Life History Strategies: Applications to Fisheries Management

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Pacific Finfish Currently "Unassessed"

- Overwhelming list of species with large bycatch or new fisheries
  - Over 400 species caught in Canadian Pacific fisheries each year
  - Less than 35 have formal assessments
    - Pacific Salmon
    - Pacific Herring
    - Hake
    - Some flatfish
    - Halibut
    - Some rockfish

Life History Traits & Environmental Forcing

- Life history traits are the underlying determinants for population response to environmental forcing
  - On top of this natural variation will be a modification of the response due to fishing removals

Here's the idea!

- If we have a number of "new" species of interest
  - No biomass estimate
  - No relative abundance measure (surveys, CPUE)
  - No reliable measure of catch
- And we assume that underlying population response to environmental forcing and fishing pressure is determined by life history traits...

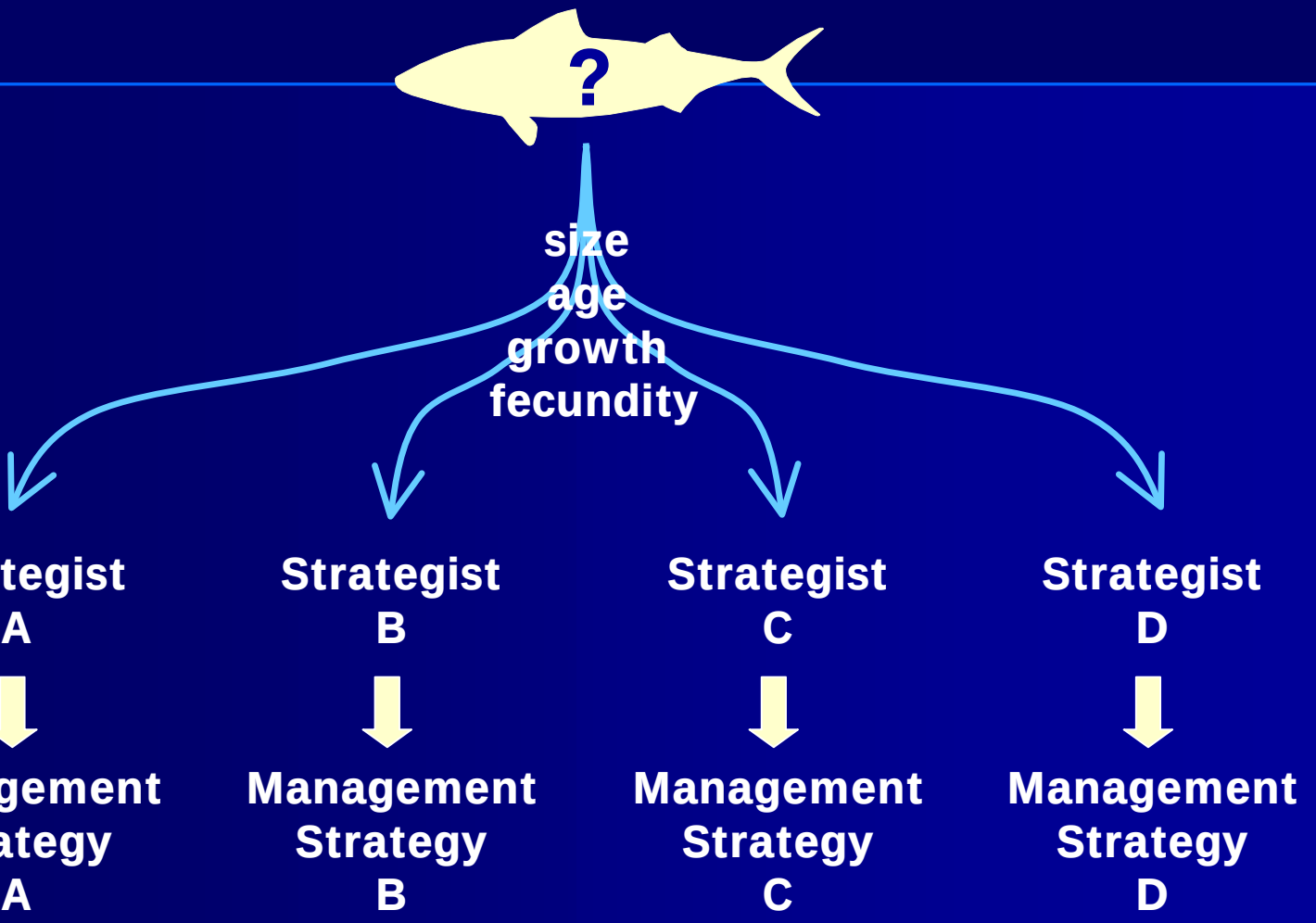
Then can we….?

