



# Imposex in Whelks (*Buccinum undatum*) from the Open North Sea: Relation to Shipping Traffic Intensities

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**Imposex in female whelks (*Buccinum undatum* L.) from the open North Sea is reported for the first time. The frequency of occurrence of a penis homologue and the mean length of this homologue increased with shipping intensity. Twenty years ago whelks from the area did not show signs of imposex.**

Imposex has been defined as the development of male primary sexual characteristics in female gastropods, and was first described for the dogwhelk *Nucella lapillus* L.—an estuarine snail—by Blaber (1970). The phenomenon is caused by exposure to tributyltin (TBT) in *N. lapillus* (Bryan *et al.*, 1986; Gibbs & Bryan, 1986; Bryan *et al.*, 1987). Strong evidence for TBT as the causative agent for imposex in *Nassarius obsoletus* (Say) had been found before by Smith (1981a,b). TBT has been used in anti-fouling paints on ship hulls since the early 1970s. On the base of the occurrence of imposex in intertidal gastropods in relationship to intense yachting traffic and marinas, the Marine Environmental Protection Committee (MEPC) of The International Maritime Organization (IMO) has adopted Resolution MEPC.46(30) to ban TBT-based anti-fouling paints from use on ships smaller than 25 m (Anon., 1990). Larger vessels have been exempted from this rule because of the lower levels of TBT in offshore waters.

This study aimed to investigate imposex in whelks (or common whelks) (*Buccinum undatum* L.) from the southern and central North Sea.

## Methods

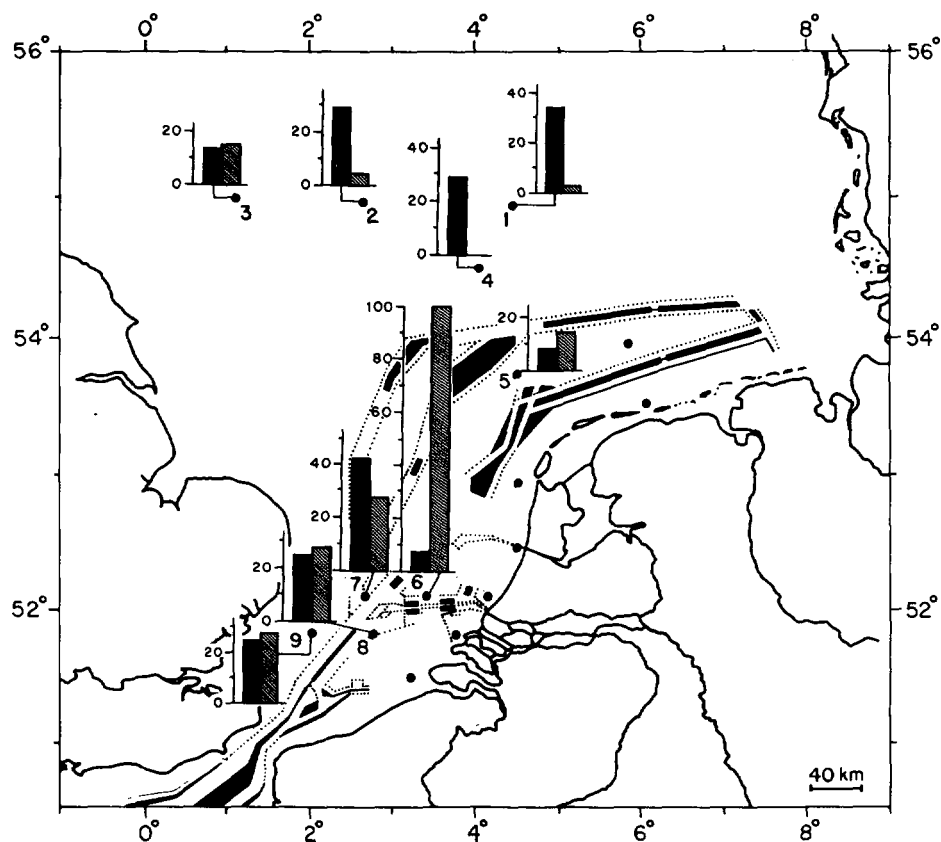
The occurrence of imposex in female whelks was characterized by the incidence of a penis, the penis length, and the occurrence of a vas deferens. The whelks were sexed by first observing the shape of the shell aperture, being a fair but not always conclusive indication of sex (Ten Hallers-Tjabbes, 1979a,b). As a second check the sexual parts were examined. First all whelks were taken from their shells. Because whelks tend to crawl out of the shell when exposed to air and

