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# Minimal temperatures in the northern Adriatic west coast during the winter of 2001/2002 and effects on the sea fauna

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*During the months of January and February 2002, particularly low temperatures were registered by several observers in the northern Adriatic. There was significant isothermy in the water column, together with cold air temperatures, frost, and persistent winds from the north. In these climatic conditions, widespread mortality of organisms of various zoological classes was noted, both in transitional waters (lagoons and "valli") and in the coastal waters of the northern and central Adriatic.*

**Key words:** sea fauna, minimal water temperature, Adriatic Sea

## INTRODUCTION

Global climate changes are widely documented phenomena. During the past decade, general warming of the water in the Adriatic Sea has been observed and effects on marine fauna have been reported (DULČIĆ *et al.*, 1999). An example is the occurrence of the clupeiform, *Sardinella aurita*, a thermophile species typical of the central and southern Mediterranean Sea which, like other species, expanded into more northern waters (KAČIĆ, 1984) within the last twenty years. Changes in the hydrographic properties of the Adriatic Sea can influence the ecology of common species such as *Sardina pilchardus* (TIČINA *et al.*, 2000).

Low temperatures, such as those recorded in the winter of 2001/2002, can have strong repercussions on marine organisms by increasing mortality and affecting reproduction cycles (VATOVA, 1934). This paper presents information obtained from various sources on the effects of the low temperatures in winter 2001/2002 on marine fauna in the Adriatic Sea.

## MATERIAL AND METHODS

Between December 2001 and February 2002, vertical profiles of water temperature were recorded in six stations. Four stations were located about 10 km off the coast between Bagni di Volano (Ferrara) and Cesenatico

(Forlì-Cesena), the fifth station was situated about 5 km from the mouth of the Adige River (Venice), and a sixth station was 10 km off the coast of Porto Caleri (Rovigo; Fig. 1).

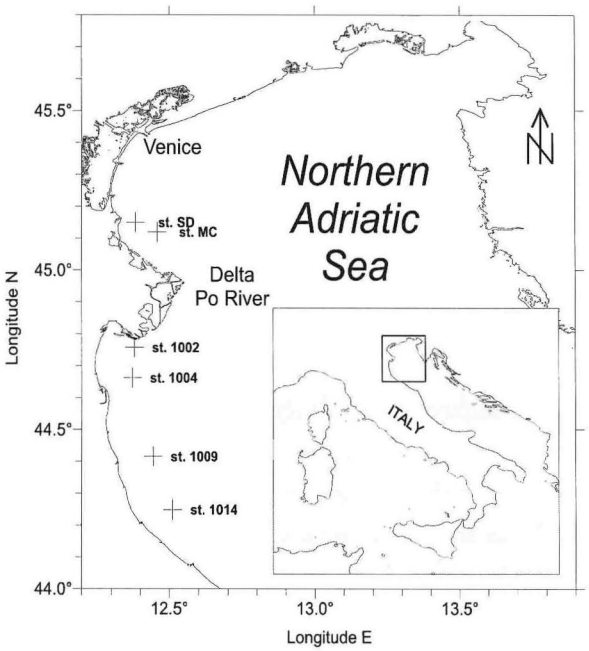


*Fig. 1. Monitored sites locations*

Data were collected using two CTD multiprobes: an SBE 25 CTD with an SBE 3 temperature sensor (Sea-Bird Electronics, Inc., Bellevue, WA, USA) and an Ocean Seven 316 CTD (Idronaut S.r.l., Brugherio, MI, Italy). At station MC, temperature data were also recorded by a moored multiprobe RCM 9, equipped with a temperature sensor (model 3621, AANDERAA Instruments, Bergen, Norway) and situated at -23 m (1.5 m above the seabed).

## RESULTS AND DISCUSSION

In the second half of November 2001, temperatures were significantly lower than in the same month during 2000. Off the Emilia-Romagna coast, the differences in temperature between autumn-winter 2000/2001 and autumn-winter 2001/2002 were 10°C in December, 7°C in January and 4°C in February (Fig. 2). In the two northernmost stations, the values for January and February 2002 were 3°C and 2°C lower, respectively, than the lowest temperature registered for 2001, which was 10°C throughout the water column in March.

This phenomenon affected the entire northern basin. A comparison with data from previous years ("Daphne" monitoring by ARPA Emilia-Romagna, the European Union INTERREG program, and the MAT project of the Italian Ministry for the Environment - ICRAM) suggests that there was considerable heating of the basin's waters during the whole of 2000, followed by a mild cooling during the first winter months of 2001. A sudden, significant cooling occurred in the autumn and winter of