Use fish groupings based on life history traits

➔ life history strategies

to typify strategists population dynamics and outline fishery management strategies that are fundamentally based on a fish's biology

Why?


?
size
age
growth
fecundity
Strategist A
Strategist B
Strategist C
Strategist D
Management Strategy A
Management Strategy B
Management Strategy C
Management Strategy D

Life History Strategies

- Winemiller & Rose (1992)
- McCann & Shuter (1997)
  1. Opportunistic strategists
  2. Periodic strategists
  3. Equilibrium strategists
  4. Salmonic strategists

Life History Strategies

- Winemiller & Rose (1992)
- McCann & Shuter (1997)
  1. Opportunistic strategists
     - fast-growing; short-lived; intermediate fecundity
  2. Periodic strategists
     - slow-growing, long-lived, high fecundity
  3. Equilibrium strategists
     - fast-growing, long-lived, low fecundity
  4. Salmonic strategists
     - opportunistic strategists but with freshwater and marine phase

Life History Strategies

- Winemiller & Rose (1992)
- McCann & Shuter (1997)

→ Freshwater and some tropical species

→ Limited range of life history parameters

- King and McFarlane (2003)

→ Focus on marine sub-arctic species

→ Inclusion of elasmobranchs

Methods

1. Assemble life history traits of commercially important Pacific marine species
2. PCA on life history traits
3. Identify marine life history strategists
4. Assign management scenarios

