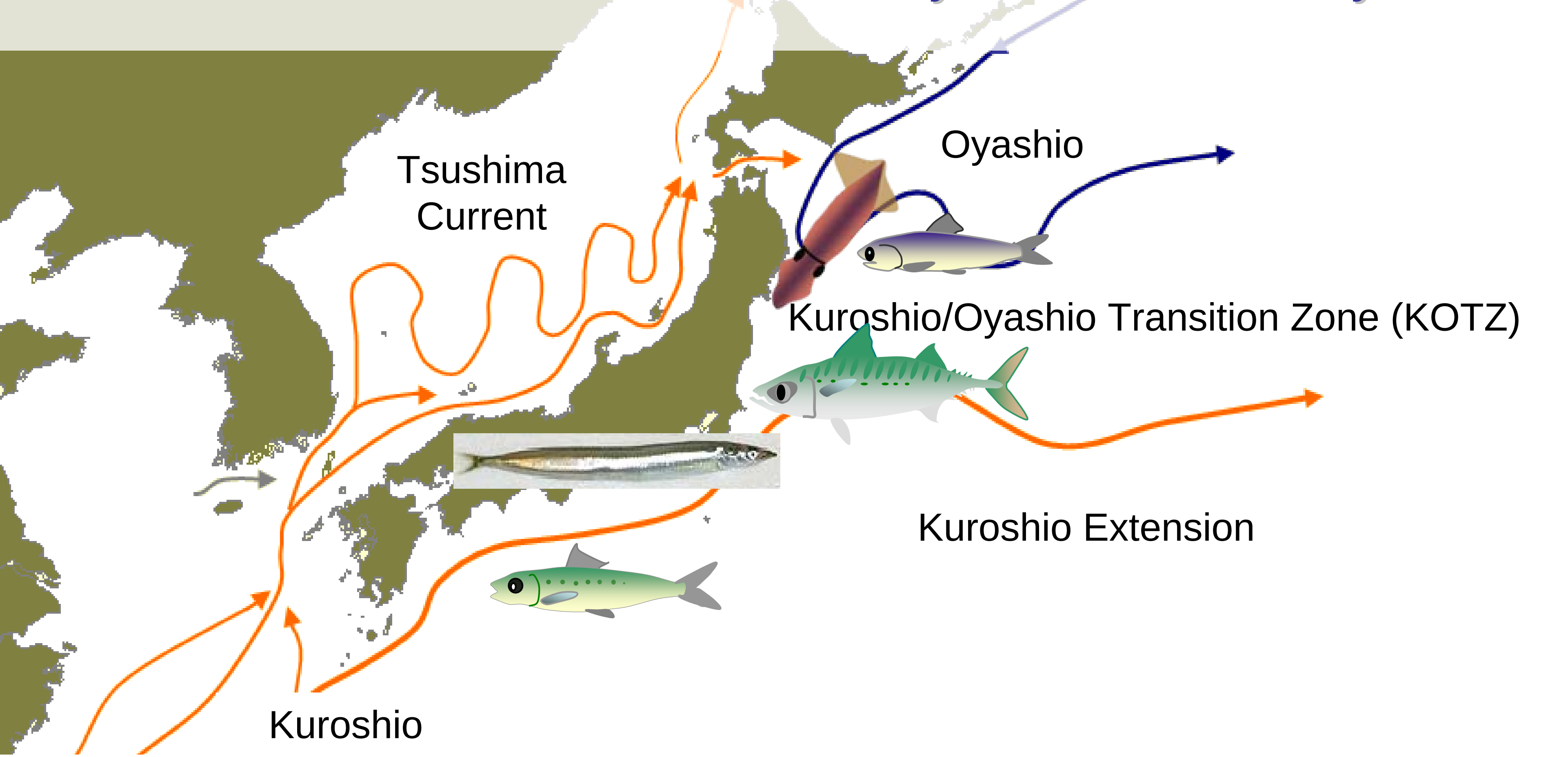
Fisheries Management and Ecosystem Regime Shifts: Lessons Learned from Kuroshio/Oyashio Current System



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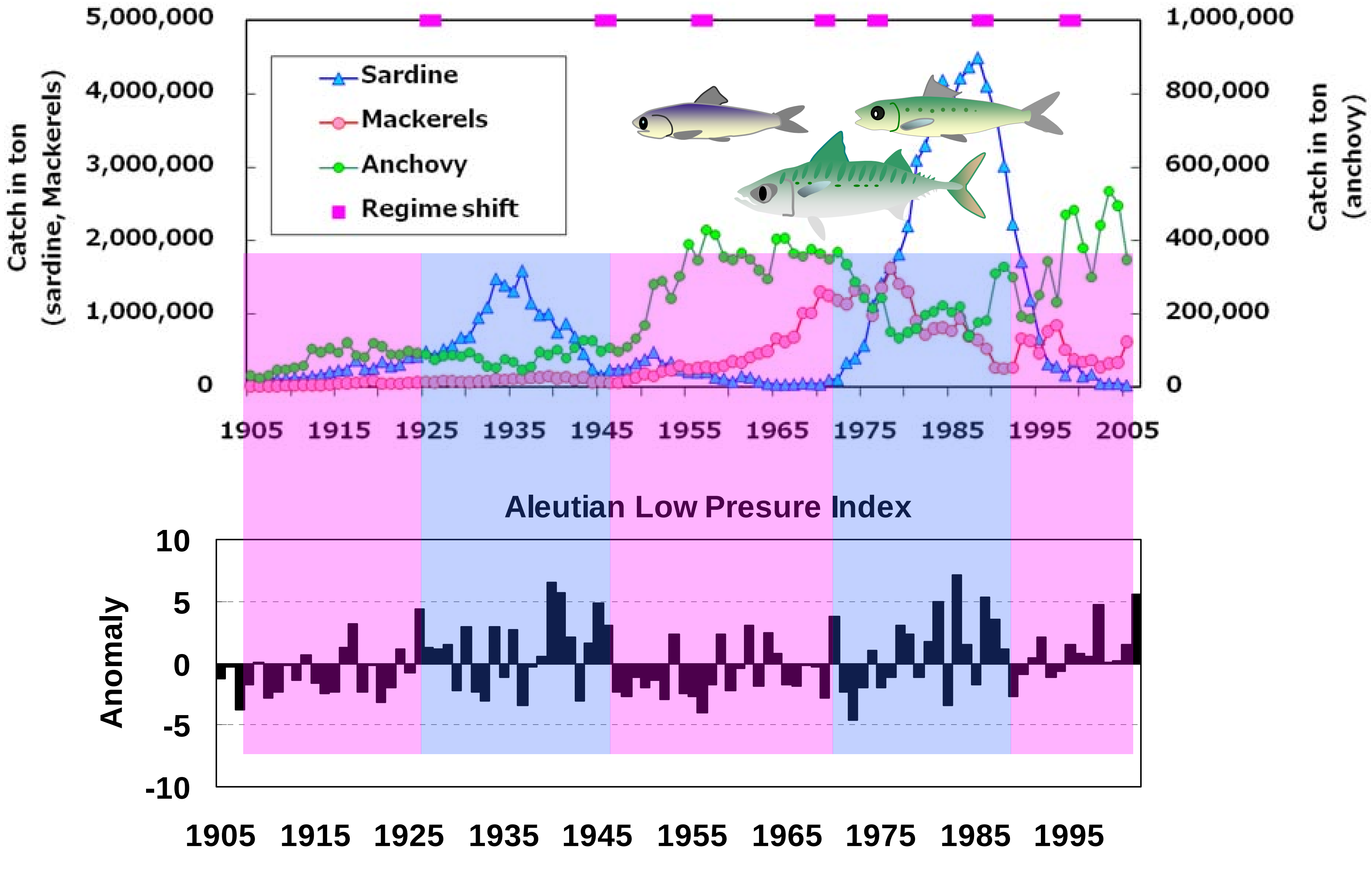
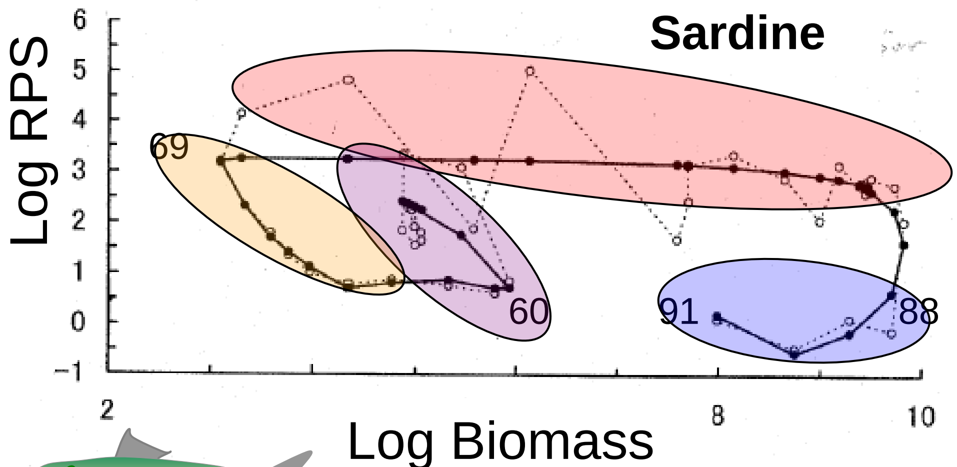
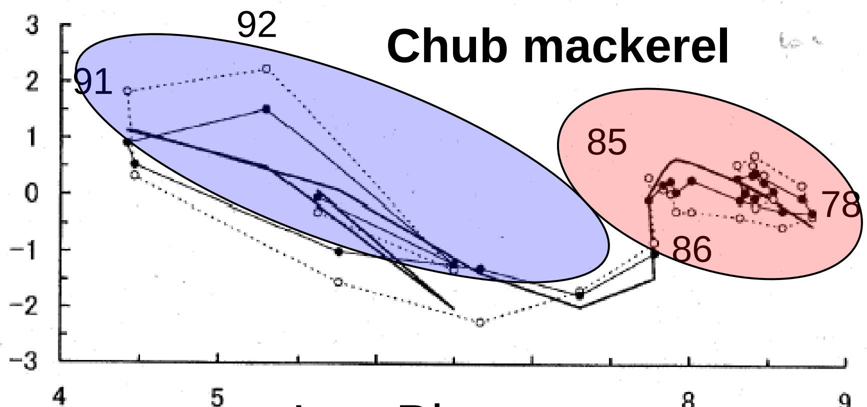
October 2008 Dalian

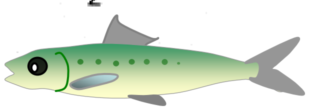
Japanese catch of Japanese sardine, anchovy, and mackerels (chub and spotted) during 1905-2006

