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A Tropical Eastern Pacific Barnacle, *Megabalanus coccopoma* (Darwin), in Southern California, following El Niño 1982–83[1]

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ABSTRACT: The Tropical Pacific Ocean experienced "El Niño" in 1982–83. The event was marked by increased water temperatures in the Eastern Pacific and, near shore in Southern California, the appearance of nekton normally found well to the south. The present note records the appearance of waifs of the large, tropical, benthic barnacle, *Megabalanus coccopoma*, in waters off San Diego, California, following this event. The timing of the appearance of this species, a year or so after El Niño 1982–83 was officially over, and the appearance of the related species, *M. californicus*, north of its normal range, a year or so prior to the recognition of El Niños 1940–41 and 1982–83, indicate that significant range extensions apparently related to El Niño events may bracket El Niño years designated by physical oceanographers.

"EL NIÑO" OF 1982–1983 in Southern California consisted of 1) anomalously high sea surface temperatures over wide areas (as much as 4°C coastally), 2) reduced nutrient concentrations, 3) a significant rise in sea level (as much as 20 cm in September of 1983), 4) severe winter storms, 5) depression of the thermocline (deep mixed layer), especially offshore, 6) a vast reduction in macrozooplankton and kelp beds, and 7) the widespread nearshore occurrence of nekton normally found well to the south, off the coast of central Mexico (cf. Dayton and Tegner 1984; McGowan 1985; Gains and Roughgarden 1987). While El Niño was generally considered over in 1983 in the eastern Pacific, it lasted a year longer in Southern California (M. Tegner, personal communication).

Daily sea surface temperatures taken throughout 1983 at the Scripps Institution of Oceanography (SIO) pier showed positive anomalies of several degrees Celsius, except during the period of May through July, and as much as 4°C through the late summer and fall (Dayton and Tegner 1984). Except for three occasions in 1984, sea surface temperatures were uniformly warmer than normal off the SIO pier, at least 2°C, but with highs of 4°C for a period of several months (M. Tegner, personal communication). Some of the warming has been attributed to an influx of waters from the west, but the appearance of southern nekton and plankton, as well as physical data, indicate strengthening of the warm, northward-flowing, nearshore counter-current system (Figure 1; cf. Dayton and Tegner 1984, Norten et al. 1985, and Brodeur 1986). An example among the nekton has been the Red Crab, *Pleuroncodes planipes* Stimpson, juveniles of which are frequently transported north by the California Counter-Current, from approximately 25°N on the Pacific coast of Baja California to Point Conception (35°N). However, juveniles were reported somewhat north of Point Conception in 1983, and as far north as San Francisco in 1984 (38°N; Smith 1985). Furthermore, a subtropical neritic euphausid, *Nyctiphanes simplex*, became an important food of resident predators off Oregon and Washington in 1983 and 1984 (Brodeur 1986). Indeed, the effects of El Niño were felt in Canada (50°N; Kabata 1985) and into the Gulf of Alaska (Cannon 1985).

Waifs of a Tropical Eastern Pacific large, benthic acorn barnacle, *Megabalanus coccopoma* (Darwin, 1854), became established in intertidal and shallow waters off San Diego,