so expose their sexual parts, most whelks could be easily examined without breaking the shell. The length of the penis homologue of female whelks was measured; establishing relative penis size of females as compared to males was not feasible because of the crooked shape of the male penis. The data were collected during two cruises of the Integrated North Sea Programme, theme 'Microcontaminants' in August–September 1991 and May–June 1992. Stations 1–6 were sampled both in 1991 (August/September) and 1992 (May/June). Stations 7–9 were sampled in 1991 only; stations 10 and 11 were sampled in 1992.

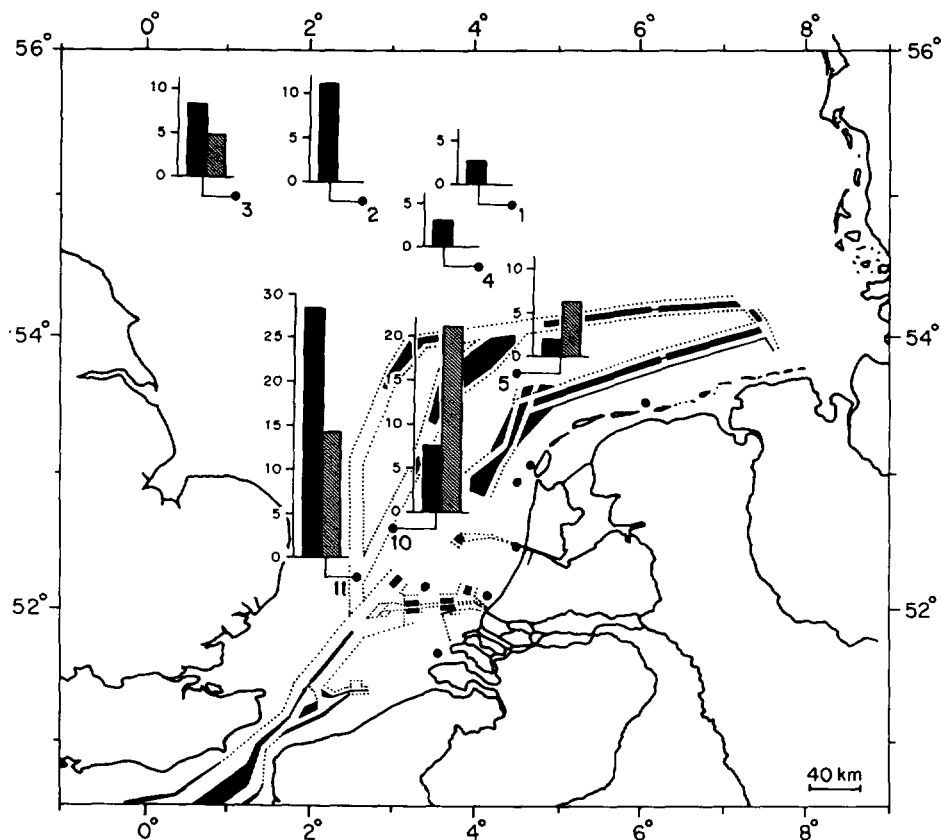
## Results and Discussion

Imposex was found at different incidences and at different stages of development at the different stations. However, the development of a vas deferens as occurs in the most advanced stages of imposex in the dogwhelk (Bryan *et al.*, 1986; Gibbs & Bryan, 1986) was not seen.