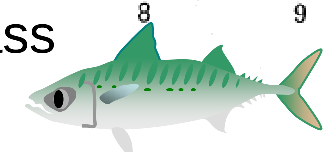


Regimes and regime shifts in stock-recruitment relations of the Japanese sardine and chub mackerel in the Kuroshio/Oyashio system (Tanaka 2003 Fish Sci)







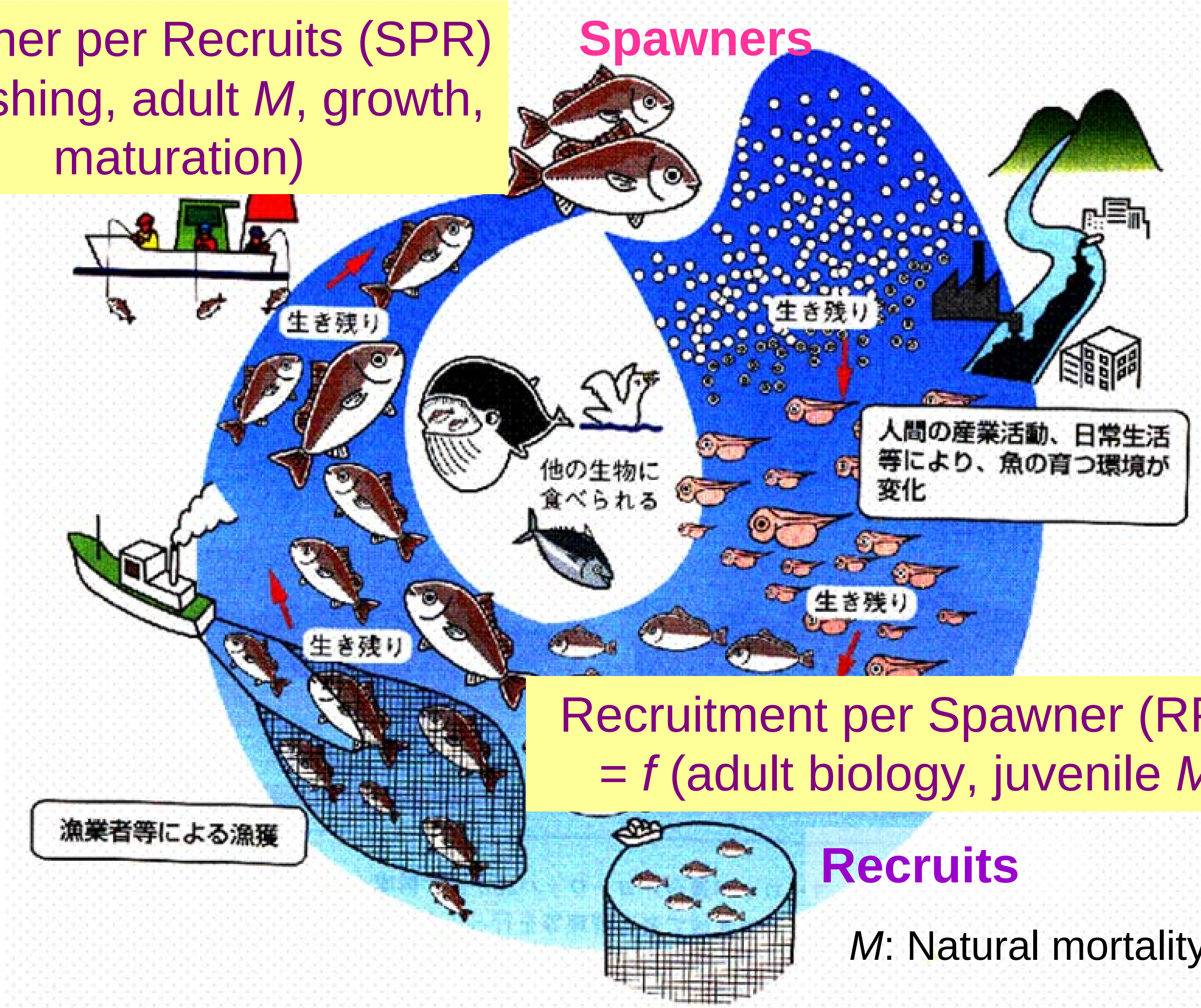


Estimated Carrying Capacity (*K*, 1000 ton) for each “regime”

Sardine	1950- 61 258	1962- 69 38	1970- 87 44,490	1988- 95 786
Chub mackerel			1970- 85 5,976	1986- 95 353

Fish lifecycle and fishing

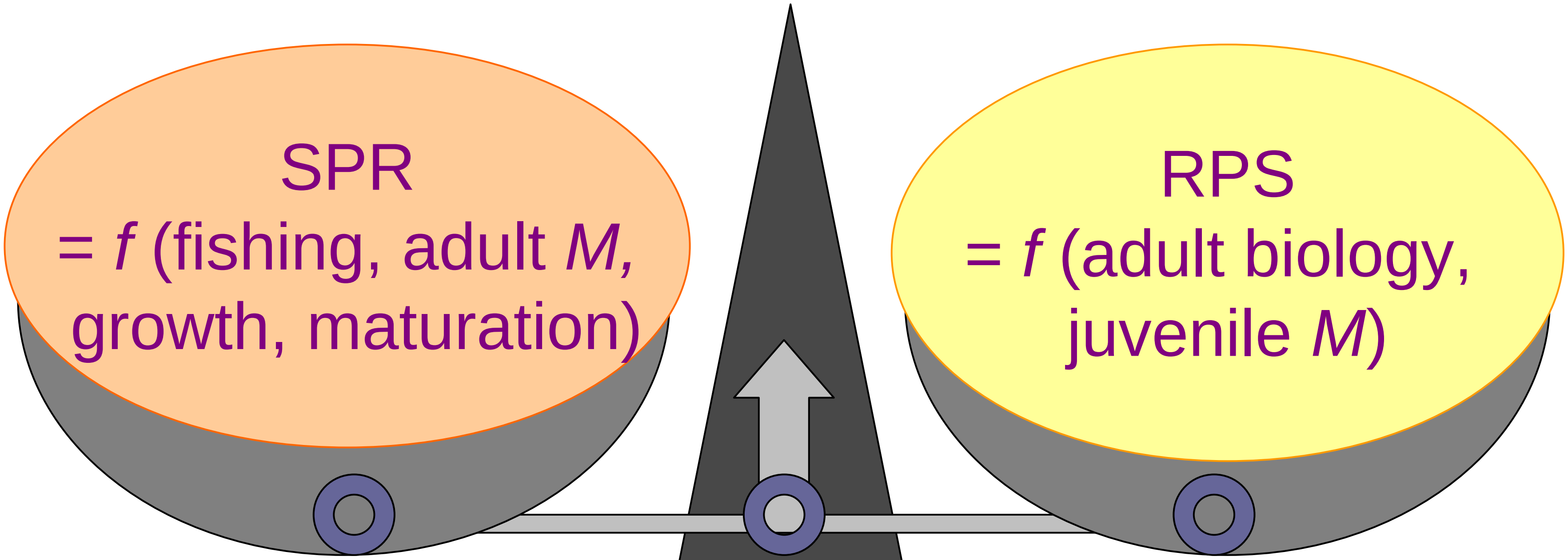
Spawner per Recruits (SPR)
= *f* (fishing, adult *M*, growth, maturation)



Recruitment per Spawner (RPS)
= *f* (adult biology, juvenile *M*)

M: Natural mortality rate

Sustainable use: A balance between RPS and fishing



NB1: Juvenile *M* is affected by ecosystem regime shifts

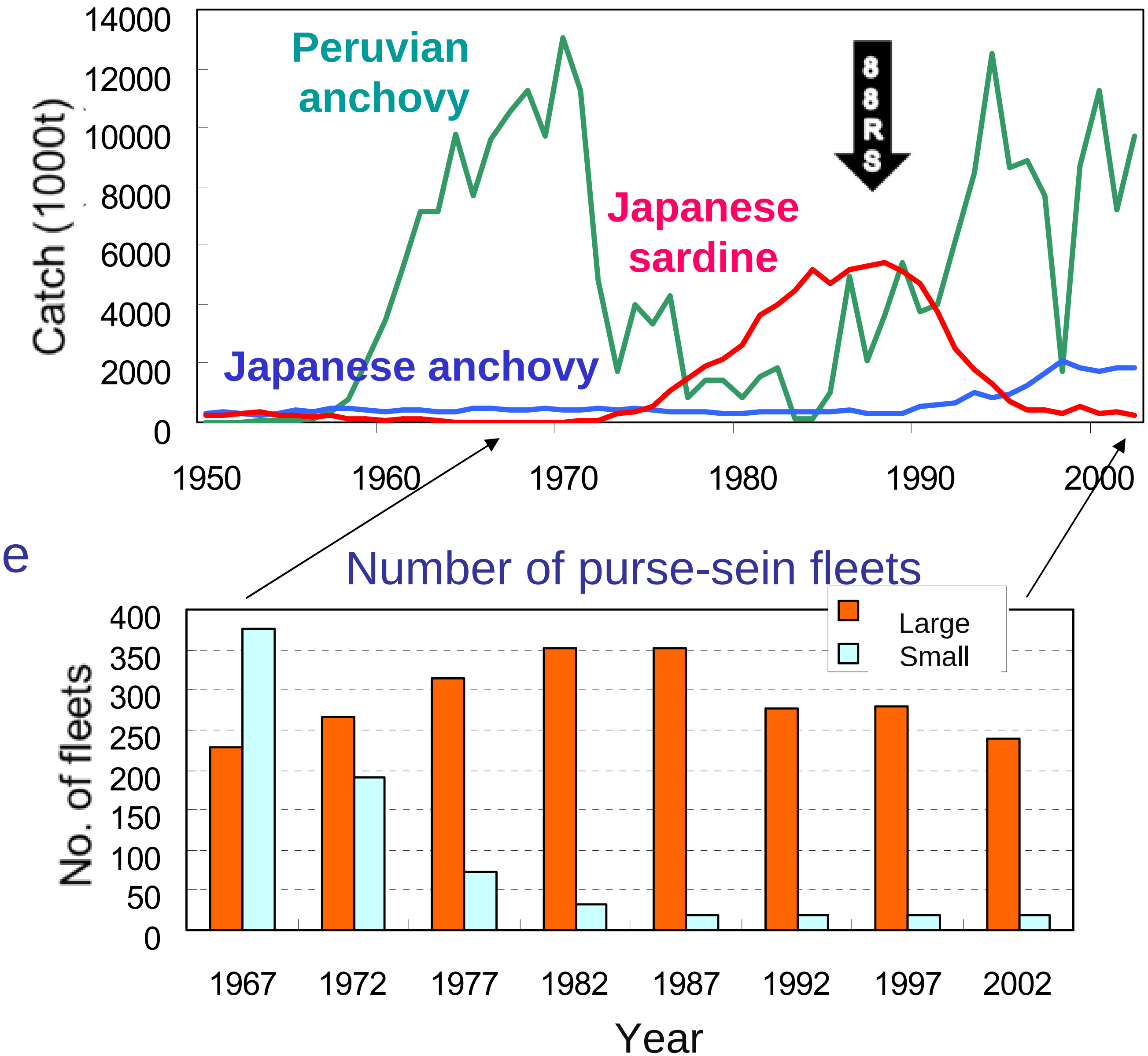
NB2: Adult biology (age/ size composition, fatness, etc.) are changed by fishing