Assemble Life History Traits

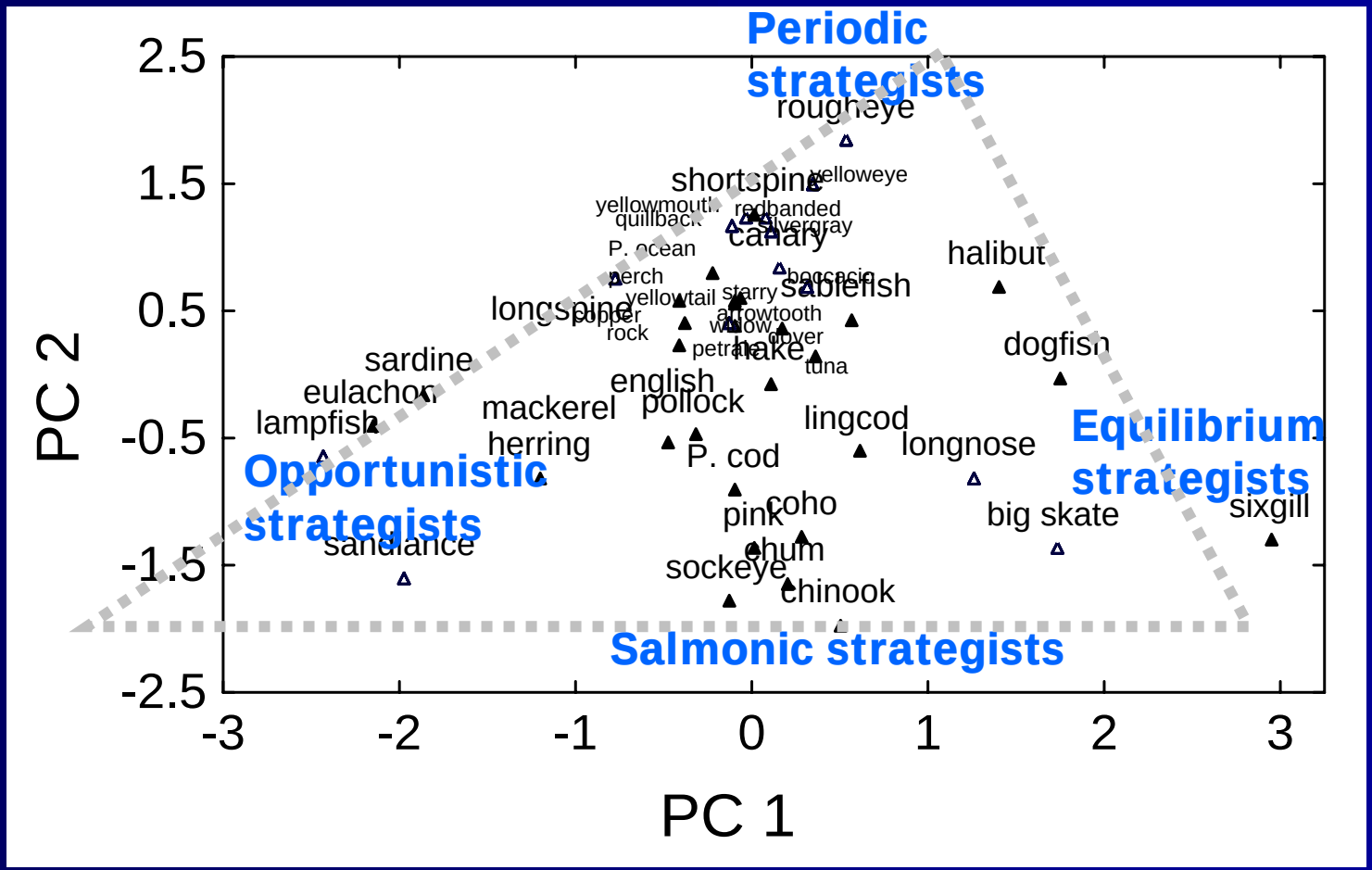
- Selected 42 marine species across ecological guilds
  - Plankivores → top predators
  - Pelagics → demersal
  - All of commercial importance or interest
- Life history traits (literature or research data)
  - Size at 50% maturity
  - Maximum size
  - Growth coefficient (*k*)
  - Fecundity
  - Egg size
  - Maximum age

