WA's unique oceanography and its implications for larval fish survival

***Barbara Muhling*, who has recently completed her PhD thesis at Murdoch University, explains how larval fishes are influenced by ocean currents off south-western Australia.**

The life-cycles of virtually all species of fishes include a pelagic larval stage. During this phase, larvae spend weeks to months drifting in the open ocean, and develop from tiny yolk-sac larvae (a few millimetres long), into juvenile fish (a few centimetres long).

Many fish larvae look nothing like their parents, and some larvae possess highly specialised features, such as large spines, and unusual pigment patterns. These adaptations are designed to equip them for open ocean life, where they will occupy different habitats, eat different foods, and have different predators from adult fish.

A scorpionfish larva with extensive head spines. This species is common in the offshore plankton in south-western Australia (Photo: B. Muhling).

At the end of the pelagic phase, larvae develop into juveniles, complete with scales and fins. At this time, most species settle out of the plankton, be it onto a reef, or into a nursery area such as a seagrass meadow or an estuary.

The chances of a fish larva surviving the pelagic phase, and being transported by ocean currents to a suitable habitat by the time they have grown into juveniles, seems extremely remote. Indeed, it is estimated that in most species, less than one per cent of larvae survive their open ocean journey.

However, if a population of fishes is to persist, enough larvae must survive their initial journey to provide steady recruitment to the population. Variability in the survival rates of larval fishes thus affects the size of adult populations, and recruitment to fisheries for targeted species.

Transported on ocean currents

The distribution, and final destination, of larval fishes is strongly influenced by oceanographic patterns. Ocean currents may transport larval fish hundreds of kilometres away from where they were spawned, or help to retain them in the local area. Larval fishes may be transported to areas with varying concentrations of food, or of predators, and this will affect their survival.

While the swimming behaviour of larval fishes may be highly influential in determining their dispersal, transport by ocean currents is usually the dominant process behind larval fish distributions (on a regional scale). Movement by currents therefore influences the survival, transport and growth of larval fishes, and hence adult populations.

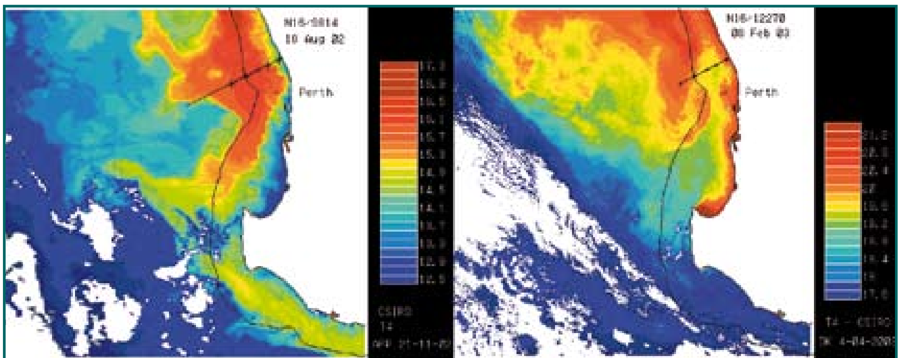
Larval fishes spawned off Western Australia are released into an area characterised by a unique oceanography. While most major ocean currents flowing along the western margins of continents (known as eastern boundary currents) flow toward the equator, the Leeuwin Current off south-western Australia flows pole-wards (i.e. southwards). This has a significant impact on the Western Australian marine environment.

The ocean currents found to the west of South America, and southern Africa, are characterised by cold, northward flows, and upwelling of cold, nutrient-rich deep water, caused by the interaction of dominant winds and the Coriolis effect. In contrast, the warm Leeuwin Current flows southward along the continental shelf break, and suppresses large-scale upwelling. As a result, Western Australian coastal waters are warmer, lower in nutrients, and support finfish fisheries of far lower magnitudes than coastal oceans at similar latitudes off South America or southern Africa.

The Leeuwin Current flows strongest, and closest inshore, during autumn and winter, and is weakest, and located farther offshore, during spring and summer. This is due to the strong southerly winds that prevail during summer, which slow and weaken the current. These strong summer winds cause a cooler counter-current to be initiated around the Capes region. This current, known as the Capes Current, flows northward along the inner continental shelf, inshore of the weakened Leeuwin Current, and may reach as far north as the Abrolhos Islands.

These oceanographic features have a number of implications for larval fishes. The lack of upwelling results in low levels of phytoplankton and primary productivity. Consequently, there are lower concentrations of microscopic crustaceans, such as copepods, which are common prey items for pelagic fish larvae.

The Leeuwin Current can also transport larval fish southward along the coast, and as a result, many tropical fish species can be seen at more temperate locations, such as at Rottnest Island. In contrast, the Capes Current provides a potential northward transport mechanism for larvae on the inner continental shelf, during summer.



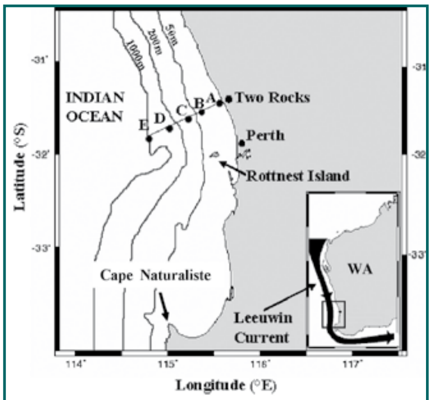
Sea surface temperature images of the Leeuwin Current during winter (left), and the Leeuwin and Capes Currents during summer (right) (Images, A. Pearce, CSIRO and WASTAC). Note different temperature scales.