NB3: Sustainable fishing pressure varies with RPS

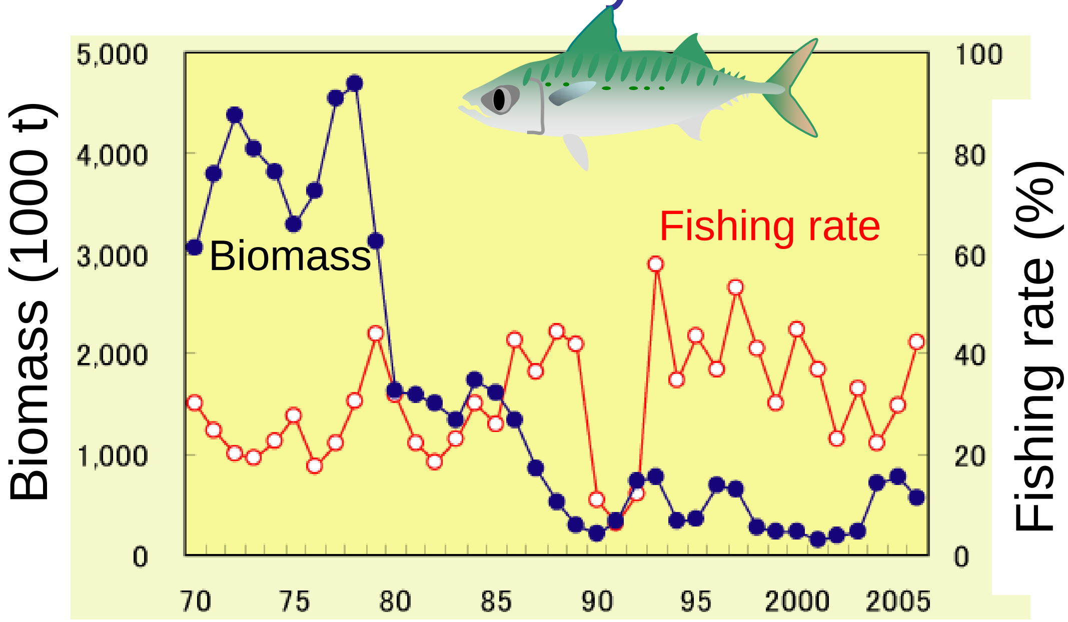
Mismatch between investments and 1988 regime shift: example of Japanese purse-sein fishery

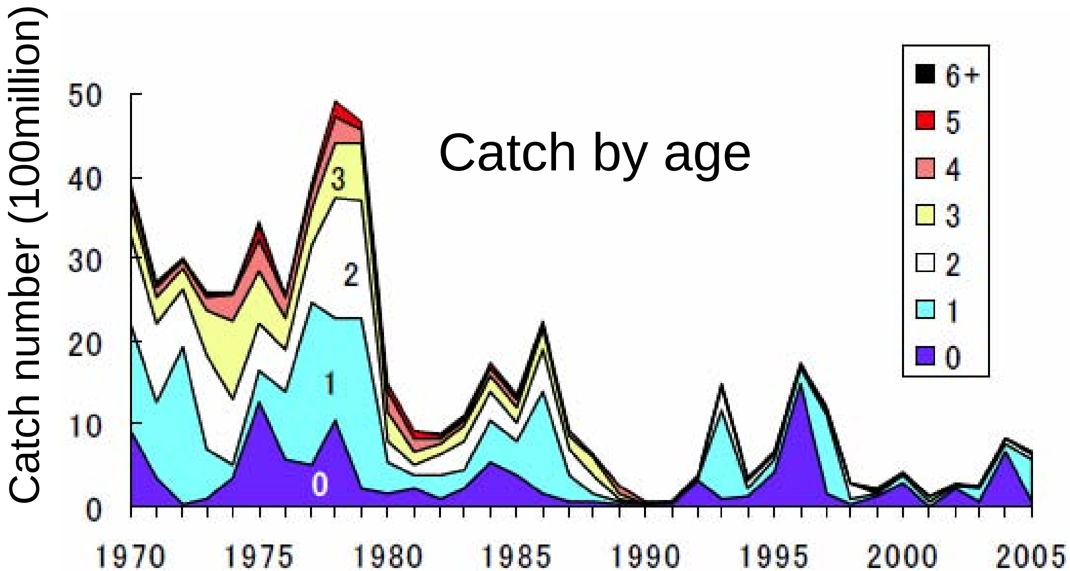
Late 1970s-1980s:
increase of larger fleets for fish-meal production, to compensate for collapse of Peruvian anchovy

After 1988/89 RS:
collapse of Japanese sardine and birth of excess fishing capacity, due to longer life of fleets and difficulties in reduction of fleets once established



Outcome of excess fishing capacity: prevention of recovery of chub mackerel stock





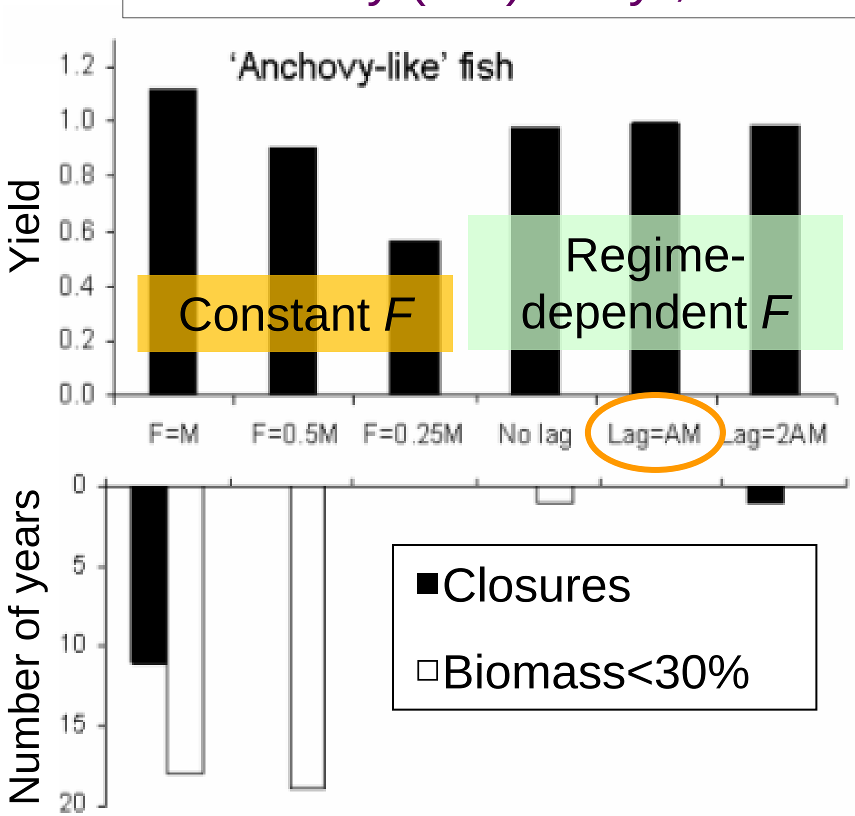
<u>Mid 1990s-:</u> fishing pressure increased, due to collapse of sardine

<u>1990s-:</u> Excess fishing capacity and catch of immature fish (age 0 and 1) prevented recovery of chub mackerel despite the occurrences of strong year classes in 1992, and 1996

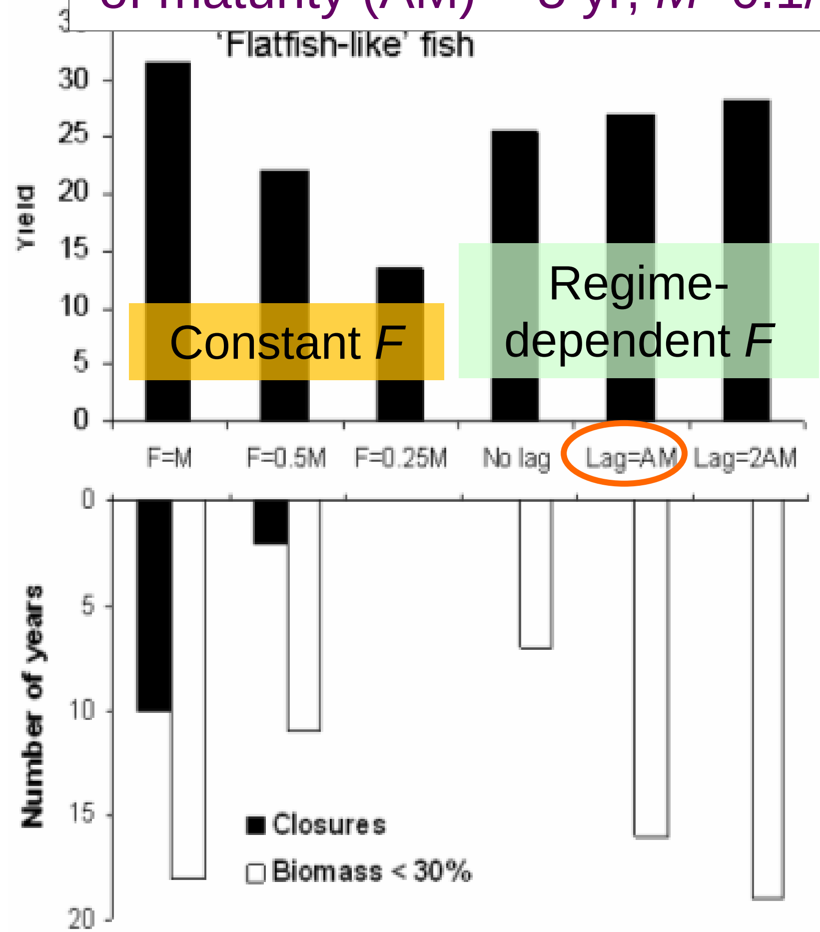
Also, reduced old fishes

How and when shall we change the fishing rates? - Results for 60-years simulation (Barange et al., in press)

