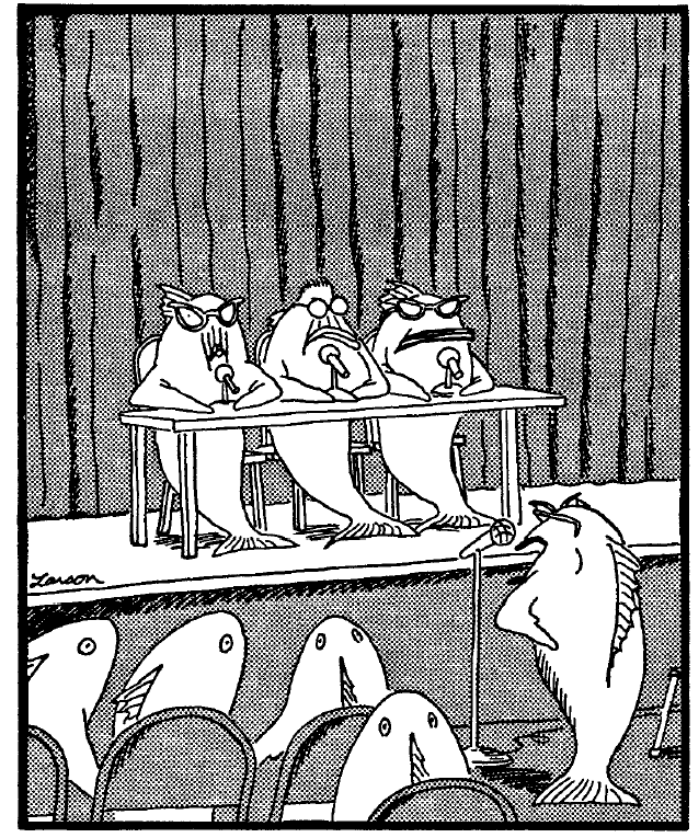
FT 273 - FUNDAMENTALS OF FISHERIES BIOLOGY



The committee to decide whether spawning should be taught in school

9 March 2015 Reproduction

Part I. Fill in the blank (2 points each)

1. Ostracoderms means ___shell skinned____.
2. Osteichthyes means ____bony fish_____.
3. Fish like halibut and skates have a flattened body shape called __depressiform__.
4. Sharks commonly have __placoid___ scales.
5. The swimming style of eel-like fish (snake-like) is called ___anguilliform_____.
6. A fish tail is also called the ___caudal___ fin.
7. A mouth pointed down, as seen in skates and rays, is called ___inferior__ mouth.
8. __Red_ muscle is used by fish for slow continuous swimming (hint: it's a color).
9. _Counter Current Exchange_ is the efficient extraction method that fish use where water flow over the gill goes one way and direction of blood flows the other.
10. The term ___hypoxia_____ means reduced oxygen content of air or a body of water detrimental to aerobic organisms

Part II. TRUE/FALSE (2 points each; circle one)

1.	TRUE	FALSE	Systematics is the study of the evolutionary relationship among organisms.
2.	TRUE	FALSE	Many sharks have paired spiracles on their head that they may use to aerate the gills.
3.	TRUE	FALSE	The bony fishes have evolved light weight and flexible scales in comparison to their ancestors.
4.	TRUE	FALSE	Salmon are anadromous fishes.
5.	TRUE	FALSE	Meristic traits are standard measurement of fish size (length or width) anatomical
6.	TRUE	FALSE	Sharks have a homocercal tail hetercercal
7.	TRUE	FALSE	Ram gill ventilation is a passive form of gill aeration achieved by swimming with the mouth open.
8.	TRUE	FALSE	Fish need oxygen to digest food.
9.	TRUE	FALSE	Body weight is a major factor affecting oxygen consumption rate
10.	TRUE	FALSE	The name of the instrument used to measure respiration in fish is called a respirometer.

Part III. SHORT ANSWER (5 points each)

1. Compare allopatric and sympatric speciation

   Allopatric - causes different selection pressures that when combined with intrinsic factors such as original size and makeup of gene pool of isolated population results in development of genetically distinct populations. GEOGRAPHICALLY SEPARATED

   Sympatric – new species evolve from a single ancestor despite overlap. NOT GEOGRAPHICALLY SEPARATED

2. Provide three alternate strategies (not normal) that fish use for respiration. Provide a brief description of how it works (1 sentence or phrase so I know you can associate it with use).

   Skin Breathers – Diffusion of oxygen through the epidermis. Important in larval fish, Black Bullhead is the only fish that can supply up to 5% of their total oxygen demand, European eels move at night when cooler and usually through wet grass

   Respiratory Trees – Widely spaced lamella allow for terrestrial exposure. Walking catfish

   Mouth Breathers – Greatly reduced gills, most of the oxygen is taken through the mouth at the surface. Electric eels

   Gut Breathers – Swallow water and extract in the stomach. CO_2 dumped at the gills. Tropical catfish

   Lungs/Swimbladders – Have true lungs or breath with a modified swimbladder. Lungfish, Bichirs, Bowfin, Gars

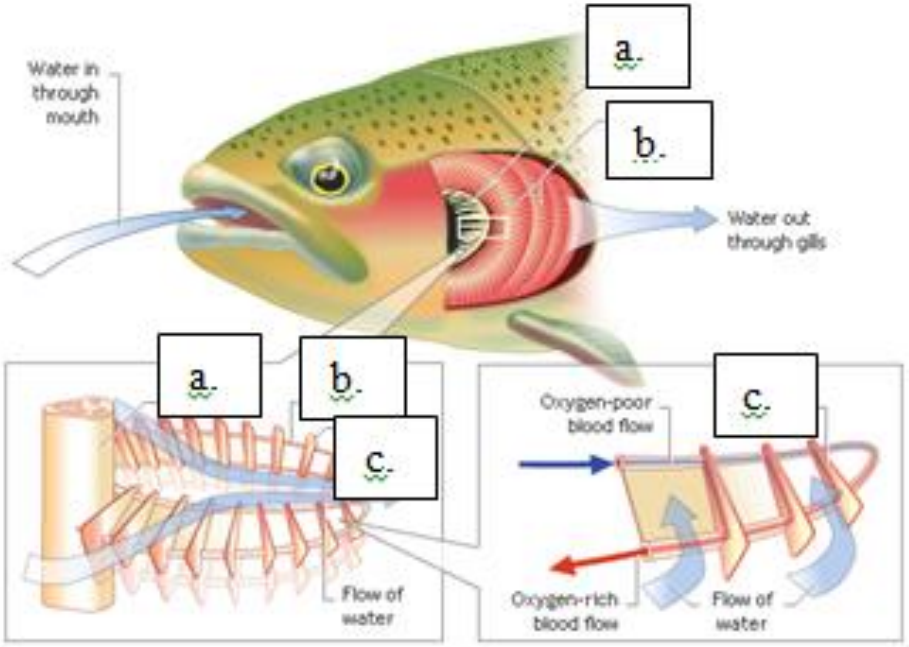
3. What are the two type of fish blood cells and what is the function of each?

Leukocytes – white blood cells, provide ability to clot blood and rid body of foreign material. Several types found in fish blood though less abundant than RBCs.

Erythrocytes – red blood cells, most abundant in fish blood, contain hemoglobin, carry oxygen from the gills to the tissues.

4. List the appropriate parts of the fish gill

a. __gill arch_____
b. __gill filament___
c. ___lamella_____



Part IV. SHORT ESSAYS (20 points each)

1. Fishes have six basic and broad defining body shapes. List the six shapes; include what they are and what the defining characteristics are of each shape and give an example of a fish with this shape.

