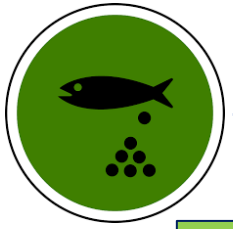
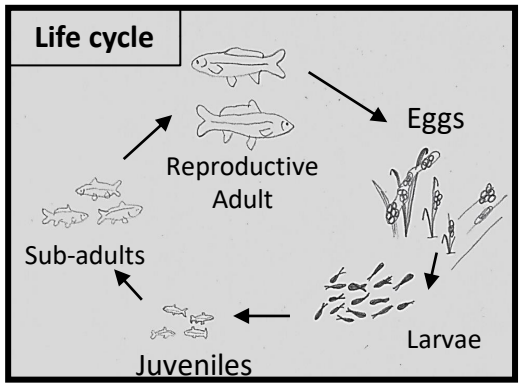
Understanding ecology is important for defining management objectives

Life Cycles

Spawning behaviour

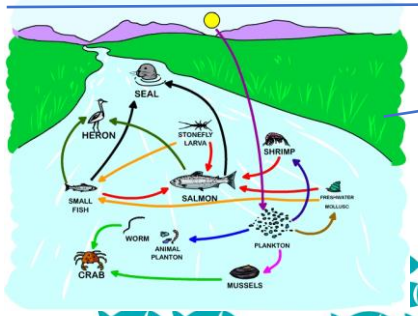




Movement & migration

Feeding behavior

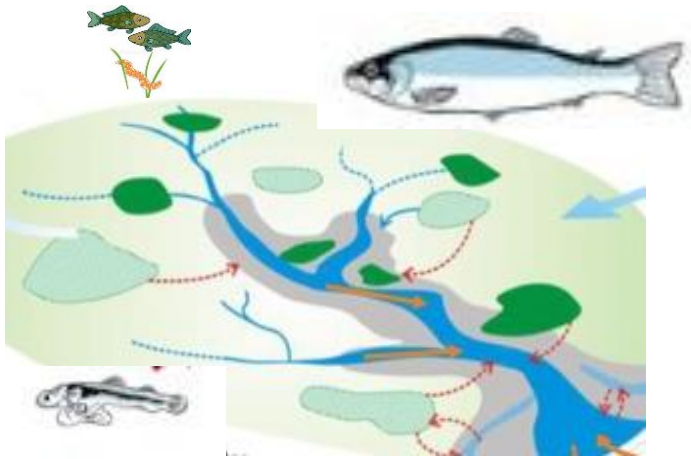
Substrates, localities, spawning aggregations

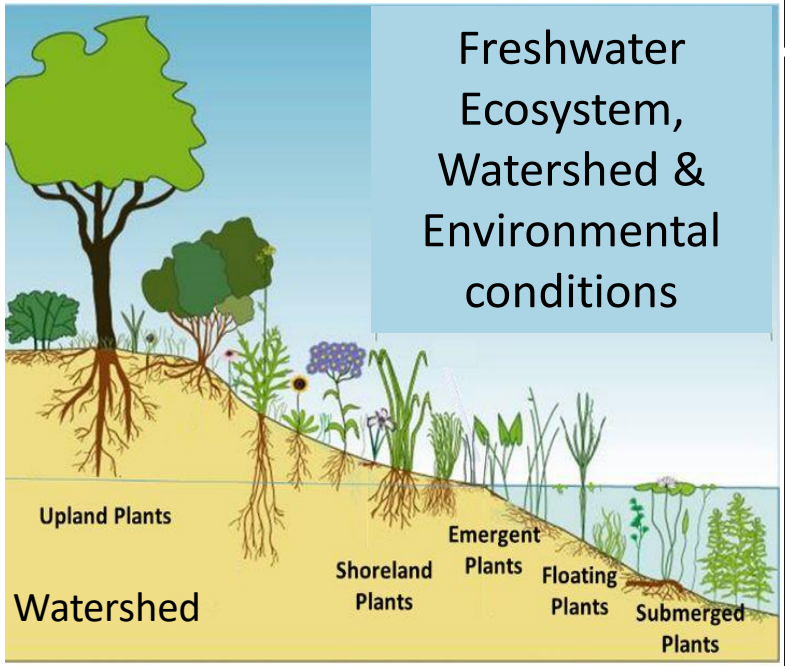


Population structure

Community Composition

Freshwater Ecosystem Function





Management Objectives:

- Protect Spawning grounds
- Keep migration routes free flowing
- Maintain ecosystem function
- Retain foodweb dynamics
- Enhance diversity
- Safe-guard life-history stages

Ecological character

Life-history traits

Feeding ecology

Movement and behaviour

Community ecology

Interact with Environmental conditions

Importance for management

Fish are environmentally plastic

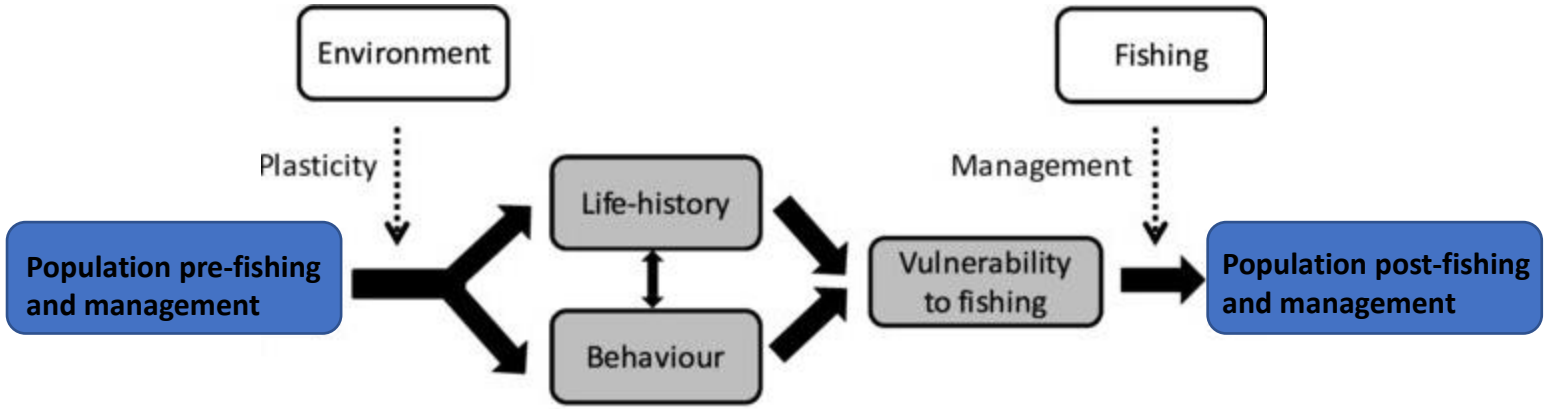
Life-history interacts with behaviour to increase or decrease vulnerability to fishing

Fishing interacts with these characteristics to increase or decrease mortality and vulnerability

Knowing the characteristics of the environment, behaviour and life-history can help support improvements in management

Management actions that support ecology

Management actions that account for the environment, the life-history, the behaviour and the vulnerability of species and populations to fishing pressure are better able to sustain healthy fish populations.



