11 Northeast Atlantic blue whiting

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Life-history traits

Northeast Atlantic blue whiting (*Micromesistius poutassou*) individuals 10 years old or older are currently rare, although ages in excess of 20 years have been reported. Most blue whiting are believed to mature at 2–4 years of age, although the maturity ogive used by the Working Group on Widely Distributed Stocks (WGWIDE and, until 2007, its predecessor the Working Group on Northern Pelagic and Blue Whiting Fisheries, WGNPBW) assumes that maturation of a cohort is not complete before the age of 7 years (ICES, 2009e). The blue whiting is a batch spawner. Growth is very fast during the first year (up to 18–20 cm), but decelerates rapidly thereafter (more so in males than in females). Most fish are less than 32 cm in length, with the reported maximum length of ca. 50 cm.

Wintering

Overwintering juveniles can probably be found throughout the species' range. Adults migrate towards the spawning grounds during winter.

Spawning

Time. Spawning occurs mainly during February–April, with a seasonal northward progression.

Habitat. Blue whiting spawn in open water over great depths (>1000 m) or close to and on the shelf edge (Figure 11.1). Hátún *et al*. (2009a) demonstrated that the North Atlantic Subpolar Gyre influences spawning distribution, with a strong gyre (associated with cooler and fresher conditions west of the British Isles) resulting in a more southerly and easterly distribution than with a weak gyre.

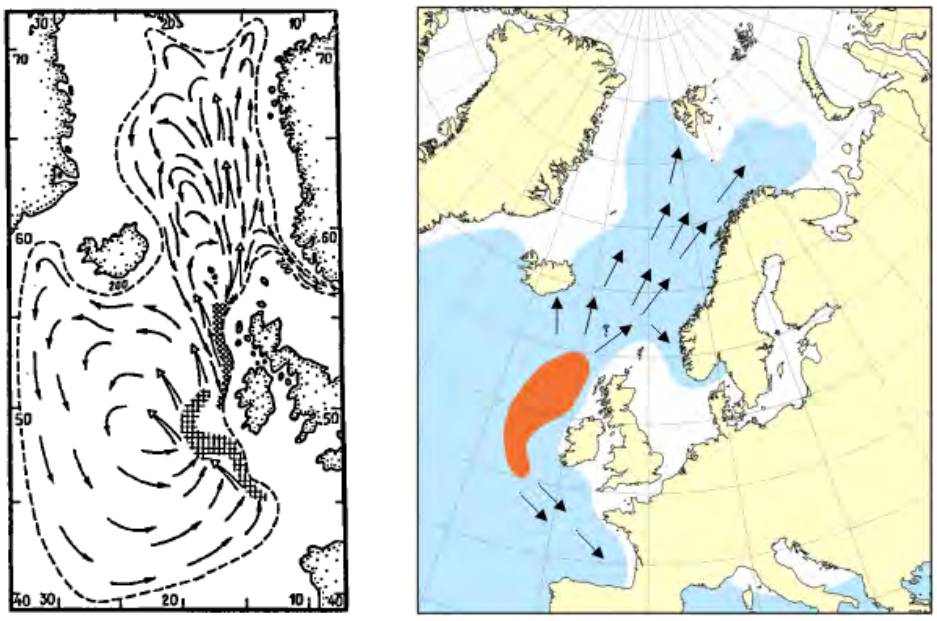

Figure 11.1. Migration of blue whiting. Left: the migration pattern of adult blue whiting, as suggested by Isaev *et al*. (1992). The hatched area shows the main spawning grounds. The current understanding does not fully support the pattern suggested for the component spawning around Porcupine Bank by not accounting for the Bay of Biscay component. The migrations in the west are also virtually unknown. Right: the current understanding of drift patterns of blue whiting larvae.

Schooling behaviour. Dense spawning aggregations are formed during the spawning season, typically at 300–600 m depth. Diurnal movements are small. Sexual dimorphism in the pelvic fin (Andersen and Jákupsstova, 1978) suggests that mating pairs are formed during spawning.

Co-occurring species. During spawning include mesopelagic fish such as hatchetfish (*Sternoptyx* spp.), lanternfish (Myctophidae), and, in recent years, dealfish (*Trachipterus arcticus*).

