

Ecology of Larval Fishes

period	phase	illustration
EMBRYONIC	cleavage egg	
	embryo	
	elautheroembryo	
LARVAL	prolepterygiolarva	
	pterygiolarva	
JUVENILE	juvenile	
ADULT	adult	
SENESCENT	senescent	

Figure 20-1. Developmental periods in the life of walleye, including specific phases of development used in larval fish descriptions. From Balon (1976).

Larval fish = after absorption of the yolk sac to completion of development

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Figure 20-2. Development of a long finis anchovy, A (2.5 mm) to E (31.0 mm) and short finis hake, F (4.3 mm) to H (11.0 mm). Reprinted with permission from Blaxter (1959).

Why is the ecology of larval fishes important?

- 1) Marine fishes occur in metapopulations (local or subpopulations connected by dispersing larval stages).

Two consequences of larval stage:

- (1) pelagic sources of population variation (mortality and advection)
- (2) open population structure ⇒ open communities

- (2) High rate of mortality (up to 99+%) occurs during the larval phase and this is largely where year-class strength is determined.
- (3) Successful recruitment into a population is dependent on:
 - (a) larval transport or retention, (b) matching spawning and larval development (in time and space) with appropriate oceanographic conditions
- (4) Relatively new development: larval behavior may mediate retention and transport; (example: retention around ocean atolls despite larval period of 2-3 months).

What happens to larvae during the pelagic larval phase?

- (1) growth
- (2) development
- (3) transport or retention to suitable sites
- (4) mortality

Two extremes of a continuum in larval development that relate to how advanced development of larvae are at the time of yolk absorption:

precocial larvae vs. altricial larvae

Precocial -- develop rapidly (more energy available)

Altricial -- poorly developed (less energy available)

Tradeoff -- fewer precocial larvae to greater number of altricial larvae produced per female (fecundity vs. survival)

Table 20-1. Some reproductive characteristics of adult fish that produce larvae that are altricial or precocial at hatching, as well as species examples of fishes across the continuum.

	Altricial			Precocial
Development at hatching	Limited			High
Fecundity of adults	High			Relatively low
Yolk per egg	Low			High
Parental care	None			Variable to much
Breeding types	Pelagic	→ nesting	→ mouthbrooding	Live bearing
Examples	Herring Cod Alewife	Blaugill Trout	Cichlids	Guppy Shark

Precocial larvae:

- usually good predators; have well-developed eyes and mouths, and better swimmers
- less susceptible to starvation after the yolk sac is absorbed

Altricial larvae:

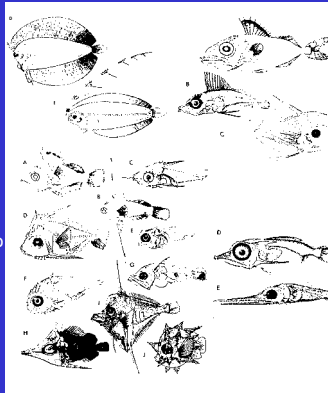
- less developed; simple linear tube as a gut; assimilation efficiency is low (20-30%)
- larvae must consume more prey to get same energy return
- larvae more likely to have high mortality during the critical period because of lesser development at yolk-sac absorption

Body shape

Unusual body shapes are common for fish larvae...

but forces on swimming fishes affect larvae and adults very differently.

Viscosity of water compared to fish length (Reynolds number) is high in larvae compared to adults. Body shape and projections cause them to sink slowly.



Mortality

Source of mortality – starvation and predation)

Hypotheses to explain variability in larval supply:

- Examples from temperate fisheries ecology
- Fishes produce enormous numbers of offspring
- (indiv. \Rightarrow 100's to 1000's)
- Mortality of larvae very high (ca. 99%)

(1) "Critical Stage" Ho (Hjort 1914):

- survival of cohort depends on abundance of food at first feeding
- low food \Rightarrow starvation poor year class
- predicts positive relationship between larval survivorship and food abundance at time of first feeding

(2) “Match-Mismatch” Ho (Cushing):

- extension of Critical Stage Ho
- food production varies in time but timing of spawning and first feeding doesn't.
- timing of feeding \neq timing of food production \Rightarrow starvation \Rightarrow
- poor year class
- if larvae compete, may be density dependent
- predicts positive relationship between larval survivorship and
- match between 1st feeding and production

“Match-Mismatch” Ho (Cushing):

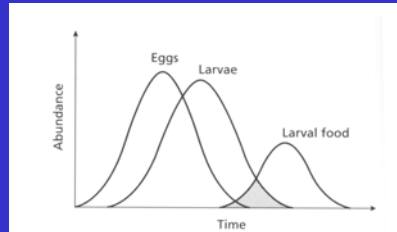


Fig. 4.11 The match-mismatch hypothesis suggests that the timing of larval production in relation to the timing of the production cycle will determine larval survival. The larger the shaded area, the higher survival will be. After Cushing (1982).