Most species can be characterized on a scale related to their biology and behaviours:

Fecundity – number of eggs
Longevity – how long they live
Maturation length/age – (early or late maturation)
Max length – small or large bodied species
Parental care – protecting and guarding investment
Spawning season duration – relates to fecundity

These characteristics interact with environmental conditions to increase or decrease survival of species.
Different management strategies are better for supporting and improving conditions for different species.

Fecundity: low (not many eggs produced) → High (many eggs)

Few eggs	Many eggs
High egg survival	Low egg survival
High parental care	Low parental care
Placement spawners	Broadcast spawners

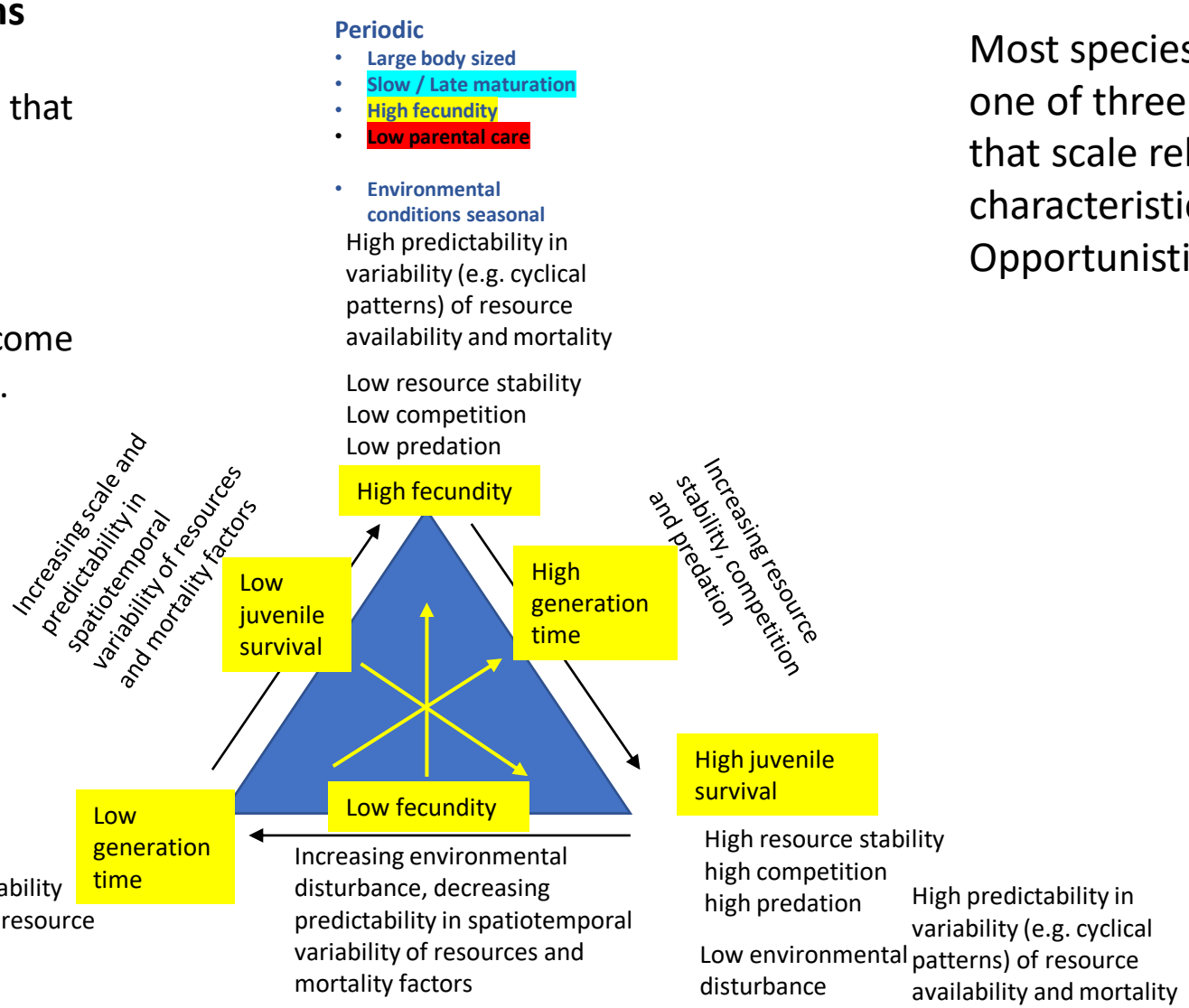
These factors interact to determine the survival of the offspring and is a balance of investment by parents in their offspring. Either producing many eggs or producing few and protecting them carefully. The strategy that is most successful depends on environmental conditions.

Maturation: age (related to size) at which they reproduce – provides an indication of the number of non-reproductive years or number of years they need to grow before they will contribute off-spring back to the population.
It relates to longevity (the number of years an individual lives and breeds)
These factors interact with the Fecundity and survival to determine the amount of off-spring produce by an individual over their life-time.
Some species will mature early, produce eggs over a few years and then die; whereas others will mature late but produce eggs for many years.

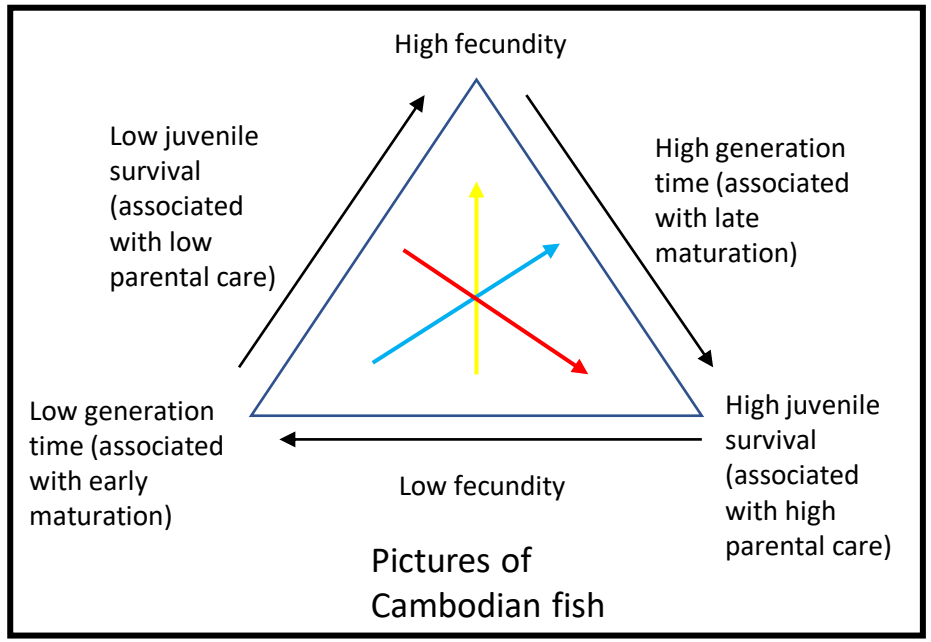
By looking for clues to these characteristics we can understand the life history strategy that a species is following, which helps us understand the best ways to manage a species or group of species.