Feeding

Time. Late spring and summer is the main feeding period for blue whiting, but some feeding may occur throughout the year. Very little feeding occurs during the February–April spawning season.

Habitat. Traditionally, the Norwegian Sea has been considered to be the main feeding area; other areas include south of Iceland and along the continental shelf edge from the Bay of Biscay to the Barents Sea.

Predation mode. Blue whiting is a snapping feeder.

Prey species. Crustaceans (large copepods, amphipods, krill), small cephalopods, small fish, and fish larvae (Bailey, 1982; Monstad, 2004; Prokopchuk and Sentyabov, 2006; Dolgov *et al*., 2010).

Schooling behaviour. Blue whiting form loose layers or schools that demonstrate diurnal migrations. Juveniles can be found in surface waters at night.

Co-occurring species. Saithe (*Pollachius virens*), redfish (*Sebastes* spp.), and various mesopelagic fish below 200 m; herring (*Clupea harengus*) and mackerel (*Scomber scombrus*) above 200 m; and demersal fish on the shelf areas.

Migrations

Mature blue whiting migrate to the spawning grounds west of the British Isles during winter (Figure 11.1). In spring to early summer, the post-spawning migration brings the adults back to the feedings areas. However, Hátún *et al*. (2009b) have demonstrated that during the post-spawning migration, more blue whiting migrate west of the Faroe Islands when the Subpolar Gyre is weak. Exact migration patterns, along with stock structure, are not well known.

Larval drift and nursery areas

Hatched larvae drift northward towards the Norwegian Sea and Iceland, or southward towards the Bay of Biscay (Figure 11.1; Bailey, 1982). The direction of drift depends on the spawning area. Hydrographic modelling suggests that the line separating northern and southern drift varies from year to year, but is usually at the northern part of Porcupine Bank (Skogen *et al*., 1999). Larval otolith-growth histories also support the hypothesis that larvae originating in a specific spawning area tend to drift together to the same nursery area (Brophy and King, 2007). By February in the year after spawning, blue whiting probably originating in the main spawning area are found in surveys in the Barents Sea (Figure 11.2; Heino *et al*., 2008). A proportion of the northward-drifting larvae enter the North Sea, and 0-group blue whiting are caught there by the third quarter of the spawning year (Figures 11.3 and 11.4). The main nursery areas are in the Norwegian Sea, south of Iceland, southwest Barents Sea, and the Bay of Biscay. The deeper parts of shelf areas around the Faroe Islands, the British Isles, and the North Sea also function as nursery areas.

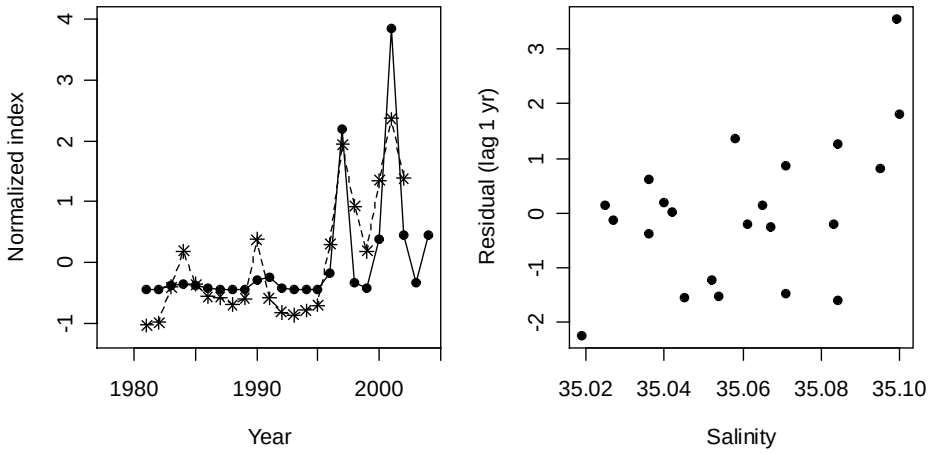

Figure 11.2. Left: abundance index of 1-group blue whiting, based on the Barents Sea winter survey conducted by IMR (Norway; unbroken line), and recruitment in the main Atlantic blue whiting stock (dashed line; ICES, 2004b). Right: Residuals from the log (abundance index)~log (recruitment) regression are positively correlated with salinity in the Fugløya–Bear Island section ($r = 0.49$). High salinity on this section is presumed to indicate a large inflow of Atlantic water into the Barents Sea, which should facilitate the entry of young blue whiting into the survey area. See also Heino *et al.* (2008).