Despite the presence of such an unusual oceanographic regime off south-western Australia, there have been few studies completed on the effects of these ocean currents on larval fishes. While some previous work has been done in estuaries, near-shore environments, and on species such as the sardine, little is known about larval fish distributions on the continental shelf, and slope.

Oceanography project

The Strategic Research Fund for the Marine Environment (SRFME) Biophysical Oceanography project, a joint venture between the CSIRO and the Western Australian State Government, was initiated in 2002, and aimed to investigate the links between oceanography, hydrochemistry and plankton biology off south-western Australia. To study these links, a transect off Two Rocks with five stations (A to E), from coastal (18m depth) to offshore (1000m depth) waters, was regularly sampled for three years.

Part of this sampling regime involved the collection of zooplankton samples, taken by towing a plankton net with fine mesh and equipped with a flowmeter through the water column. Once plankton samples were collected, and preserved, larval fishes were removed from the samples one by one, and identified under a microscope. For each station along the transect, information was thus recorded on how many larval fishes were present per cubic metre of seawater, and which species of larval fish were found at each station. This was used to characterise the larval fish assemblages (i.e., species composition and abundance) present at each station throughout the year.



The Two Rocks transect, with five sampling stations shown.

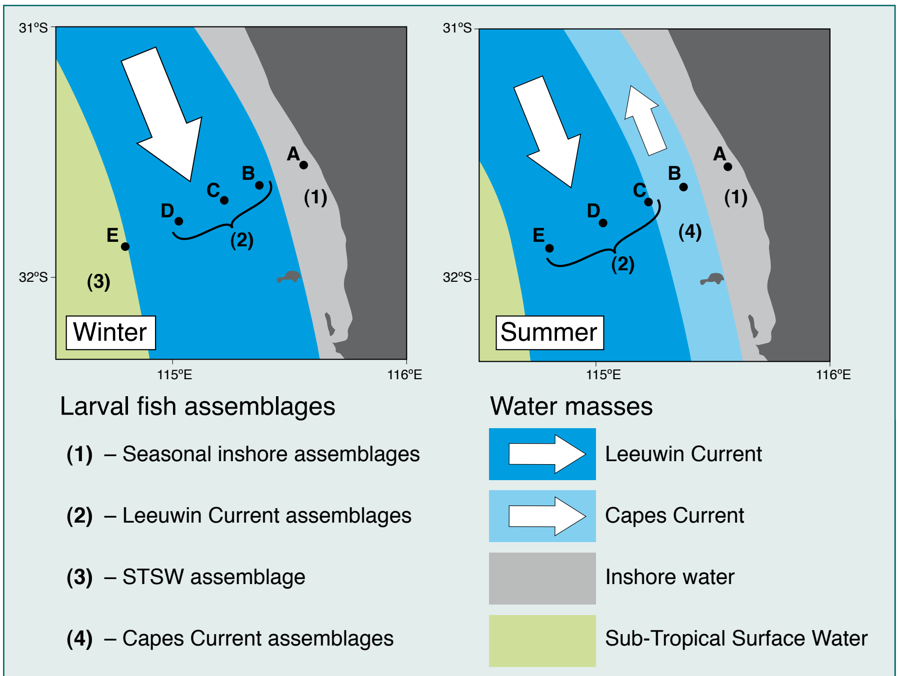
Over the sampling period, more than 24,000 fish larvae were identified from 93 families. These larvae were from inshore fishes, such as gobies (*Gobiidae*) and blennies (*Blenniidae* and *Tripterygiidae*), pelagic species, such as sardine (*Sardinops sagax*) and trevallies (*Carangidae*), and offshore, oceanic families, such as lanternfish (*Myctophidae*) and lightfish (*Phosichthyidae*). Larvae of inshore species were generally found closer to the coast, while larvae of pelagic species dominated continental shelf samples. Offshore samples, over water depths of 300m and 1000m, mostly contained larvae of oceanic and deep-sea species.

A larval silver trevally (*Pseudocaranx dentex*) (Photo: B. Muhling).

However, this assemblage structure was not constant throughout the year. In shallow coastal waters, different larval fish assemblages were found between summer and winter. Seasonal differences in larval fish species found on the continental shelf were also evident.

In winter, the larval fish assemblages from inner continental shelf waters to offshore waters (40m to 1000m depth) were similar, associated with the location of the Leeuwin Current. These assemblages often contained tropical fish larvae, brought southward from areas such as the Abrolhos Islands. During summer, a characteristic larval fish assemblage was found on the inner shelf, in association with the Capes Current. Outer shelf and offshore stations contained Leeuwin Current assemblages. Thus, each water mass had its own distinct, resident larval community, which moved with the movement of the host water masses.

Overall, we found that larval fish assemblages investigated in this study were strongly linked to water masses, which were influenced by the water depth, and the time of year in which samples were taken. The unique oceanography off south-western Australia thus has considerable implications for larval fish transport and survival, and subsequent recruitment to regional fisheries. Overseas, information on larval fish distribution and abundances has been very useful for fisheries management, and as such studies can help to understand why so many fish stocks vary in abundance from year to year. However, our understanding of larval fish in the ocean off Western Australia is just beginning, and there is much work still to be done. ■



Conceptual diagram of the relationship between larval fish assemblage structure in winter and summer oceanographic conditions. The SRFME transect stations, larval fish assemblages, and different water masses are shown.