Chapter 15

The precarious survival of fish larvae and juveniles

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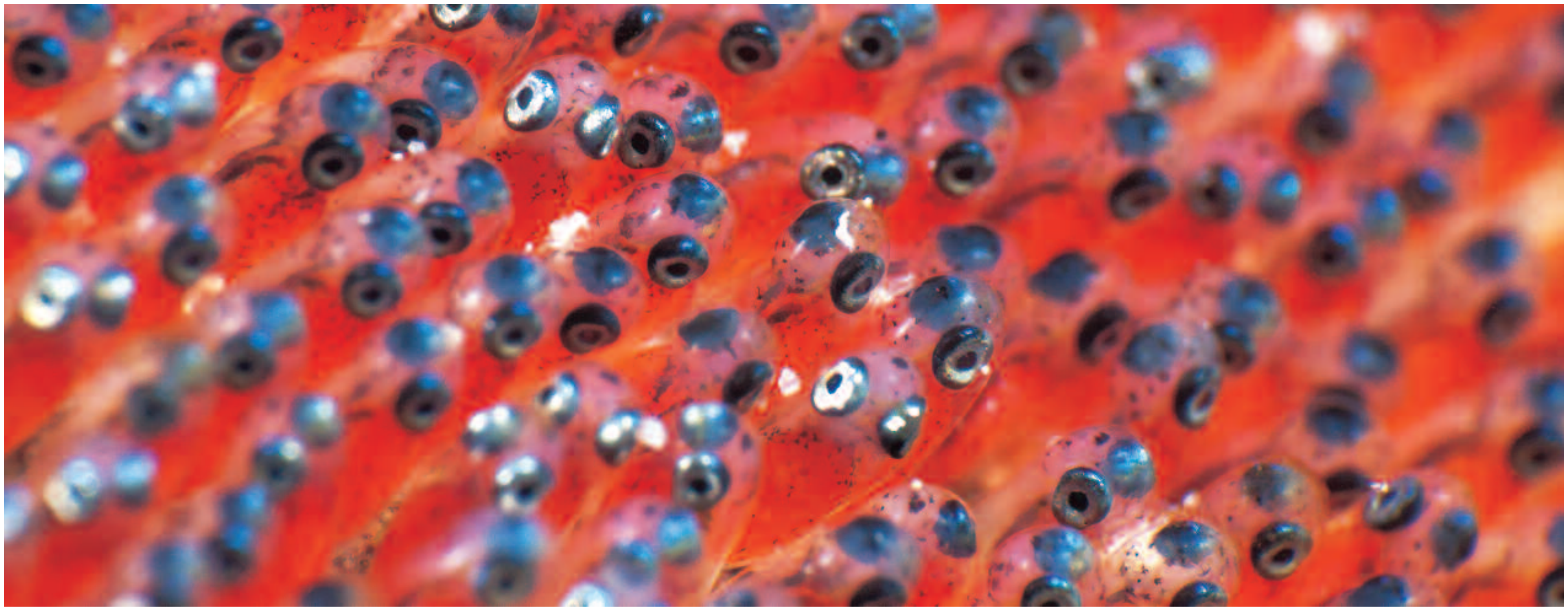


Clown fish eggs. The vitelline reserve is very colourful and the eyes of larvae are clearly visible. © G. Boussarie

Why study the early life stages of fish?

Many reef fish species have a two-stage life cycle characterized by the use of contrasting habitats: a "larval phase", which takes place in open water, followed by a "benthic phase". Once installed near the reef, or on the bottom of the lagoon, larvae become juveniles which, if they survive, will grow to become adult fish. Although few data exist in the literature, it is generally accepted that for the vast majority of species, survival during the larval phase is very low: probably less than 1% of larvae escape predation or disease. As a result, out of several thousand to several hundred thousand eggs, only a few individuals eventually settle on the bottom to grow. Juveniles also suffer a high mortality rate in the very first few days after the installation. This level of mortality has only been assessed for very few species, but is estimated to be about several dozen percent per day. In summary, an "average" young fish has every chance of dying, and only a very small proportion of juveniles reach the adult stage.

