The gulls also form a buffer against ground predators. In Zeebrugge, the first Sandwich Terns only settled in 1989; the first year a substantial number of Black-headed Gulls nested in the western harbour. Their numbers heavily fluctuated throughout the years and it was not always clear whether intrinsic factors (vegetation, disturbance, food abundance) or external factors (shifts in nearby populations) were the underlying cause.

## Preserving dynamic nature

Although mankind has greatly added to the conservation of coastal breeding birds by offering them (semi)artificial breeding grounds or by preserving the original breeding grounds, this practice also has several drawbacks. In the first place it has encouraged a general view that dynamic nature can be manipulated very easily which sometimes led to ill-considered decisions. In the specific case of coastal breeders, nature conservation or nature building is in fact a *contradictio in terminis* because it assumes that dynamic habitats can be preserved at a fixed location. As a result, there are a growing number of breeding sites that can only be ensured for a longer period by intensive management of the vegetation and/or elimination of terrestrial and avian predators (Meininger and Graveland, 2002). Even many natural sites that harbour historic populations of coastal breeders are now preserved in this way. Europe's largest Sandwich Tern colony, for example, is harboured on an artificially fixated island, Griend, located in the Dutch part of the Wadden Sea (Veen and Van de Kam, 1988). In the 1980s, a dike was built around the island to prevent it from being lost to the sea. Parts of the new island were planted with salt-resistant grasses and each year measures are taken to prevent larger gulls from breeding on the island. In addition a monitoring programme was set up on Griend to measure the health of the population in terms of breeding success. Monitoring the reproductive performance of a population is a vital activity once coastal birds are established on (semi)artificially breeding sites as it can provide valuable clues on the health of the population and may help to guide management decisions.

The excellent scientific knowledge on the habitat preferences of coastal breeders that exists nowadays can be used to create breeding sites of almost supernatural attraction to the birds. Additionally one may put other means, like decoys and sound, into place to lure the birds to a specific place. In fact it is not very difficult to set up a successful nature development project for coastal breeders if its success is merely judged from the number of breeding pairs. However, attracting and maintaining a healthy population in terms of survival is a much more complex task. In this case one should preferably have ecological information beforehand to make sure that the birds are not attracted to an ecological pitfall that merely acts as a sink for adult birds. In addition, one needs a well-considered monitoring programme and a nature management plan must be set up to ensure the health of the population. The latter step becomes particularly important if the site harbours a larger part of the total biogeographical population.

## The Zeebrugge example

In the case of Zeebrugge, we had several clues that the population was healthy and self-supporting. A first clue was provided by the number of breeding pairs. At maximum size, the populations of Little, Common and Sandwich Tern represented, respectively 3.8%, 4.8% and 7.2% of the entire geographic population of the species. However, as stated before, the number of breeding pairs is only a poor indicator of the health of a population. Should the Zeebrugge population have low survival probabilities and large dependence on immigration from other colonies then preservation of this may have a negative effect on the geographical population as a whole. A preferable monitoring tool is ring recoveries as these provide better insight into the demographic aspects of a

population. We studied the population dynamics of Zeebrugge's populations and the links with other colonies by trapping ringed adults at the nests and by reading the rings of adults from a hide using a telescope. This resulted in 163 and 113 ring recoveries of Common and Sandwich Tern, respectively. The recoveries show that the Common Tern population entirely consisted of either local birds (85.3% of the recoveries originated from Zeebrugge itself) or immigrants from the nearby Delta area in The Netherlands (14.7%). Recoveries of ringed Sandwich Terns show a similar high proportion of "own" birds (77.9% of 113 recoveries) and again a close connection with the Delta area, although some Sandwich Terns originated from colonies in the Dutch Wadden Sea and in the United Kingdom as well. The most remarkable recovery was of a Sandwich Tern that was ringed in Zeebrugge as a chick in 1989 and successfully raised a chick of its own in 2004. These are indications that the Zeebrugge population is largely self-supporting, although in this light it is not clear what caused the strong fluctuations in the number of Sandwich Terns. Only in 2004, when peak numbers settled at the "tern peninsula", we had an insight as to the origin of these birds. In that year a high flood washed away all the eggs in the nearby colony at the "Hooge Platen" in the Dutch Delta area. Consequently, most terns left the "Hooge Platen" and moved to other colonies to produce a second clutch. That is probably the reason for the peak numbers at the "tern peninsula" in 2004. Indeed we noted several birds wearing Dutch rings, but at present we have not yet received the details on these recoveries.