Understanding Life history strategies and their impact on management decisions

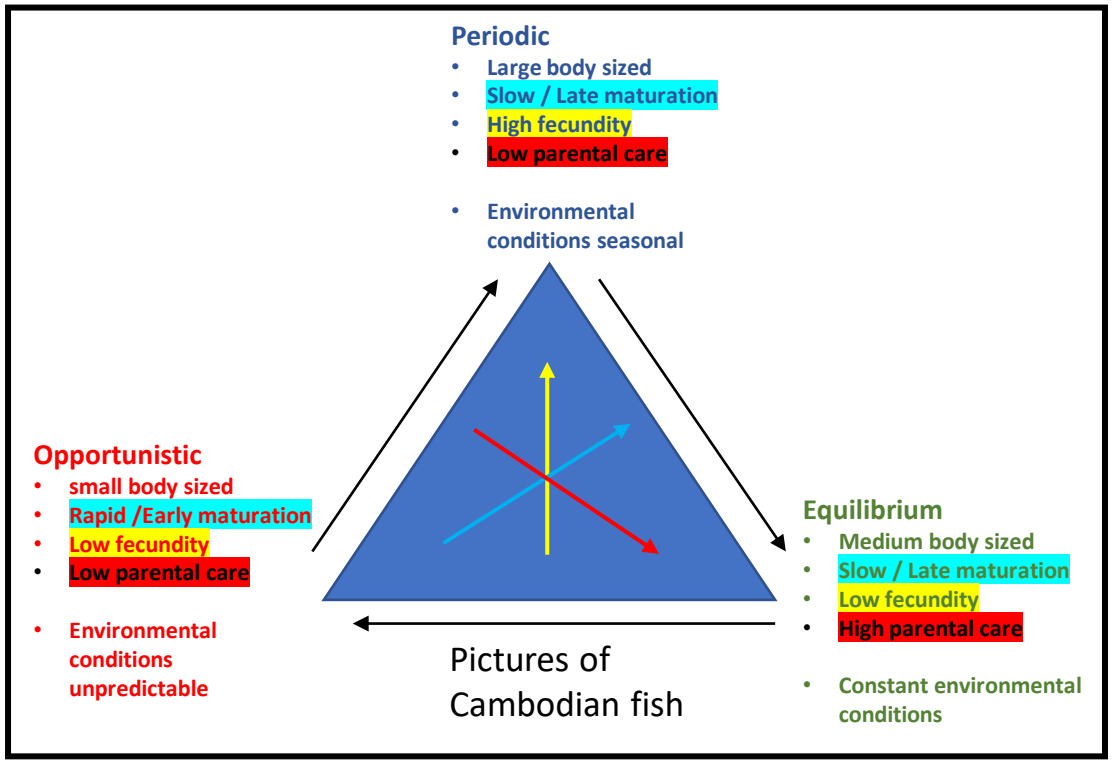
Fish have a variety of life history strategies that they follow. The life-history strategy is a combination of:
Growth: small-bodied to large-bodied
Generation time: How many
Maturity: how many years before they become sexually mature and are able to reproduce.
Fecundity: Number of eggs produced and how often they reproduce (annually, bi-annually, etc)
Adaptability: adaptable to not adaptable to environmental conditions and change e.g. able to move long-distances / require specific conditions for migrations, feeding, breeding etc.



Most species fall loosely into one of three main categories that scale relative to these characteristics: Periodic, Opportunistic, Equilibrium



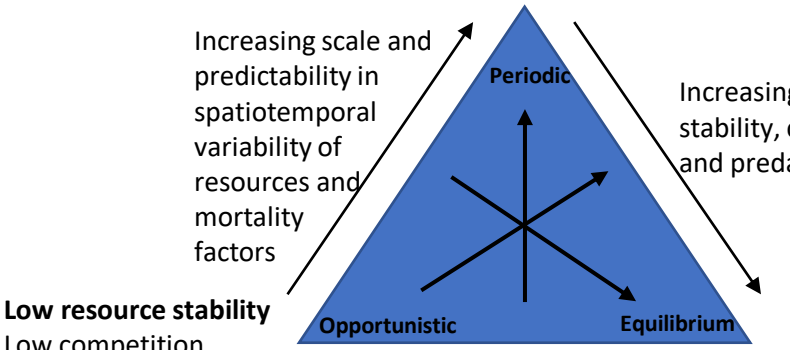
Most species fall loosely into one of three main categories that are scaled relative to these characteristics:



Environmental predictors of Life-History strategy

High predictability in variability (e.g. **cyclical patterns**) of resource availability and mortality

Low resource stability
Low competition
Low predation



Low resource stability
Low competition
Low predation

High environmental disturbance

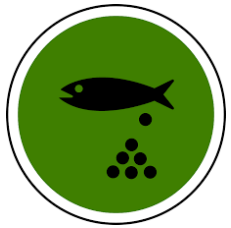
Low predictability in variability of resource availability and mortality

High resource stability
high competition
high predation

Low environmental disturbance

High predictability in resource availability and mortality

Life History



Fecundity

Many eggs vs few eggs

Deposition substrate adhesion vs broadcast

Protection of eggs or no protection of eggs

Image of Breeding behaviour examples

Importance for management

Understanding which type of spawner a fish species is will determine what important management is needed to protect the species. Understanding the spawning behavior of multiple individual species can allow managers to select management regimes and interventions that address the needs of groups of species (species assemblages/fish communities). Understanding of fish communities (groups of species that aggregate together), spawning behaviours and generation time can help to identify management opportuntieis.

A broadcast spawner for example may need the access to river locations and protection of the eggs and larvae for management to be effective. By contrast a substrate spawner will need certain habitats and localities protected from disturbance during the breeding season. Understanding these differences is important for ensuring management is effective.

The effect of fishing out a large individual of a broadcast spawner that spawns every year versus one that spawns only every five years can have very different impacts on the population.

