

Information on the Adriatic ichthyofauna - effect of water warming?*

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Observations on the Adriatic ichthyofauna over the last 25 years (1973-1998) are reported. During this time, changes in the quantitative and qualitative composition of the fish fauna have been noted. The number of thermophilic species has increased. Several species, scarce or rare until now, are more abundant, while others are new records. There are also some examples of the disappearance or increasing scarcity of some species. These observations could be related to oceanographic changes in the Adriatic Sea.

Key words: ichthyofauna, climate changes, Adriatic Sea

INTRODUCTION

There seem to be a number of areas in the land-ocean-atmosphere system at which regional climate changes reflect global scale changes. Due to its specific oceanographic conditions, the Mediterranean Sea can be of a global importance. Most of the Mediterranean outflow is composed of LIW (Levantine Intermediate Water) that is formed in the eastern Mediterranean. The most important characteristic of this water is its high salinity, which is one of the highest among the world oceans (>39 psu) (LACOMBE *et al.*, 1954; WÜST, 1961; TZIPERMAN and MALANOTTE-RIZZOLI, 1991). One part of this warm and salty water can be found in the intermediate layer of the Adriatic Sea, and can be recognised as MLIW (modified LIW) water type (ZORE-ARMANDA, 1963; see ORLIĆ *et al.*, 1992). Increase of

temperature and salinity of this water type can be explained with horizontal advection of saltier and warmer Mediterranean water (ZORE-ARMANDA, 1972; GRBEC *et al.*, 1998). As a consequence of distribution of large pressure centre over the wider Mediterranean region, the horizontal air pressure varies between the northern and the southern Adriatic influencing the intensity of water exchange between the Adriatic and the eastern Mediterranean. So, hydroclimate fluctuations in the Adriatic Sea are consequences of climate fluctuations over the area larger than Adriatic itself. Because the incoming Mediterranean water carries nutrient rich water affecting primary and secondary production, climate change could play an important role in the Adriatic ecosystems. Many fish species may move toward higher latitudes, as the sea becomes warmer. Year-to-year changes in SST (Sea Surface Temperature) closely rela-

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ted to climate fluctuations may be responsible for these longitudinal range extensions.

Changes in ichthyofauna have been associated with oceanographic changes in various studies (MEARNS, 1988; CUSHING, 1990; FRANCOUR *et al.*, 1994).

This paper attempts to discuss which observed changes in ichthyological fauna might be linked to year-to-year hydrodynamic fluctuations, especially throughout sea surface temperature changes.

MATERIAL AND METHODS

In this paper we presented ichthyological data collected on cruises organised by the Institute of Oceanography and Fisheries, Split and by caught of professional fisherman. We have only considered those fish species having well-established preferences in terms of temperature. Data were obtained from the northern, middle and southern Adriatic where scientific observation has been continuous over several decades (more than 100 years), in order to minimize the bias resulting from sampling irregularity.

Sea surface temperature fluctuations for the eastern Adriatic coast are presented as mean monthly filtered values (24m214 low pass filter; THOMPSON, 1983) for the available periods for three stations along the eastern Adriatic coast: stations Trieste (northern Adriatic, 1930-1990), Split (Middle Adriatic, 1950-1996), and Dubrovnik (southern Adriatic, 1960-1985). Non-linear trend analysis was performed on the mean monthly filtered values using a negative exponentially weighted smoothing function.

RESULTS AND DISCUSSION

There was considerable year-to-year variability in all three time-series of SST (Fig. 1) but with some simultaneous similarities between them. Based on the long-term mean for the 1961-1990 period (mean of 17.16°C for the Middle Adriatic - Fig. 2), the 1985-1987 SST anomalies were about +0.15°C and the 1990-1995 SST anomalies +0.30°C. In these two periods the most of new occurrences of ichthyological species were recorded.