Such a demographic "bottleneck" means that the factors influencing the survival of larvae and juveniles largely explain the variation in adult abundance. As suggested more than a century ago by Norwegian researcher Johan Hjort, one of the pioneers in fish larvae ecology: "The main problem that characterizes fisheries science is the description and understanding of the nature of natural fluctuations in stocks" (HJORT, 1914). This quote referred to temperate species, but it is also valid for tropical fish, although there have been very few studies on tropical larval stages. In tropical systems, and particularly in coral reefs, studies on fish larvae and juveniles mainly focus on the installation transition phase, just before, during and just after larvae settle on the bottom.

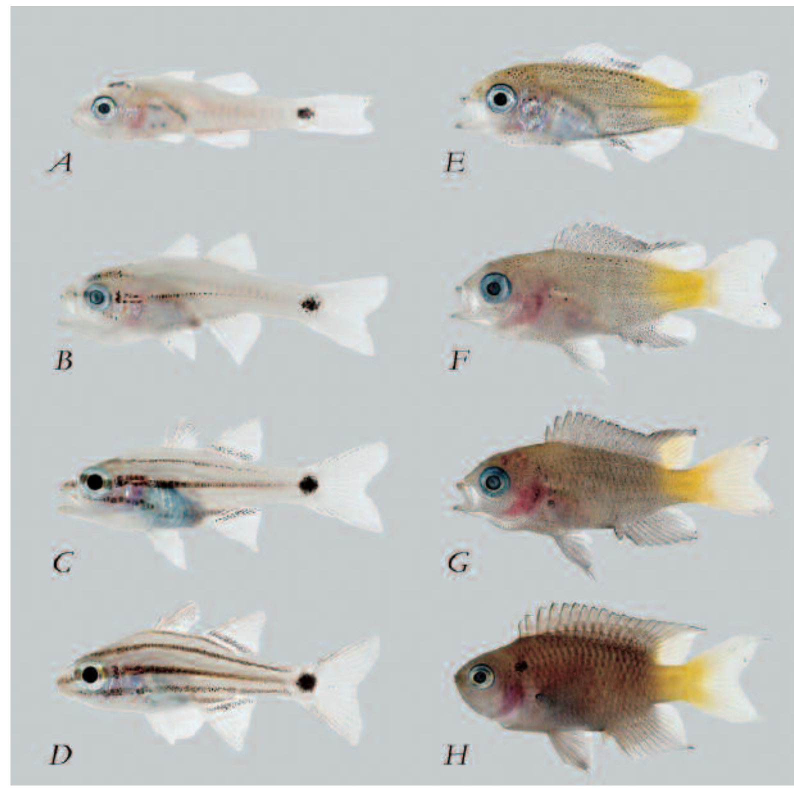
In New Caledonia, our team focused on identifying the environmental factors, zones and favorable periods for the survival of fish larvae during the pre-installation phase (CARASSOU, 2008). We also looked at the growth of juveniles, both during and shortly after their settlement on the bottom (MELLIN, 2007). We were able to demonstrate that the growth of juveniles of different species (survival rates are very dependent on species) was influenced by environmental conditions during the larval phase, as well as the timing and location of installation meaning that larval and juvenile processes are closely linked. However, these early life stages are challenging to study, mainly because of the high species diversity in New Caledonia (over 1,500 reef fish species) which makes identification difficult. To help with these difficulties, we developed methods for the identification of larvae and juveniles of reef fish in New Caledonia.

How to catch them?

Small larvae a few millimeters long are usually caught with very fine mesh nets that are towed behind a boat, or more rarely pushed in front of the boat or beside it. Capturing larger larvae requires larger nets, usually with an opening of several meters, because these faster larvae have better avoidance capacities. At the end of the larval phase, individuals can also be caught with fixed nets as they pass over the reef crest with waves. The larvae of some species are attracted to light and can be captured using light traps and at the time of their installation on the bottom, juveniles can also be caught in artificial reefs made available to them. Older juveniles can be caught in seagrass beds using bottom seines pulled by divers, or in coral colonies in which they shelter, using an anesthetic such as clove oil.

How to identify reef fish larvae and juveniles?

In the reef environment, larvae and even juveniles of most species present very different shapes and colors compared to adults and are seldom described in fish identification books. As a consequence, identifying fish larvae and juveniles is particularly difficult and has considerably hampered research on this subject. Identification guides for fish larvae exist, but either they cover vast geographical areas, and are therefore usually limited to family descriptions, or they cover a few species caught at a particular location only.