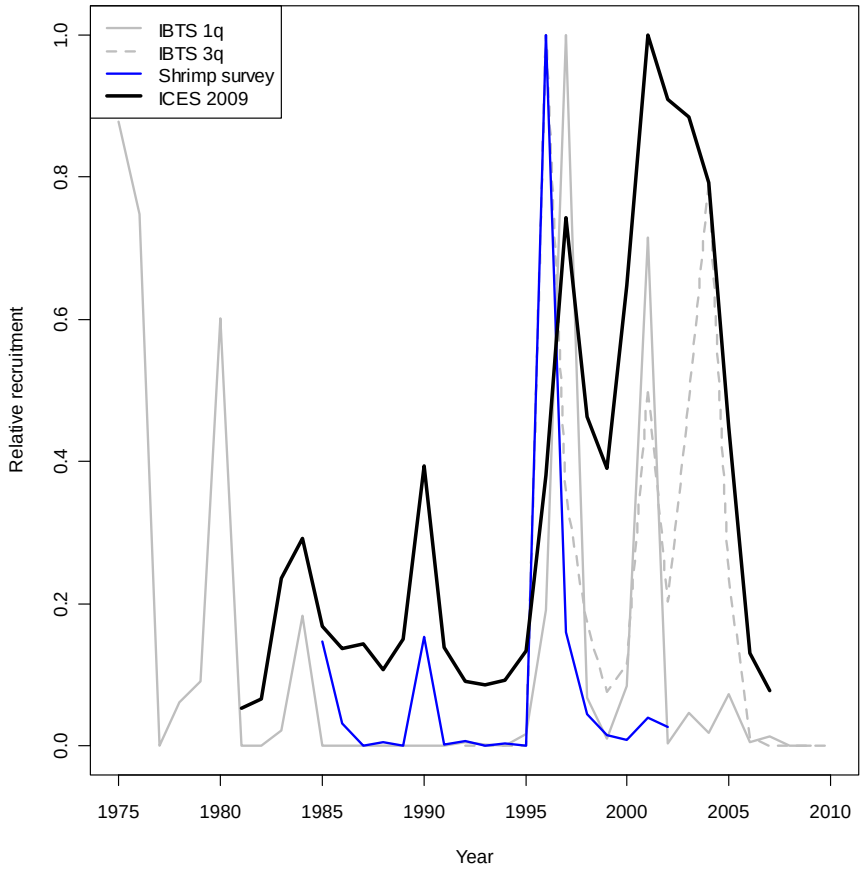

Figure 11.3. Relative recruitment indices of blue whiting in North Sea surveys compared with recruitment in the latest stock assessment (ICES, 2009e). The International Bottom Trawl Survey (IBTS) during the third quarter (1991–2009) and Norwegian shrimp survey in the fourth quarter (1984–2002) caught 0-group blue whiting; these time-series have been shifted forward by 1 year to match recruitment (age 1) in the assessment (1981–2007) and the first quarter IBTS (1975–2009). All time-series have been scaled to a maximum of 1. Strong recruitment events have been captured by at least one of the surveys, but there are large differences in how single surveys have captured recruitment signals in the main Atlantic stock. This suggests that environmental conditions are important for determining numbers of recruits entering the North Sea and how they are subsequently distributed.