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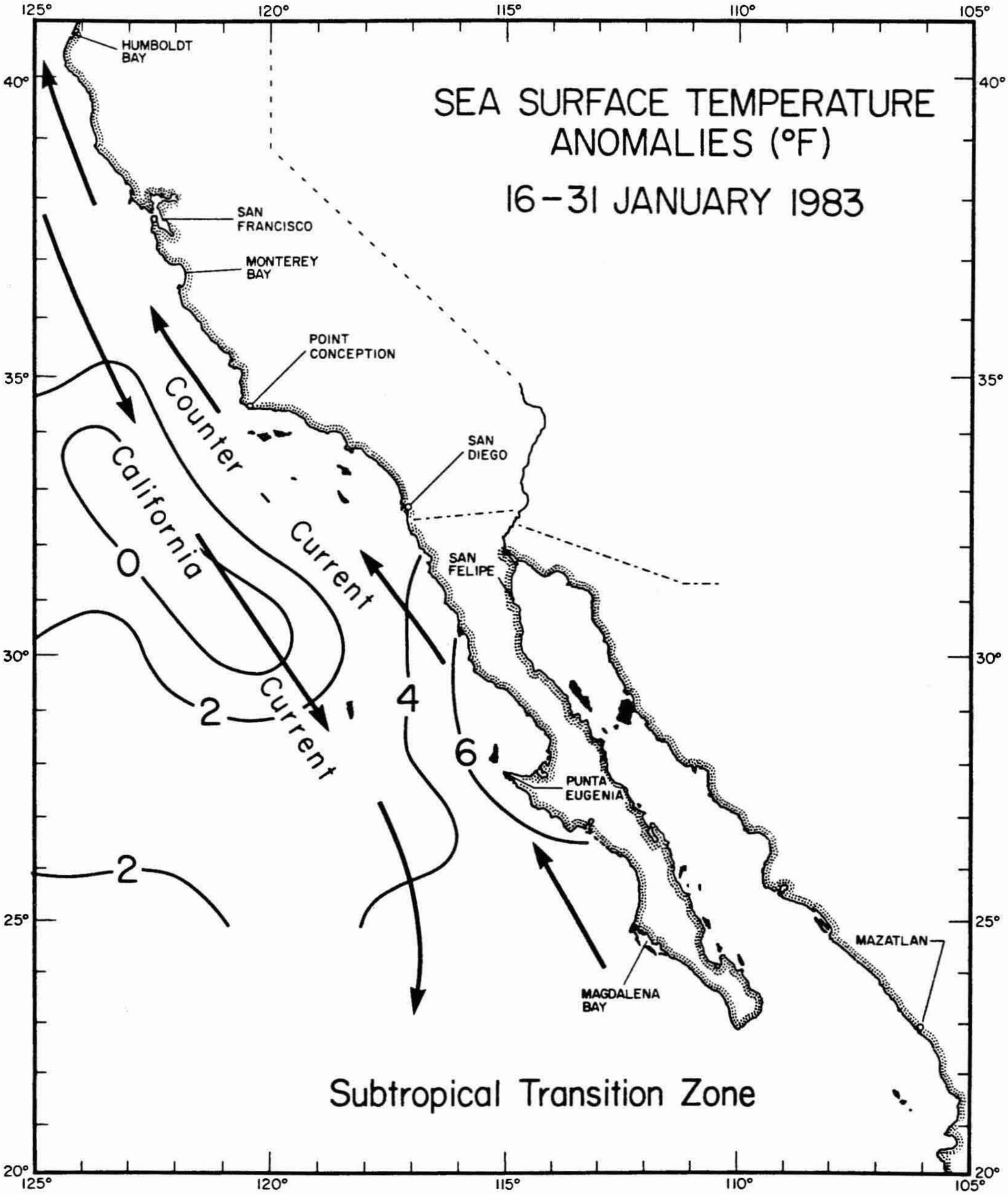

FIGURE 1. Sea surface temperature anomalies north of the Subtropical Transition Zone for the second half of January, 1983 (in degrees F, after McGowan 1985), the general position of the Subtropical Transition Zone and courses of the California Current and Counter-Current (after Norton et al. 1985), illustrating the influx of warm, southern waters between the shore and the California Current.

California, apparently as the result of El Niño 1982–83 (present report). While tolerant of moderate wave action in the lowermost intertidal, it is most commonly found in shallow water (less than 100 m). Like most members of the Megabalaninae, *M. coccopoma* is an opportunistic, highly gregarious, fouling species frequenting 1) recently disturbed areas, 2) fresh surfaces including artificial structures such as buoys and boats along with other organisms with similar requirements, and 3) vagile forms such as large crustaceans (cf. Newman and Ross 1976; Laguna 1985). The genus is Oligocene and *M. coccopoma* itself is known as far back as the Pliocene of Baja California, a time when the peninsula and its biota were some 300 km further south (cf. Newman 1979). Its range, from approximately 3°S, Gulf of Guayaquil, Ecuador-Peru, to approximately 23°N, Mazatlán, Mexico, places it as a member of the Panamic faunal province.

Reports of the occurrence of *M. coccopoma* elsewhere in the world are for the most part unconfirmed, but it has become naturalized in southern Brazil where it was apparently introduced from the Tropical Eastern Pacific by ships (P. Young, personal communication).