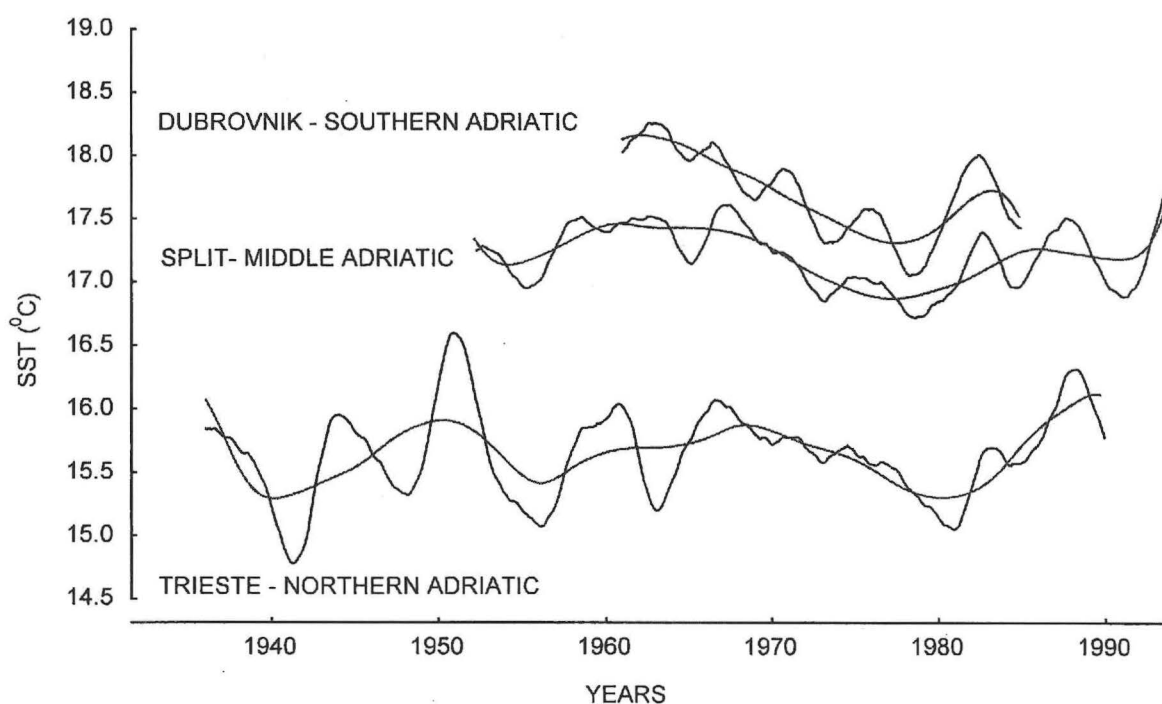


Fig.1. Filtered mean monthly sea surface temperature (24M214 low-pass filter) for stations along the eastern Adriatic coast smoothed with a negative exponentially-weighted function

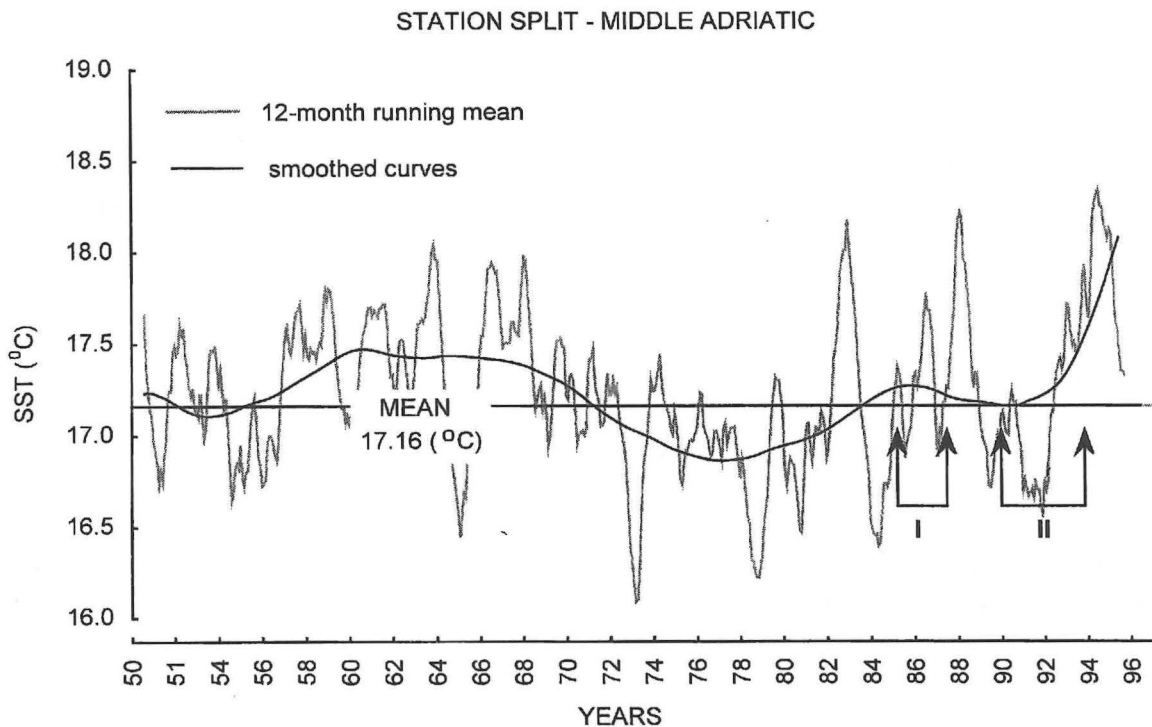


Fig.2. Inter-annual variability of sea surface temperature (12-month running mean) for the middle Adriatic smoothed with a negative exponentially-weighted function. Straight line indicates mean value for the period 1961-1990 (I - Period 1985-1987; II - Period 1990-1995)

Changes in the Adriatic ichthyofauna

Within the framework of the ichthyological observations carried out in the last twenty-five years, some changes in the Adriatic ichthyofauna have been observed. The number of thermophilic species captured over recent years is increasing. Several species, fairly rare or very rare until now, are more abundant, while others are new to the zone. There are also some cases of the disappearance or rarefaction of species.