The data in Figs 1 and 2 show the imposex frequency in whelks (*Buccinum undatum* L.) from the different stations. Whelks from the central part of the southern Bight of North Sea (between the UK and the Netherlands) appeared to be most heavily affected. The majority of these stations were located close to the deep water traffic separation system (Anon., 1987; ICONA, 1992). The longest penis measured was 18 mm; still small compared to the sturdy male penis and rather different in shape. Whelks from the northernmost stations either showed no imposex or only a minor growth of penis homologues of 2–4 mm long at a low frequency. At most stations in the area of the coastal TE (Texel-Elbe) shipping route, many empty shells and shells were inhabited by hermit crabs, but no live whelks were found. The positions of such stations are also indicated in Figs 1 and 2. The shipping traffic intensities are again much higher in this coastal area than in the deep water traffic separation system (ICONA, 1992). Data on shipping traffic intensities were only available for 1982, when TBT had been in use for over 10 years. Since the offshore deep-water routing has only been changed in minor detail between



**Fig. 1** Number of females investigated and imposex incidence during the first cruise (1991). Black bars = total number of females investigated. Shaded bars = percentage of females with a penis homologue. Dotted lines = demarcation of deep water routes. Solid blocks within dotted lines = traffic separation scheme. Station positions without a number = locations where no live whelks were caught.



**Fig. 2** Number of females investigated and imposex incidence during the second cruise (1992). Black bars = total number of females investigated divided by 10. Shaded bars = percentage of females with a penis homologue. Dotted lines = demarcation of deep water routes. Solid blocks within dotted lines = traffic separation scheme. Station positions without a number = locations where no live whelks were caught.

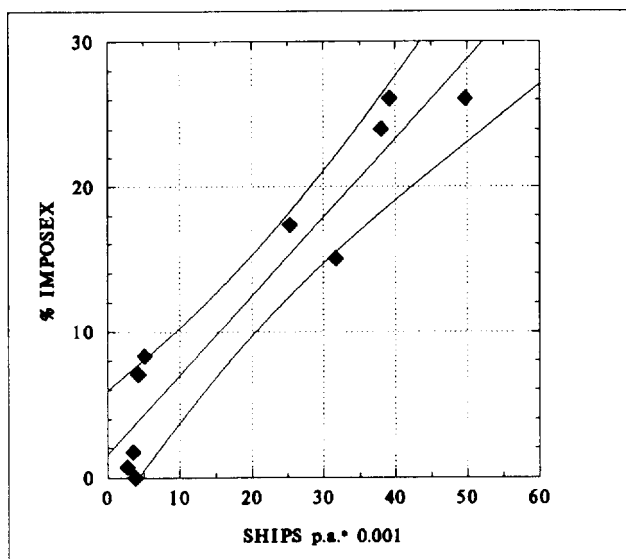


Fig. 3 Correlation between shipping intensities (1982 data) and imposex incidence for stations where more than 20 female specimens were sampled.  $r=0.96$ . Ships p.a.\* 0.001 = ships per annum\* 0.001 to pass within 15 miles of the sampling station (fishing vessels not included). % Imposex = percentage of females with a penis homologue.

1975 and 1992 (Anon., 1987) the 1982 situation was considered to be a fair representation of the situation in 1991–1992. Figure 3 shows the relationship between shipping intensities and imposex incidence for the stations where more than 20 female specimens were sampled. For the stations sampled during both cruises the results were combined. The relation coefficient  $r=0.96$  ( $p<0.005$ ), indicates that 90% of the variability in whelk abnormality could be explained by the number of passing ships.

In 1991, six female whelks with a penis homologue were found at station 6, located directly north of the Euro Channel, the entrance to the harbours of Rotterdam. However, in 1992, only one live male specimen was caught, despite an extensive trawling effort.

The data can be compared with those from a study 20 years ago, when male and female specimens of *B. undatum* were collected and sexed from different locations in the North Sea. At this time females all

lacked any development of a penis homologue (Ten Hallers-Tjabbes, 1979a). Davies & Bailey (1991) have reported the occurrence of imposex in the related species *N. lapillus* due to large ships visiting the oil terminals in Sullum Voe (Shetlands) and Scapa Flow (Orkneys). The data indicate that commercial shipping in the open sea may contribute to the occurrence of imposex as well as crowded yachting in coastal waters. The policy consequences of these results may reach further than the present regulations on the use of TBT-based anti-fouling paints in Resolution MEPC 46(30).

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