Management Actions

Controlling and regulating fishing activity seasonally and spatially

Establishing restrictions on fish catch practices that accommodate spawning needs

Locating and protecting important habitats

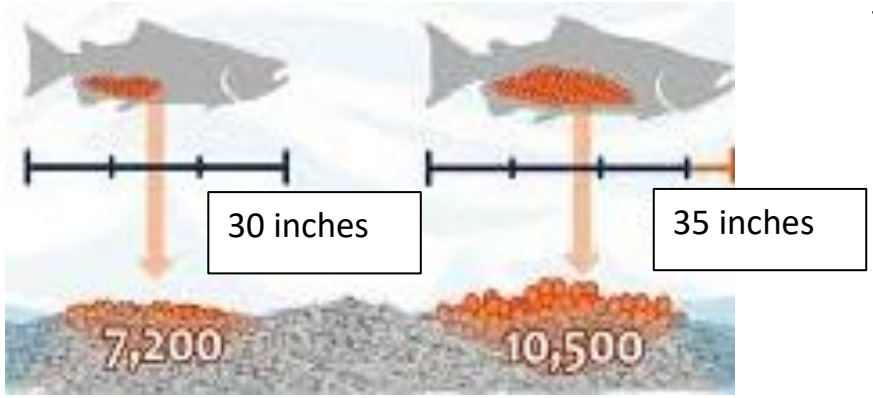
Identifying breeding behaviours and applying relevant interventions for similar groups

Selective fishing practices, i.e. either using gears that target only some species or sizes and/or returning caught fish that are below size or of restricted species.

Image of management intervention example

Importance of fecundity

What is fecundity?
Fecundity is the number of eggs or offspring that are produced each season.



Why size matters…

- Only the larger fish can breed
- Additionally, larger reproductive females produce more eggs
- A female only 5 inches longer (15%) can produce almost twice as many eggs (50% more).
- The eggs they produce are larger, having more fat content increasing their survival chances.
- For some species this is more important than for others (see life-history info-card)

Relevance for management

If the number of eggs a species produces at a given spawning period is known it allows managers to determine the relevance of specific management actions to each species and identifies the importance of small and large individuals in the population.

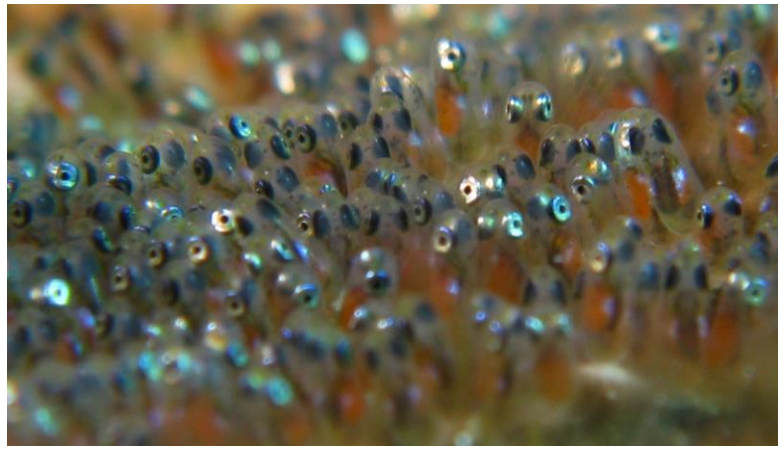
The risks of overfishing:

If too many larger sized individuals are taken out of the population (or all of them), you significantly reduce the ability of fish to reproduce and replenish stocks.
Even ensuring that reproductive females remain but not considering their size can reduce the reproductive potential of the fishery.

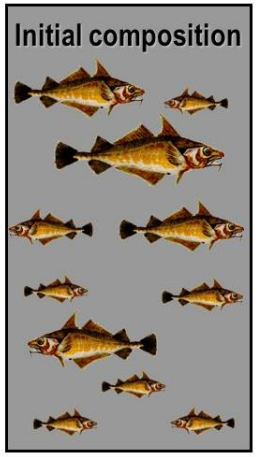
Management Opportunities

- Protecting spawning sites
- Restrict fishing of some species under a certain size
- Set size-based quotas for harvest of larger individuals
- Adopt fishing seasons so that harvest occurs after spawning
- Preserve access to breeding / spawning aggregation sites
- Enhance conditions on breeding grounds

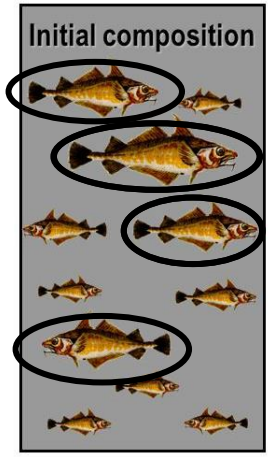
A Cautionary note: many species reproduce over many generations (years) and setting a fishing seasonal in the absence of other size regulations only prevents over-harvest of reproductive females for one fishing season but prevents their future contribution to the population. Larger individuals have a much greater fecundity and it takes many years for younger fish to grow, mature and replace the reproductive capacity of these larger individuals. Management interventions can protect reproductive individuals by regulation to set restrictions on the harvest of large or fecund individuals and spatially to avoid breeding sites or spawning aggregations.



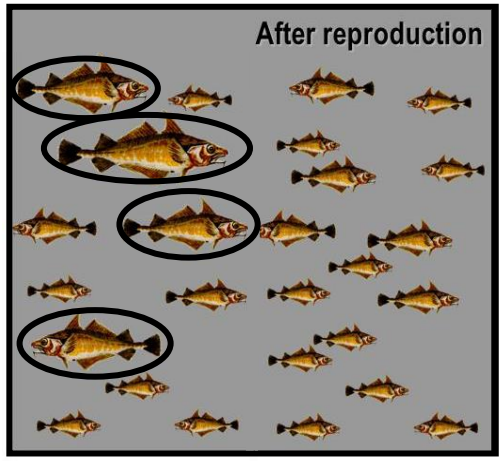
Importance of stock composition And the dangers of fishing pressure / risks of over-fishing



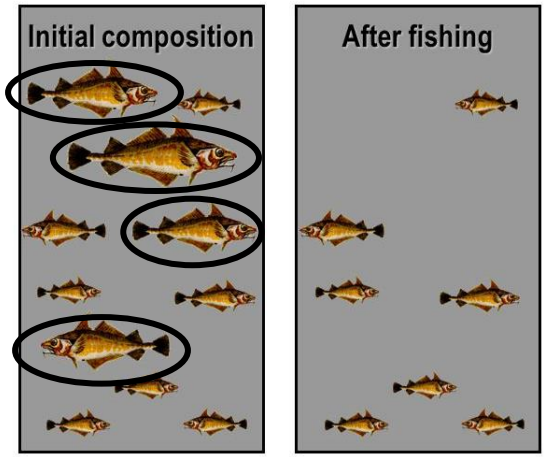
Larger individuals represent the breeding population.