“Anchovy”: lifespan = 5 yrs, age of maturity (AM) = 1 yr, *M*=1.2/yr



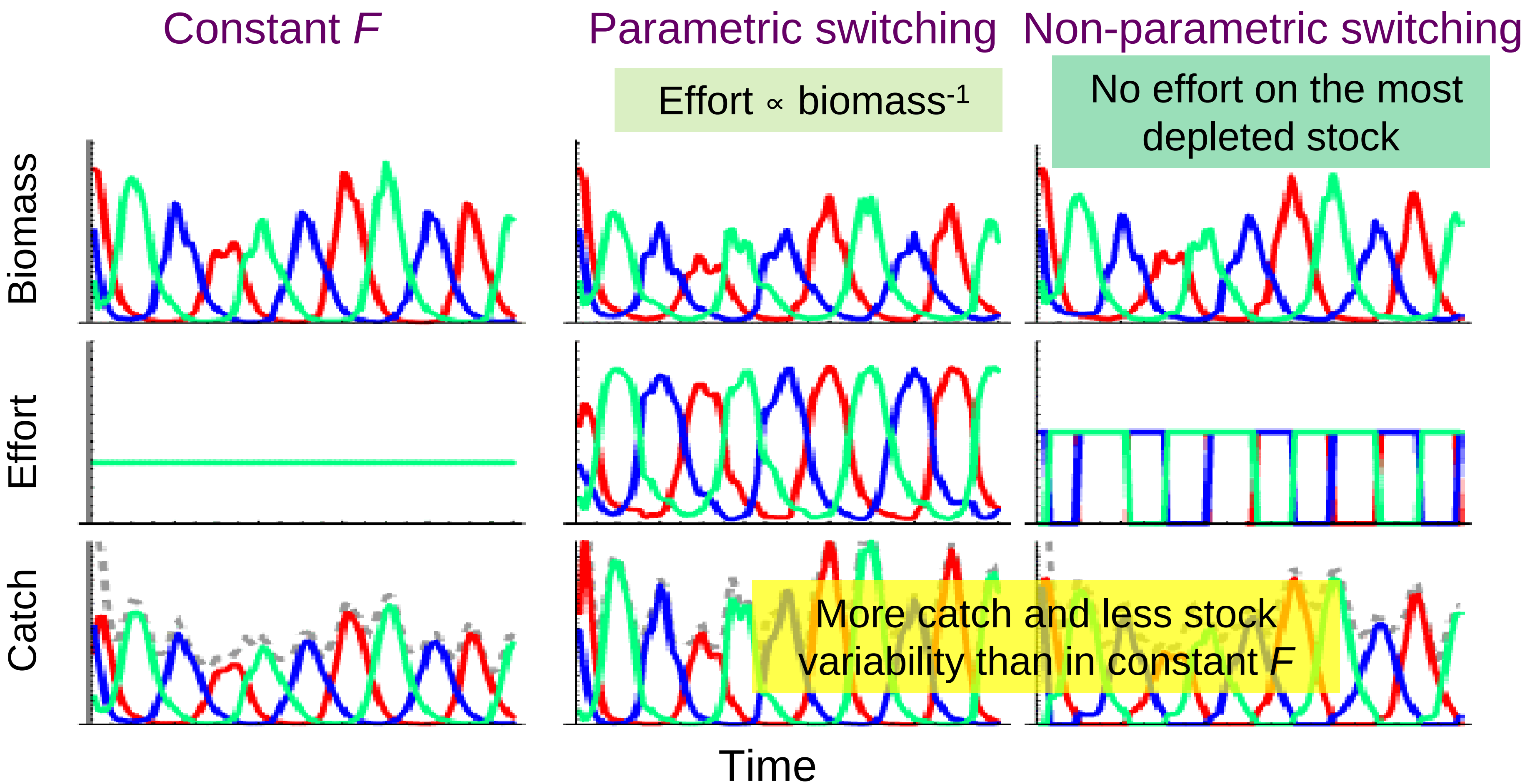
“Flatfish”: lifespan = 50 yrs, age of maturity (AM) = 5 yr, *M*=0.1/yr



Best balance: Regime-dependent *F* with a lag of years at AM

Target switching among 3 alternating stocks

(Katsukawa 2004, Katsukawa and Matsuda 2003 Fish Res)

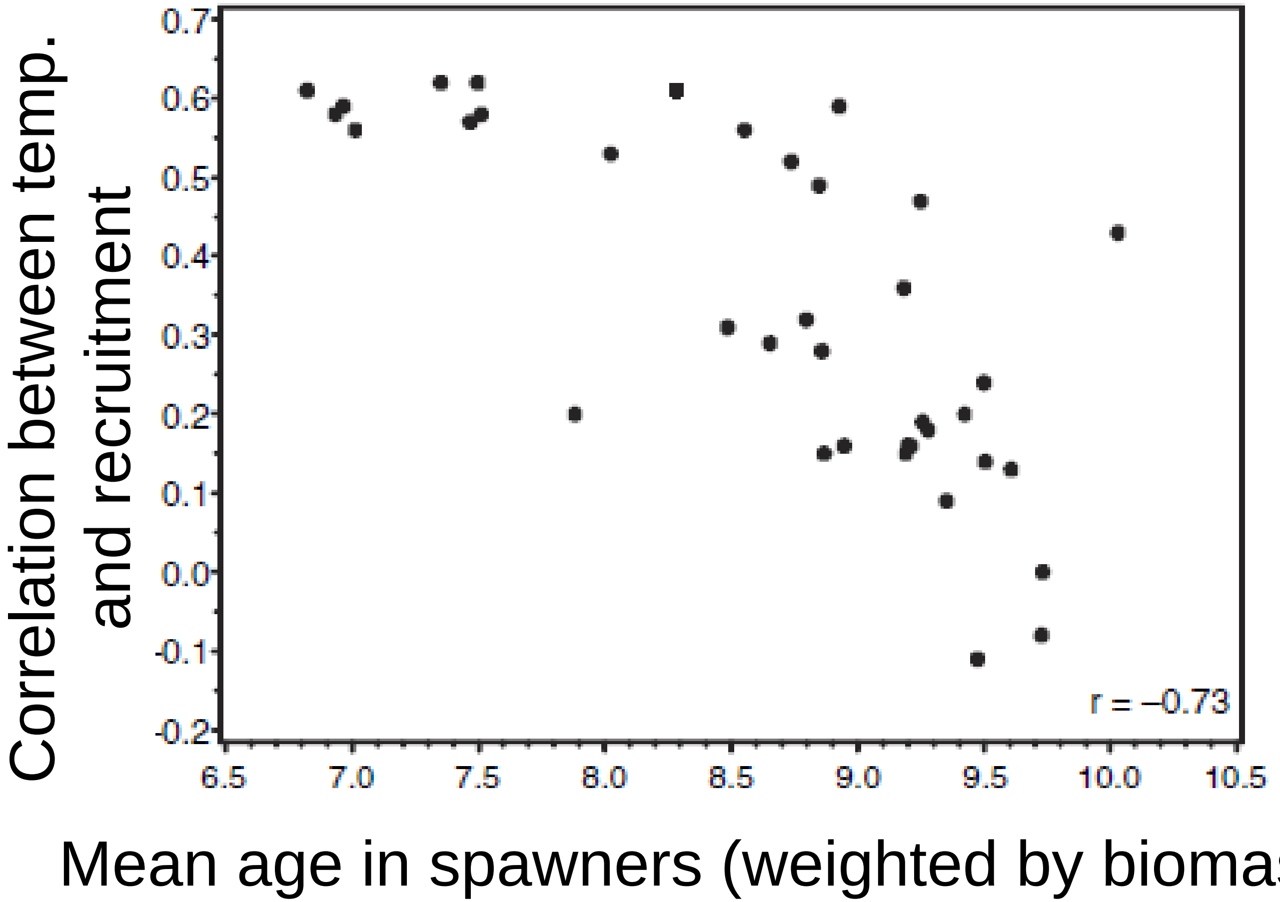


Issue 1: Differences in fish price and catchability

Issue 2: How to determine multi-species *Fmsy* or optimum fishing effort?

Importance old/big spawners of Atlantic cod

(Ottersen et al., 2006 FO)



Mechanism:

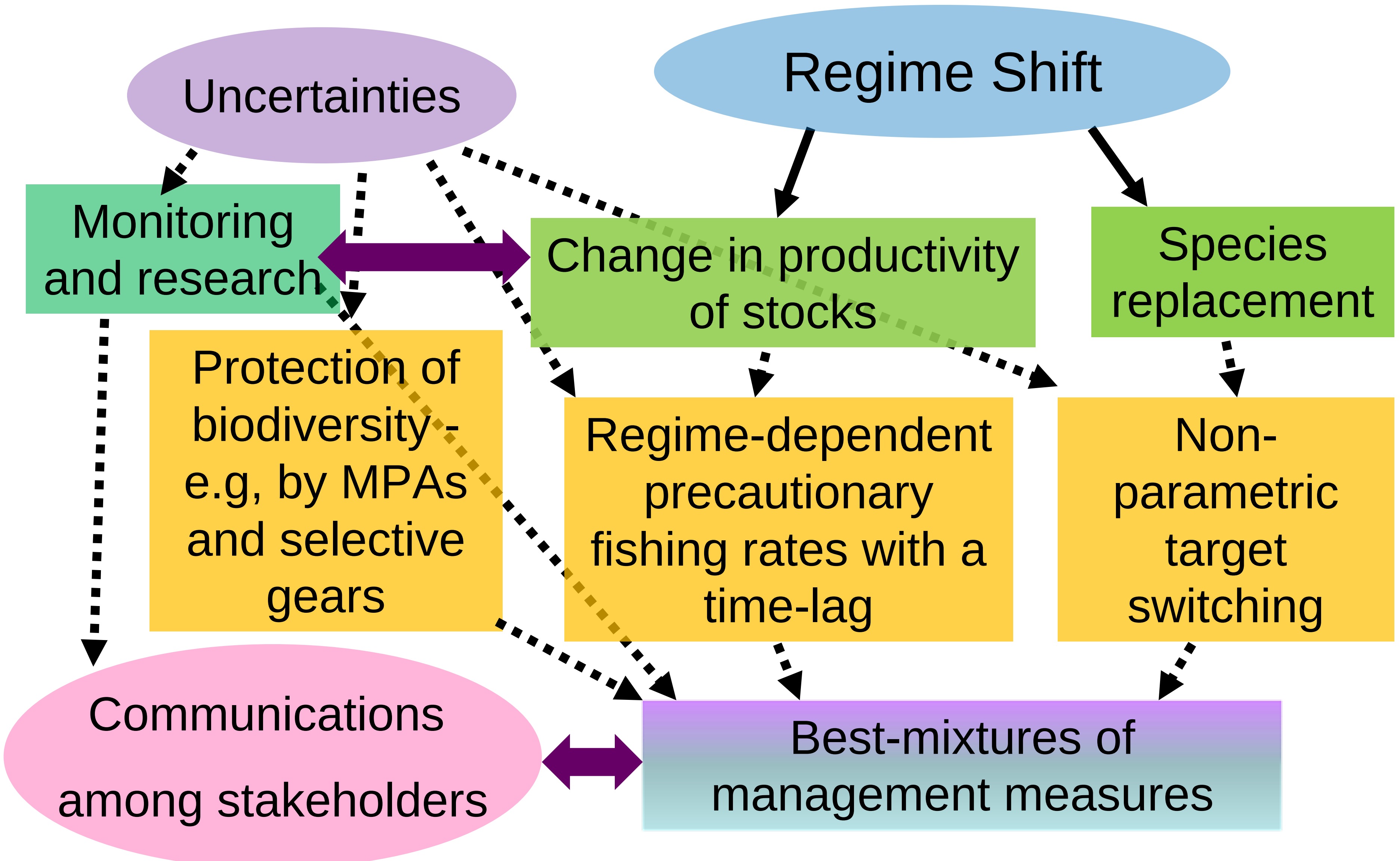
Older > younger

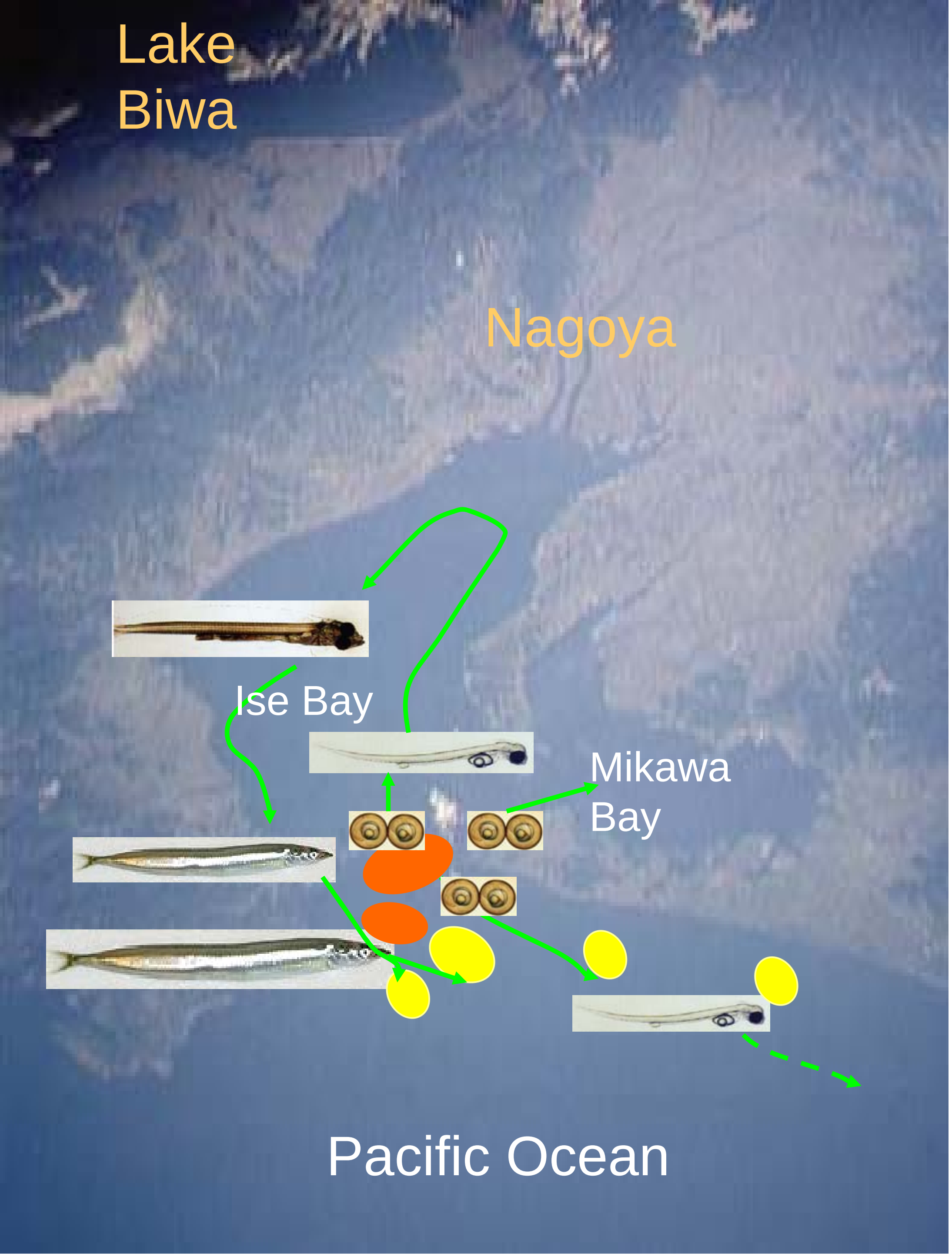
Spawning period

Vertical range of egg distribution

BOFFF (Big, Old, Fat, Fecund Female) hypothesis

“Regime Concept” of fisheries management





Co-management of sandlance in the Ise Bay

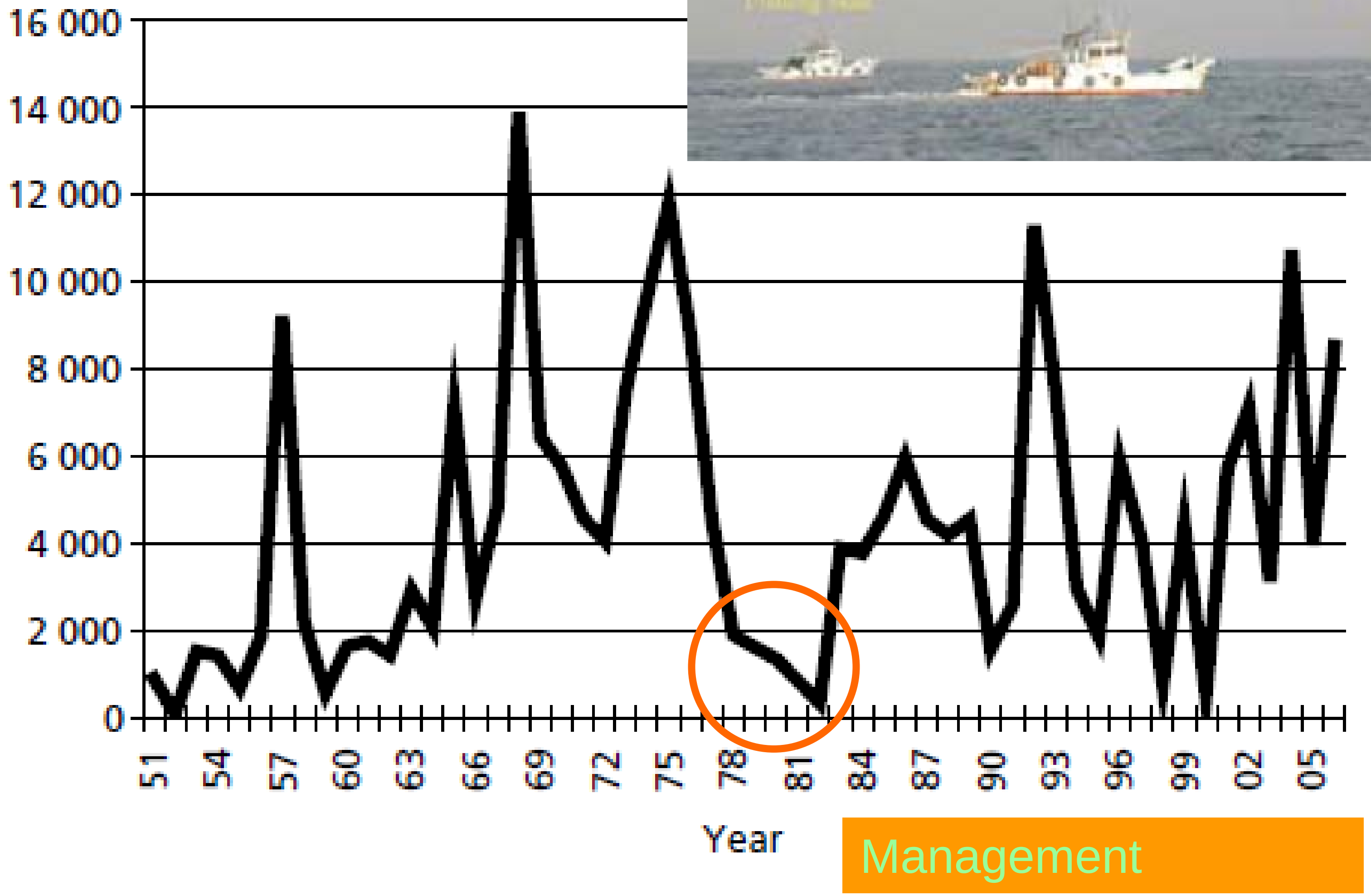
Life span: 3 years
Age of maturation: 1 yr
Fishery: pair trawl for larvae for human consumption and adult for aquaculture bait

Spawning Gr in winter

Estivation Gr in summer and autumn

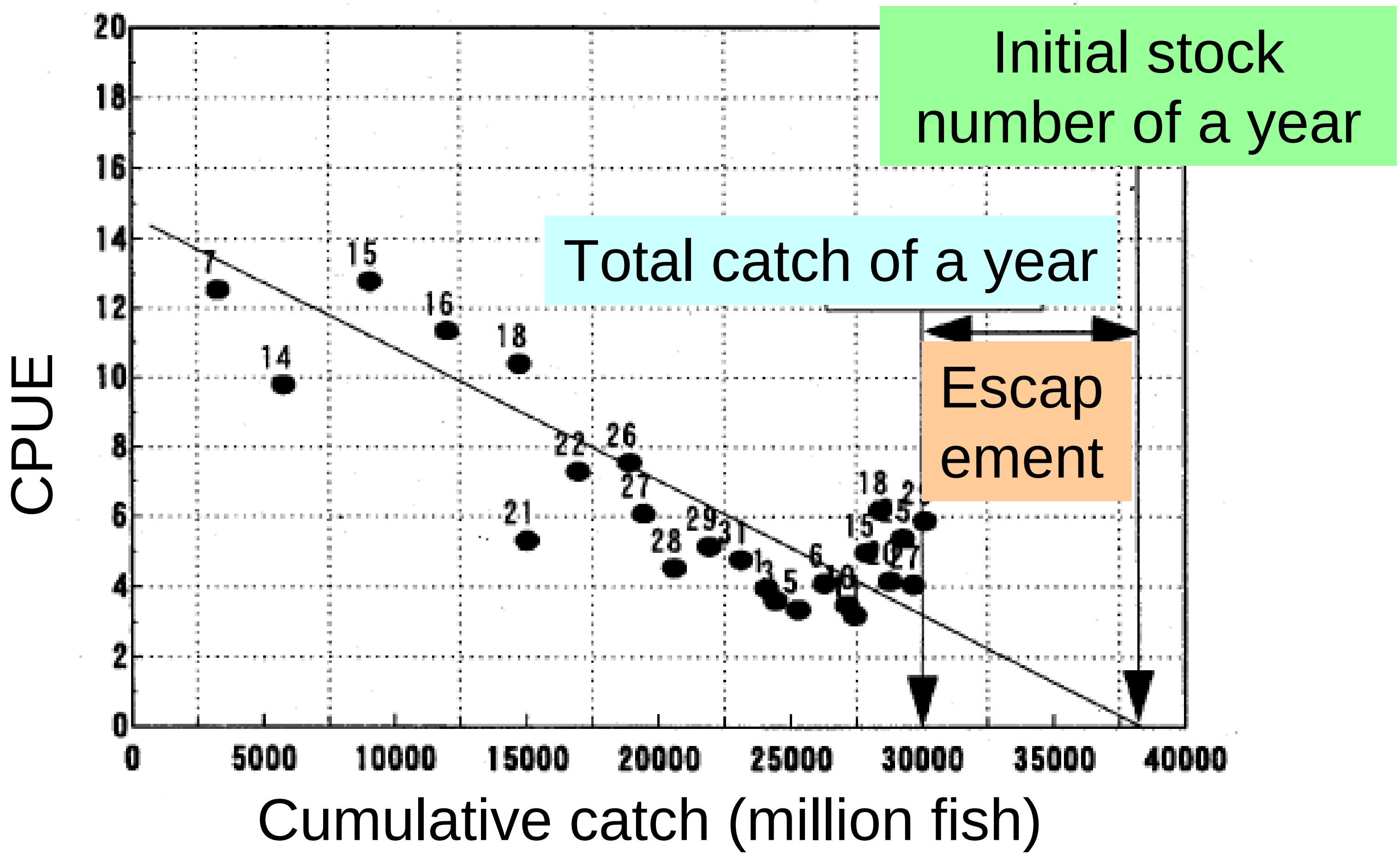
Catch history of sandlance in the Ise Bay
(Tomiyama et al., 2008)