Developmental series in two fish species.
A cardinal fish eventually identified as *Ostorhinchus doederleini*.
A: On the day of capture. B: After 7 days of aquarium rearing.
C: After 22 days. D: After 51 days.
A damselfish eventually identified as *Neopomacentrus violascens*. E: On the day of capture.
F: After 7 days of aquarium rearing. G: After 15 days.
H: After 91 days. © IRD/D. Ponton

The most accurate guides are obtained by photographing, or drawing, larvae or juveniles caught in the wild, and then rearing them until they resemble small adults and can be identified by their morphology. This method of identification is long and expensive and cannot be used as a laboratory routine. An alternative and increasingly widespread approach is, therefore, the use of genetic markers such as DNA barcodes (Fig. 1).

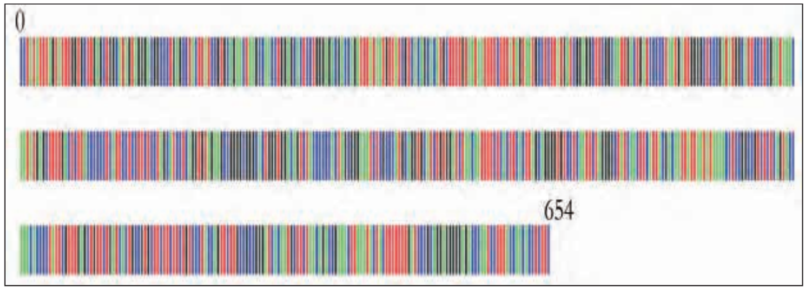


Figure 1: DNA Barcode of a long-nosed emperor *Lethrinus olivaceus*, as represented in the international BOLD database. The four nucleotides that make up the DNA (A, C, G, T) are coded in four different colors. Here, the length of the barcode is 654 nucleotides. Adapted from BOLD (http://v4.boldsystems.org/)

The most common DNA barcode used in fish is the nucleotide sequence of a fragment of mitochondrial gene that encodes an enzyme, which corresponds to the gene of an enzyme in the respiratory metabolism, cytochrome-oxidase 1. The larva's DNA barcode is compared to a DNA barcode database obtained from a collection of adult individuals identified by experts. Each species generally corresponds to a unique barcode, with only a few mutations, due to natural variability between individuals of the same species. In most cases, it is possible to identify larvae by their DNA barcodes alone. However, there are exceptions. For example, closely related species may sometimes share the same DNA barcode following more or less recent hybridization events that allowed mitochondria of one species to colonize the other species.

New Caledonia fish larvae and juveniles

Reef fish larvae and juveniles have a wide range of colors and sometimes extravagant shapes. As mentioned above, it is difficult to identify them with a species based on their external morphology alone. This is particularly true for the large-eye seabreams, long-nosed emperors (individuals 28 to 32) and rabbitfishes (individuals 63 and 64) in which the shape of the body and patterns of spots and colors are very similar from one species to another.

Clear temporal variations and misunderstood interannual variations

Understanding which larvae are present in open water, and their timing, is important in order to anticipate changes in the abundance of juvenile fish in reef environments, as these depend, for example, on the global climatic context or local human population pressures. To this end,