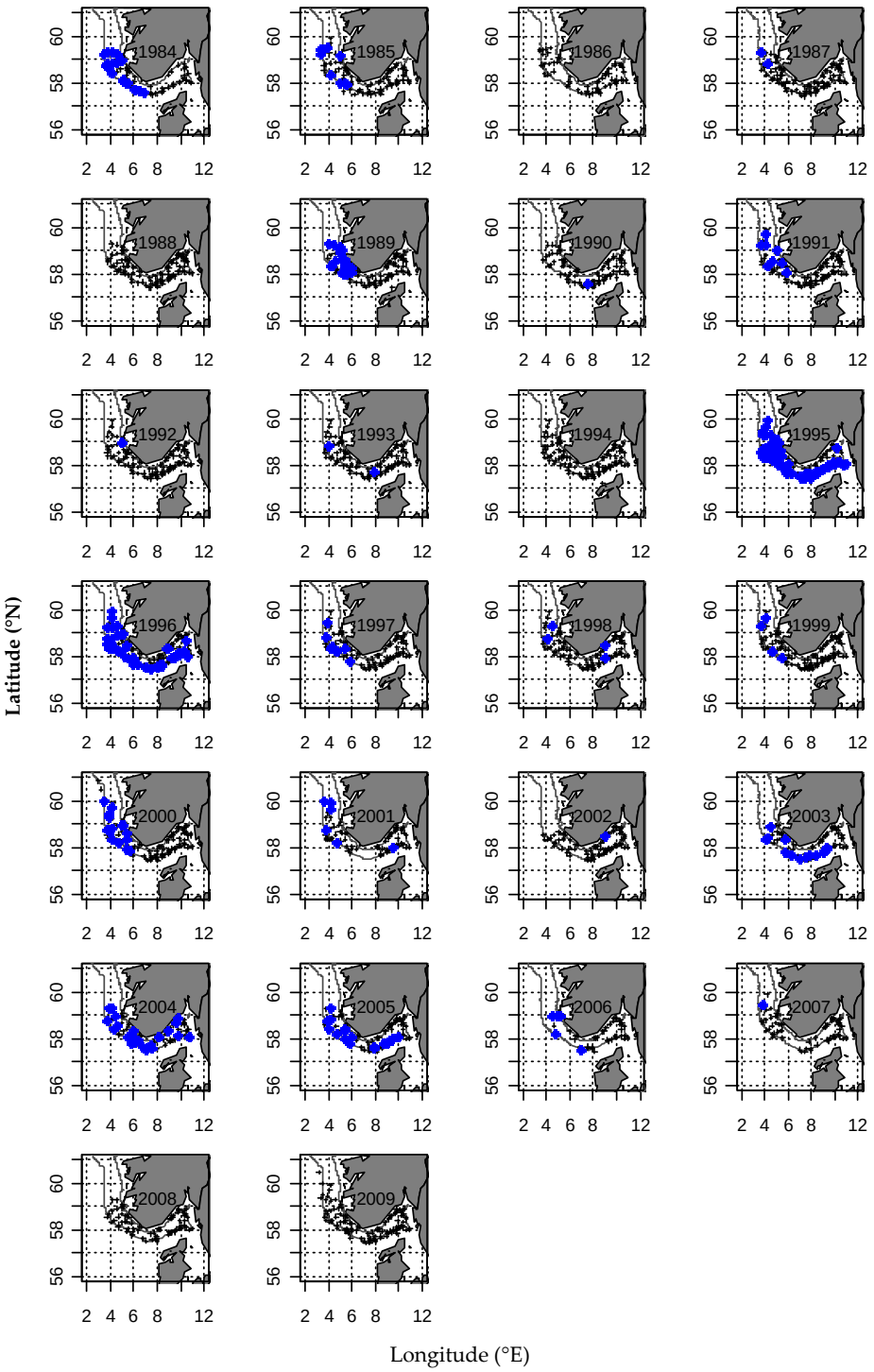

Figure 11.4. Distribution of trawl stations (crosses) and stations with likely 0-group blue whiting (blue dots) in the North Sea shrimp survey conducted by IMR (Norway). The 0-group blue whiting tend to occur in the western parts of the survey area and also, in some years, in the southern slopes of deep waters in the Skagerrak. Since 2002, the survey gear and timing of the survey have undergone changes.

Long-term trends

Stock size. Little is known about stock size prior to 1981, the first year in the current ICES assessment time-series. The stock was relatively stable until the late 1990s, after which it increased owing to a period of strong recruitment. Figures for the latest years in the

assessment are uncertain, but suggest that the stock is in decline from the historical high reached around 2003.

