

NOTES

DISPERSAL OF JUVENILE AND ADULT REEF FISHES ASSOCIATED WITH FLOATING OBJECTS AND THEIR RECRUITMENT INTO GORGONA ISLAND REEFS, COLOMBIA

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It is well known that most marine reef fishes have complex life cycles with two distinct phases. Typically, the reproduction of the benthic adult produces numerous planktonic larvae, which are dispersed by current transport. At the end of the larval period larvae settle on reefs and recently transformed juveniles recruit into benthic populations. Thus, most marine reef fish populations are replenished by the supply of larvae from the plankton (Caley et al., 1996). In consequence, processes of larval dispersal and juvenile recruitment have profound implications for several fundamental aspects of coral reef fish biology (e.g., Sale, 1991). However, because of the importance of larval biology, reef fish ecologists have tended to ignore alternative mechanisms of dispersal and recruitment.

One of the main questions in the study of dispersal and recruitment processes in marine organisms concerns the origin of individuals that recruit into a population. In a closed population, recruiting individuals come exclusively from the same population (pelagic larvae are locally retained), whereas in an open population, recruits come from other populations (larvae disperse from other reefs). Whether larvae from a given population are dispersed or locally retained seems to be a variable outcome depending on the particular characteristics of species and local current patterns (e.g., see Richards, 1994, and associated papers).

In this paper we present evidence of the arrival on reefs of Gorgona Island, Colombia (2°58'10"N, 78°11'05"W) of juvenile and adult fishes from Ecuador and/or Peru by drifting in close association with floating objects implying the existence of at least partially open populations at Gorgona independently of larval transport. On 28 April 1999, we observed a marine current moving northward along Gorgona's eastern coast. The current was carrying several floating objects including logs, tree branches, seeds, packing materials and plastic bottles. We observed juveniles and adults of several fish species, including reef fishes, in close association with the floating objects (Table 1). Many of the fishes transported by the current finished their journey at Gorgona when the object harboring them ran aground, whereas others continued being transported by the current.

Surface current patterns in this area of the Pacific Ocean (Fig. 1) and the labels of many of the floating bottles and packing materials, which belonged to products made in Ecuador and Peru, strongly support the idea that the floating objects came from areas south of Gorgona. This suggests the spatial scale at which organisms could have been transported by currents. Fishes may have come from Colombia (south of Gorgona), Ecuador, and Peru (but not from farther south given that the southern limit of distribution of the species involved is in Peru).

Although it is impossible to determine exactly where and when the fishes became associated with the floating objects, it is likely that they settled as larvae on the substrate provided by the larger floating objects (e.g., logs). Floating objects are easily colonized by planktonic larvae (Kingsford and Choat, 1985; Kingsford, 1992) and offer sufficient

Table 1. List of fish species observed associated with floating objects at Gorgona Island, Colombian Pacific coast. Reef species are indicated by an asterisk.

Family and species	Number of individuals	Total length (cm)
Balistidae		
<i>Pseudobalistes naufragium</i> *	4	7–20
<i>Canthidermis maculatus</i>	20	5–15
Blenniidae		
<i>Hypsoblennius brevipinnis</i> *	20	2–6
<i>Coryphaenidae</i>		
<i>Coryphaena</i> sp.	15	1–3
Carangidae		
<i>Seriola peruana</i>	4	2–6
<i>Seriola rivoliana</i>	4	2–14
Kyphosidae		
<i>Kyphosus analogus</i> *	50	12–20
Lobotidae		
<i>Lobotes surinamensis</i>	20	19–30
Polynemidae		
<i>Polydactylus approximans</i>	5	2–3
Pomacentridae		
<i>Abudefduf troschelii</i> *	20	7–15
<i>Chromis atrilobata</i> *	1	3
Tetraodontidae		
<i>Sphaeroides</i> sp. *	20	1–2

shelter and food resources for the survival of several species of fish (Gooding and Magnuson, 1967; Kingsford, 1992). It is likely then that fishes reached their adulthood while associated with the floating objects. This possibility is supported by the observation that some reef fishes exhibit an association with floating objects for a sufficiently long period to be considered as residents (Gooding and Magnuson, 1967).