PCA on life history traits

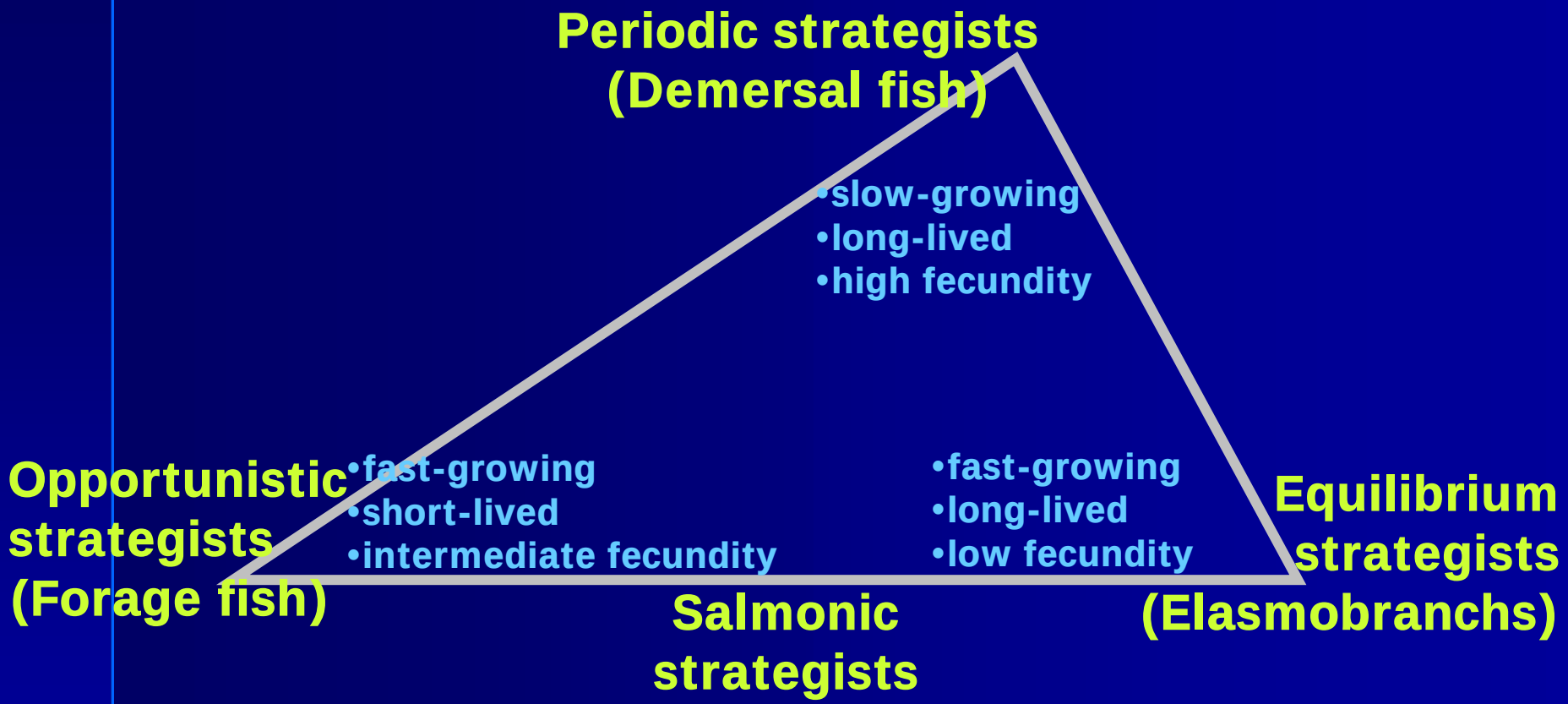
- First 2 components are significant

	PC1	PC2
Eigenvalue	2.64	2.06
Percent Variation	44.05	34.31
Eigenvector		
Size at maturity	0.94	-0.15
Maximum size	0.95	-0.13
Growth (*k*)	-0.34	-0.79
Fecundity	0.06	-0.76
Egg size	0.79	-0.41
Maximum age	0.34	0.84