Unit: metric ton

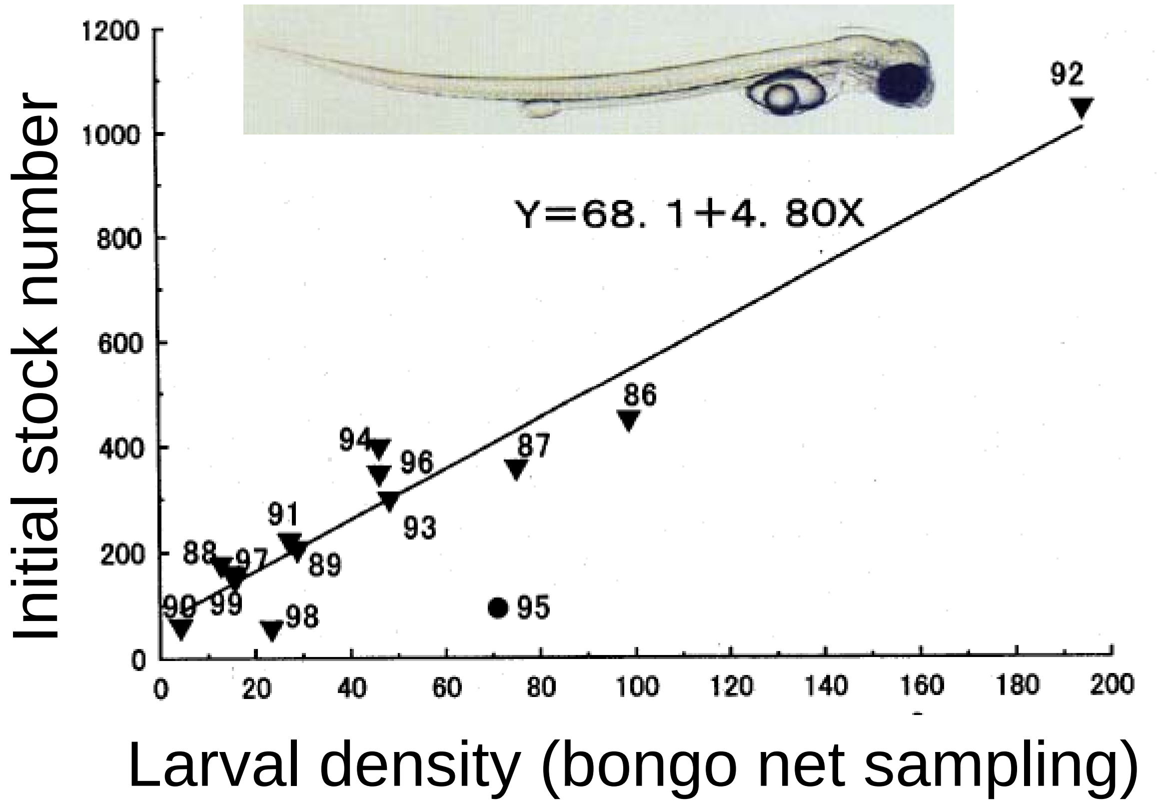


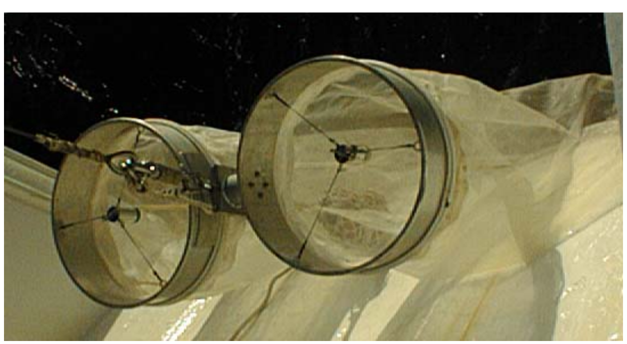
In-season stock assessment, monitoring and constant escapement strategy (CES) for sandlance

(Tomiyama 2000)



Pre-season monitoring of sandlance (Tomiyama 2000)



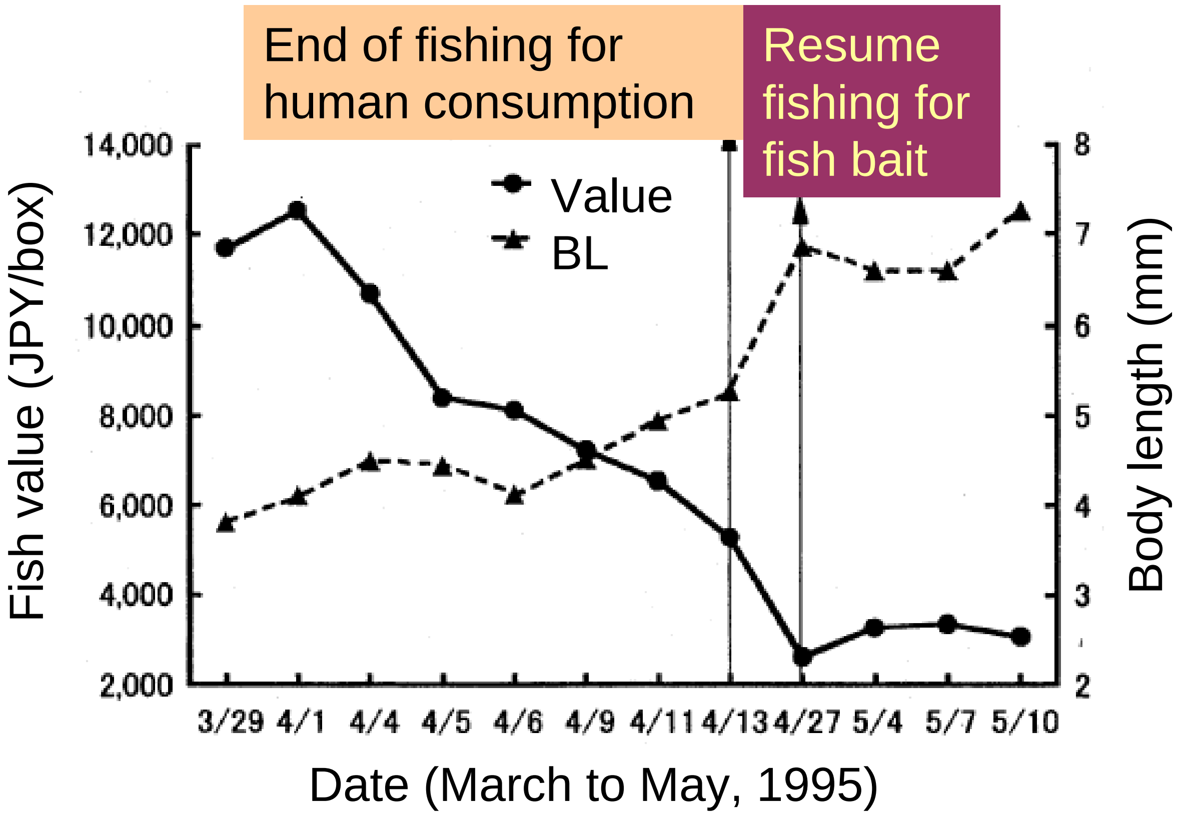


Pre-fishing monitoring gives a good estimate of initial stock

Under CES, good estimate of annual total catch

Optimum fishing plan

Consensus of management (Tomiyama 2000)



Small area, limited number of fishers, and good relation between fishers and scientists

The fishing strategy is determined through consensus between local fisher's associations based on scientific information provided by fishery research stations

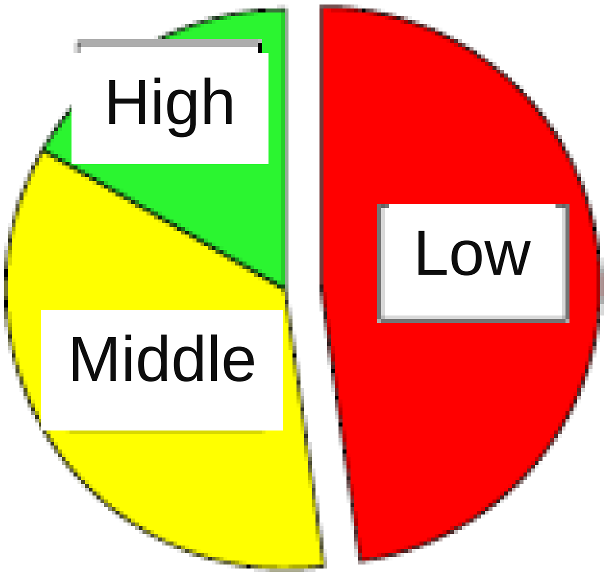
Why co-management of sandlance succeeded?