Rover-predator – classic fish –fusiform, pointy headed terminal mouth, evenly distributed fins, narrow caudal peduncle, capture prey by pursuit – bass, tuna, mackerel, salmon

Ambush-predators – torpedo streamlined, flattened head to present narrow profile, large mouth, prominent teeth, cryptic coloration, large caudal fin, fins set back on body in a row, secretive, lunging – pike, gar, barracuda, needlefish

Surface-oriented fish – usually small, upward, superior mouth position, dorsovent flat head, large eyes, dorsal fin toward rear of body – feed in surface waters – flyingfish killifish, mosquitofishes

Deep bodied fish – wider than long, dorsal and anal fins long, pec fins high on body,some fins w/ sharp spines, mouth small and protrusible, eyes large, snout short - bluegill

Eel and eel like fish – elongate bodies, blunt wedge shaped heads, crevice and hole dweller, macro beds, anal and dorsal fins may run into caudal fin

Bottom feedeing fishes – no or reduced swim bladder, flattened dorsoventrally, variety of feeding habits

2. Describe the fish circulatory system and how air travels from the water to the tissues. (Don't forget to mention type of heart, type of blood pigment, oxygen affinity, etc.)

Fish have a two chamber heart and a closed circulatory system.
Fish blood is composed of plasma, Erythrocytes (RBCs) and Leucocytes (WBCs).
When a fish opens its mouth oxygenated water is extracted at the gills.
As the flow of blood in the lamella is in the opposite direction of the flow water, oxygen is extracted via counter-current-exchange.
The Erythrocytes contain hemoglobin which have a high oxygen affinity and can bind four molecules.
As blood flows in though the body and as tissues produce CO_2 as part of metabolism, the oxygen molecules are driven off of the hemoglobin.
The oxygen in the plasma transfers to the tissues while the CO_2 is carried in the blood back to the gills where it is released.

TOPICS WE WILL COVER REGARDING REPRODUCTION

Reproductive anatomy

Breeding behavior

Development

Physiological adaptations

Bioenergetics

Mating systems

Alternative reproductive strategies

Sex change

REPRODUCTION OVERVIEW

Reproduction is a defining feature of a species and it is evident in anatomical, behavioral, physiological and energetic adaptations

Success of a species depends on ability of fish to be able to reproduce in an ever changing environment

REPRODUCTION TERMS

Fecundity – Number of eggs in the ovaries of the female. This is most common measure to reproductive potential.

Dimorphism – differences in size or body shape between males and females

Dichromatism – differences in color between males and females

Bioenergetics – the balance of energy between growth, reproduction and metabolism

REPRODUCTIVE ANATOMY

Different between sexes

Different depending on the age/ size of the fish

May only be able to determine by internal examination

Reproductive tissues are commonly paired structures closely assoc with kidneys

FEMALE OVARIES (30 TO 70%)

MALE TESTES (12% OR <)

Anatomy

hagfish, lamprey: single gonads

no ducts; release gametes into body cavity

sharks: paired gonads

internal fertilization

sperm emitted through cloaca, along grooves in claspers

chimaeras, bony fishes: paired gonads

external and internal fertilization

sperm released through separate opening

most teleosts:

ova maintained in continuous sac from ovary to oviduct

exceptions: Salmonidae, Anguillidae, Galaxidae, non-teleosts

- these release eggs into body cavity when ripe

Anatomy

in general:

gametes produced only during spawning season
gonads reduced during non-reproductive season

Timing and location of spawning

strategy:

avoid competition for spawning habitat
maximize access to food for offspring
minimize access to offspring by predators

SPERM DISPERSAL

- different means of dispersing sperm found in fish, despite very similarly structured reproductive organs
- lampreys, hagfish salmon shed sperm directly into body cavity where it is expelled through abdominal pore(s)
- in Chondrichthyes sperm passes through duct shared with kidney and may be stored in seminal vesicle before being expelled
- Teleosts have separate sperm ducts

BREAK 1

EXTERNAL DIFFERENCES B/T MALES AND FEMALES

Size or shape

Color

Body structures

Mating structures

Behavior

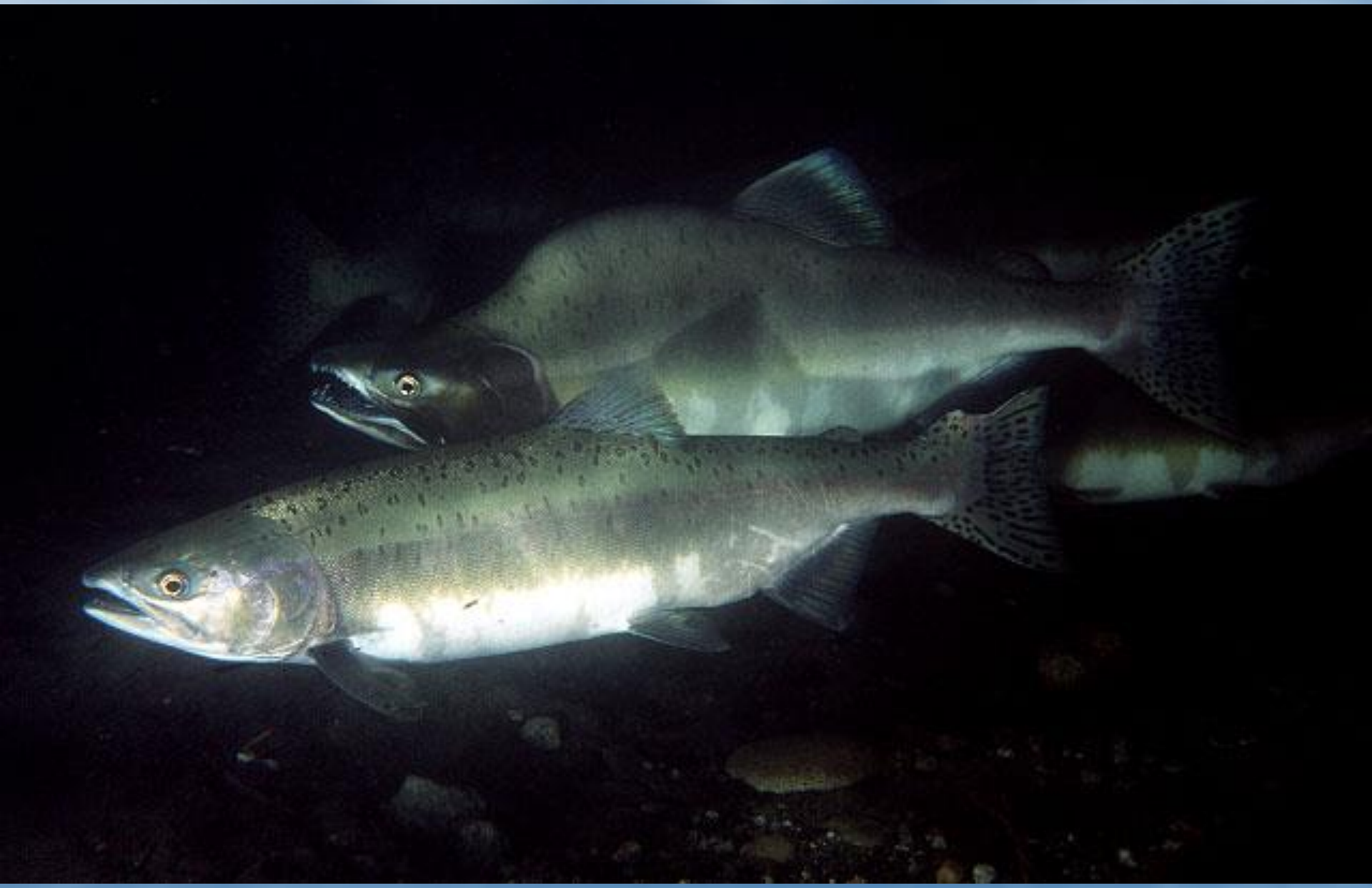
SEXUAL DIMORPHISM/DICHROMATISM

(wrasse – male
(initial phase)

wrasse – male
(terminal phase)


ARKive
www.arkive.org
© Jane Burton / natur

cichlids (male is yellow fish)



dolphin(fish)