PCA on life history traits



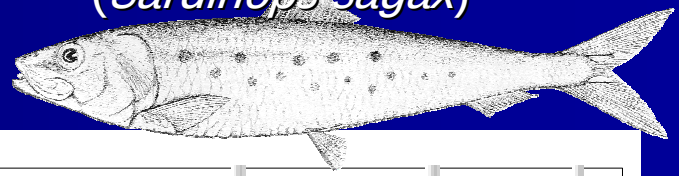
Marine Life History Strategies

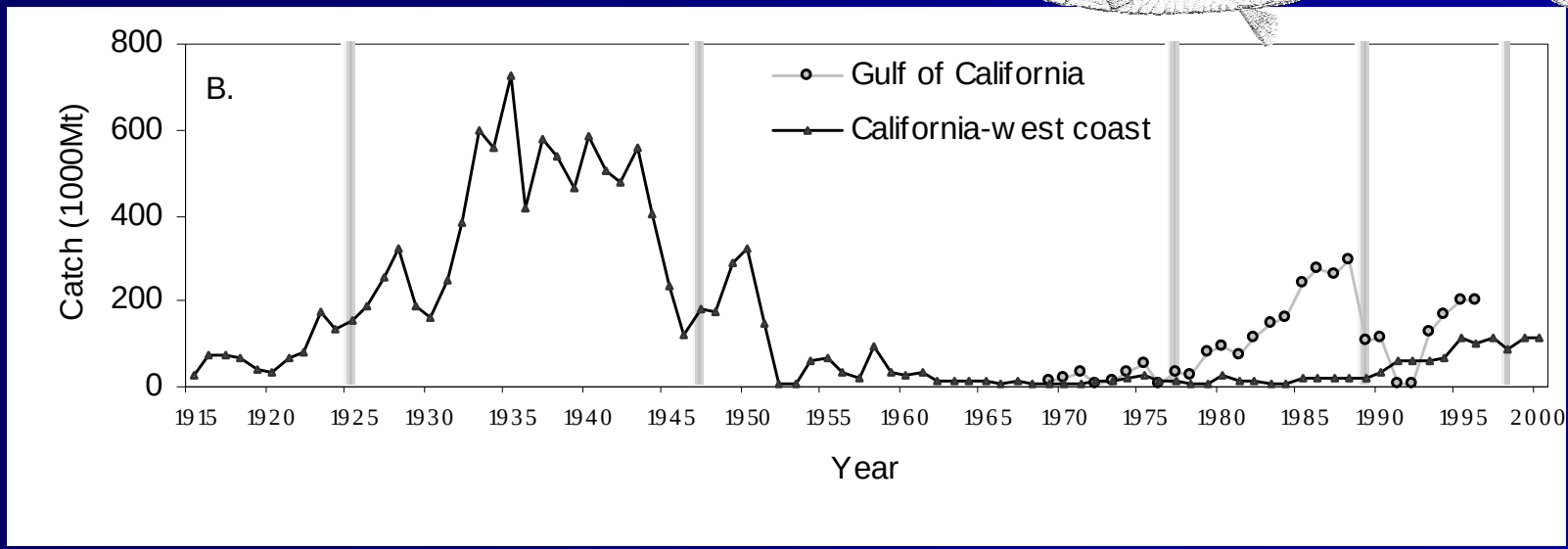


Typical Population Dynamics:
opportunistic strategists

- Small, rapidly maturing, short-lived
- Small eggs, intermediate fecundity