Recruitment. During the period 1996–2005, recruitment (age 1, corresponding to the 1995–2004 year classes) was considerably higher than previously observed. What were "weak" year classes during this period would have been considered "strong" before 1995. In 2007–2009, recruitment appeared weak by any standard. No stock-wide recruitment estimates exist prior to 1981, but data from the International Bottom Trawl Survey (first quarter) in the North Sea indicate that there was a period of strong recruitment in the 1970s (Figure 11.3). Drivers of changes in recruitment are poorly known (an ICES Workshop on Blue Whiting Recruitment held 10–12 November 2009 focussed on this topic; see ICES, 2009f).

Body size and growth. At the level of the whole stock, there are indications of declining weights-at-age (ICES, 2008b). Interpretation of this trend is complicated by the aggregated nature of the data and potential biases in age readings.

Present characteristics

The stock is still relatively large because of the period of strong recruitment that ended just a few years ago. With declining recruitment, the numbers of young blue whiting are declining, and the average age of blue whiting is increasing.

Potential environmental influences

Hydrographic conditions during the spawning season affect the relative amounts of eggs and larvae drifting to northern and southern nursery areas. A particular spawning area may seed northern areas in one year and southern areas in another (Skogen *et al*., 1999).

The large inflow of warm Atlantic water into the Barents Sea (as indicated by a positive salinity anomaly on the Fugløya–Bear Island section) has a positive effect on the abundance of blue whiting in the Barents Sea one year later (Heino *et al*., 2008; Figure 11.2).

The strength of year classes, as 0- or 1-group, in the North Sea is linked only to the strength of year classes in the main Atlantic stock. High abundance in the North Sea tends to coincide with strong year classes in the main stock. However, some strong year classes do not show up strongly in the North Sea. The success of surveys in different parts of the North Sea and at different times of the year in catching recruits is highly variable (Figures 11.3 and 11.4). This suggests environmentally driven variation in the transport of larvae into the North Sea as well as their subsequent distribution.

The North Atlantic Subpolar Gyre influences spawning distribution (Hátún *et al*., 2009a), and its strength is correlated with landings (Hátún *et al*., 2009b).

The North Atlantic Subpolar Gyre is probably also influencing recruitment. The strength of the gyre started to decline (the gyre index started to increase) at the same time as recruitment increased (Hátún *et al*., 2009a, 2009b). As this change is associated with an increased inflow of Atlantic water into the Norwegian Sea through the Faroe–Shetland Channel, a main dispersal route of eggs and larvae to the Norwegian Sea, it is likely that these changes are causally linked. However, the mechanism is not trivial, because earlier periods of high gyre index did not witness greatly enhanced recruitment, nor is the recent decline in recruitment explained by this link.

There is evidence to suggest density-dependent juvenile growth in the Norwegian Sea, indicating that growth of young blue whiting can be food-limited (Figure 11.5).

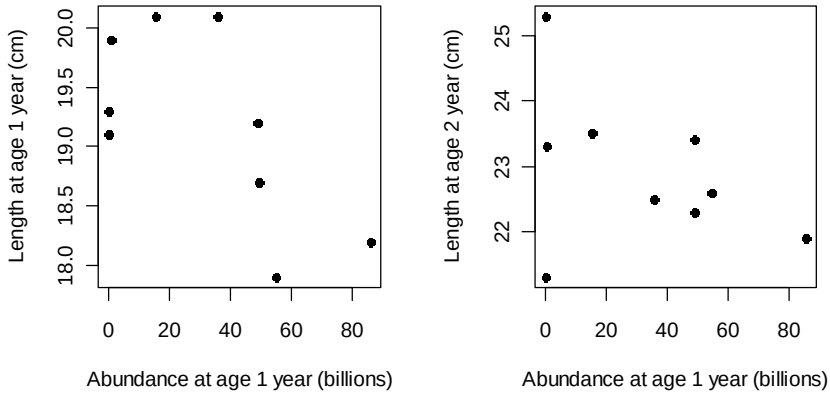

Figure 11.5. Relationship between abundance (2000–2008) and length-at-age in the International Pelagic Ecosystem Survey in the Norwegian Sea, May 2000–2009. Left: For age 1, the relationship is for the observations in the same year. Right: for age 2 years, length-at-age is plotted against a cohort's abundance in the previous year. There is a negative relationship that is approaching statistical significance ($p = 0.057$) at age 1 year; there is no clear relationship at age 2 years ($p = 0.29$).