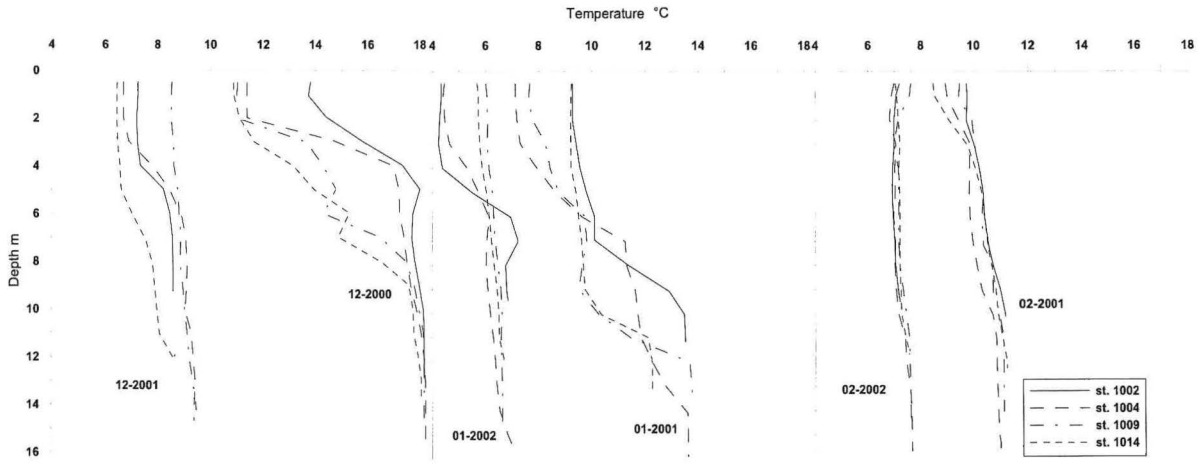


*Fig. 2. Temperature graphs for the 4 stations 10 km off the coast of Emilia-Romagna*

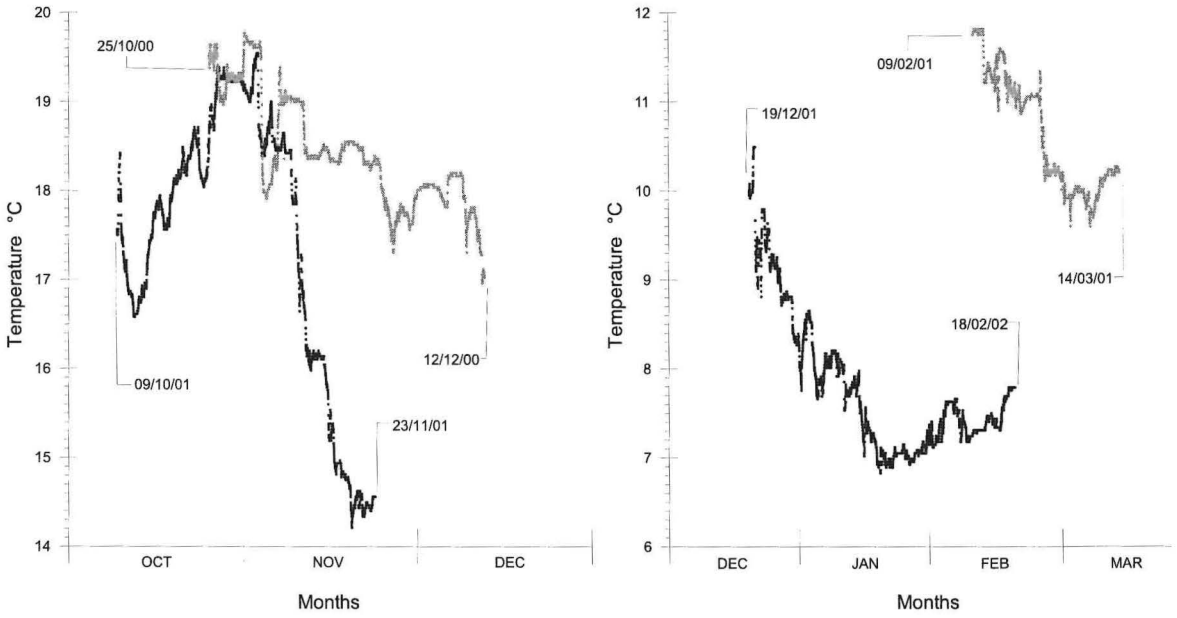


*Fig. 3. Changes in water temperature near the sea-bed (-23 m) at the station MC off Porto Caleri*

2001/2002, that was also registered near the seabed at station SD (Fig. 3).

During this rapid and intense cooling in January and February 2002, the mortality of marine organisms was observed. In the "valli" of the lagoons of Grado and Marano (Udine), more than 80% of the farmed fish died, including an estimated 220 tons of sea bass, 246 tons of gilthead sea bream, 1200 kg of grey mullet, and thousands of fry, as reported by trade associations to the Ministry for Agricultural and Forestry Policies.

In the early months of 2002, national fishing associations reported to relevant ministries regarding mortality of bivalve molluscs (*Pecten jacobeus* and *Aequipecten operculari*), sardines (*S. pilchardus*), anchovies (*Engraulis encrasicolus*) and crustaceans (*Penaeus kerathurus*) 5 to 16 nautical miles from the coast in the maritime sector ("compartimento") of Venice, estimating a 59% reduction in total catch compared to January 2001. In the Chioggia maritime sector, high mortality rates for *P. kerathurus*, *Solea* spp. and *Conger conger* were also noted.