Only half of the population can reproduce and replenish stocks.

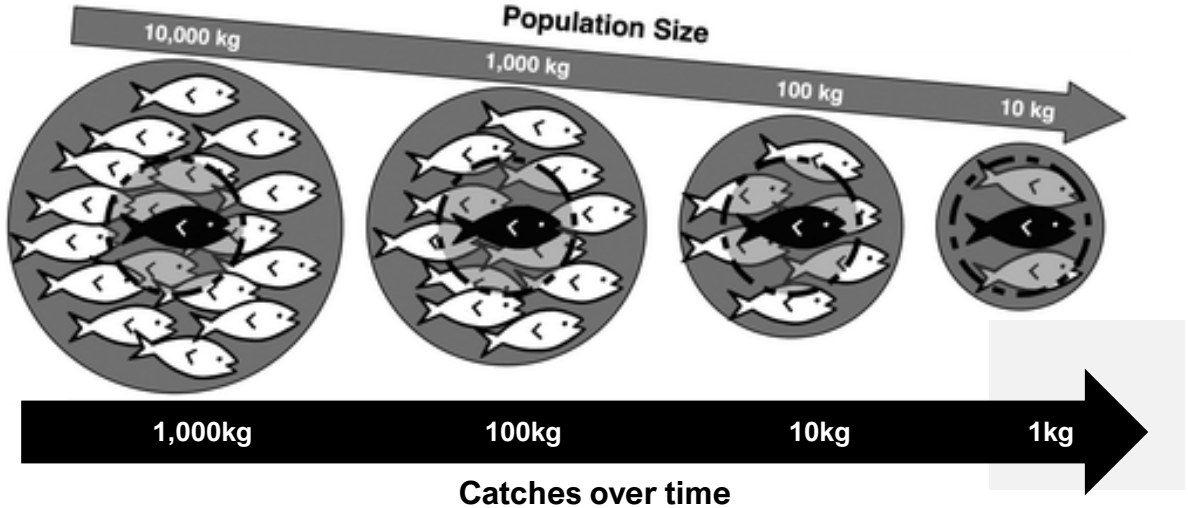


After reproduction stocks increase but the **<u>proportion</u>** of the population that can breed remains the same.



Fishing can result in large individuals being selectively removed from the population further reducing the ability of the population to breed and replenish.

Impact of over-fishing



Management actions to combat over-fishing

Set fishing quotas for total harvest quantities
Establish catch share agreements
Restrict gear types used to be size or species selective
Restrict fishing in some areas (e.g. important for spawning)
Restrict fishing in some seasons
Prevent barrier fishing (e.g. that blocks migration or blocks river mouth)
Ensure sufficient reproductive individuals remain in the population to replenish stocks (=sustainable harvest)
Allow individuals to grow to maturity before allowing harvest

Movement patterns relevance for management

Movement patterns

Mobility - many fish are mobile and move great distances from one part of the river to another or from ponds and lakes to rivers. Connectivity between these different locations is needed for fish to be able to access the different grounds that they need to complete their life cycles.

Image

Migration type - short or long distance travelling along the river or in and out of floodplains is tightly linked to the life history characteristics of each species.

Image

Migration cues – indications in the river conditions that signal to fish that it is time to move to spawning, feeding or refugial grounds. For example, changes in temperature, changes in flow direction, changes in current level, changes in water height, changes in turbidity, changes in acidity, etc.

Image

Relevance for management

Understanding the movement patterns and what areas of the river and lake system are needed by different species at different stages of their life can help identify what actions can be conducted to ensure that the different habitats (locations) remain connected. Understanding these different needs can help to determine what management actions are needed to protect the fish life history.

Understanding whether a species has a long or short migration can determine the extent of river or lake that needs protecting. It can also help to identify whether a group of fish in one location is in the same 'population' as a group seen in another location at a different time of year.

Understanding migration cues is important for making sure that changes are not made to these important cues that would disrupt the signals indicating that it is time to migrate, breed, feed or move to refugial habitats. If these signals are not received at the appropriate time it can result in loss of individuals and ultimately population decline.

Image

Management Actions

Avoid disturbing key habitats

Ensure channels remain open

Prevent over-fishing during key movement periods

Establish rules and regulations for harvest size

Establish regulations for seasonal harvests

Set quotas for harvest that are within sustainable levels

With additional information provided by an understanding of fish ecology (migration and movement) the implementation of regulations can be better targeted and thus more effective for achieving the desired outcomes.

Image

Ecological character

Movement & migration

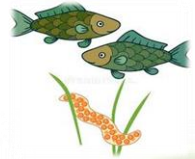
Importance for management

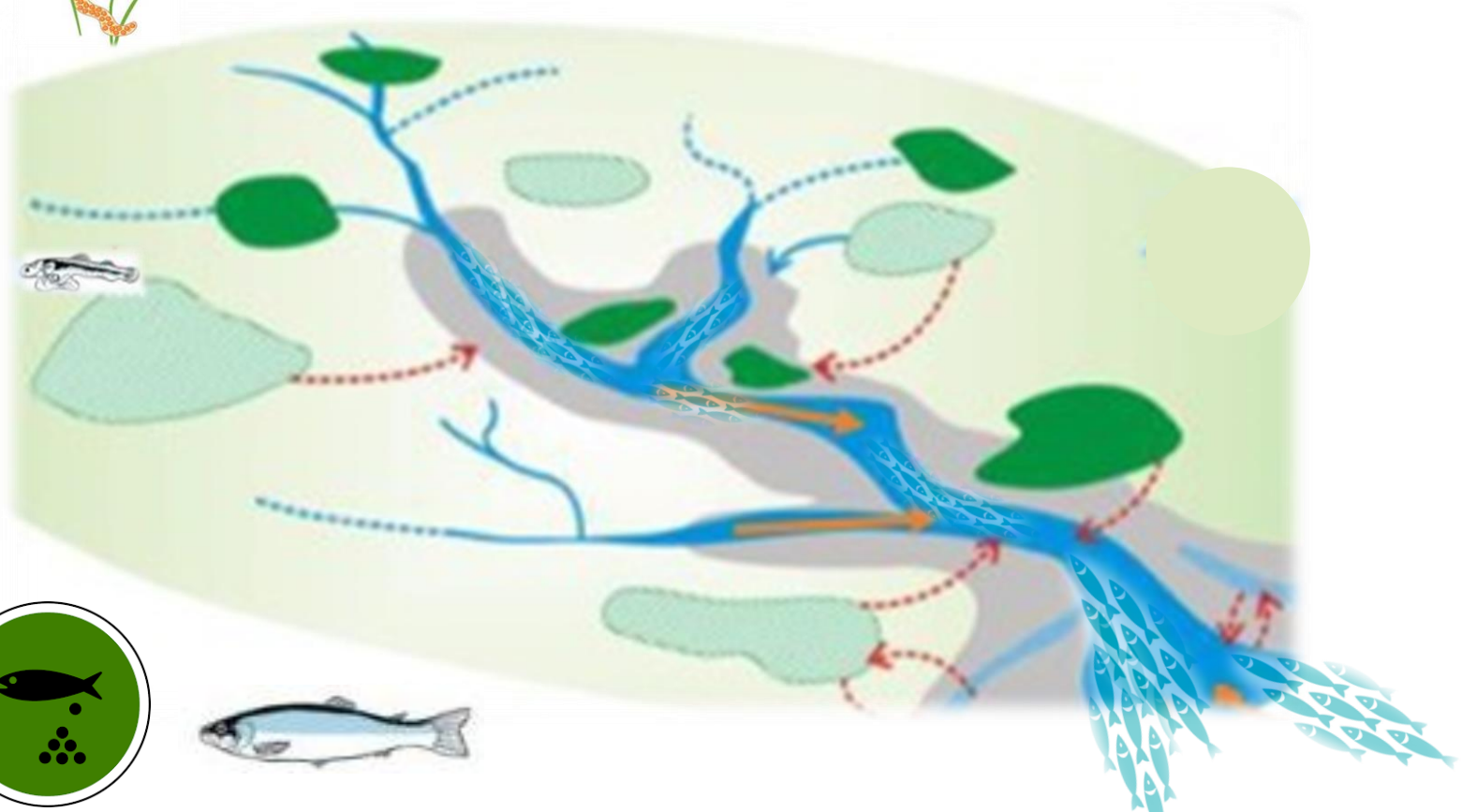
Awareness of migration patterns and movement of fish in and out of the flood plains are critical for targeting and ensuring management actions are effective.