e.g. Pacific sardines (*Sardinops sagax*)





Assign Management Scenarios:
opportunistic strategists

- Pelagic, planktivores
  - Highly variable habitat
  - Large sources of energy

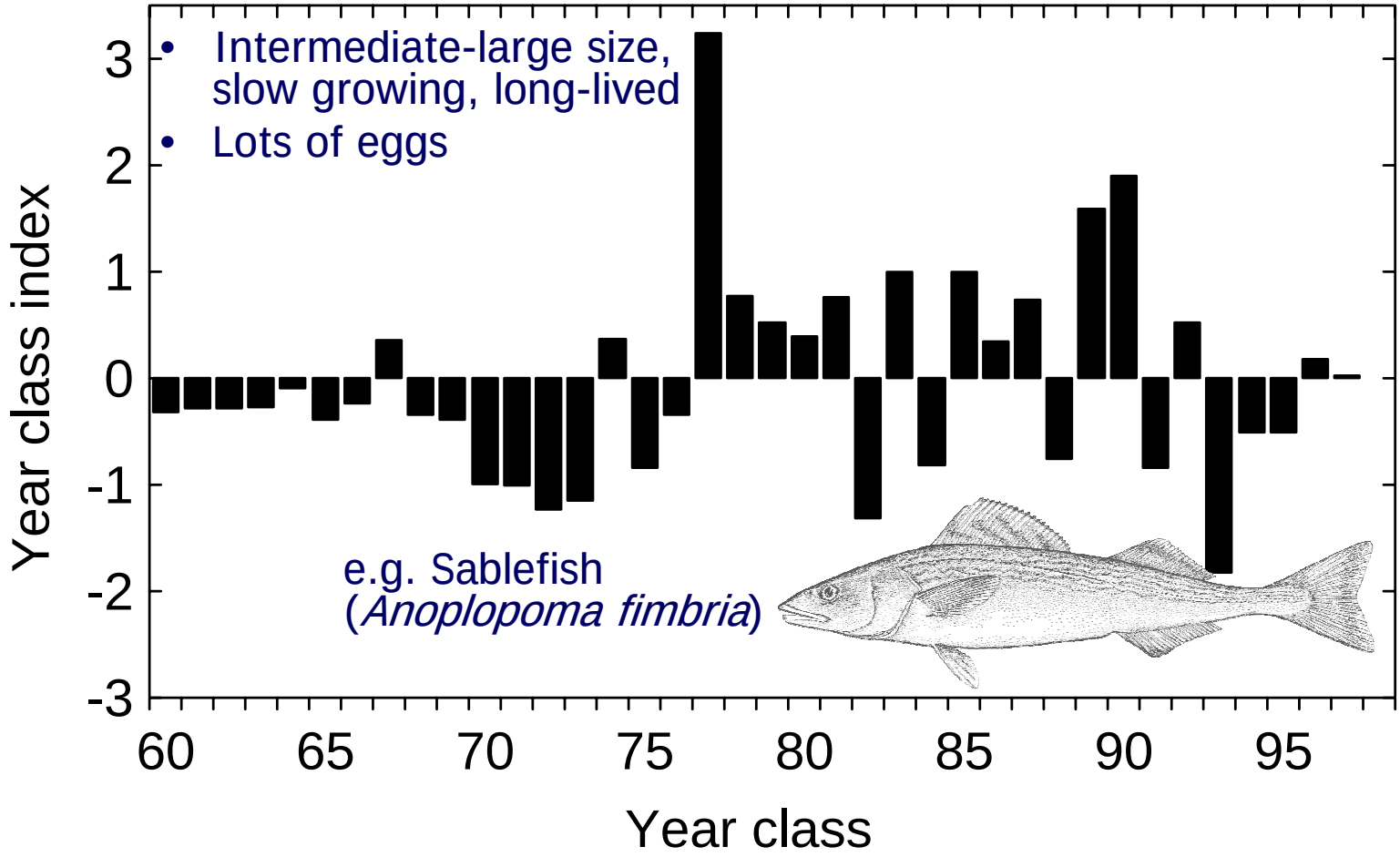
➔ Tightly linked to climate-ocean conditions