In the second half of January 2002, a pair of mid-water pelagic trawlers from Chioggia caught several tons of adult sea bass (*Dicentrarchus labrax*; 1-10 kg per fish) in a few trawls effected close to the harbor mouth. This unusual catch, never before witnessed in living memory in Chioggia, may be attributed not only to reproduction but also to a behavioral reaction to the exceptional cold of the coastal waters and the Venetian lagoon which had been covered by ice for some time. At that time, veterinary researchers from the University of Bari noted that the cause of death of some *S. aurita*, *S. pilchardus* and *Diplodus sargus sargus* (caught on 7 Jan. 2002 at Capitolo, Bari, southern Adriatic) could be attributed to exposure to critically low water temperatures or sudden changes in temperature.

A high mortality rate for *S. aurita* was observed during the same period off the Croatian coasts of the central basin, especially in Kaštela Bay, where in some areas the surface of the sea was covered with ice (TIčINA, pers. comm.). *S. aurita* appears to have been one of the most hard-hit species. Encouraged by the particularly mild temperatures of winter 2000/2001, schools of *S. aurita* may well have pushed further north than their normal distribution and remained there longer, only to be decimated by the rapid drop in temperature at the

end of autumn 2001. The significant presence of this small pelagic species throughout the northern Adriatic during this period was confirmed by the initial results of an echo-survey undertaken in November 2001 as part of the ADRIAMED program (TIČINA, pers. comm.). *S. aurita* is not usually sold in the Adriatic area, but fishermen were unable to sell catches of other sardines that had come into contact with rotting animals in the trawl net and absorbed the offensive smell.

VATOVA (1929, 1934) described a great cooling in the northern Adriatic waters in the winter of 1928/1929 and the subsequent high mortality of marine organisms. The thermal anomaly occurred in February and March 1929, with minimum temperatures in the water column ranging from 5.9 to 6.2°C (measured approximately 2 km from the Croatian coast). VATOVA observed exceptional mortality of cuttlefish (*Sepia officinalis*) throughout the central and northern basins of the Adriatic and exceptional catches of suffering common dentex (*Dentex dentex*), conger eels (*C. conger*), grey mullet (*Mugil* spp.), sea bass (*D. labrax*), gilthead sea bream (*Sparus aurata*), turbot (*Bothus maximus*), common pandora (*Pagellus erythrinus*), black sea bream (*Spondyliosoma cantharus*) and salema (*Boops salpa*). He also noted the almost total disappearance of fish in the Comacchio "valli" (Ferrara). The widespread, massive mortality of the cuttlefish in 1929 was probably linked to the reproductive period of the species. In these coastal areas, cuttlefish usually reproduce in spring which, in that year, partly overlapped the minimal temperatures, affecting the later April-May 1929 catch. Commercial catches of horse mackerel (*Trachurus trachurus*), sea bass (*D. labrax*), mantis shrimp (*Squilla mantis*) and spider crab (*Maja squinado*) were smaller in the following years as well.

Compared to 2001, sales data from the Chioggia wholesale fish market revealed that catches of some crustaceans, such as *P. kerathurus* and *M. squinado,* increased in January and February 2002, whilst in the following months and until fishing halted in August, they decreased. On the other hand, catches of *S. mantis, S. officinalis, C. conger* and *T. trachurus* were smaller in the early months of the year. In January, *S. aurita* accounted for 11 tons, whilst in preceding and subsequent months, there was very little trading of this species.

## CONCLUSIONS

At present, little information is available to enable quantification of the effects of the water temperature drop in winter 2001/2002.

From observations and sales data, it cannot be proven that the event negatively affected the reproduction of commercial species, unlike in the case described by VATOVA. It is probable, however, that the cold temperatures affected the catchability and/or vulnerability of some of these species. The cold may have increased these factors as in the case of *M. squinado* and *P. kerathurus*, or decreased them as in the case of *S. mantis* (which may have lengthened its stay within its burrow in response to the temperature drop).

There was a difference in timing of the minimal temperatures for 1929 and for 2002. In 1929, the coldest period occurred in March, whereas in 2002 it occurred in January and the beginning of February. This difference is significant and might have affected the species which suffered high mortality in different ways in 1929 and 2002.

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# Minimalne temperature na zapadnoj obali sjevernog Jadrana tijekom zime 2001 - 2002 i njihov utjecaj na morsku faunu

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## SAŽETAK

Tijekom siječnja i veljače 2002. godine nekoliko znanstvenika registriralo je vrlo niske temperature u sjevernom Jadranu u uvjetima značajne homotermije vodenog stupca, zajedno s klimatskim uvjetima tog perioda: niskim temperaturama zraka, mrazom i neprestanim sjevernim vjetrovima. U takvim uvjetima uočen je mortalitet različitih zooloških razreda i to kako u tranzicijskim vodama (lagune i zaljevi), tako i u priobalnim vodama sjevernog i srednjeg Jadrana.

**Ključne riječi:** fauna mora, minimalne temperature mora, Jadransko more