Management actions that support ecology

- Preventing barriers in rivers that block migration patterns
- Ensuring that agriculture does not impact movements in and out of flood plain habitats.
- Establish protection for migration routes.

Life Cycles





Management Objectives:
Protect Spawning grounds

Keep migration routes free flowing

Ecological character

Fish move to different locations in the river, lakes, ponds, and floodplain to carry out different parts of their life cycle.

Importance for management

If fish cannot access spawning, feeding and refugial sites they cannot complete important stages of their life history and the population will decline.

Management actions that support ecology

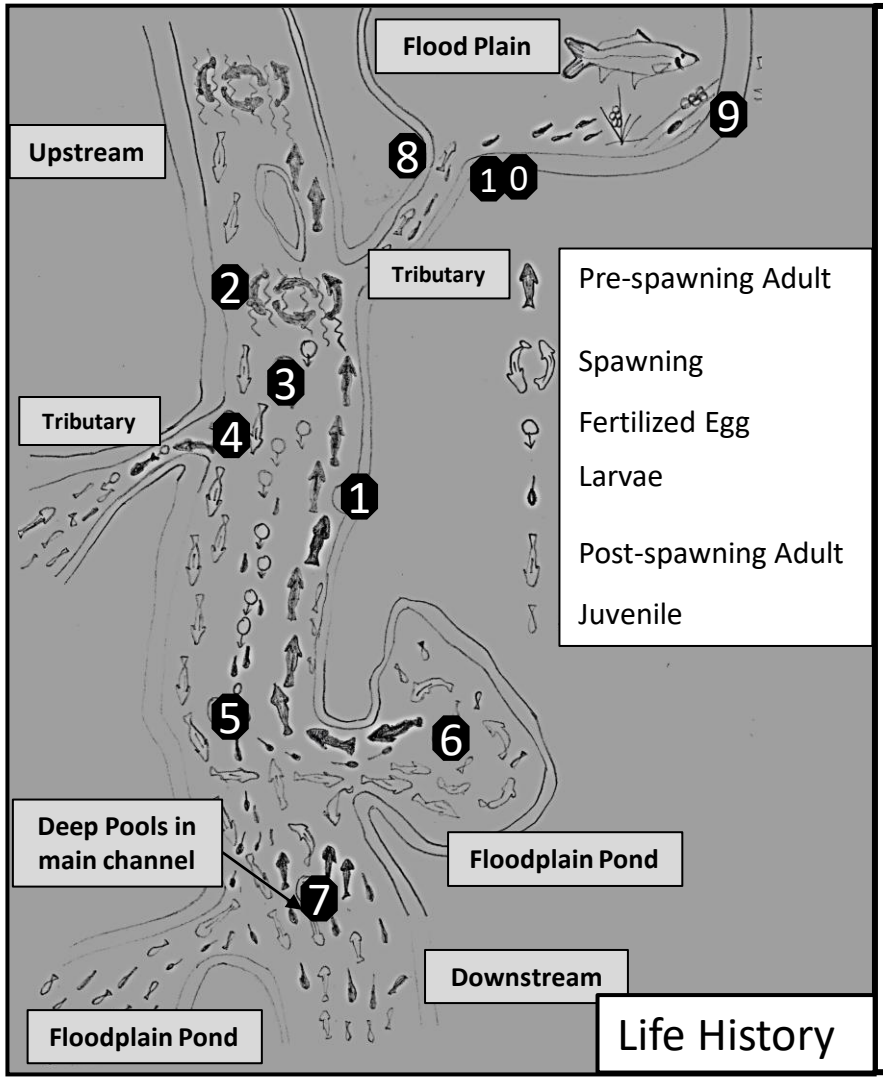
Protecting important sites for spawning

Ensuring access to feed sites

Maintaining corridors and connectivity between sites

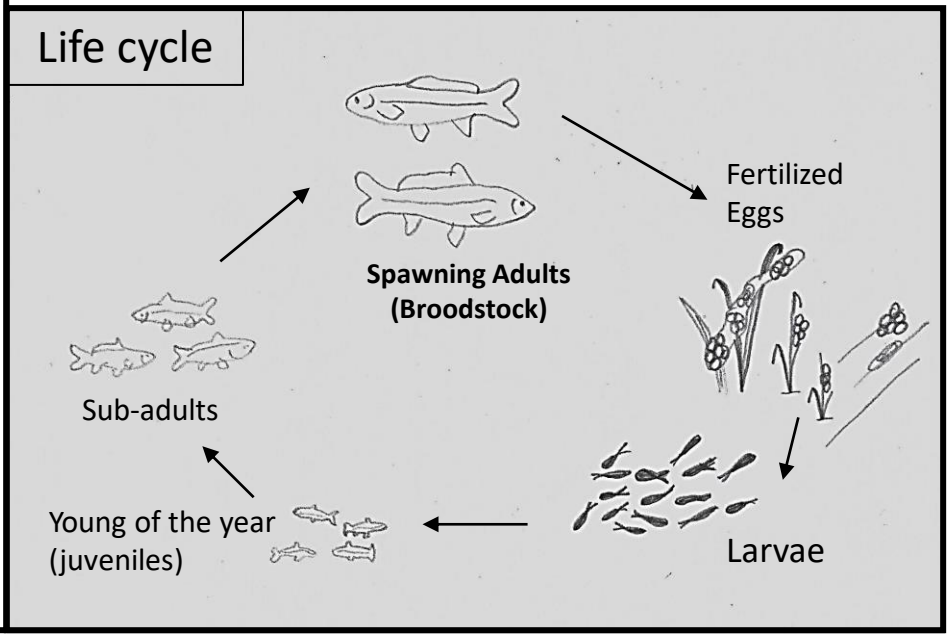
Enhancing habitats required for breeding