Scomber scombrus LINNAEUS, 1758

Atlantic mackerel, *Scomber scombrus*, was more or less caught throughout the Adriatic, particularly in its northern part. Disappeared about the seventies of this century. It occurred again in 1993 but in poor quantities. Now it is absent once again. Known by its long-term oscillations at 10-15 years scale. For the time being, absent for 25 years.

Tylosurus acus imperialis (RAFINESQUE, 1810)

The agujon needlefish, *Tylosurus acus*, is a circumtropical polytypic species, which is divided into five geographical subspecies; the Mediterranean Sea is inhabited by *Tylosurus acus imperialis*. Two male and one female specimens of the agujon needlefish, *Tylosurus acus imperialis*, were collected off the southwestern Adriatic coast (males in May 1994, female in July 1995). This finding extends the distribution of the species to the Adriatic Sea (BELLO, 1995). It is not on the list of Adriatic species presented by JARDAS (1996).

Plectorhinchus mediterraneus (GUICHENOT, 1859)

Rubber-lip grunt, *Plectorhinchus mediterraneus*, is widespread in the eastern Atlantic from Portugal south to Angola, and in the

Mediterranean basin it occurs off the North Africa coast as far as Tunisia (BEN-TUVIA and McKAY, 1986). The first specimen (373 mm in total length) of this species was caught on August 1993 by a diver in the Gulf of Trieste - Diga Rizzo. On 24 December 1993, a second specimen of rubber-lip grunt (346 mm in total length) was captured in a fish trap set in the middle of the Piran Bay opposite the River Dragonja estuary - northern Adriatic (LIPEJ *et al.*, 1996; DULČIĆ and LIPEJ, 1997). No haemulids have been recorded previously from the Adriatic. It is not on the list of Adriatic species presented by JARDAS (1996).

Sphoeroides pachygaster
(MÜLLER and TROSCHER, 1848)

Sphoeroides pachygaster is a widely distributed species. It has, so far, been recorded from tropical and subtropical Atlantic, including the Mediterranean, near Japan, Hawaii and Australia (TORTONESE, 1986). Its northernmost distribution in the Atlantic is somewhere about 45° N, which is in agreement with its northernmost records: near Azores (CONCALVES, 1941), Portugal (CALVARIO *et al.*, 1980) and finally in the Gulf of Biscay (QUERO *et al.*, 1991). In 1992 nine specimens of *S. pachygaster* were caught by fishermen from three fishing grounds far apart from one another in the eastern half of the Adriatic: a) fishing ground about 3 n.m. north-westward from the Sušac Island towards the Vis Island, b) the triangle between the Mljet Island, Korčula Island and Islet Glavat and c) fishing zone around the Islet Blitvenica (JARDAS and PALLAORO, 1996). These records added to the Adriatic ichthyofauna not only a new species but also a new genus and a new family.

Epinephelus aeneus
(GEOFFROY ST. -HILARE, 1817)

Present in all the meridional area of the Mediterranean, it had never been found in the Adriatic Sea before. There are some indications that *Epinephelus aeneus* was recorded in the

South Adriatic (GLAMUZINA and SKARAMUCA, personal communication).

***Apterichthys anguiformis* (PETERS, 1877);**
***Opichthys rufus* (RAFINESQUE, 1810);**
***Notacanthus bonapartei* RISSO, 1840;**
***Scorpaena elongata* CADENAT, 1943;**
***Scorpaena loppei* CADENAT, 1943;**
***Lepidotrigla dieuzeidi* AUDOIN, 1973**

All mentioned species were caught between 1985 and 1987 in the South Adriatic along the coast of Puglia (BELLO and RIZZI, 1988). These records added to the Adriatic ichthyofauna a new species.

***Epinephelus marginatus* (LOWE, 1834)**

Its distribution is in the eastern Atlantic northward to the British Isles (very rare), and around the Azore, Madeira and the Canaries, also the Mediterranean. Elsewhere, the eastern Atlantic southward to around South Africa; the western Atlantic from the Bermudas and the Guianas to Brazil (TORTONESE, 1986). It is common in the middle and especially in the southern Adriatic (JARDAS, 1996). Several specimens of dusky grouper were caught by fishermen in the Slovenian coastal waters and those are the first records of this species for the northern Adriatic (DULČIĆ and LIPEJ, 1997).

***Trachinotus ovatus* (LINNAEUS, 1758)**

Pompano, *Trachinotus ovatus*, occurs in the eastern Atlantic northward to Gulf of Biscay and in the Mediterranean. It is also common along African coast, including offshore islands, to southern Angola (SMITH-VANIZ, 1986). It is rare in the Adriatic Sea and it mostly occurs in the southern Adriatic (JARDAS, 1996). Its fingerling was caught for the first time in vicinity of small island settlement Bol and sandy beach Zlatni rat, Island Brač - eastern middle Adriatic in December 1994 (DULČIĆ *et al.*, 1997).