- ✓ Fishing right: ownership of the stock by several autonomous fishers organizations
- ✓ Sandlance fishers can control fish price (to some extent) due to the limited market
- ✓ The local stock of sandlance was compact enough to manage by multiple fisheries: all fishers can feel effects of management simultaneously
- ✓ There were good relations among fishers, researchers and managers, to develop a management protocol based on scientific knowledge

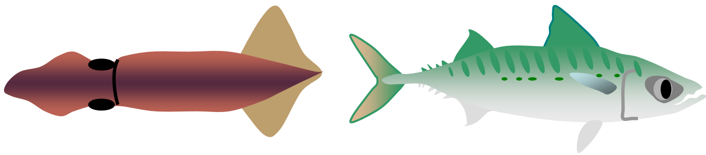
Many of the Japanese fishery stocks are still bad

Why Japanese right-based management did not work?

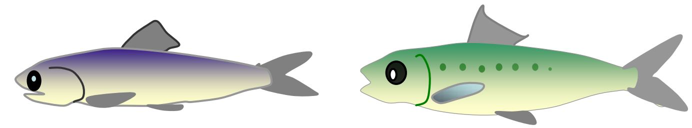
- ✓ Race for fish
- ✓ Over-capitalization
- ✓ Degradation of habitat
- ➢ Insufficient scientific knowledge on population dynamics and uncertainties
- ➢ Insufficient mechanism for stock recovery *or* avoid severer management: misuse of "right" ?



Stock level of 90 stocks assessed in 2007 around Japan



Summary



The “regime concept” of fishery management includes:

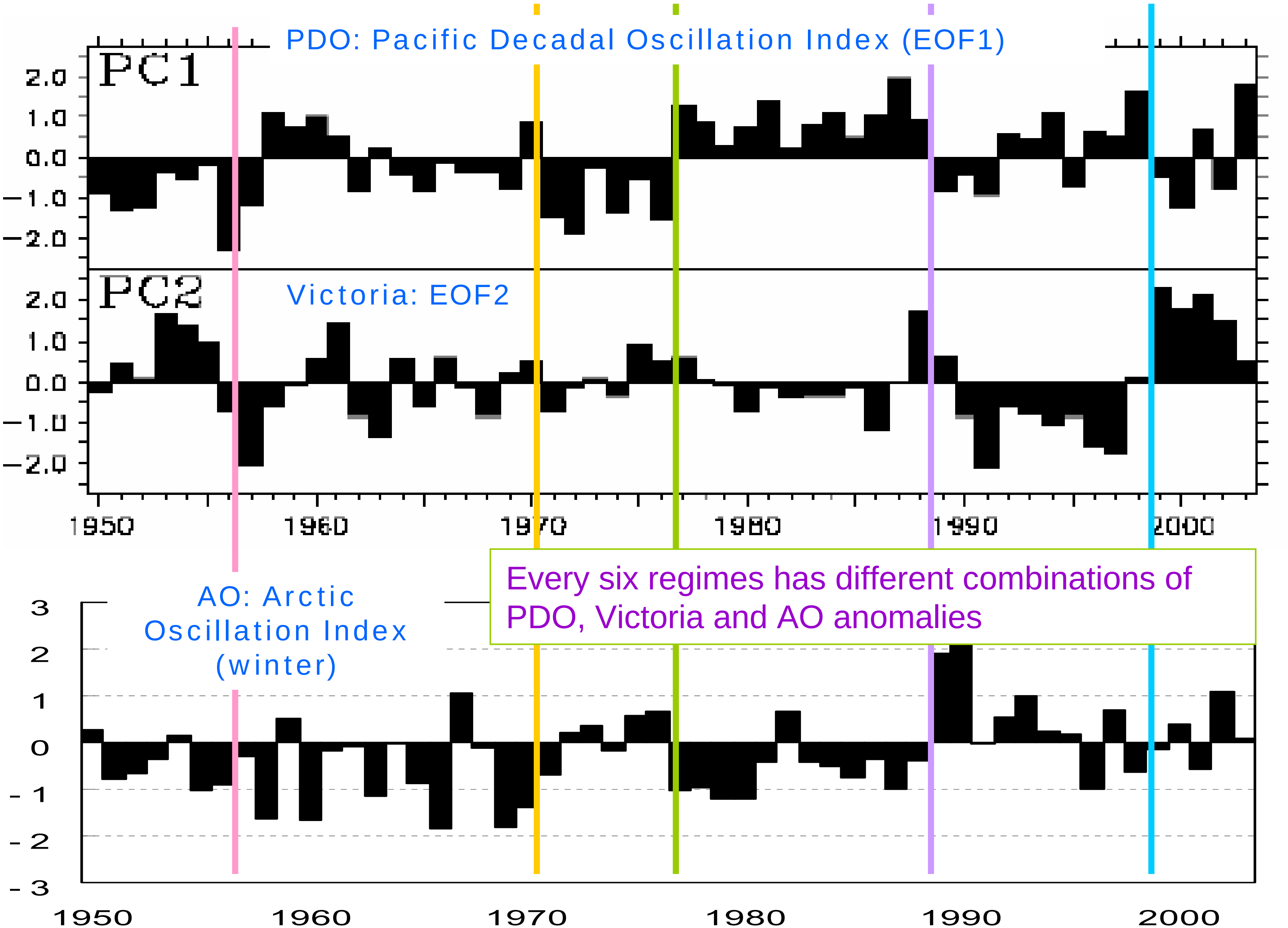
- ➢ Regime-dependent fishing rates with a time-lag after the year of regime shift
- ➢ Target switching
- ➢ Conservation of age/size diversity
- ➢ Precautionary approach
- ➢ Consider mismatches between life spans of fishing fleets and ecosystem regimes
- ➢ CAVEAT: RS is not a mare reversal to previous state

Co-management of fishery stocks needs:

- ✓ Incentives for management (economic and social)
- ✓ Studies for explanations on stock depletion
- ✓ Good relations among fishes, researchers and managers to develop a science-based management
- ✓ Seek alternative stocks when the target stock is depleted

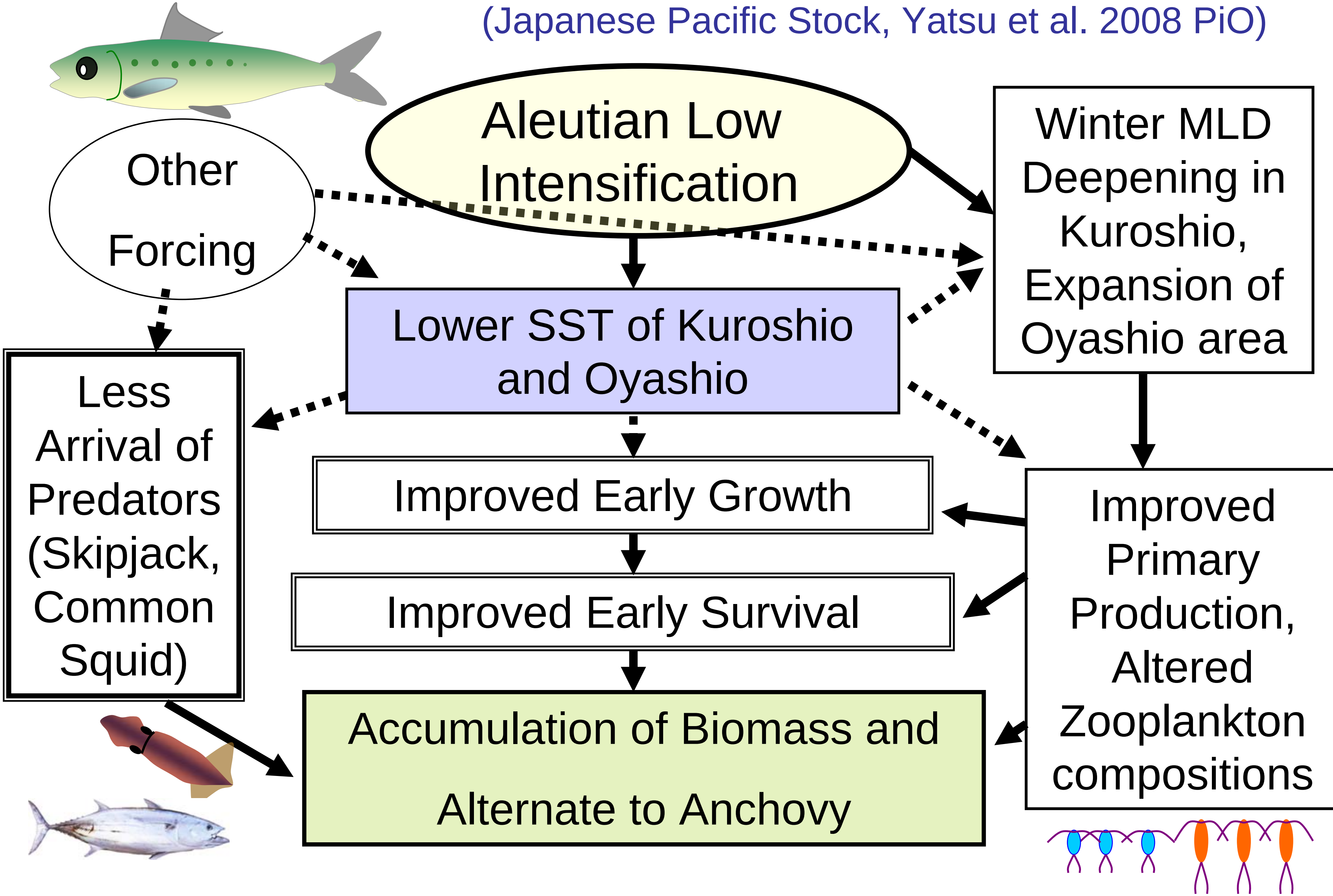
PDO, Victoria, AO and SST regime shifts

(regime shift years: after Yasunaka and Hanawa, 2002)