- male

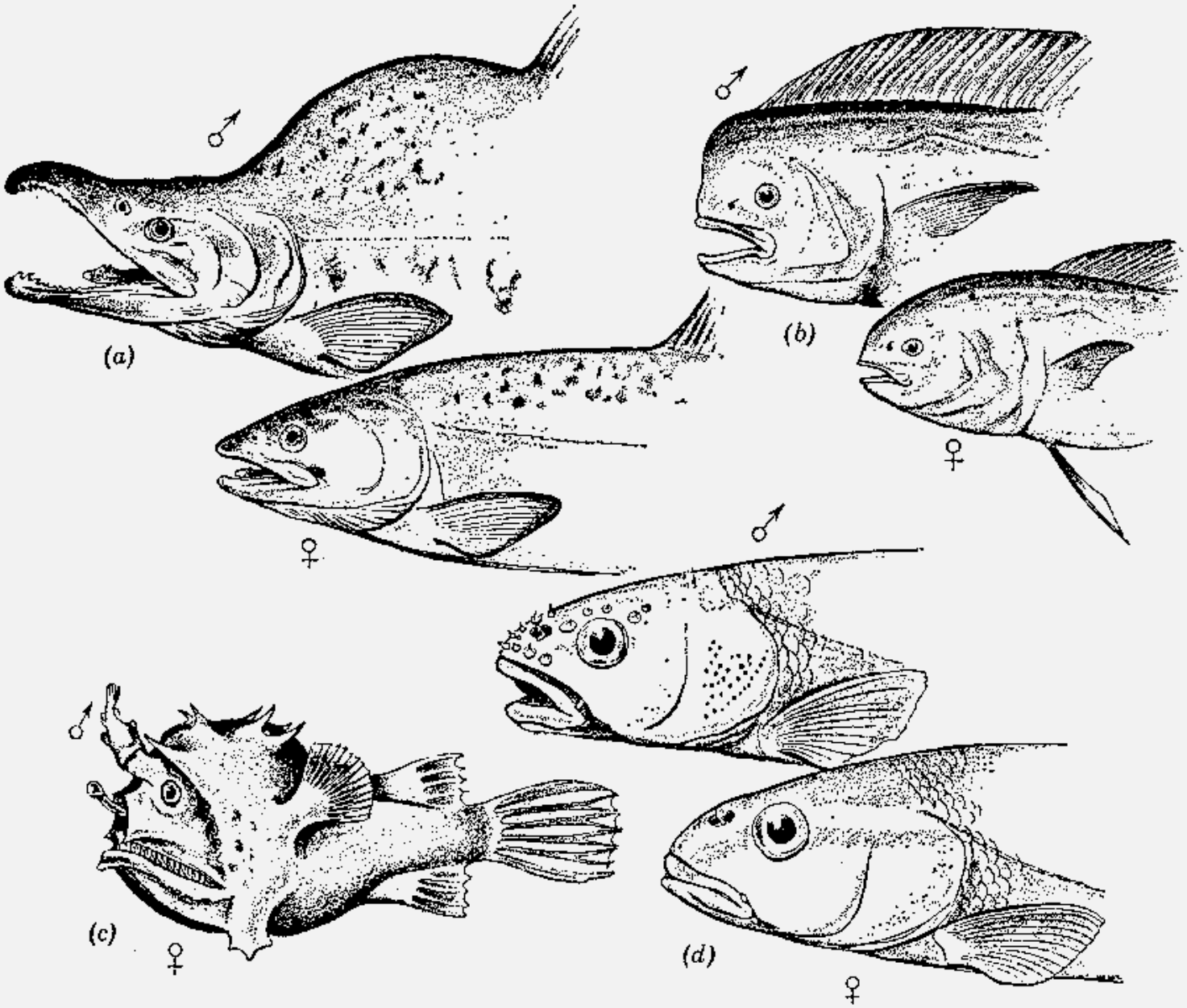
female

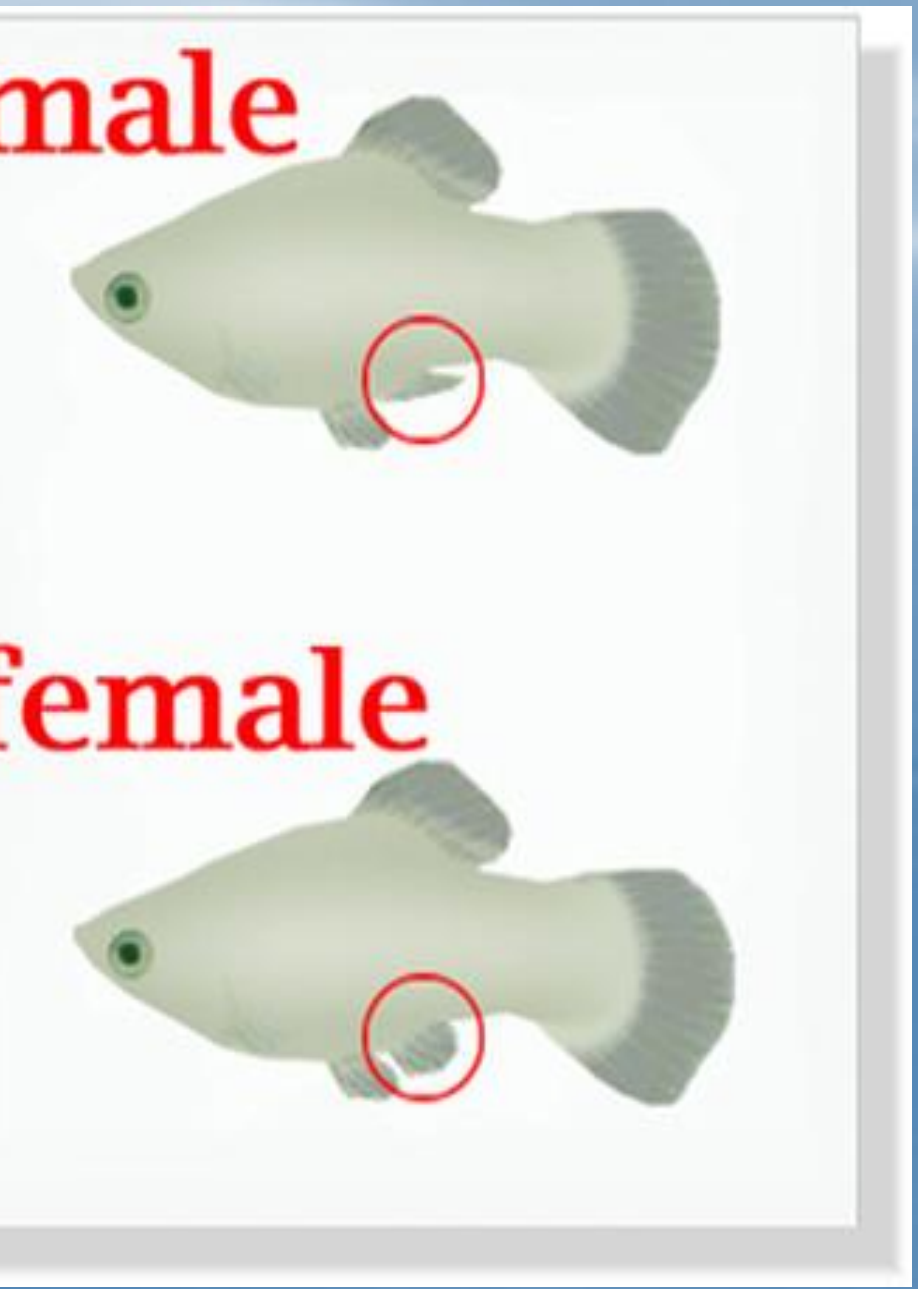
cichlid

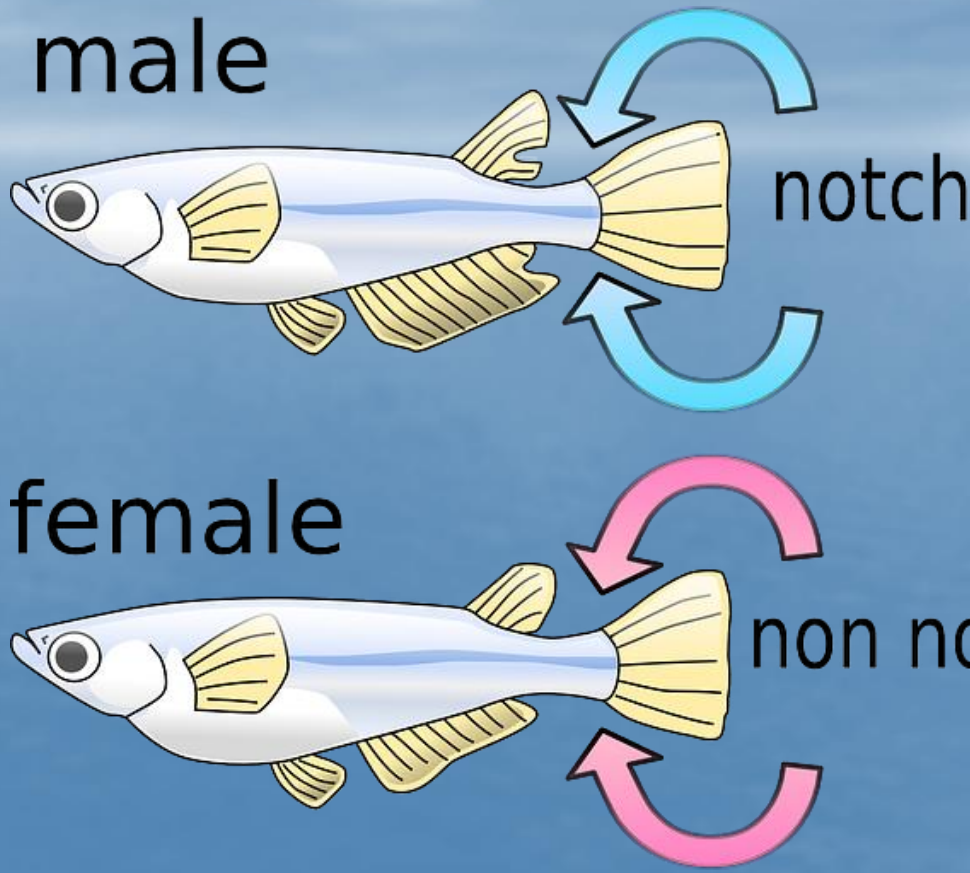
- male

female

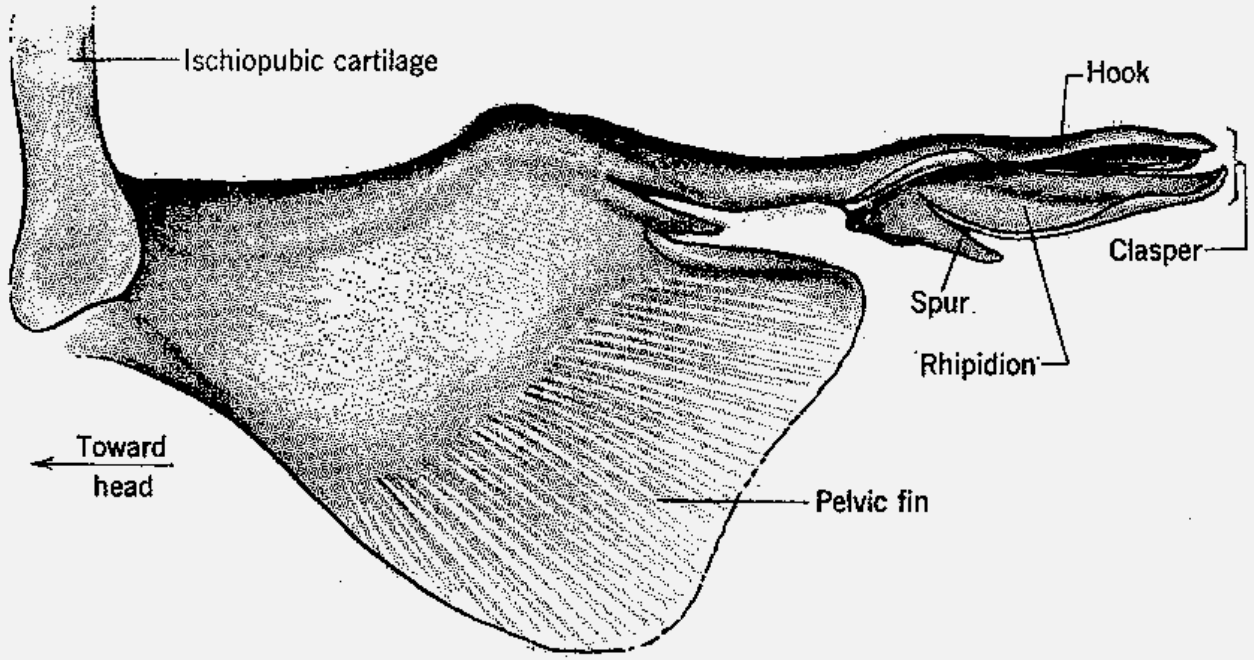
SEXUAL DIMORPHISM



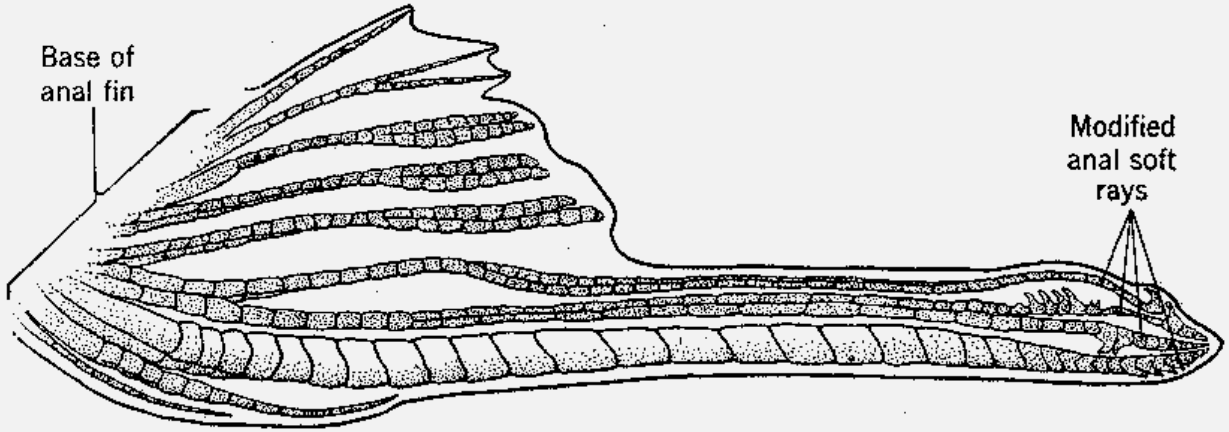

male
female


male
notch
female
non no

INTROMITTENT ORGANS



(a) Shark clasper (myxoptergium)



(b) Gambusia gonopodium

BREEDING BEHAVIOR

large array of behaviors exhibited as related to reproduction

reflects evolutionary heritage as well as environment in which fish live

BREAK 2

Three main classifications –

- Non-guarders
  - Open substrate spawners
    - Pelagic spawners
    - Benthic bottom spawners
  - Brood hiders
- Guarders
  - Substrate spawners
  - Nest Spawners
- Bearers
  - Internal
  - External

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NONGUARDERS

Do not protect eggs or young once spawning is finished

Two groups:

- Open substrate spawners
  - Pelagic spawners – tuna, sardines
  - Benthic bottom spawners – carp, pikes
- Brood hiders (salmon and trout, for example)

OPEN SUBSTRATE SPAWNERS

Spawn in groups without elaborate courtship behavior or specialized reproductive structures

Hard to describe this behavior because all that is seen is big swirling mass of fish

PELAGIC SPAWNING

Widely dispersed

High mortality

Latitudinal gradients

PELAGIC SPAWNERS

BENTHIC SPAWNERS

Usually lack elaborate courtship rituals

In spawning one female may be followed closely by several males – they fertilize eggs as they are released

Eggs and embryos stick to surfaces laid upon – take in water and expand enough to wedge themselves into a place