It goes without saying that the success of the birds in terms of reproductive output is the best indicator for the quality of a breeding site. Monitoring breeding success can provide a very detailed insight into the quality of the breeding habitat and provide clues for future management, in particular if one is able to distinguish between various causes of egg loss and chick mortality. In Zeebrugge, we started measuring the breeding results of the Common Tern population in 1997. Each year, a representative part of the colony was fenced in and the enclosed nests were checked on a regular basis. The monitoring study pinpointed the specific problems of the population in Zeebrugge and enabled us to compare the reproductive output with other colonies.

Clutch size (number of eggs per clutch) and hatching success of the eggs (*i.e.* percentage of the eggs that actually hatched) were rather stable throughout the years (Table I) and close to maximum values reported elsewhere (Stienen and Brenninkmeijer, 1992; Becker *et al.,* 1997; Nisbet, 2002). This indicates low predation rates as well as low concentrations of some specific contaminants that affect hatchability of the eggs. Chick survival as well as productivity (*i.e.* number of fledged chicks per pair) showed much more variation than clutch size and hatching success. Still, compared to adjacent colonies in the Dutch Delta area, Zeebrugge generally scores very highly when it comes to the survival probabilities of the chicks (Meininger *et al.,* 2002). Also compared to Wadden Sea colonies in Germany and The Netherlands – where the same method was used to measure reproductive output – productivity is often higher at Zeebrugge (Table II). The mean productivity at Zeebrugge is comparable to the high values recorded along the Atlantic coast of North America (Nisbet, 2002). This points towards a combination of good feeding opportunities in the surrounding of the colony and low predation rates on chicks. In most years breeding success was well above 1.1 fledglings/pair. Only in 2000, 2002 and 2004 breeding success was below this figure because of either predation or food shortage. In 2000 and 2002, the chicks suffered from predation by Herring and

Lesser Black-backed Gulls. However, in 2002 this was a secondary effect of food shortage among the terns. In that year, chick growth seriously lagged behind the normal pattern. Many chicks died from starvation and the remaining chicks (also in very poor body condition) were preyed upon by the gulls. Also in other colonies along the southern North Sea it was reported that Common Tern chicks suffered from a poor food situation. In 2004, we recorded high levels of predation by mammals (probably ferrets). The predation was restricted to the western part of the harbour were 1220 pairs nested. Here parents only raised 0.1 fledglings per pair, while at the "tern peninsula" in the eastern part of the harbour breeding success amounted to 1.1 fledglings per pair (1832 pairs).

Table I. Parameters of the reproductive performance of Common Terns in Zeebrugge during the period 1997-2004. Each year, the measurements were performed in an enclosed part of the colony that was representative of the entire population

| Year | Number of nests | Clutch size | Hatching success | Fledgling success | Productivity (fledglings/ pair) |
|---|---|---|---|---|---|
| 1997 | 78 | 2.4 | 78% | 50% | 1.2 |
| 1998 | 185 | 2.5 | 77% | 61% | 1.2 |
| 1999 | 90 | 2.5 | 78% | 67% | 1.3 |
| 2000 | 52 | 2.3 | 91% | 37% | 0.8 |
| 2001 | 35 | 2.3 | 80% | 74% | 1.4 |
| 2002 | 34 | 2.2 | 79% | 8% | 0.1 |
| 2003 | 36 | 2.6 | 87% | 74% | 1.7 |
| 2004 | 37 | 2.1 | 81% | 38% | 0.7 |

Table II. Breeding performance of Common Terns in various northwest European colonies. Information presented is limited to colonies where the same methodology was used. Data from Becker et al. (1997) supplemented with own data for Zeebrugge and data abstracted from Griend reports 1996-2003

| Colony ( country) | Years (number of years) | Productivity fledglings/pair (overall mean) |
|---|---|---|
| Baltrum (Germany) | 1993-1995 (3) | 0.3-1.8 (1.0) |
| Griend (Netherlands) | 1993-2003 (11) | 0.0-1.0 (0.5) |
| Minsener Oldeoog (Germany) | 1993-1994 (3) | 0.0-1.3 (0.9) |
| Trischen (Germany) | 1993-1995 (3) | 0.0-0.0 (0.0) |
| Zeebrugge (Belgium) | 1997-2004 (8) | 0.1-1.4 (1.1) |

Finally chick growth and body mass of the chicks can provide clues on the local feeding conditions. In this paper, the body mass of the chicks is expressed as a relative difference from the expected body mass (*i.e.* the average body mass of all chicks of similar size), and is forthwith called body condition. A negative value for body condition tells us that the chick's body mass is below average. In Fig. 3 the body condition index of Common Tern chicks in Zeebrugge 2004 is plotted against time. It shows that, except for two

periods of stormy weather, the body condition of the chicks fluctuated around zero, indicating that the chicks grew at an average growth rate and that there were no problems related to food. During the two periods of strong winds the hovering capabilities of the foraging terns were severely affected and the transparency of the water column deteriorated, so that parents could not catch enough fish for their offspring. Consequently growth lagged behind and body condition immediately dropped below zero. As a result of the poor feeding situation some chicks died from starvation, but the surviving chicks quickly recovered after the storm died down (Fig. 3).