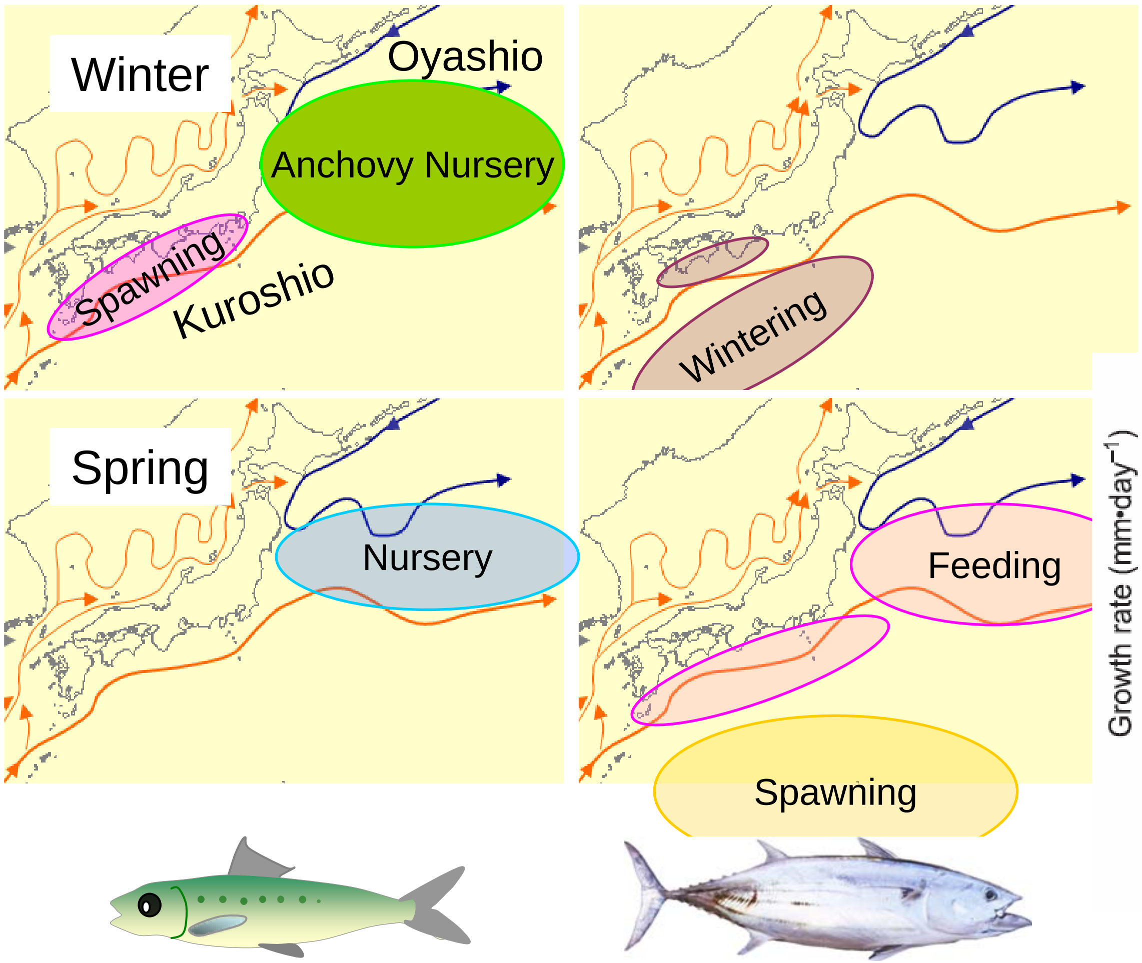


Conceptual Model Diagram for Japanese Sardine

(Japanese Pacific Stock, Yatsu et al. 2008 PiO)

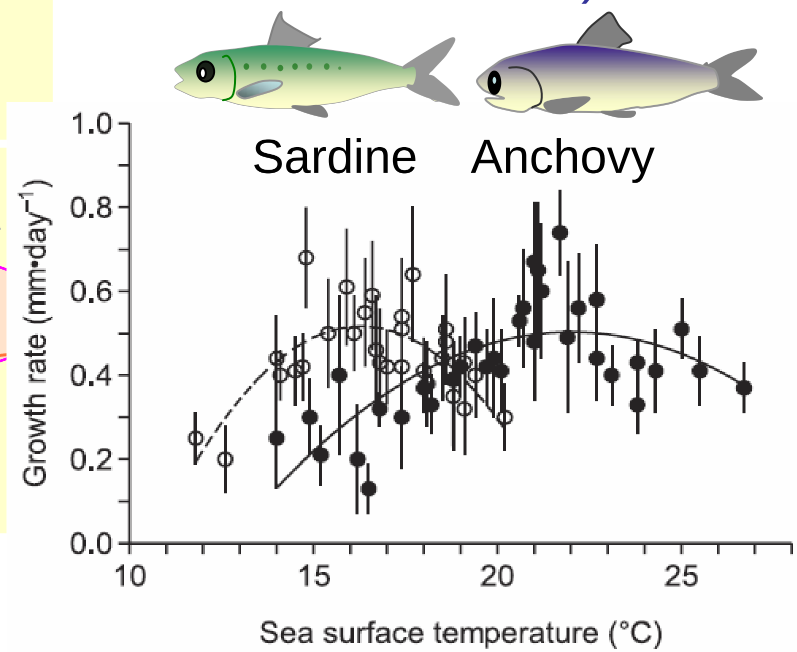


Connectivity to predators



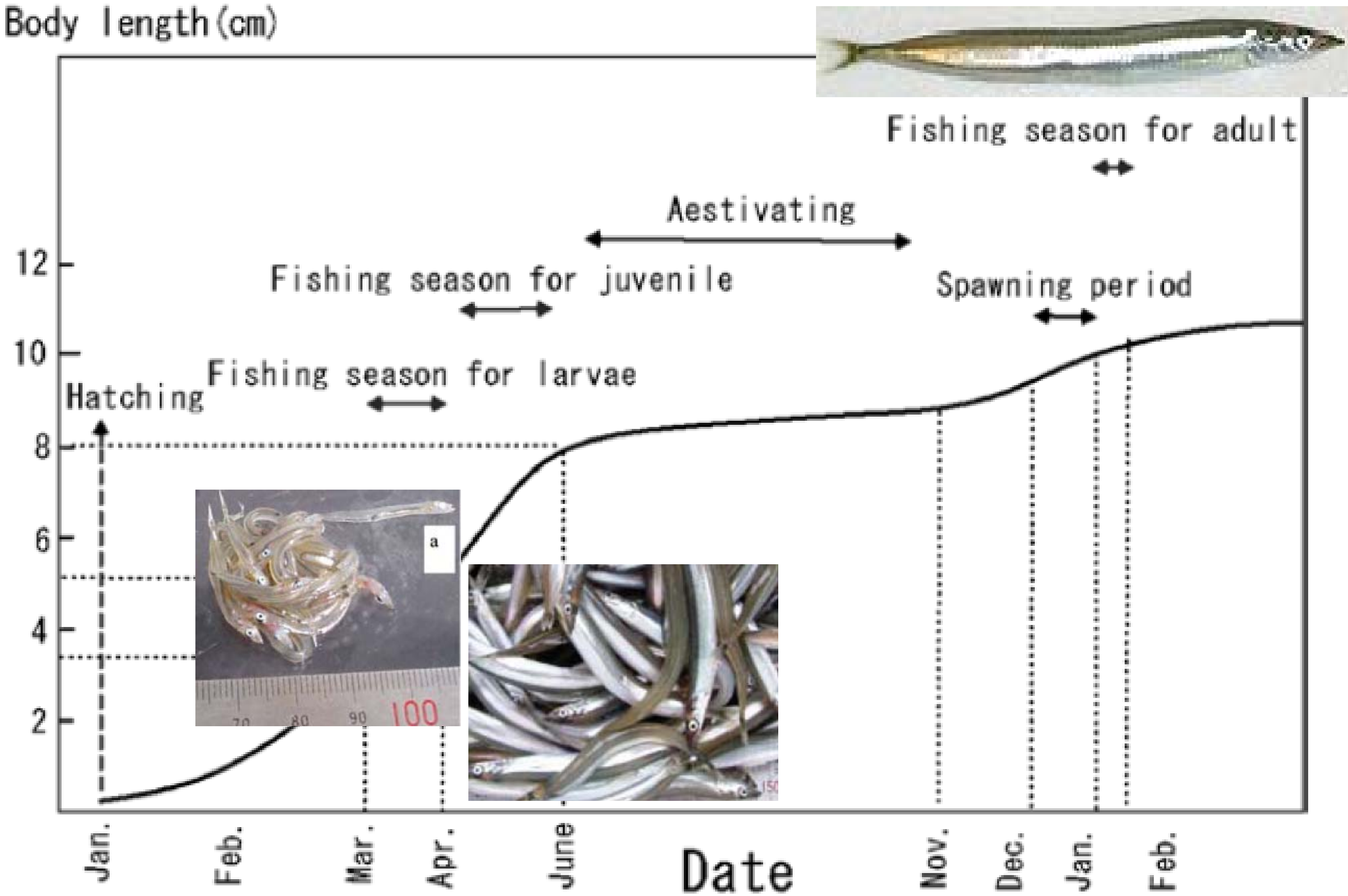
Optimum temperature for early growth and survival

(Takasuka et al., 2007CJAFS)



Higher SST would enhance arrival of skipjack and biomass of Japanese common squid

Growth, fishing and aestivation of sandlance in the Ise Bay (Tomiyama et al. 2008)

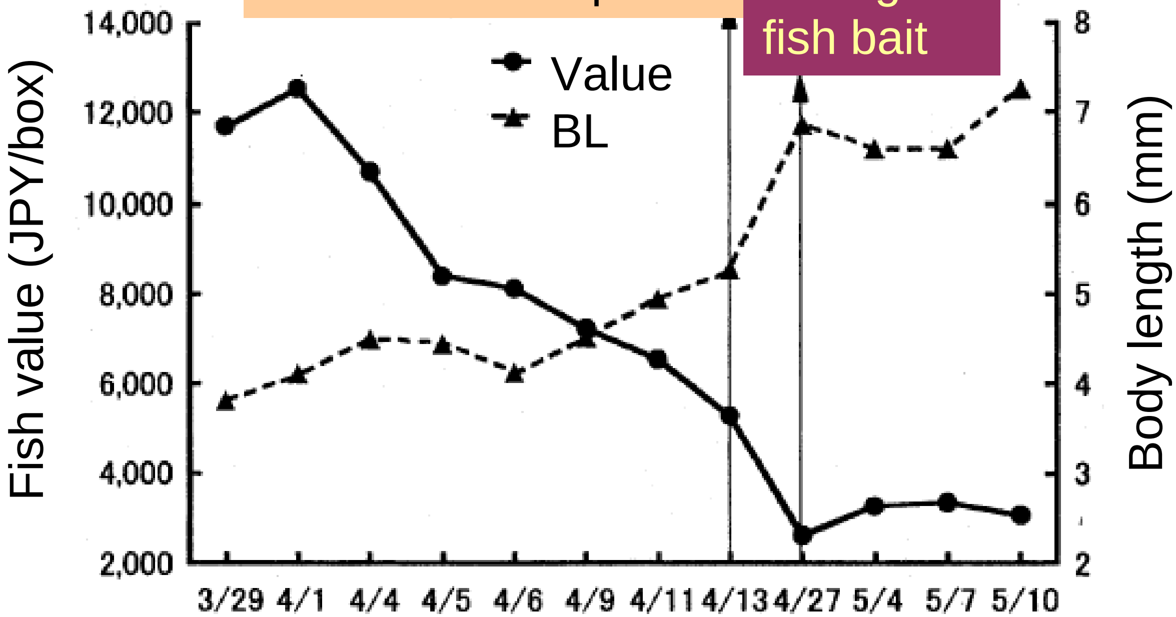


In-season stock assessment, monitoring and constant escapement strategy (CES)

(Tomiyama 2000)

End of fishing for human consumption

Resume fishing for fish bait



Date (March to May,

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