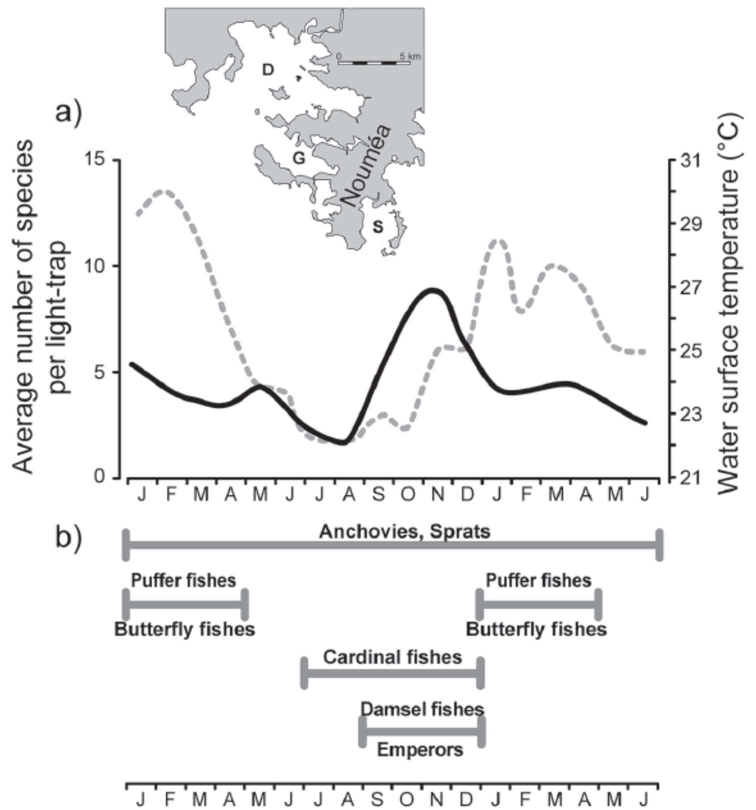


Figure 2: Temporal variation of larvae catches in light traps.
A: Average number of species per trap (black line) in Dumbéa Bay (D), Grande Rade (G) and Sainte-Marie Bay (S) and water surface temperature (dotted grey lines).
B: Periods during which the main families are observed. Adapted from CARASSOU, 2008

Examples of the shape and color diversity observed in reef fish larvae and juveniles of New Caledonia.

01 to 03: Acanthuridae.
04: Antennariidae.
05 to 07: Apogonidae.
08: Balistidae.
09 to 12: Blenniidae.
13: Bothidae.
14: Centriscidae.
15 to 18: Chaetodontidae.
19: Gobiesocidae.
20: Gobiidae.
21: Haemulidae.
22: Hemiramphidae.
23: Holocentridae.
24 to 27: Labridae.
28 to 32: Lethrinidae.
33: Lutjanidae.
34: Microdesmidae.
35 and 36: Monacanthidae.
37 and 38: Mullidae.
39: Ophidiidae.
40: Platycephalidae.
41: Plesiopidae.
42: Poecilopsettidae.
43 and 44: Pomacanthidae.
45 to 54: Pomacentridae.
55 to 57: Scaridae.
58: Scorpeanidae.
59 to 62: Serranidae.
63 and 64: Siganidae.
65: Soleidae.
66: Syngnathidae.
67: Synodontidae.
68 and 69: Tetraodontidae.
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School of juvenile fish sheltered under an overhang. © G. Boussarie

it is important to identify the time of year when larvae of different species colonize the lagoon. In New Caledonia, studies using light traps in bays around Nouméa have indicated that larval diversity is the highest during the austral summer from September to December (Fig. 2, A), but larvae have different preferences according to their family (Fig. 2, B). These studies have only been carried out over an 18-month period between 2002 and 2003 and cannot be generalized because seasonal patterns can vary from one year to the next, depending on climatic conditions, for example. Unfortunately, extending sampling efforts over several years is difficult because it is costly.

Larvae and juveniles: a way to study biodiversity?

An unexpected result obtained during our genetic analyses on the larvae of reef fish in New Caledonia was the presence of previously unknown species in our samples. These included a relatively rare fish, the oblong large-eye seabream Gymnocranius oblongus and a cryptic species of the long-nosed emperor, which has yet to be formally described. This example illustrates the power of molecular techniques for identifying and describing species, and the value of working on larvae for the discovery of previously undetected reef species.

Juvenile sailfin tang (*Zebrasoma veliferum*). © G. Boussarie

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New Caledonia
World of corals

Scientific direction: Claude E. Payri

IRD Editions
French National Research Institute for Sustainable Development, Marseilles, 2018
Editions Solaris

Translation: Lydiane Mattio
Editorial coordination: Claude E. Payri
Page and cover layout : Pierre-Alain Pantz - Editions Solaris
Printing: Winson Press, Singapour

Cover illustrations

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ISBN : 978-2-7099-2677-5

Recommended citation:
Payri, C.E. (dir.), 2018 – New Caledonia: world of corals. IRD Editions/Solaris, Marseilles/Nouméa, 288 pp.