  - Interannual and decadal
  - Very high degree of variability
  - Susceptible to rapid depletion augmented by fishing pressure

Critical Minimum Spawning Biomass

- Historical low abundance
- Periods when population can not be exploited
- Higher maintenance stocks need careful monitoring

Typical population dynamics:
periodic strategists



Assign Management Scenarios:
periodic strategists

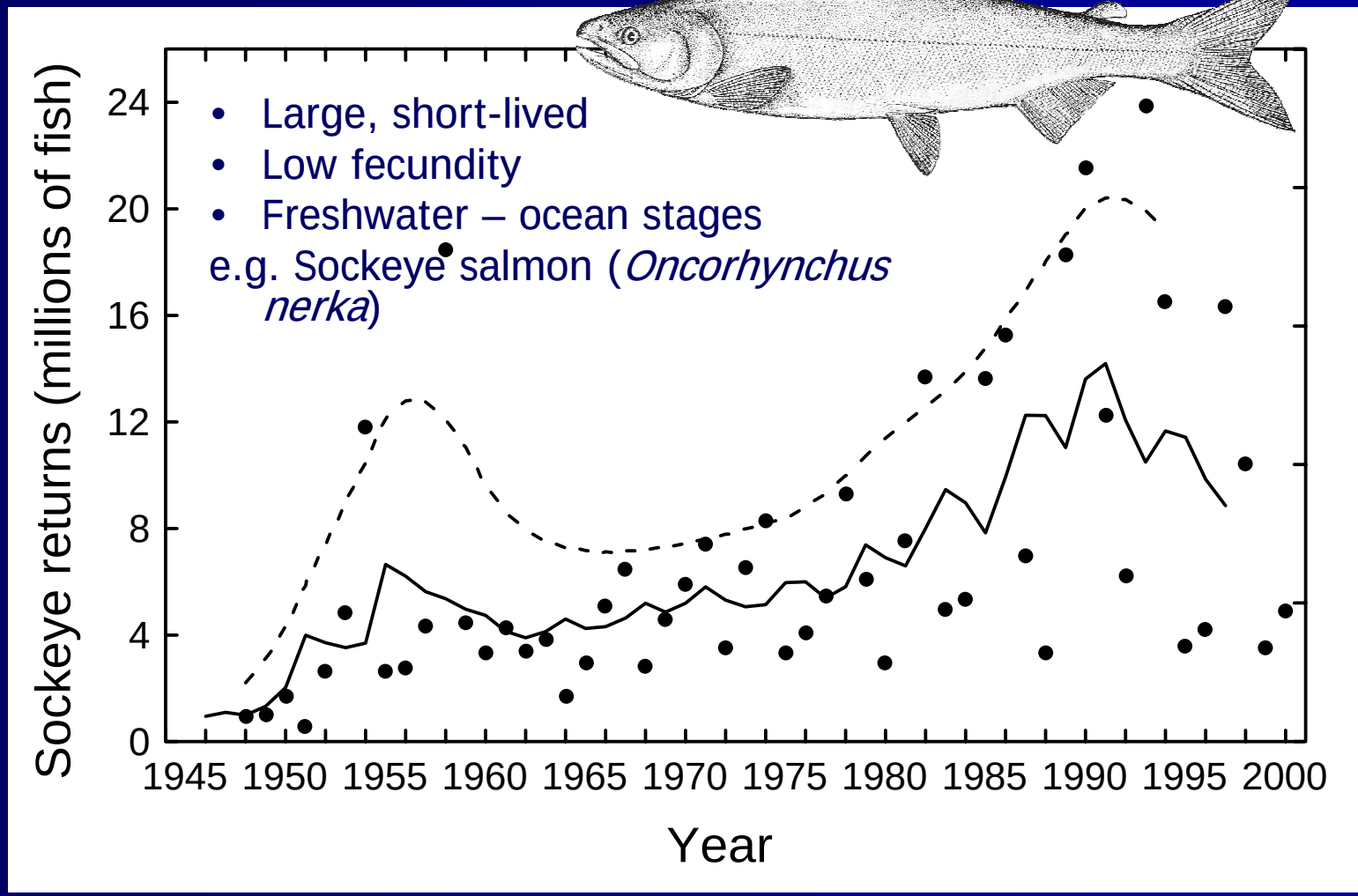
- Demersal, piscivores
  - Low variable habitat
  - Limited sources of energy
- Longevity ensures long reproductive cycle
  - Ability to outlast poor environmental conditions
  - Period between strong year classes can be long

➔ Association with decadal-scale climate-ocean conditions

Robust Age Structure e.g. Rockfish Conservation Areas

- Annual recruitment only a fraction of spawning stock biomass
- Paramount to <u>always</u> maintain appropriate age structure, ensuring older fishes are in the spawning biomass

Identify typical population dynamics: *salmonic strategists*



Assign Management Scenarios: *salmonic strategists*

- Opportunistic strategist with freshwater and marine survival components
- Marine survival (first ocean summer & winter) is important
  - ➔ Strong linkage to climate-ocean conditions

Freshwater density dependent relationship

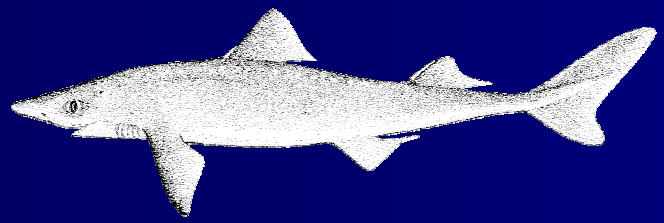
(egg to smolt production)

Marine Survival Rate

(smolt to adult production)

- Low marine survival, low returns
- Reduced hatchery programs

Typical population dynamics:
equilibrium strategists



e.g. Spiny dogfish (*Squalus acanthias*)

- Late maturation: 35 years
- Long lived: 100+ years
- Extreme low fecundity: 9 pups