Comparison of the ages of fishes found on the floating objects with the time required to travel to Gorgona from southern localities, given known current patterns and velocities, provides additional clues about the origin of the immigrants. Considering that typical surface current velocities in this part of the Pacific vary between 5 and 25 cm s⁻¹ (Wyrski, 1965), the time required to travel to Gorgona (following the shortest trajectory) is 9–46 d from the nearest locality in Ecuador and 24–120 d from the nearest point in Peru. Otolith analyses indicate that *Hypsoblennius brevipinnis* individuals (4–6 cm TL) were 120–420 d old (n = 3), and a *Chromis atrilobata* individual (3 cm TL) was 71 d old. Based on juvenile growth rates between 5 and 15 mm mo⁻¹ for pomacentrids (Allen and Robertson, 1994), individuals of *Abudefduf troschelii* observed on the floating objects were approximately 300–900 d old given their total length of 15 cm. Therefore, the possibility that fishes became associated with floating objects in Ecuador and Peru is likely given that the ages of some of the fishes observed were similar to or greater than the minimum time required to travel such distances. Given the short time required to travel from any locality in Colombia to Gorgona (less than 9–46 d) only small larvae found in the flotsam could have come from colombian localities.

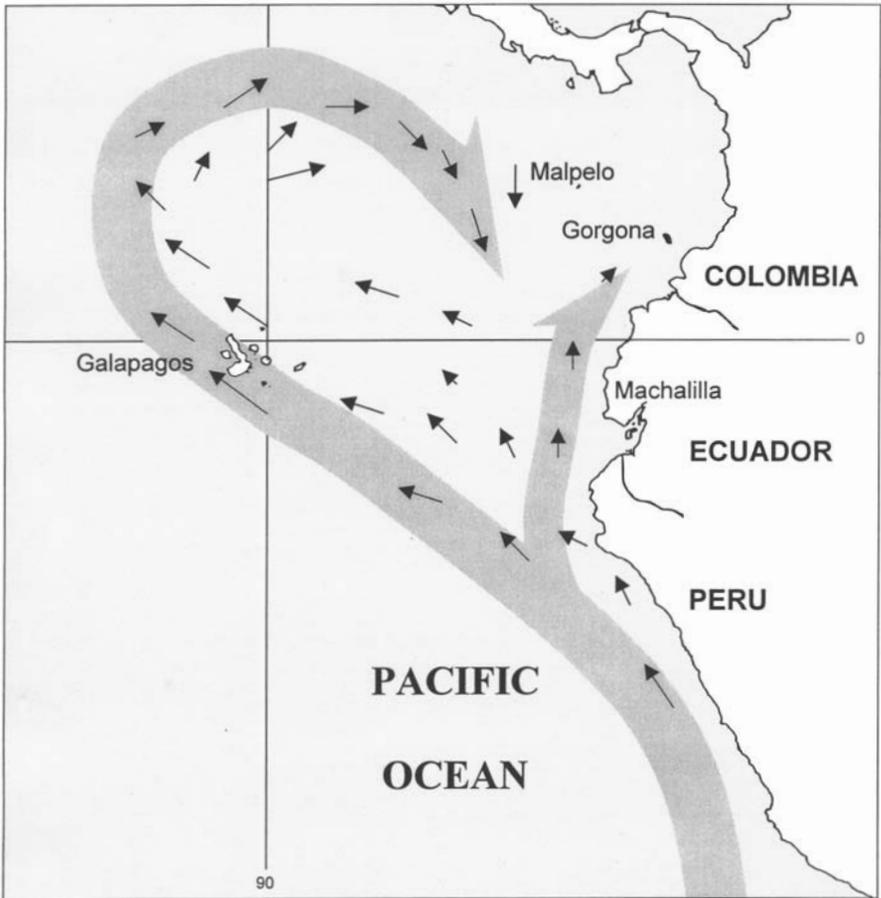


Figure 1. Pattern of sea surface currents in the area between Peru and Panama in the tropical eastern Pacific Ocean during the month of April (after Wyrki, 1965).