By averaging all measurements of body condition over the entire chick rearing season one gets a rather robust parameter that gives insight into the food availability in a specific year. In Fig. 4 this parameter is plotted for Common Tern chicks in Zeebrugge during the period 1991-2004. The figure shows that 2002 was a very deviant year in terms of chick growth. As stated above, in 2002 many chicks died from starvation and the surviving chicks showed very conspicuous begging behaviour each time a parent (whether or not it was their own parent) landed with prey in the colony. This attracted some larger gulls to the colony that were apparently specialised in preying upon tern chicks. When omitting 2002 from the analysis, the graph suggests that the body condition index of the Common Tern chicks in Zeebrugge has slowly decreased over time (Fig. 4). It is not clear whether this decrease reflects changes in the local food situation or is the result of intraspecific competition owing to the growing numbers that breed in Zeebrugge. It might be a first indication that the Zeebrugge population has almost reached its carrying capacity and that the size of the population will ultimately be limited by the amount of food. The evolution of the number of pairs, however, shows no signs yet that the population is reaching an upper limit (Fig. 2).

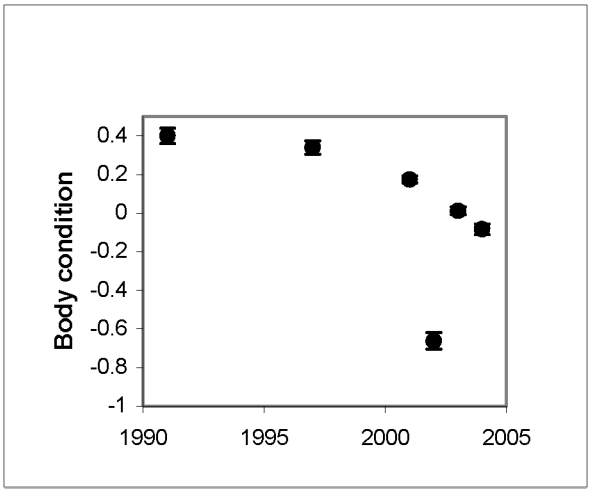


*Fig. 4. Averaged yearly body condition index (± standard error) of Common Tern chicks in Zeebrugge during the period 1991-2004.*

In conclusion, studies revealed that Zeebrugge is an outstanding breeding site for coastal breeders. It serves a very thriving, healthy, self-supporting and internationally important population that is worthwhile to preserve. Increasing pressure of harbour activities and habitat loss in the western part of the harbour created an urgency for the construction of a permanent breeding site in the eastern part of the harbour. The first experiences at this so-called "tern peninsula" show that the population can be successfully relocated. Advanced plans exist to designate the western part of the harbour entirely to economic activities. The harbour's ecological value will be ensured by further enlarging the "tern peninsula" to a final size of 22ha. The breeding site as well as the foraging areas will soon be designated as Important Bird Area because of the presence of significant numbers of the three tern species. The major challenges in the future will be to maintain the quality of this breeding site so that its important population of coastal breeders will be preserved. Due to the fact that the peninsula lacks sufficient dynamics constant management of the vegetation follows. Predator control, avoidance of competition from Herring and Lesser Black-backed Gulls and minimising collision against windmills, as well as scientific monitoring are required to guarantee the success in the long term.

Zeebrugge is an excellent example of how port development and dynamic birds can go together. It shows that fish-eating birds like terns can be successfully harboured in major ports. The underwater constructions of ports can act as artificial reefs and may enhance fish abundance. The availability of prey fish is further facilitated by the heavy ship traffic (in particular Common Terns often feed in large numbers behind ships) and by the sheltered environment provided by the jetties, so that the terns can find enough food even under adverse weather conditions. In the USA and Canada there are many examples of how major ports (*e.g.* the ports of San Diego, Aukland and Colborne) contribute to the protection of endangered seabirds, but in most European ports this is still a major challenge.

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