Regulating capture of certain life stages to ensure there are enough reproductive adults in the population



Life History and Cycle

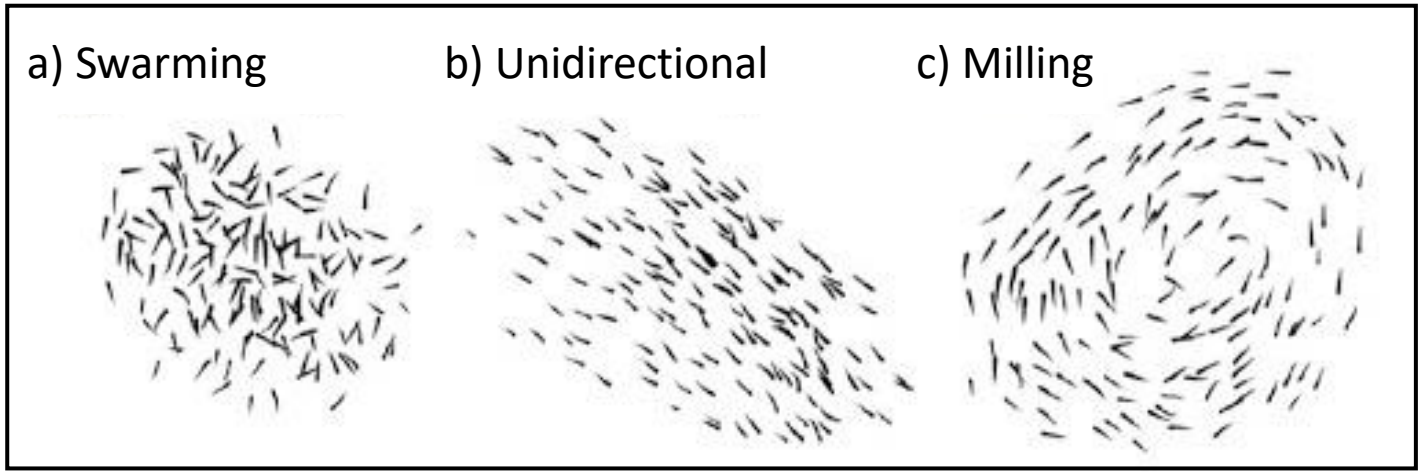
1, Pre-spawning Adults travel upstream to spawning sites
2, Male and female mature adults aggregate in spawning groups
3, Eggs released into the river channel travel downstream on the current
4, Post-spawning adults return downstream to feeding grounds and dry season refugia
5, Eggs hatch and larvae actively travel downstream and into floodplains and ponds
6, Post-spawning adults, larvae and juveniles feed and grow on the feeding grounds
7, Pre-spawning adults move to deep pool refugia in the dry season before they begin their annual migration to breeding grounds
8, Deposition spawners travel to calm waters to spawn on substrates
9, Deposition spawners spawn on substrates
10, once the eggs hatch the larvae travel downstream with the current



Aggregation behaviours

Aggregation behaviours provide an indication of life-history. By recognizing these behaviours in the environment it can be possible to identify important areas for management.

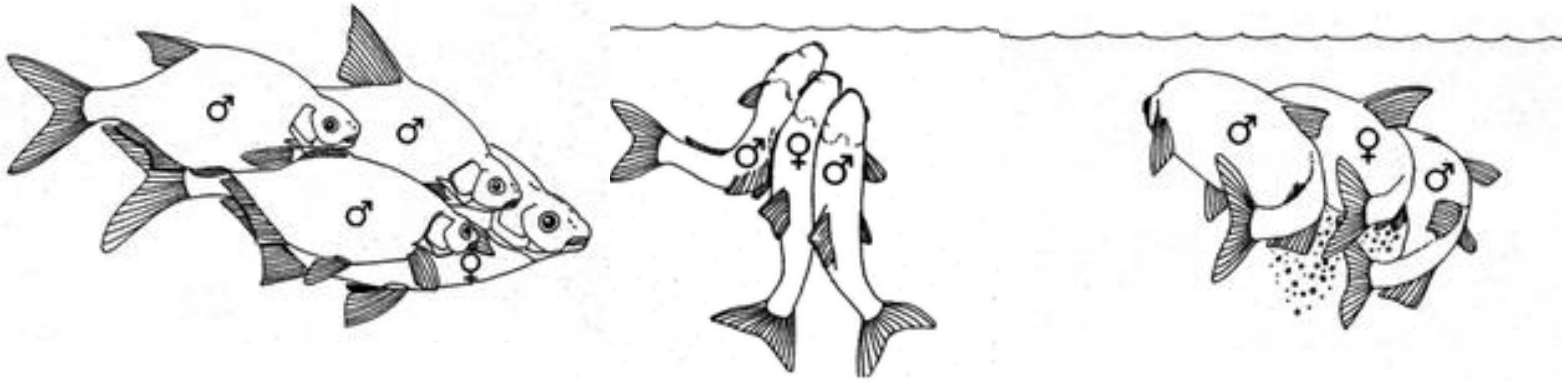
a) Swarming behaviour is often associated with feeding
b) Unidirectional behaviour usually indicates either active or passive migration to breeding or feeding sites
c) Milling behaviour is usually associated with breeding aggregations



Links to management

Learning to recognize these behaviours and recording where they occur provides guidance for management spatially, and temporally.