➔ very low rate of intrinsic population increase

Assign Management Scenarios:
equilibrium strategists

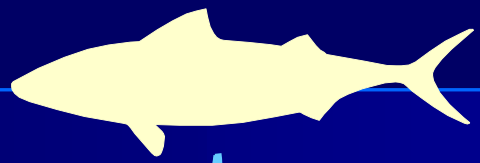
- Top predators
- Low intrinsic rate of increase
- Young are very well developed

➔ Little linkage to climate-ocean conditions

Low Harvest Rates

- No targeted fisheries (or very low F)
- Bycatch fisheries managed to maintain low capture rates

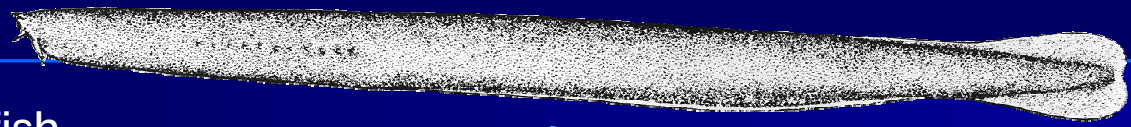
Framework



size
age
growth
fecundity

Opportunistic Strategists	Periodic Strategists	Intermediate Strategists	Equilibrium Strategists	Salmonic Strategists
Critical Spawning Biomass	Robust Age Structure	Critical Spawning Biomass	Very Low Harvest Rates	Marine Survival Component

“We want to fish hagfish”



Pacific hagfish
(Eptatretus stouti)

Opportunistic Strategists → **Critical Spawning Biomass**

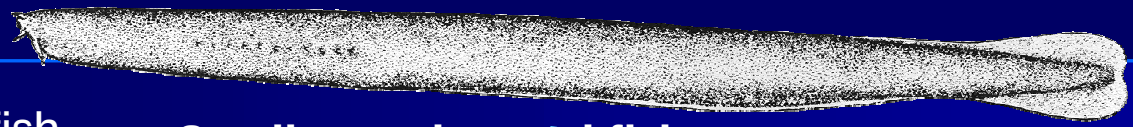
Periodic Strategists → **Robust Age Structure**

Intermediate Strategists → **Critical Spawning Biomass**

Equilibrium Strategists → **Very Low Harvest Rates**

Salmonic Strategists → **Marine Survival Component**

“We want to fish hagfish”



Pacific hagfish
(Eptatretus stouti)

Small experimental fishery:
Size = 63 cm
Fecundity = 15
Maximum age =17
Egg size = 5 mm
Size at 50% maturity = 35 cm
***k* = 0.07**

Opportunistic Strategists → **Critical Spawning Biomass**

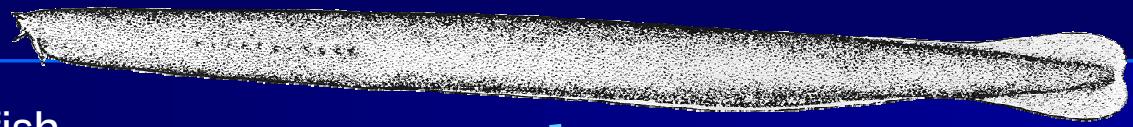
Periodic Strategists → **Robust Age Structure**

Intermediate Strategists → **Critical Spawning Biomass**

Equilibrium Strategists → **Very Low Harvest Rates**

Salmonic Strategists → **Marine Survival Component**

“We want to fish hagfish”



Pacific hagfish
(Eptatretus stouti)

Opportunistic Strategists → **Critical Spawning Biomass**

Periodic Strategists → **Robust Age Structure**

Intermediate Strategists → **Critical Spawning Biomass**

Equilibrium Strategists → **Low Harvest Rate ≅ 4% (Incidental catch)**

Salmonic Strategists → **Marine Survival Component**

Filling in the Assessment and Management Gaps

- Fishermen are increasingly diversifying their operations
  - must account for all species caught
  - large-scale ecosystem changes and major abundance/distribution changes
- Greater demand for advice on “new and developing” fisheries and unassessed species
- Using a species’ biology (life history strategies)
  - to advise on likely population dynamics under fishing pressure and climate variability
  - select suitable management scenarios