***Synodus saurus* (LINNAEUS, 1758)**

It is very rare in the Adriatic Sea (JARDAS, 1996). It was recorded several times in the period 1986-1987: in December 1986 near Bol - Island Brač, in August 1987 at the Island Lastovo, in September 1987 near settlements Bol and Milna - Island Brač and in October 1987 at the Kornati archipelago - eastern middle Adriatic (PALLAORO, 1988). Atlantic lizard fish were found in commercial quantities in the Adriatic all summer round in 1993-1994 (KAČIĆ, personal communication). It is also recorded for the first time in the northern Adriatic in 1998 (BETTOSO, personal communication).

***Sardinella aurita*
VALENCIENNES, 1847**

Young round sardinella, *Sardinella aurita*, occurred in commercial quantities together with sardine and anchovy in the middle Adriatic in spring and early summer 1974 (KAČIĆ, 1976). Round sardinella is not an unknown species of pelagic fish in the Adriatic. From time to time it was found some adult specimen of this fish in catches of sardine *Sardina pilchardus* but it happened rarely. It is normally distributed within 37° North and 34° South (JARDAS, 1996). Now, commercial quantities (in winter, as well) of round sardinella are constantly present throughout the Adriatic between 43° North - 45° North (600 km northward from their earlier range of distribution). KAČIĆ (personal communication) found populations of round sardinella in the northern Adriatic off western coast of Istra Peninsula.

***Ruvettus pretiosus* COCCO, 1829**

The first record of oilfish, *Ruvettus pretiosus*, was in last century in 1875 near the Island Šolta (eastern middle Adriatic) (KOLOMBATOVIĆ, 1882). MOROVIĆ (1960) reported about the second record of this species in the Adriatic near the small village Igrane - little bit southern

from the previous location. The third record (northernmost) was in 1998 in Gulf of Trieste (BETTOSO and DULČIĆ, in press).

***Centracanthus cirrus*
RAFINESQUE, 1810**

The first record of this species was in South Adriatic (496 individuals were caught by deep trawl between 60 and 200 m) (MERKER and NINČIĆ, 1973). PALLAORO (1988) reported about findings in April 1987 near the Island Vis (about 15 kg) and in May 1987 near the town Omiš (middle Adriatic). These records were the first for the middle Adriatic.

***Aulopus filamentosus* (BLOCH, 1792)**

Aulopus filamentosus occurs in the eastern Atlantic from Portugal to Mauritania, including Canaries archipelago and Azores, and in the Mediterranean (not in Black Sea) (BAUCHOT, 1987). In October 1987 one specimen was caught by trawl near Islet Jabuka - eastern middle Adriatic (PALLAORO, 1988). Its first record (and last until now) dated from last century from Boka Kotorska Bay - southern Adriatic (FABER, 1883).

***Pseudocharanx dentex*
(BLOCH et SCHNEDIER, 1801)**

Pseudocharanx dentex occurs in tropical and temperate areas of Pacific and Atlantic Ocean and in the Mediterranean (not in Black Sea) (BAUCHOT, 1987). First records of this species were from KOSIĆ (1889) and KOLOMBATOVIĆ (1904). In July 1987 the third specimen of this species was caught near small village Duba at the entrance of Malostonski Bay - southern Adriatic (PALLAORO, 1988).

***Centrolophus niger* (GMELIN, 1788)**

It is rare in the Adriatic (JARDAS, 1996). In 1986 and 1987 two specimens were caught

near Islet Blitvenica (at 190 m depth) and in Malostonski Bay (at 10 m depth), respectively (PALLAORO, 1988). Significant quantities of this species were recorded in the years 1990 and 1991 (ONOFRI, 1997).

***Lepidopus caudatus* (EUPHRASEN, 1788)**

This species is rare and occurs just in the southern part of the Adriatic Sea (JARDAS, 1996). It is interesting occurrence of this species more northerly in Novigrad Sea in July 1987 (PALLAORO, 1988).

***Trachipterus trachipterus*
(GMELIN, 1789)**

This species is rare in the Adriatic Sea and between 1888 and 1980 only 40 adult individuals were recorded (JARDAS, 1980). DULČIĆ (1996) reported about the first record of ribbon fish larva from the eastern middle Adriatic at the station "Stončica" near the Island Vis. BUS-SANI (1992) recorded this species (114 cm, 2 kg) in the Gulf of Trieste (near Grignano). One specimen of ribbon fish (110 cm) was recorded in Slovenian coastal waters near the Cape Ronek in February 1992 (DULČIĆ and LIPEJ, 1997). It should also be emphasised that the Adriatic in 1992 was characterised by very frequent records of the ribbon fish in the central and northern Adriatic (JARDAS and PALLAORO, 1996).