Recognizing Spawning Behaviour



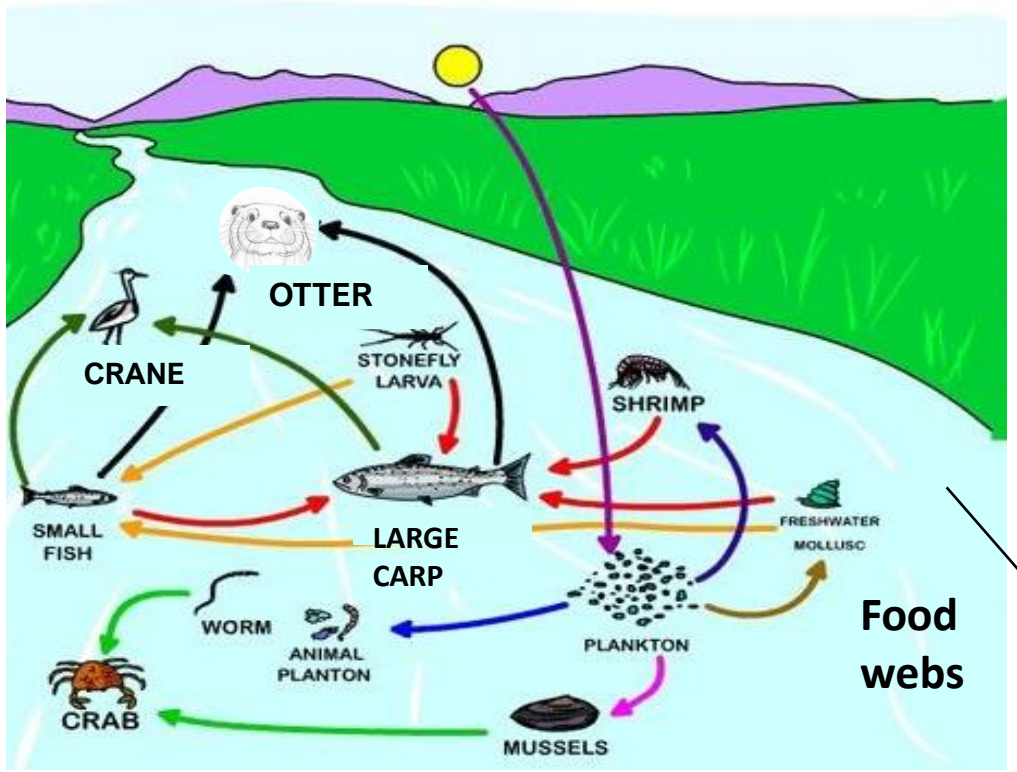
Multiple males ♂ will chase and compete for access to a female ♀
Females will release their eggs into the current and males release milt that fertilizes the eggs that then travel downstream with the current

Links to management action
Recognizing the milling behaviour associated with these spawning aggregations will help to determine important locations to protect.

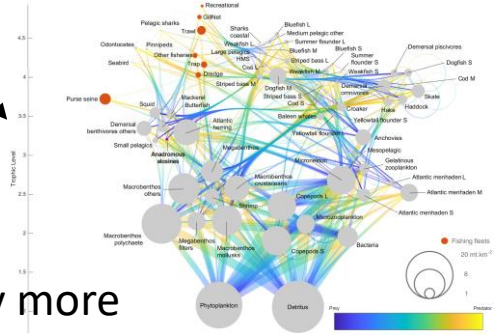
Relevance for management – spawning aggregations can be protected spatially or seasonally.

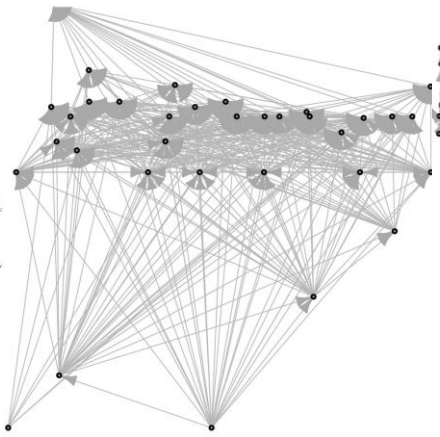
Ecological character

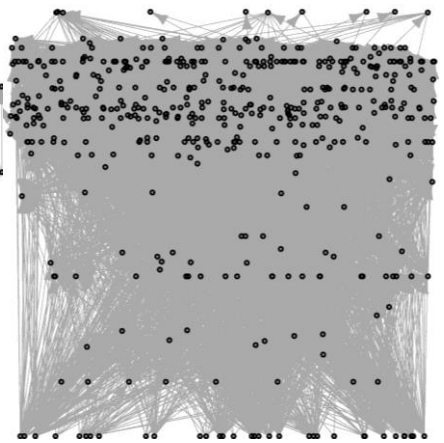
Feeding ecology and behaviour:
Trophic interactions
Species-species interactions
Food web ecology



Food webs







But it's actually more complicated ->
many trophic interactions among species.

Importance for management

Ensuring feeding areas are maintained and accessible

Recognizing refugial sites important for juvenile development

Management actions that support ecology

Maintaining access to rice fields, dry-season ponds etc.
Preventing blockages(e.g. damming) along migration routes to feeding grounds.

Preventing the use of chemicals that can remove 'pests' that feed fish

Maintaining flooded forest habitats and other scrub lands used as refugia by young and juveniles

Why it is important to understand fish community structure and function?

What is fish community?
A fish community is the group of different fish species that live together in an environment.

Fish community structure:
the structure of the community is the number of individuals of different species and the age and size of those individuals.

Fish population is a group of a single species of fish that are associated with each other.

Fish community function:
the function of the community is how the community interacts and stays in balance. For example, ensuring that there not too many predators (those that eat other fish) in the community, and making sure that fish reach the size at which they become sexually mature and can breed and replenish the population.

Fish community structure and function link to the feeding behaviour of fish and how they interact in a "food web". Who eats what or who in an ecosystem determines how well balanced it is and how much of the fish can be harvested.

Age and size are important because they indicate whether there are individual fish capable of reproducing and replenishing the number of fish there are in the system and ultimately available for fishers to harvest.

If there are too many predators in the system then the fishery will be in constant decline.

If too many young fish are taken out of the system, the fish population will grow old and die and there will be no new sexually mature individuals that will replace them and the fishery will decline.

If there are too many fishers taking too much fish, the fish populations will not be able to recover and replenish stocks for fishing in the future

If too many fish are harvested…
The fishery will be in constant decline.

If too many fish that are sexually reproductive are removed from the community the fishery will not recover.

If there are too many young immature individuals (not enough sexually mature to breed and produce offspring) the population will decline.

If the fishery cannot recover, stocks will decline and there will not be enough fish to continue to support the fishery.

By understanding the fish community management actions can take into consideration interactions among species (such as predator – prey interactions that impact the availability of fish).

Understanding the fish community, its structure, and its functions help managers to determine and implement the most effective management guidelines and actions.

More effective management is enabled by information on community structure and function

Knowing the structure and function of a community helps for setting regulations and restrictions on fish size and species to allow the fishery to recover.

Without restrictions the fishery will collapse

Knowledge of how fish communities are spatially distributed (where and when they are present) is also key for designing effective management. *Much of this information links to an understanding of feeding, breeding ecology and life-history.*

Ecological character

Importance for management

Management actions that support ecology

Community ecology:
Community structure
Population structure
Stock structure
Frequency distribution
Patterns in distribution and abundance