Megabalanus coccopoma has been found, together with the Panamic *M. peninsularis* (Pilsbry, 1916) (= *M. galapaganos* [Pilsbry, 1916] according to Henry and McLaughlin 1986) and the Californian *M. californicus* (Pilsbry, 1916), on a fishing boat at San Felipe in the Gulf of California (31°N; personal observation). This is well north of the normal range of these Panamic species on both sides of the peninsula. The presence of the Californian species together with the Panamic species indicates that the boat probably had been on the Pacific coast of Baja California, and then at or north of Magdalena Bay (approx. 24.5°N), the southern limit of *M. californicus* (Newman and Ross 1976; Southward and Newman 1977; Newman 1979; Newman and Abbott 1980; Laguna 1985).

There are no previous benthic records of *M. coccopoma* north of Mazatlán; that is, north of the Subtropical Transition Zone (Figure 1). However, it would not be too surprising if *M. coccopoma* were occasionally encountered on benthic substrates on the Pacific coast of Baja California as far north as Magdalena Bay, where it would overlap the southern limit of *M. californicus* as well as the peninsular range of *M. peninsularis*. An occurrence as far north as Punta Eugenia (approx. 28°N) would be a substantial range extension, but it still would not be considered worthy of special notice at the present state of our knowledge. On the other hand, considering our previous knowledge of coastal marine climates, and the ecology and normal distribution of these barnacles, the appearance of *M. coccopoma* as far north as San Diego (approx. 33°N) would indicate that something extraordinary had happened. It is instructive therefore that some specimens were collected at San Diego for the first time, in 1985. However, because they appeared after the main thrust of El Niño (see discussion), it is unlikely that the larvae that produced them were transported from as far south as Mazatlán, some 900 nautical miles (1,680 km), in a single step.

METHODS AND MATERIALS

Megabalanus coccopoma and *M. californicus* are readily distinguished from each other in the field by color, color pattern, texture and shape. The former has 1) relatively uniform pinkish-red, smooth parietes, 2) purple to white, relatively narrow radii, and 3) small aperture, while the latter has 1) deep-purplish red parietes with white ribs, 2) similarly reddish, relatively wide radii, and 3) large aperture. There are similar though smaller local species resembling *M. californicus* to some extent in form and coloration (*Balanus pacificus* Pilsbry, *B. trigonus* Darwin, and *B. amphitrite* Darwin), but there is none resembling *M. coccopoma*. Therefore, not only is it easy to distinguish between the two species of *Megabalanus* in the field, but field identification of *M. coccopoma* in San Diego is virtually certain. Voucher specimens were hand collected by one of us (McConnaughey, with the last four years of diving concentrated on local, undersea structures). These specimens, from three localities, are listed and discussed below:

1). 29 April 1985: Large, dead specimen of *M. coccopoma* 30 mm in rostro-carinal (r-c) diameter; with living and dead specimens of *M. californicus* and a juvenile of *Tetraclita rubescens* Darwin; from cable in water 7 months (installed 20 September 1984 and removed date of this collection); from 7.6 m of depth in 18 m of water; Naval Ocean Systems Center Tower, approximately 0.9 km off Mission Beach, San Diego, California.

2). 2 October 1985: Live specimen of *M. coccopoma* 24 mm in r-c diameter; not brooding larvae, ovaries plump but not ovigerous, posterior cirri of right side cleanly cut off at about half their length and not yet in state of regeneration; on *Mytilus edulis* Linnaeus; from 24 m of depth in approximately 162 m of water; Scripps Institution of Oceanography Bioluminescence Field Station, approximately 0.9 km west of SIO Pier, La Jolla, San Diego, California.

3). 2 December 1985: One living *M. coccopoma* 22 mm in r-c diameter; not brooding larvae, ovaries undeveloped, seminal vesicles not charged with sperm; posterior cirri of both sides in process of total regeneration; with several specimens of *Chthamalus* sp. juveniles on the side of the wall, attached to *Mytilus californianus* Conrad; one dead, broken individual estimated at 14 mm in r-c diameter; both specimens of *M. coccopoma* from approximately +0.3 m of mean lower low water in approximately 5.5 m of water, outer pilings of the SIO Pier.

DISCUSSION

To our knowledge, these are the first records of *Megabalanus coccopma* on benthic substrates north of Mazatlán. The first to be observed was the first collected and it is known to have settled some time between the end of September, 1984 and the end of April, 1985. Judging from size, it is likely to have settled out of the plankton shortly after the cable was placed in the water in late September, 1984, a time when sea surface temperatures were warmer than normal; waters became cooler than normal during the ensuing winter and did not become warmer than normal until the latter half of April, 1985 (F. Miller, personal communication), the time when this large specimen was collected. The remaining specimens, collected in October and December of 1985, are all smaller and probably settled after sea surface temperatures rose above normal in April of the same year. Thus, all apparently settled within a year and a half after El Niño in Southern California was officially over.

