Fish kills in coastal waters

Normally two types of events related to eutrophication can cause fish kills. It is either toxic algae or low oxygen concentrations. Low oxygen concentrations in the bottom waters result in the release of hydrogen sulphide (H_2S) from the sediments. The H_2S is lethal to most animals and the result of the sudden release is often extensive and leads to the immediate death of animals living at or near the sea floor as well as in the water column. This immediate effect, therefore, also includes fish. **However, the most spectacular fish kills with dead or dying fish accumulating on the shores, as an example in 1981 and 2002, are due to upwelling of oxygen poor or H_2S containing bottom water to the surface along the coasts due to changing wind directions and forces, trapping the fish in these water masses with no chance to escape.**

The Danish EPA published the first comprehensive national assessment of the effects of oxygen depletion and harmful algal blooms in 1984 (Danish EPA 1984) This report assessed fish kills in the Danish waters and concluded that fish kills were restricted, and were exceptional, but natural events, before the 1970s, and that the problem increased in the 1970s and early 1980s.

The four best known Danish examples of fish kills are from 1981, 1988, 1997 and 2002. In 1981 the kills were caused by severe oxygen depletion in most of the Danish waters (Danish EPA 1984). Fish kills in May and June 1988 were due to a large bloom of the flagellate *Chrysochromulina polylepis* (Lancelot et al. 1989). In 1997, almost all fish were killed in the inner part of Mariager Fjord due to oxygen depletion and release of H_2S in the entire water column. In October 2002 fish kills occurred several places along the Jutland east coast due to upwelling of oxygen poor and H_2S containing bottom water.

The ongoing national monitoring programme does not include fish monitoring. However, fish kills have been reported annually since 1989 as an integral part of the National Aquatic Monitoring and Assessment Program. Table 2.12 summarises the recorded fish kills in Danish marine waters. It might be argued that the situation has not improved since the mid 1980s, mainly because inputs of nutrients are still high, especially in wet years, and that the events of oxygen depletion that might trigger fish kills are tightly coupled to meteorological and hydrographic forcing.

Regional authorities have carried out studies on fish populations and fish kills in Limfjorden, Mariager Fjord, Ringkjøbing Fjord, Roskilde Fjord, the area around Rødsand, the Wadden Sea and Århus Bugt. Studies in Århus Bugt, which covers the period 1953–1998 and includes coherent data on fish, fisheries, zoobenthos and water quality, are summarised by Jensen (1999):

- The occurrence and composition of fish have changed significantly during the last 50 years, due to changes in fishing intensity and duration of oxygen depletion.
- Fishing intensity has had an impact on plaice (*Pleuronectes platessa*), which has decreased from the 1950s to the 1990s.
- Conversely, the dab (*Limanda limanda*) has become more frequent and is now the dominating flat fish in the bay.
- The mean length of dab has decreased since 1957 and is unambiguously linked to the duration of oxygen depletion. The growth is limited in years with longer

periods of oxygen depletion compared to the situation in the 1950s. Less that 1% of dabs reach the minimum size limit of 25 cm.

Future possibilities to assess the health of coastal fish populations will improve from 2004, when monitoring of non-commercial fish in six representative coastal waters will be conducted on a regular basis within the monitoring and assessment programme.

Table 2.12
Recorded fish kills and their causes in Danish marine waters 1981-2003.
Find the location of places at Map of Danish marine waters.

Year	Place	Cause
1981	Hevring Bugt, Århus Bugt, Pæregård Strand, Dalby Bugt, Båring Vig, Vejle Fjord, Limfjorden, including Thisted Bredning, Visby Bredning, Bjørnsholm Bugt, Risgårde Bredning, Skive Fjord and Lovns Bredning	Oxygen depletion
1981	Fjaltring Strand, Glyngøre Harbour	Harmful algal bloom
1982	North Sea, Køge Bugt, Holckenhavn, Kalø Vig, Isefjord	Oxygen depletion
1983	Lillebælt, Als Sund, Langelandssund	Harmful algal bloom
1987	Sejerø Bugt	Oxygen depletion
1988	North coast of Sjælland, Sejerø Bugt, Ringkøbing Fjord	Oxygen depletion
1988	North Sea, Skagerrak, Kattegat, and the northern part of Øresund	Harmful algal bloom
1989	Ringkøbing Fjord	Oxygen depletion
1990	Århus Bugt	Oxygen depletion
1990	Djurslands Østkyst	Oxygen depletion or harmful algal bloom
1991	Lillebælt	Oxygen depletion
1992	Lillebælt	Oxygen depletion
1994	Årgab, Hovvig, Mariager Fjord, Vejle Fjord, Isefjord, Roskilde Fjord, Thisted Bredning, Skive Fjord, Lovns Bredning	Oxygen depletion
1995	Årgab, Hanstholm	Oxygen depletion
1997	Mariager Fjord, Vejle Fjord, Sydfynske Øhav, Korsør Nor, Isefjord	Oxygen depletion

1998	North Sea and Skagerrak	Harmful algal bloom
1999	Vejle Fjord	Oxygen depletion
2000	Kattegat, Smålandsfarvandet, Ebeltoft Vig, Sydfynske Øhav	Oxygen depletion
2001	Vejle Fjord	Oxygen depletion
2002	Ålborg Bugt, Hevring Bugt, Vejle Fjord, Kalø Vig, Øresund, Sydfynske Øhav	Oxygen depletion