***Coryphaena hippurus* LINNAEUS, 1758**

In November 1993, a record on the capture of a small specimen of the dolphin fish, *Coryphaena hippurus*, was reported in the local newspaper "Mandrač" from Izola - Slovenia (DULČIĆ and LIPEJ, 1997). Several specimens were also recorded in the Slovenian coastal waters ranging from 70.0 to 125.0 cm in the period from May to September 1996 (DULČIĆ and LIPEJ, 1997). According to COLLETTE (1986) the distribution of this species is in the

Mediterranean and from NW Spain southwards excluding the Adriatic Sea, but JARDAS (1996) reported this species is considerable rare occurring in the southern part of the Adriatic Sea. It is interesting that several records of this species in greater number were reported by fishermen in the middle Adriatic in 1993 and 1994 (islands Brač, Hvar, Šolta, Vis and Kornati Archipelago). Report on this species for the Gulf of Trieste as already documented by GRAEFFE (1906). DULČIĆ (1999) reported about the first occurrence of larval stage of this species in the Adriatic Sea.

***Schedophilus medusophagus*
COCCO, 1839**

Schedophilus medusophagus is a mesopelagic species from temperate waters of the northeastern and northwestern Atlantic and the western Mediterranean (HAEDRICH, 1986). The first record of this fish for the Adriatic Sea was reported in 1880 according to NINNI (1912). The second record was during the invasion of medusae *Pelagia noctiluca* in Pelješac Channel near the town of Korčula - Island Korčula (southern Adriatic) in 1982 (ONOFRI, 1986). Ten juvenile specimens from 10.0 to 20.0 cm in total length were collected with medusae at 2 m depth. Together with *S. medusophagus* some specimens of *Schedophilus ovalis* (VALENCIENNES in CUV. VAL., 1833) were also caught. JARDAS (1996) noted that both species are very rare in the Adriatic Sea. The capture of two cornich blackfish *S. medusophagus* larvae from the Adriatic Sea (station "Stončica") represents an easterly extension in range of this species, and the first larval record in Adriatic waters (DULČIĆ, 1998).

***Naucrates ductor* (LINNAEUS, 1758)**

It should be emphasised that the Adriatic in 1992 was characterised by very frequent records of termophilous species *Naucrates ductor* (JARDAS and PALLAORO, 1996).

***Balistes carolinensis* GMELIN, 1789**

The grey triggerfish, *Balistes carolinensis*, is relatively common in the southeastern Adriatic and belongs to amphiatlantic biogeographical elements (JARDAS, 1996). It is considered very rare in the northern areas, and only occurs in some years in the central Adriatic in the regions of Split and Zadar. The last occurrence was recorded in 1986 and 1987 when several adult specimens were caught near the Island of Ugljan and in Kornati Archipelago. Specimens occurred around the Island of Lošinj in the northern Adriatic (PALLAORO, 1988); in 1969 and again in 1978, specimens were reported from the extreme north of the Adriatic in the Gulf of Venice (BUSSANI, 1992). Specimens were also recorded in Slovenian coastal waters (Piran Bay) and on are kept in the Piran Aquaria (DULČIĆ and LIPEJ, 1997). In last years this species was caught in few occasions. In November 1998 two small specimens were caught in the nets of a fisherman ship of the Delamaris enterprise in the waters off Izola - Slovenia. Two large specimens, caught in the summer of the same year are kept in the Piran Aquarium. Three fingerlings were found under floating wreckage near the coast of the Islet Gubavac in vicinity of the settlement Lumbarda - Korčula Island - southern Adriatic in September 1994, provided the first occurrence of the grey triggerfish fingerlings in the eastern Adriatic (DULČIĆ *et al.*, 1997a).

***Brama brama* (BONNATERRE, 1788)**

The Ray's bream, *Brama brama*, is rare in the Adriatic, occurring almost in the southern part (JARDAS, 1996). DULČIĆ (1999) reported about the first occurrence of larval stage of this species in the Adriatic Sea. PALLAORO and JARDAS (1996) reported about the occurrence of this species in the Kaštela Bay-Split area (middle Adriatic).

***Xyrichthys novacula* (LINNAEUS, 1758)**

This species is very rare in the Adriatic (JARDAS, 1996). The first data about the presence of this species in the Adriatic Sea (CARRARA, 1846) are not confirmed, so the caught of this species in 1983 in Pelješac Channel could be treated as the first (ONOFRI, 1997). PALLAORO and JARDAS (1996) reported the occurrence near the Lumbarda-Korčula Island in 1988.

***Luvarus imperialis* RAFINESQUE, 1810**

The louvar, *Luvarus imperialis*, is very rare species in the Adriatic Sea (JARDAS, 1996). One specimen (luvarella stage) was caught on 24 December 1994 in Split Harbour.

There are also a series of other phenomena, which could be brought out: sprat, *Sprattus sprattus phalericus*, reduced yearly migration, European anchovy, *Engraulis encrasicolus*, stock collapsed drastically from 1985. However, there remains an open question, which of these changes have natural background so that they may appear at any time and which are due to global changes.