A second alternative considers that fishes may have become associated with floating objects as subadults or adults during the transit of floating objects through southern coral or rocky reefs, or even near Gorgona itself. Although the association with passing objects by subadult and adult reef fishes is less known, Robertson and Foster (1982) reported that individuals of the Indo-Pacific labrid *Epibulus insidiator* moved from one area to another by associating with passing floating leaves, occasionally migrating off the reef for short distances. Nonetheless, we believe that this second alternative is less likely to explain the presence of adults on floating objects. Most adult reef fishes are sedentary or strongly site-attached (Sale, 1978) and, except for the unusual behavior of *E. insidiator*, there is little evidence of off-reef migration on floating objects by adult reef fishes. Even considering possible this second alternative it is more likely that fish came from Ecuador and/or Peru because there are no reefs in Colombian waters south of Gorgona that could have supplied the floating objects with adults. We also rule out the possibility that fish associated with floating objects in reefs of Gorgona itself because we observed the fish on the

flotsam and followed their trajectory since they were in open water at least 600 m from the nearest reef.

Passage and arrival at Gorgona Island of floating objects with labels from Ecuador and Peru have been observed in previous years by residents of the island. We also observed an additional event to the one reported here on May 2000, suggesting that transport of fish from southern localities to Gorgona could be frequent. The arrival in Gorgona of juvenile and adult fishes originating from southern populations indicates that: (1) northward-moving currents from the south play an important role in the dispersal and transport of marine organisms towards Gorgona, (2) some species of reef fishes at Gorgona have demographically open populations, and (3) pelagic dispersal and recruitment of reef fishes are processes not necessarily restricted to the earlier stages of the life cycle; after larval settlement and subsequent growth on floating objects, subadults and adults may disperse and recruit to other populations. Additionally, because significant transport by currents can occur while fishes reach their adulthood, the association of fishes with flotsam can be an important mechanism for long distance dispersal in these species.

Finally, among the specimens collected from the floating objects there were both male and female adults with advanced gonadal development (e.g., some females of *H. brevipinnis* had well developed eggs in their ovaries). The presence in floating objects of reproductively mature individuals of some invertebrate species is not uncommon (e.g., Jokiel, 1984, 1989) and in fact we found gravid female crabs (Palicidae) associated with the floating objects arriving in Gorgona. Although we are unaware of reports of the occurrence of reproduction by reef fishes while associated with floating objects, the presence of mature individuals of both sexes suggests the plausibility that some reef fish species may be capable of reproducing while associated with floating objects and may, in fact, complete their life cycle in the pelagic environment.

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LITERATURE CITED

- Allen, G. and D. R. Robertson. 1994. Fishes of the tropical eastern Pacific. Univ. Hawaii Press, Honolulu.
- Caley, M. J., M. H. Carr, M. A. Hixon, T. P. Hughes, G. P. Jones and B. A. Menge. 1996. Recruitment and the local dynamics of open marine populations. *Ann. Rev. Ecol. Syst.* 27: 477–500.
- Gooding, R. M. and J. J. Magnuson. 1967. Ecological significance of a drifting object to pelagic fishes. *Pac. Sci.* 21: 486–497.
- Jokiel, P. L. 1984. Long distance dispersal of reef corals by rafting. *Coral reefs* 3: 113–116.
- _____. 1989. Rafting of reef corals and other organisms at Kwajalein Atoll. *Mar. Biol.* 101: 483–493.
- Kingsford, M. J. 1992. Drift algae and small fish in coastal waters of northeastern New Zealand. *Mar. Ecol. Prog. Ser.* 80: 41–55.

- Kingsford, M. J. and J. H. Choat. 1985. The fauna associated with drift algae captured with a plankton-mesh purse seine net. *Limnol. Oceanogr.* 30: 618–630.
- Richards, W. J. 1994. Symposium on recent advances in reef fish recruitment research. *Bull. Mar. Sci.* 54: 203–205.
- Robertson, D. R. and S. A. Foster. 1982. Off-reef emigration of young adults of the labrid fish *Epibulus insidiator*. *Copeia* 1982: 227–229.
- Sale, P. F. 1978. Reef fishes and other vertebrates: a comparison of social structures. Pages 313–331 in E. S. Reese and F. J. Lighter, eds. *Contrasts in behavior. Adaptations in the aquatic and terrestrial environments*. Wiley Interscience, New York.
- _____. 1991. ed. *The ecology of fishes on coral reefs*. Academic Press, San Diego, California.
- Wyrski, K. 1965. Surface currents of the eastern Pacific ocean. *Bull. Inter-Amer. Trop. Tuna. Comm.* 9: 269–304.

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