Free floating embryos and larvae of these fishes may be pelagic or benthic

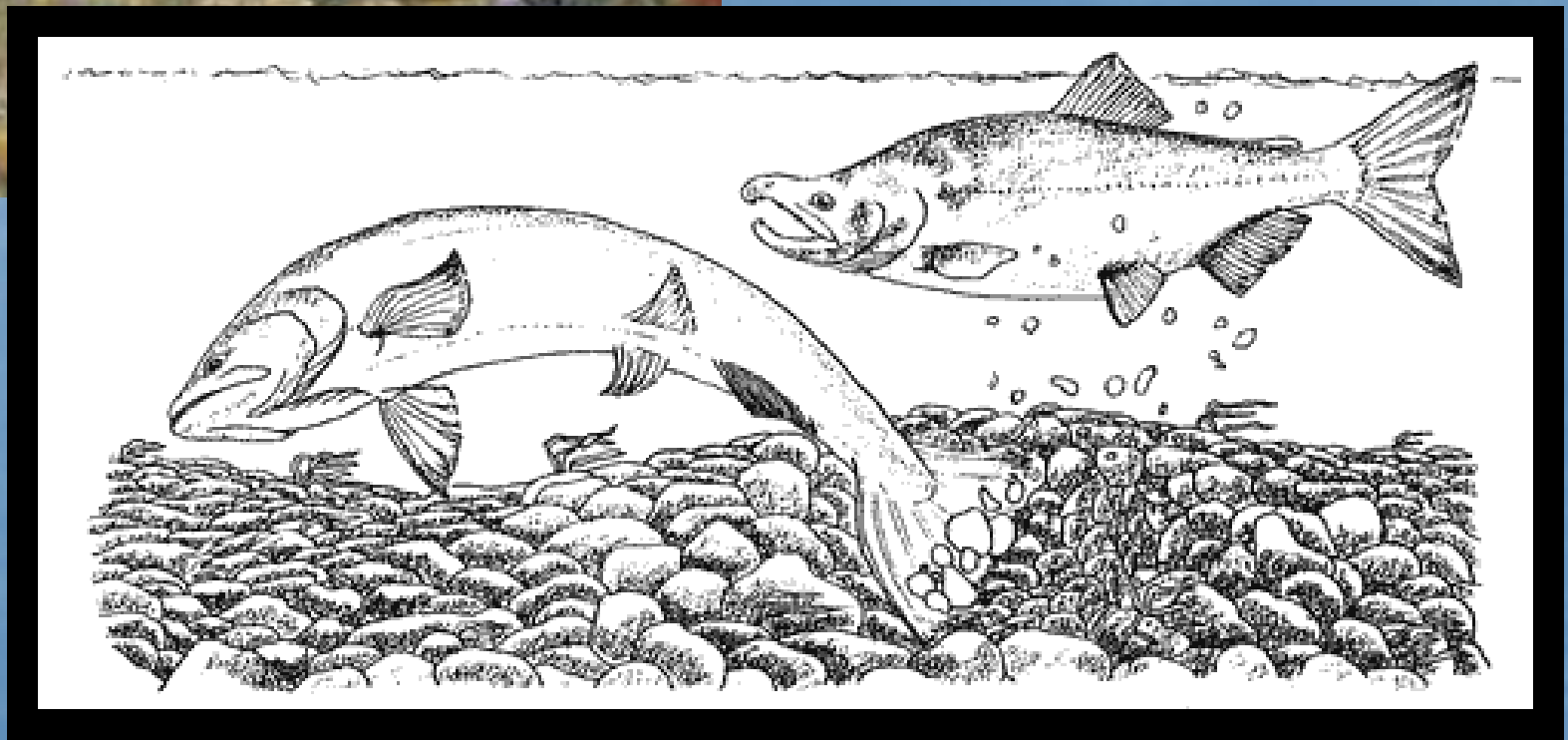
BENTHIC FISH ARE ALSO PELAGIC SPAWNERS…

BROOD HIDERS

Egg hiders with no care beyond spawning

Females of salmon and trout dig nests (redds) with their tails

Once eggs are laid, fertilized and buried, the nest is abandoned



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GUARDERS

Best the brood hiders by **guarding the embryos** until hatching and sometimes through larval stage

Location specific

Males

- protect against predators,
- maintain high oxygen levels to embryos by fanning water across them,
- clean the embryos of dead ones and debris

SUBSTRATE SPAWNERS

Clean off a suitable surface for eggs

NEST SPAWNERS

construct a spawning structure and guard embryos

most common substrate is gravel and rock

young are also often defended in nest and in some this protection extends beyond the nest where parents herd schools of young around and defend them

- Rock and gravel nesters
- Sand nesters
- Plant-material nesters
  - Gluemakers
  - Nongluemakers
- Bubble nesters
- Hole nesters
- Misc-materials nesters
- Anemone nesters

ANEMONE FISH NESTING IN AN ANEMONE

PARADISE FISH UNDER A BUBBLE NEST

ATKA MACKEREL NESTING BEHAVIOR, ALASKA

Three main classifications –

- Non-guarders
  - Open substrate spawners
    - Pelagic spawners
    - Benthic bottom spawners
  - Brood hiders
- Guarders
  - Substrate spawners
  - Nest Spawners
- Bearers
  - Internal
  - External

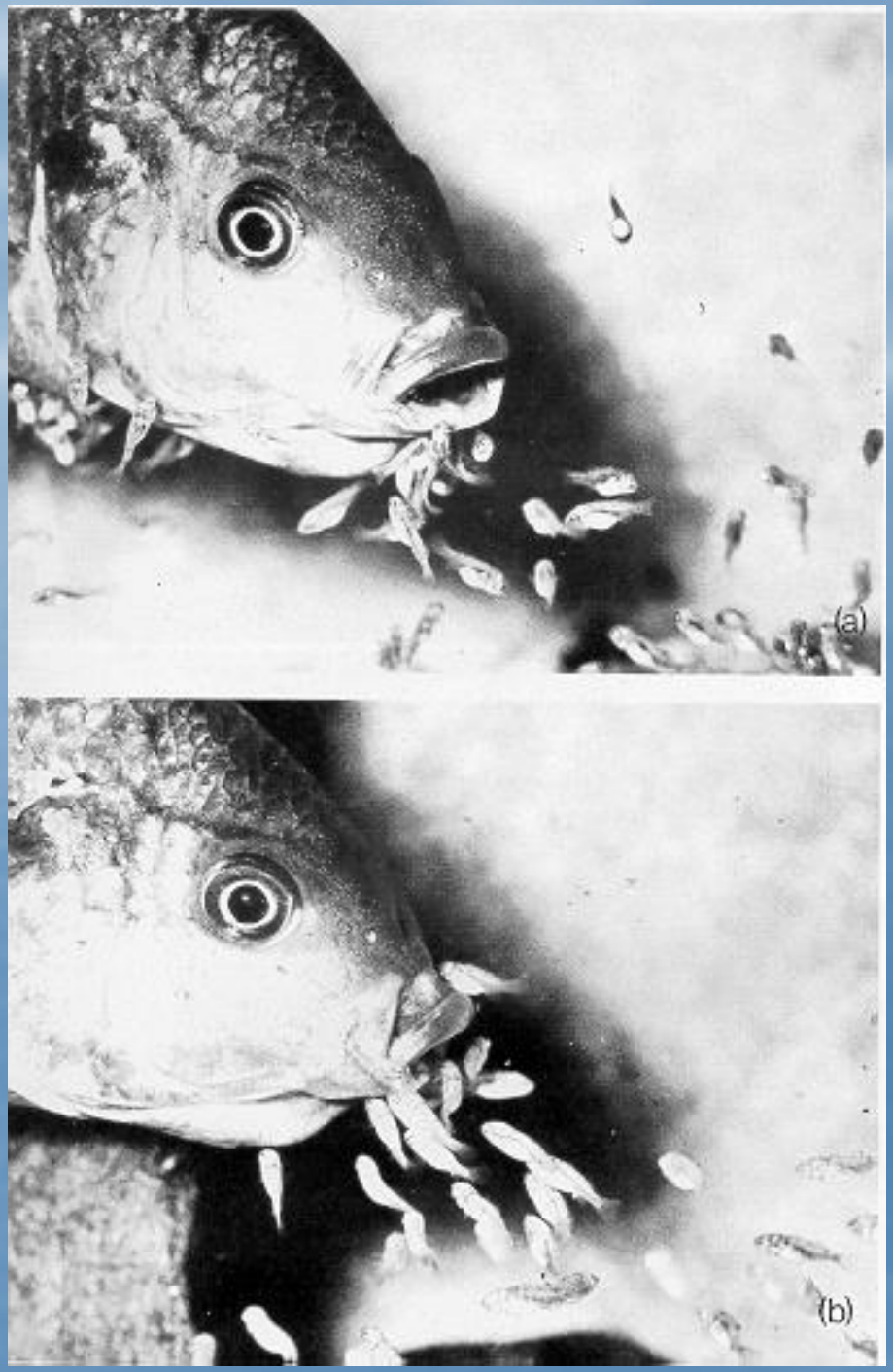
BEARERS

Internal

External

BEARERS – SEAHORSES AND PIPEFISHES

MOUTH BROODERS


(a)
(b)

Jawfishes

Family Opistognathidae

A male Yellowhead Jawfish churns his mouthful of eggs

Yellowhead Jawfish

Opistognathus aurifrons

Passionate courtship displays, male mouthbrooding and burrow-building are a few of the delightful behaviors that make jawfishes so fascinating to observe. Typically, the rather small, elongate, blunt-headed fishes with great bulging eyes and large mouths inhabit sand plains, where they construct rock-lined burrows in the seafloor.