Unusual occurrences in marine life may be used as indicators of changing ocean conditions (MEARNS, 1988). Have highlighted that changes in fish assemblages can reflect changes in oceanographic conditions and may be the first indication of an environmental shift. According to these authors, temperature is the most important large-scale variable, which could affect fish populations. On the Croatian Adriatic coast, the northern records of southern species have followed similar trends: a) migration of small numbers of adult specimens are observed first and adult migration of fish species may be considered as a primary indicator of change resulting in an increased adult population of southern species; b) recruitment follows and juveniles can now be found. These changes could indicate a more long-term change, as proposed by FRANCIS (1990) and

TONN (1990). In the literature, long-term coastal observations are scarce, but their analysis has shown correlation between temperature and abundance variation of a species, as is the case for fish found along the west coast of the USA (MEARNS, 1988). The characteristics of the species examined in this paper and the caution that we have exercised in data selection make it possible to state, therefore, that thermophilic species have become newly established or more abundant in the Adriatic Sea, during the last 25 years. Simultaneous and recent biological changes are documented in the northern Atlantic (POWER, 1990), in the North Sea (CUSHING, 1990), in the northern Pacific (WING and MERCER, 1990), in the north-western Mediterranean (FRANCOUR *et al.*, 1994), and in the Galician waters - north-west Iberian Peninsula (BANON-DIAZ *et al.*, 1997) and similar modifications might have already existed in the past. Therefore, we are not absolutely certain that the modifications described here are related to a long-term shift in climate. Ecological consequences of increased mean temperature in shallow waters can be spectacular (for example, coral reef bleaching) and are often difficult to evaluate for an ecosystem. It is possible that changes in the specific composition of ichthyofauna in the Adriatic Sea can have considerable impact upon the local fishing industries. These modifications may still be minor, but they should be more thoroughly analysed in terms of their ecological and economic implications. The status of the mentioned species needs to be evaluated on a continuous basis because it is becoming increasingly apparent that uncommon species, and particularly those on the edge of their distribution, can be essential indicators of environmental change.

CONCLUSIONS

Warmer water is affecting marine ecosystems. Sea surface temperature (SST) fluctuations for the eastern Adriatic coast are presented as mean monthly filtered values for the available periods for three stations along the eastern Adriatic coast: stations Trieste (northern Adriatic, 1930-1990), Split (middle Adriatic, 1950-1996), and Dubrovnik (southern Adriatic, 1960-1985). There was considerable year-to-year variability in all three time-series of SST but with some simultaneous similarities between them. In two periods (1985-1987; 1990-1995) the most of new occurrences of ichthyological species were recorded. Eleven subtropical and tropical fishes were recorded for the first time, and several species, fairly rare or very rare until now, are more abundant. There are also some cases of the disappearance or rarefaction of species. The characteristics of the species examined in this paper and the caution that we have exercised in data selection make it possible to state, therefore, that thermophilic species have become newly established or more abundant in the Adriatic Sea, during the last 25 years. It is possible that changes in the specific composition of ichthyofauna in the Adriatic Sea can have considerable impact upon the local fishing industries. These modifications may still be minor, but they should be more thoroughly analysed in terms of their ecological and economic implications. The status of the mentioned species needs to be evaluated on a continuous basis because it is becoming increasingly apparent that uncommon species, and particularly those on the edge of their distribution, can be essential indicators of environmental change.