The two voucher specimens collected when alive were in relatively poor condition judging from their reproductive states. Furthermore, cirri or feeding limbs of both had been attacked by some predator, most likely fish considering the size and rapidity needed to inflict such severe damage. Cirri are often found in the stomachs of local fish, but they are usually of smaller species which are frequently taken whole. Specimens of large barnacles, such as *Megabalanus californicus*, are rarely found to have cirri damaged or in a state of regeneration (personal observations). Therefore it seems that the specimens of *M. coccopoma* were unable to react quickly enough to escape damage by certain predators here, and/or they attracted more attention by predators than their congener, *M. californicus*, in the same habitat.

The arrival of *Megabalanus coccopoma* in San Diego in late 1984 and early 1985, after El Niño was essentially over, requires an explanation. It doesn't seem likely that the larvae came from as far south as Mazatlán because of the distance involved. If the Counter-Current averaged 1 knot (1.85 km/hr), it would take some 38 days to travel the 1,680 km from Mazatlán to San Diego. However, 1) currents actually experienced are rarely that strong and by no means that direct, 2) the Counter-Current was not strong in 1985, and 3) benthic barnacle larvae rarely persist in the plankton for more than three weeks. Therefore, it seems more likely that if the larvae arriving along the shore here came from some benthic population, it was from a population that previously had become established on the northern coast of Baja California, if not closer. On the other hand, ships may have been responsible.

The larvae of strictly marine species such as *M. coccopoma* are unlikely candidates for transport in the ballast water of ships (cf. Carlton 1985) because, unlike those of estuarine species known or suspected of having been so transported, they occur along coasts rather than being concentrated in harbors. Furthermore, unlike the larvae of estuarine forms, they are unlikely to be as tolerant of the relatively rigorous conditions found in ballast tanks. However, *Megabalanus coccopoma* is a fouling species, as noted earlier in connection with 1) its introduction to southern Brazil, 2) its propensity to settle on fresh surfaces, and 3) its occurrence on a fishing boat at the northern end of the Gulf of California. It is therefore possible the larvae that settled locally were produced by adult barnacles fouling one or more fishing vessels from southern waters enroute to or moored at Ensenada, Baja California (140 km to the south), or perhaps San Diego and Mission bays. This would have to have happened at least twice and therefore is deemed unlikely. However, whether it happened by boat or by some nearby local population just south of here, warmer temperatures for reproductive purposes, dispersal, settlement, and growth are required. It is therefore instructive to note again that local waters and those immediately to the south were in fact warmer than normal in the fall of 1984, and following the first quarter of 1985 (F. Miller, personal communication).

The only published record of a northward range extension of a benthic barnacle in California is for *Megabalanus californicus*. While its northern limit on shore is Monterey Bay (37°N; Newman and Abbott 1980), Zullo (1968) reported findings on buoys near Humboldt Bay (approx. 41° N) in 1939. In fact, not only was the intensity signal for El Niño-like events high in 1939 (magnitude 3, on a scale of 1–4), there had been no previous El Niño-like event signals since 1932, and there was the Rabual eruption of 1937 (cf. Rasmusson 1984 and Handler 1984 respectively). Therefore this significant range extension was apparently part of El Niño designated 1940–1941, whose influence was felt as far as Washington State (45°–50°N; cf. Schoener and Fluharty 1985). Furthermore, it may be noteworthy that this species was again found north of its range, on Cordell Bank (approx. 38° N) in 1980 and 1981 but not in 1978 and 1979 (R. Schmieder, personal communication), prior to El Niño 1982–1983, even though the last event signal previous to 1982 had been in 1976 (magnitude 3; Rasmusson 1984). The appearance of *M. californicus* well north and somewhat north of its range a year or so prior to the official recognition of El Niños 1940–1941 and 1982–1983 respectively, and the appearance of *M. coccopoma* well north of its range a year or so after El Niño 1982–1983 was officially over, indicates that changes in range related to El Niño events may at times bracket El Niño years designated by physical oceanographers.

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