Of the eight species that inhabit the region's waters, the Yellowhead Jawfish is by far the most commonly sighted. These pearly, three- to four-inch fairylike fish with bluish fins and yellowish heads spend nearly all of their day plucking zooplankton from the current just above their burrow entrances. Colonies, which normally consist of two to ten individuals, are found on sand aprons encircling coral and rock reefs at depths from five to more than 150 feet. The association with reef structures insures an abundance of coral, rock and shell rubble essential for the construction of their masterfully built burrows.

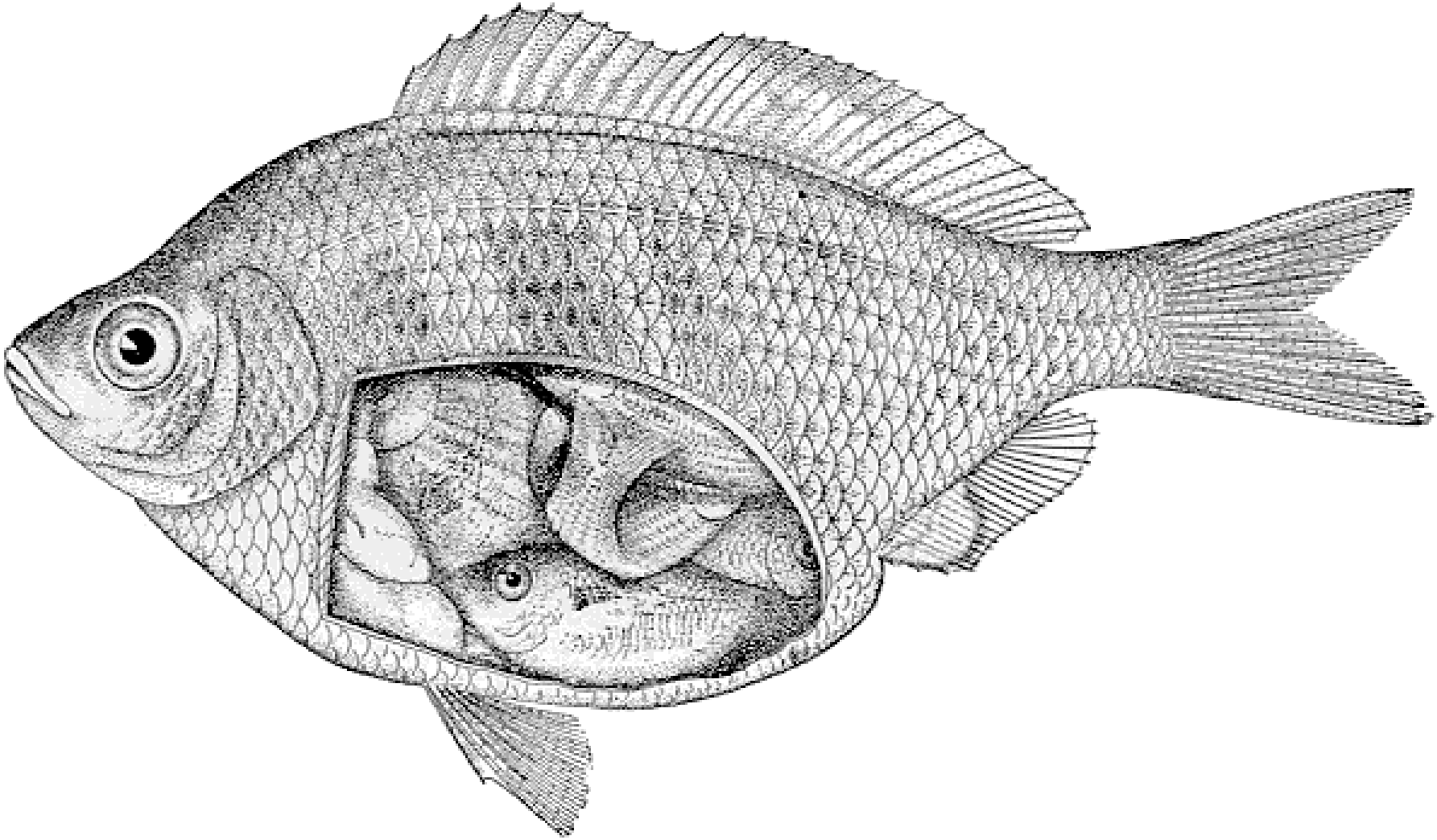
Yellowheads usually allow divers to approach within five or six feet before dropping close to their burrow entrances or slipping inside tail first. Most reappear within a minute or two and cautiously begin feeding once again. If you