REFERENCES

- BANON-DIAZ, R., J.M. CASAS SANCHEZ, C.G. PINEIRO ALVAREZ and M. COVELO. 1997. Capturas de peces de afinidades tropicales en aguas atlanticas de Galicia (noroeste de la península Iberica). Bol. Inst. Esp. Oceanogr., 13: 13-33.
- BAUCHOT, M. L. 1987. Poissons osseux (Osteichthyes). In: Fiches FAO d'identification des espèces pour les besoins de la pêche. Revision 1. Méditerranée, mer Noire. Vol. II. Vertébrés. FAO, EEC, Roma: 763-1529.
- BELLO, G. 1995. *Tylosurus acus imperialis* (Osteichthyes, Belonidae), a fish new to the Adriatic Sea. Cah. Biol. Mar., 36: 197-199.
- BELLO, G. and E. RIZZI. 1988. I Teleostei raccolti nell'Adriatico meridionale nelle campagne sperimentali di pesca a strascico 1985-87. Quad. Ist. Ric. Pesca Maritima, 5: 77-90.
- BEN-TUVIA, A. and R. MCKAY. 1986. Haemulidae. In: Fishes of the Northern-eastern Atlantic and the Mediterranean (P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese Editors. UNESCO, Paris: 858-864.
- BUSSANI, M. 1992. Ricomparsa nel Golfo di Trieste di alcune species ittiche. Hydrores, 10: 5-7.
- CALVARIO, J.R., J.C. MARQUES and M.A. POUSADA. 1980. Occurrence of *Sphoeroides cutaneus* (Gunther, 1870) (Pisces, Tetraodontidae) off the Portuguese coast. Publ. Mus. Lab. Zool. Antrop. Fac. Ciencias de Lisboa, 10: 131-137.
- CARRARA, F. 1846. Catalogo de pesci della Dalmazia, particolarmente delle specie piu utili di quelle che sono nove affato od almeno non comuni, secondo il sistema di Cuvier. La Dalmazia descritta. Fratelli Battara tipografi editori. Zara: 89-92.
- COLLETTE, B.B. 1986. Coryphaenidae. In: Fishes of the Northern-eastern Atlantic and the Mediterranean (P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese Editors. UNESCO, Paris: 845-846.
- CONCALVES, B.C. 1941. Colecao oceanografica de D. Carlos I. Catalogo dos pexes. Trav. Stn. Biol. Marit. Lisb., 46: 108 pp.
- CUSHING, D.H. 1990. Recent studies on long-term changes in the sea. Freshwat. Biol., 23: 71-84.
- DULČIĆ, J. 1996. First record of ribbon fish larva, *Trachipterus trachipterus*, from the eastern Adriatic. Cybium, 20: 101-102.
- DULČIĆ, J. 1998. First record of the cornich black-fish *Schedophilus medusophagus* (Pisces: Centrolophidae) larvae from the Adriatic Sea. J. Mar. Biol. Ass. U.K., 1998: 1035-1038.
- DULČIĆ, J. 1999. First record of larval *Brama brama* (Pisces: Bramidae) and *Coryphaena hippurus* (Pisces: Coryphaenidae) in the Adriatic Sea. Journal of Plankton Research, 6: 1171-1174.
- DULČIĆ, J. and L. LIPEJ. 1997. New records of marine fishes from the Slovenian coastal waters. Falco, 12: 35-40.
- DULČIĆ, J., A. PALLAORO and M. KRALJEVIĆ. 1997. First record of pompano fingerling, *Trachinotus ovatus* (Linnaeus, 1758) (Pisces: Carangidae), in the eastern middle Adriatic. Nat. Croat., 1: 61-65.
- DULČIĆ, J., M. KRALJEVIĆ, F. KRŠINIĆ and A. PALLAORO. 1997a. Occurrence of fingerlings of grey triggerfish, *Balistes carolinensis* Gmelin, 1789 (Pisces: Balistidae), in the eastern Adriatic. Annales. Annals for Istrian and Mediterranean Studies, 11: 271-276.
- FABER, G.L. 1883. Fisheries of the Adriatic and the fish thereof. Bernard Quaritch (Editor). London: 292 p.
- FRANCIS, R.C. 1990. Climate change and marine fisheries. Fisheries, 15: 7-9.
- FRANCOUR, P., C.F. BOUDOURESQUE, J.G. HARMELIN, M.L. HARMELIN-VIVIEN and J.P. QUIGNARD. 1994. Are the Mediterranean waters becoming warmer? Information from biological indicators. Mar. Poll. Bull., 9: 523-526.
- GRAEFFE, E. 1906. Uebersicht der Seethierfauna des Golfes von Trieste nebst Notizen über Vorkommen, Lebensweise, Erscheinungs- und Fortpflanzungszeit der einzelnen Arten. Pisces (Fische): 445-471.
- GRBEC, B., M. MOROVIĆ. and M. ZORE-ARMANDA. 1998. Some new observations on the long-term salinity changes in the Adriatic Sea. Acta Adriat., 39: 3-12.
- HAEDRICH, R.L. 1986. Centrolophidae. In: Fishes of the Northern-eastern Atlantic and the Mediterranean (P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (Editors). UNESCO, Paris: 1177-1188.
- JARDAS, I. 1980. Contribution à la connaissance des trachiptères dans la mer Adriatique. 1. *Trachipterus trachipterus* (Gmelin, 1780). Acta Adriat., 21: 3-17.
- JARDAS, I. 1996. Jadranska ihtiofauna. Školska knjiga, Zagreb, 552 pp.
- JARDAS, I. and A. PALLAORO. 1996. The record of *Sphoeroides cutaneus* (Gunther, 1870)