(3) “Prey Dispersion” Ho (Lasker 1975):

- threshold prey density for larval survival, density achieved in patches
- oceanic conditions (storms) break up patches \Rightarrow reduce prey density \Rightarrow larvae starve
- predicts larval survivorship negatively related to storm frequency and intensity

(4) “Larval Advection” Ho (Parrish 1976, Nelson 1977, Methot 1983, Sinclair 1985):

- current patterns carry larvae away from areas (e.g., nearshore) of high food availability
- larvae advected offshore \Rightarrow starve \Rightarrow poor year class
- coastal upwelling: Pacific mackerel & northern anchovy (west coast) and menhaden (east coast)
- predicts larval survivorship negatively related to strength of offshore currents / upwelling

(5) “Larval Predation” Ho (Bailey & Houde 1989):

- variation in predator abundance \Rightarrow variation in year class survival
- may be density-independent or density-dependent
- predicts larval survivorship negatively related to predator abundance

(6) “Stage-Duration” Ho (Chambers and Leggett 1987) = “Growth-Mortality” Ho (Ricker & Foerster 1948)

- combined feeding-predation hypothesis
- low food / low temperature \Rightarrow low growth
- small fish more susceptible to predation
- slow growth prolongs period of susceptibility
- predicts larval survivorship related (positively) to growth rate

Movements and Migrations

- **Temporal movements**

Diel cycle (movement within a day)

- diurnal species (active during the day) – most species
- nocturnal species (active at night) -- 1/4 to 1/3 of species
- crepuscular species (active during twilight – dusk and dawn)

Tidal cycle

- foraging movements with the tide

Seasonal cycle

- movement nearshore / offshore

Movements and Migrations

- **Spatial movements**

Movement related to environment or to presence of other fish(es)

Three patterns of space use:

- (1) Movement within well-defined area – fish restricts its ambit or activities to particular area
- (2) Movement not restricted to limited area, nor are their directional movements
- (3) Directional movement – significant directional component (migration)

A fish can display all of these patterns of interaction and movement during its life cycle:

Example: salmon defends feeding territory in stream, migrates to sea where it has less-directional movements in feeding, and migrates back into fresh water for breeding purposes

Movement related to presence of other fish(es)

- **Schooling or grouping behavior:**

- most vertebrates show grouping behavior
- "selfish herd" (schools or groups are artifacts of selfish behavior by individuals, e.g., hiding behind others for protection)
- often occurs with migration
- schooling vs. aggregating

Schooling: about 1/2 known species show schooling behavior

- most common in smaller individuals and individuals of similar size

Advantages: -- lower detection by predators

- predator vigilance (many eyes)
- confusion of predators (too many targets)
- hydrodynamics – energy efficiency (rotation of individuals)

Movement related to presence of other fish(es)

- **Territoriality (= successful defense of an area)**

- most rigid level of space use – to sequester resources
- territories maintained for food, refuges, breeding locations
- resource quality and quantity influences territory size (food)
- territory size influenced by individual density

- **Social hierarchies (= based on agonistic encounters)**

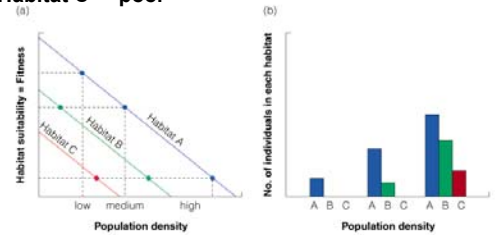
- dominants (alpha individuals) to subordinates
- "first access" to food, mates, other resources
- hierarchy often based on size
- territory size influenced by individual density

Movement related to environment

- Habitat use and selection (preference for area based on environmental cues)
 - choice based on refuge availability, food
 - microhabitat choice – costs and benefits
 - ontogenetic changes in habitat use
 - density-dependent habitat selection (e.g., ideal free distribution)

Ideal free distribution

- Habitat A = good**
- Habitat B = intermediate**
- Habitat C = poor**



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Migration

- Horizontal migration
 - oceanodromous (migration within oceans only)
 - potamodromous (migration entirely within fresh water)
 - diadromous (migration between marine and fresh water habitats)
 - anadromous: spawns in fresh water but spends life in oceans
 - catadromous: spawns in ocean but spends life in fresh water

Basis for migration: fitness benefits and costs of residing at a location changes with stages in the life cycle

Four types of habitats for activities (1) spawning, (2) feeding, (3) unfavorable periods, (4) refuges for young (nursery grounds)

Migration

- Vertical migration
 - following vertical movements of prey
 - behavioral thermoregulation
 - tradeoff between foraging and predator avoidance

Migration allows fishes to maximally use resources that may be separated spatially from each other

Classic example of migration: salmon

- Homing – returning to natal streams

Benefit: allows adaptation to local conditions

Cost: If spawning habitat is degraded or vulnerable, homing can cause lower reproductive success