Right: *Males mouthbrood clutches of eggs for five to seven days.*

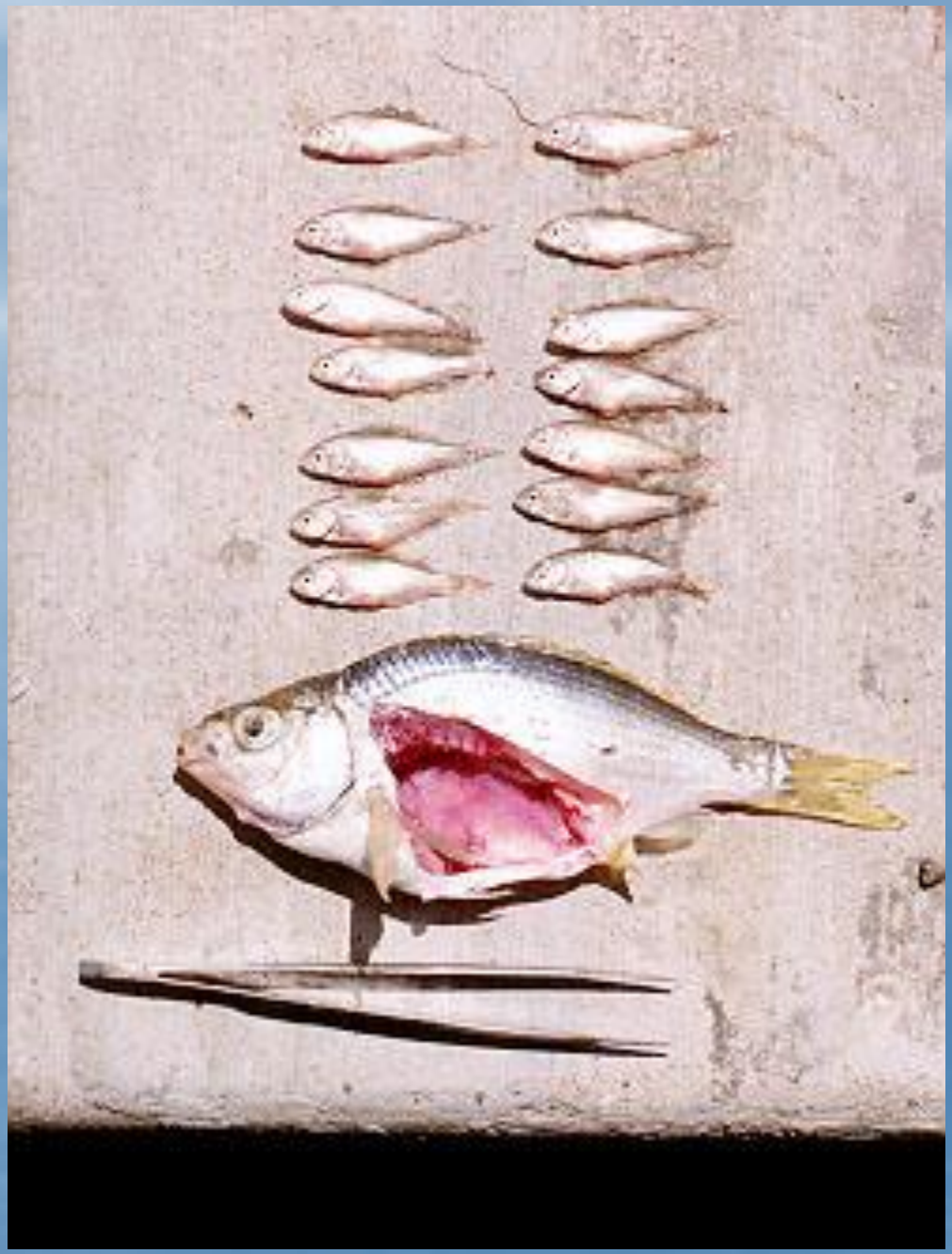
INTERNAL BEARERS

Similar to pouch brooding except fertilization is internal and female always carries embryos and/or young

Produce small number of large active young – all sharks and rays use this method; few bony fish families do



surfperch - female



BREAK 3

MODES OF REPRODUCTION

- OVIPAROUS – egg laying
- OVOVIVIPARITY – embryos are retained, but have individual yolks
- VIVIPARITY – embryos are retained, but young fed by a placenta from mother

EGGS OR LIVEBORN YOUNG?

	Oviparity	Viviparity
Literally means	Ovum = egg, parus = bearing	Vivus = living, parus = bearing
Description	Eggs released by mother, embryos develop outside mother's body, nourished by egg yolk	Embryo develops in mother, born as young. Mode of nutrition varies
Benefits	Reduced energy use in care of young Yolk provides good nutrient source	More likely for offspring to survive to birth
Drawbacks	Eggs may need to be incubated Less chance of survival to birth due to eg. Eggs desiccating, predators, poor environment	Energy expenditure for female carrying offspring
Examples	Birds, sharks, reptiles, monotremes	Humans, some snake species, most mammals

PARENTAL CARE OR NOT?

	No parental care	Care of laid eggs	Care of young
What is it?	No contact with offspring after eggs are laid	Guarding and/or incubating eggs to hatching	Care of young after hatching/birth
Benefits	Free to mate more No energy expenditure	Eggs have protection from predators/ harsh conditions	High chance of offspring survival
Drawbacks	High levels of mortality	Energy expenditure Some mortality after hatching	Very high levels of energy expenditure – may not be able to mate for many years after offspring birth
Examples	Reef fish, frogs, turtles	Seahorse, diamond python, cephalopods (eg. Octopus, squid), spiders	Humans, primates. Mammals (milk), emperor penguins, emus

SHARK/RAY REPRODUCTION

Fertilization Methods

external - most common

- great fecundity
- less time, energy, and risk
- higher potential # of mates
  - no or little selectivity

internal (~ iteroparous sp.)

- lower fecundity
- more time, energy, and risk
  - courtship, bonding, etc.
- mate selectivity (quality)
- some mate guarantee

Mating Systems

- promiscuous - most common
  - multiple partners (both ♀♂)
- polygynous (more common)
  - ♂ > 1 partner (or harems)
- polyandrous (much less common)
  - ♀ > 1 partner (some 'leks')
- monogamous (rare)
  - *single mating pair*
    - each reprod. or lifetime
  - *parasitic* (also be polyandry?)
    - male(s) attaches to female

triggerfish

- ♀ ‘lek’

butterflyfishes

- strong & lengthy monogamy

- from Masuda et al. (1984) (Dr. J. McEachran – Texas A&M)

What's Love Got to Do With It? The Truth About Seahorse Monogamy

Written By: Tami Weiss | Date Posted: 10/04/2010 | 7 Comments |

- male (parasitic)

Peter David/ Planet Earth Pictures

HOW MANY, AND HOW OFTEN?

	r Selection (aka. Quick-and-many)	K selection (aka. Slower and fewer)
Age of maturation	Young – usually before the next breeding season	Older – usually many seasons after birth
Number of offspring	Many	Few
Frequency of breeding	Usually frequently (many times a season) – high fecundity = many eggs produced per breeding season	Generally once a season. Low fecundity
Size of offspring	Usually small	Generally larger
Mortality rates	High – many offspring do not live to sexual maturity	Low – offspring generally survive
Examples of species	Mice, rabbits, most insects, cane toads, octopus, mass spawning organisms	Humpback whales, elephants, humans, some birds

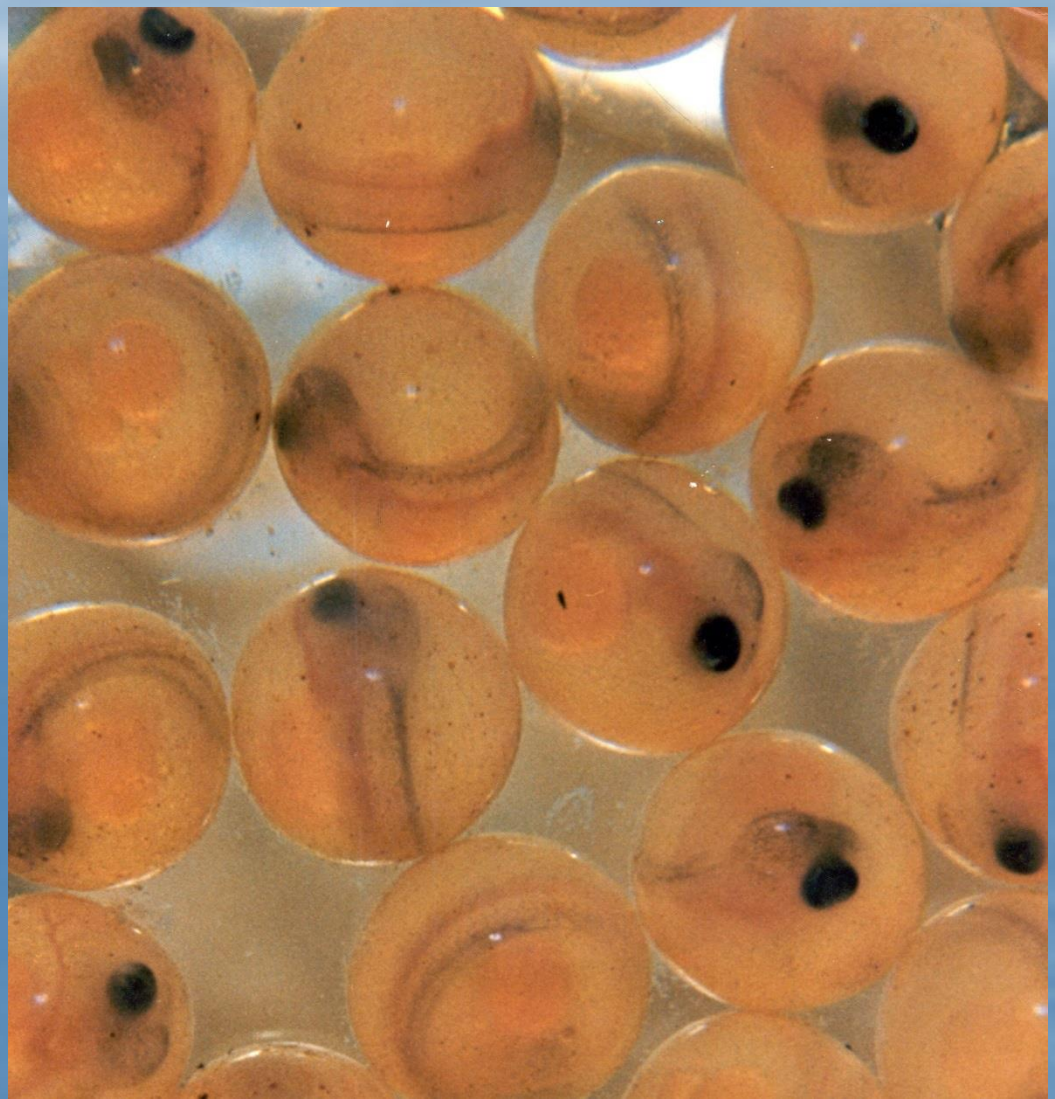
DEVELOPMENT STAGES

5 major development periods:

- embryonic
- larval
- juvenile
- adult
- senescent

EMBRYONIC PERIOD

Period during which young is entirely dependent on nutrition provided by mother – either from yolk or placenta or compromise b/two



LARVAL PERIOD

- Appearance of ability to capture food
- Special larval structures related to resp and other functions may also develop
- Ends when axial skeleton formed and embryonic median fanfold is gone

JUVENILE PERIOD

Period begins when organ systems fully formed

Fully formed fins present

Miniature adults in appearance

Period lasts until gonads fully formed – period of most rapid growth in life of fish

ADULT PERIOD

Once gonads mature fish is considered an adult

Onset of this period is indicated by spawning behavior, development of reproductive structures and color patterns

SENESCENT PERIOD

Few fish reach this old age stage when growth is nearly stopped and gonads degenerate

Period may last from years in sturgeon – to days in Pacific salmon

indirect development (perch)

- larval stages go through trophic phases different from adults

intermediate (salmonids)

- embryonic stage with yolk; virtually no larval stage

direct development (gobies)

- juvenile is fully functional miniature of adults (no larval stage)

PHYSIOLOGICAL ADAPTATIONS

Environmental conditions favoring survival of offspring critical to reproductive success

Thus reproductive cycles of fishes are closely related to environmental changes – particularly seasonal changes in light and temp

BIOENERGETICS

Life history strategies seen as mechanisms to balance energy put into reproduction with that of growth and metabolism (bioenergetics)

The amount of energy invested in various stages of reproduction varies among and even within fish species

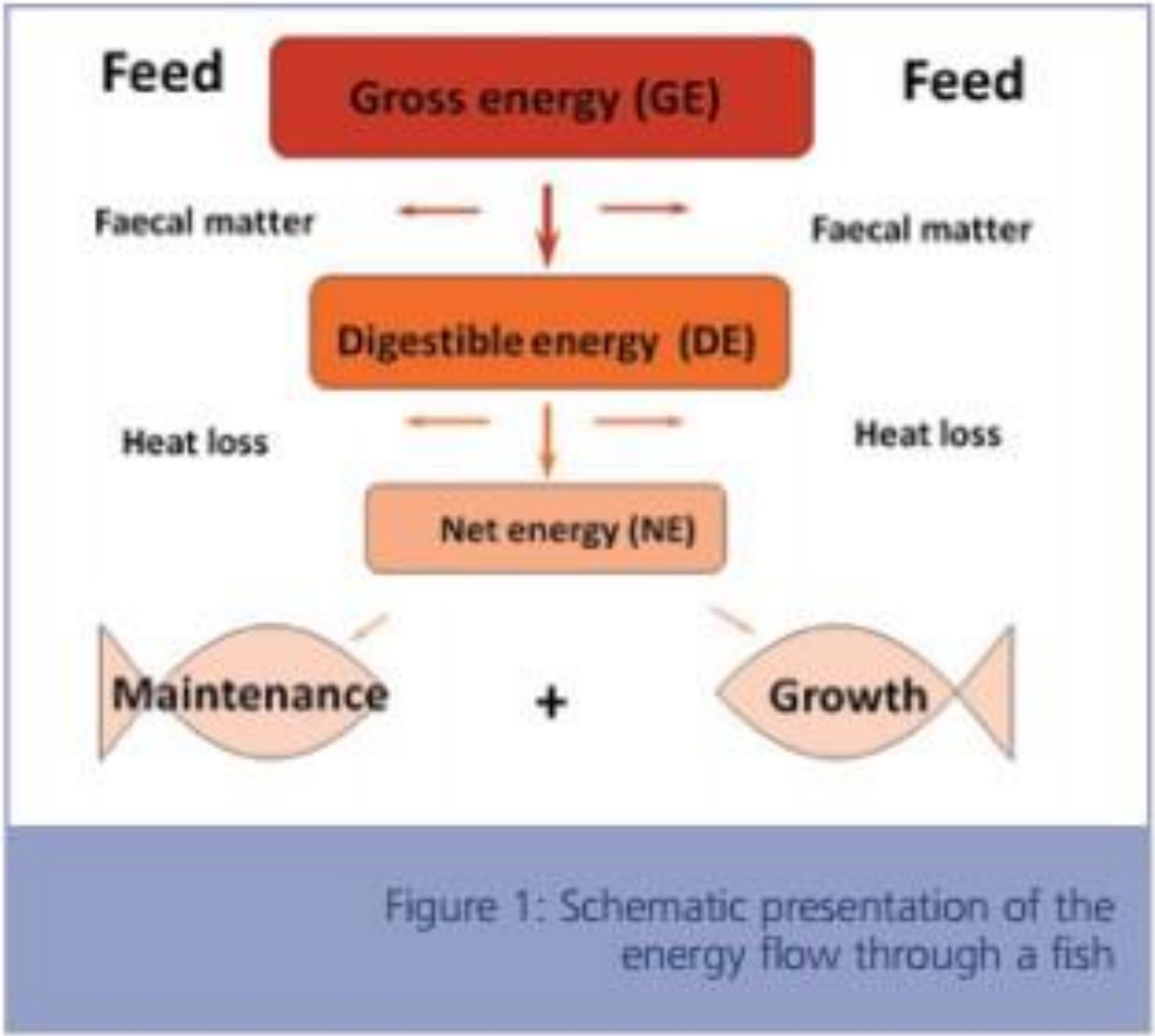


Figure 1: Schematic presentation of the energy flow through a fish

FACTORS CONTRIBUTE TO THIS VARIATION

1. age of onset of reproduction
2. reproductive effort
3. fecundity
4. survivorship rates
5. frequency of reproduction

1. AGE OF ONSET OF REPRODUCTION

Varies with sex

Males typically mature at smaller sizes and younger ages than do females

For both sexes age at first reproduction depends on condition of environment as well as nature of population itself

2. REPRODUCTIVE EFFORT:

Measure of amount of E or time invested in production of offspring

Size of gonads compared to rest of body size is measurable index of this.

As ovaries larger than testes, believed F put more E into reproduction than do males

Females are more careful in choice of mates due to higher E involved in reproduction for them

3. FECUNDITY

Fecundity is the number of eggs in ovaries of female fish (most commonly used)

Fertility is actual number of offspring produced rather than number of eggs

4. SURVIVORSHIP

Inversely related to fecundity

Fishes w/high fecund have high death rates – especially in free embryo to larval stages – characteristic of many pelagic fishes of commercial importance

Viviparous fishes produce fewer larger offspring that have higher survival rates

Page 159 (advantages paragraph)

5. FREQUENCY OF REPRODUCTION

Many offspring per event

No of offspring

Few offspring per event

One reproductive event

No of events

Many reproductive events

Semelparous

Iteroparous

ALTERNATIVE REPRODUCTIVE STRATEGIES

ALTERNATIVE MALE STRATEGIES

HERMAPHRODITISM

UNISEXUALITY

Alternative reproductive strategies

Alternative male strategies

- jacks (salmon and trout)

- sneakers ("SF"s) in bluegills, wrasses, sunfishes
  evolutionarily stable strategy - if small, become SF, avoid stress of being parental male

- satellite males (mimic females) in bluegills, hover near nest

HERMAPHRODITISM

Individual can be male or female

Synchronous

Sequential

- Protogyny – female then male
- Protandry – male then female

UNISEXUALITY

Parthenogenesis – female produce only female offspring with no involvement from males – Texas silverside

Mexican mollies complex exhibits all female populations in which males are required for egg development (gynogenesis)

Hybridogenesis requires female and male to mate but in meiosis the male chromosomes are lost and only female genes passed on to next generation

SEX CHANGE IN FISH

Occurs mainly when one sex has higher survival and reproductive rates

In some fish sex change is reversible

Some sex change is environmentally determined

Pollution research is indicating pollutants can cause sex changes in fish by disrupting endocrine cycles

ANEMONE FISH