- (Pisces, Tetraodontidae) in the Adriatic Sea. *Oebalia*, 23: 83-90.
- KAČIĆ, I. 1976. On the occurrence of young *Sardinella aurita* in the Adriatic Sea. *Rapp. Comm. Int. Mer Médit.*, 23: 35-36.
- KOLOMBATOVIĆ, J. 1882. Pesci rari e nuovi per l'Adriatico. *Izvjješće Velike realke, Split*, 29pp.
- KOLOMBATOVIĆ, J. 1904. Contribuzioni alla fauna dei Vertebrati della Dalmazia. *Glasnik HND, Zagreb*, 15: 187-199.
- KOSIĆ, B. 1889. Nova grada za dubrovačku nomenklaturu i faunu riba. *Glasnik HND, Zagreb*, 10: 90-117.
- LACOMBE, H., P. TCHERNIA et G. BENOIST. 1958. Contribution à l'étude hydrologique de la mer Egée en periode d'été. Extrait du Bulletin d'Information du Comité Central d'Océanographie et d'Etude des Côtes, X, 8, juillet-août 1958, pp. 453-467.
- LIPEJ, L., M. SPOTO and J. DULČIĆ. 1996. *Plectorhinchus mediterraneus* from off north east Italy and Slovenia-the first records of fish of the family Haemulidae from the Adriatic Sea. *J. Fish. Biol.*, 48: 805-806.
- MEARNS, A.J. 1988. The odd fish: unusual occurrences of marine life as indicators of changing ocean conditions. In: *Marine organisms as Indicators*, D.F. Soule and G.S. Keppel (eds) Berlin, Springer, pp. 137-173.
- MERKER, K. and T. NINČIĆ. 1973. Sastav i gustina bentoskih ihtionaselja u južnom Jadranu. *Studia Marina*, 6: 75-117.
- MOROVIĆ, D. 1960. Sur la présence du genre *Ruvettus* Cocco en Adriatique. *Bilješke-Notes. Institut oceanogr. i rib.*, Split, 15: 1-8.
- NINNI, E. 1912. *Catalogo dei pesci del Mare Adriatico, Venezia*.
- ONOFRI, I. 1986. The rare saw-cheeked fish (*Schedophilus medusophagus* Cocco, 1839) (Pisces: Centrolophidae) in the central Adriatic. *Zbornik Matice Srpske za prirodne nauke*, 70: 135-141.
- ONOFRI, I. 1997. On rare fish species in the Adriatic Sea. In: *Zbornik radova znanstvenog skupa "Tisuću godina prvog spomena ribarstva u Hrvata"* B. Finka, S. Jukić, S. Kaštela, M. Maras, I. Petricioli and T. Vodopija (Editors). Zagreb. *Razred za filološke znanosti HAZU*, pp. 531-541. (in Croatian)
- ORLIĆ, M., M. GAČIĆ, and P. LAVIOLETTE. 1992. The current and circulation of the Adriatic Sea. *Oceanologica Acta*, 15: 109-124.
- PALLAORO, A. 1988. O mogućnostima pojave nekih rijetkih vrsta riba na srednjejadranskom području u vezi sa jadranskom ingresijom 1986/87 godine. *Morsko ribarstvo*, 3: 82-87.
- PALLAORO, A. and I. JARDAS. 1996. Ichthyological collection of the Institute of Oceanography and Fisheries in Split (Croatia). *Nat. Croat.*, 3: 177-219.
- POWER, G. 1990. Salmonid communities in Quebec and Labrador; temperature relations and climate change. *Pol. Arch. Hydrobiol.*, 38: 13-28.
- QUERO, J.C., M.H. DU BUIT, J. FONTENEAU, B. KERGOAT and J.J. WAYNE. 1991. Premières observations dans les ports français de *Sphoeroides pachygaster* (Pisces, Tetraodontiformes, Tetraodontidae) captures au Nord de leur aire de répartition connue. *Annls. Soc. Sci. Nat. Charante-Maritime*, 9: 1059-1063.
- SMITH-VANIZ, W.F. 1986. Carangidae. In: *Fishes of the Northern-eastern Atlantic and the Mediterranean* (P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (Editors)). UNESCO, Paris: 815-844.
- THOMPSON, R.O.R.Y. 1983. Low pass filters to suppress inertial and tidal frequencies. *J. Phys. Oceanogr.*, 13: 1077-1083.
- TONN, W.M. 1990. Climate change and fish communities: conceptual framework. *Trans. Am. Fish. Soc.*, 119: 337-352.
- TORTONESE, E. 1986. Tetraodontidae. In: *Fishes of the Northern-eastern Atlantic and the Mediterranean* P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (Editors). UNESCO, Paris: 1341-1345.
- TZIPERMAN, E. and P. MALANOTTE-RIZZOLI. 1991. The climatological seasonal circulation of the Mediterranean Sea. *J. Mar. Res.*, 49: 411-434.
- WING, B.L. and R. W. MERCER, 1990. Temporary northern range extension of the squid *Loligo opalescens* in southeast Alaska. *Veliger*, 33: 238-240.
- WÜST, G. 1961. On the vertical circulation of the Mediterranean Sea. *J. Geophys. Res.*, 66(10): 3261-3271.
- ZORE-ARMANDA, M. 1963. Les masses d'eau de la mer Adriatique. *Acta Adriat.*, 10(3): 88pp.
- ZORE-ARMANDA, M. 1972. Response of the Mediterranean to the oceanographic/meteorological conditions of the Northern Atlantic. *Rapp. Comm. Int. Mer Médit.*, 21: 203-205.

Novi podaci o ihtiofauni Jadrana - utjecaj zagrijavanja vode?

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SAŽETAK

Prikazana su opažanja ihtiofaune Jadrana u posljednjih 25 godina (1973-1998). Za to su vrijeme zabilježene promjene u količini i kvaliteti sastava faune riba. Broj toploljubnih vrsta se povećao. Nalazi nekoliko vrsta, rijetkih ili neobičnih do sada su češći, dok su preostali novi nalazi. Također postoje neki primjeri o nestajanju ili povećanju učestalosti nekih vrsta. Ova se opažanja mogu povezati s oceanografskim promjenama u Jadranskom moru.

