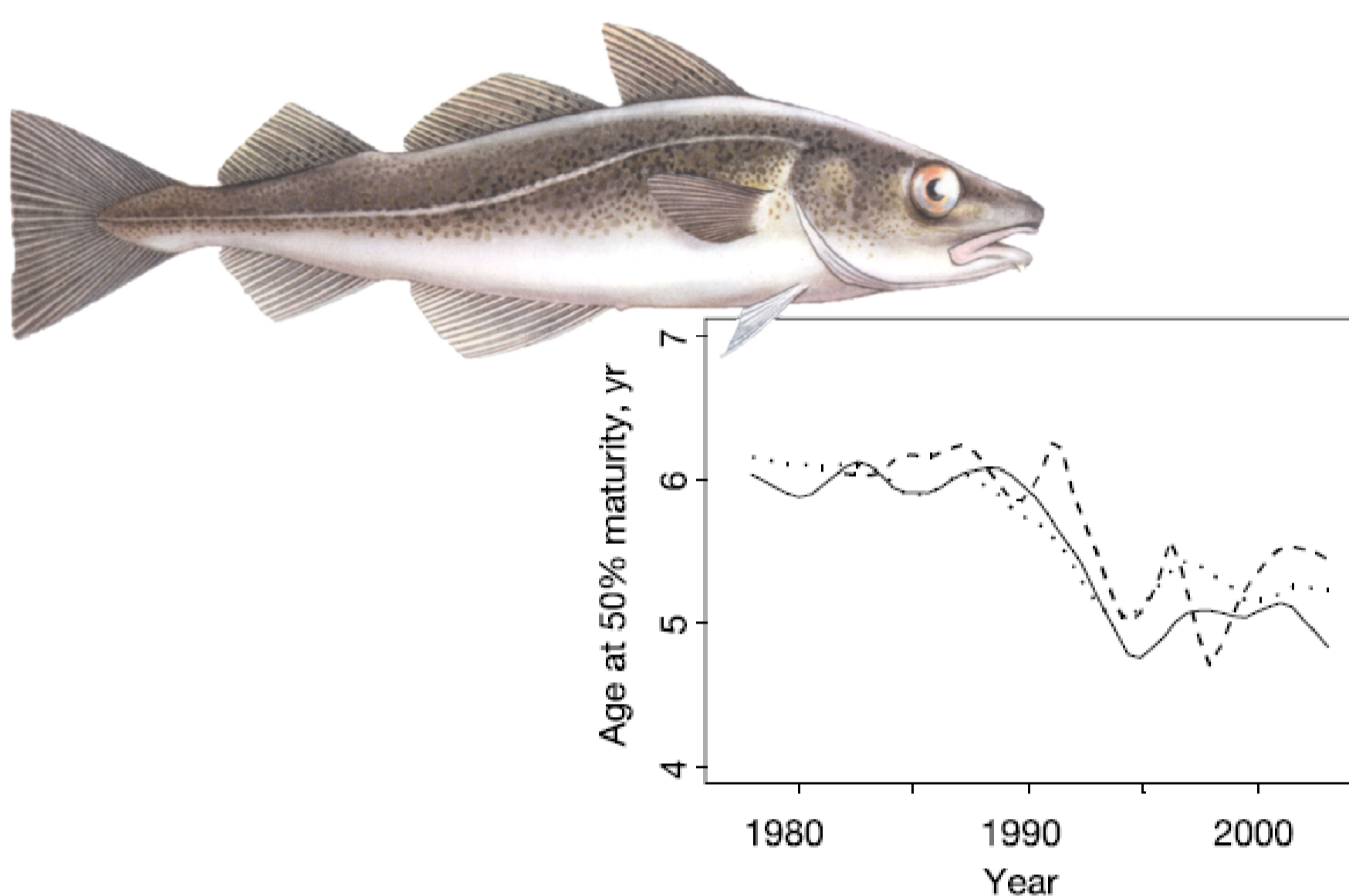


Fishing as a Driving Force of Evolution

- ✓ A key determinant of life-history diversity is the trade-off between fitness gains in early and late life
 - Example: **growing big** requires sacrificing early reproduction in favour of growth
 - Benefits** of growing big: ⤴ outgrowing natural predators ⤴ big fish are highly fecund
 - Costs** of growing big: ⤴ loss of reproduction in early life ⤴ chance of dying before reproduction
 - **Fishing reduces the benefits and increases the costs** of growing big → fishing favours faster life



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Period of heavy exploitation coincided with declining age at maturation in northern cod (Olsen et al. 2004)

Evidence

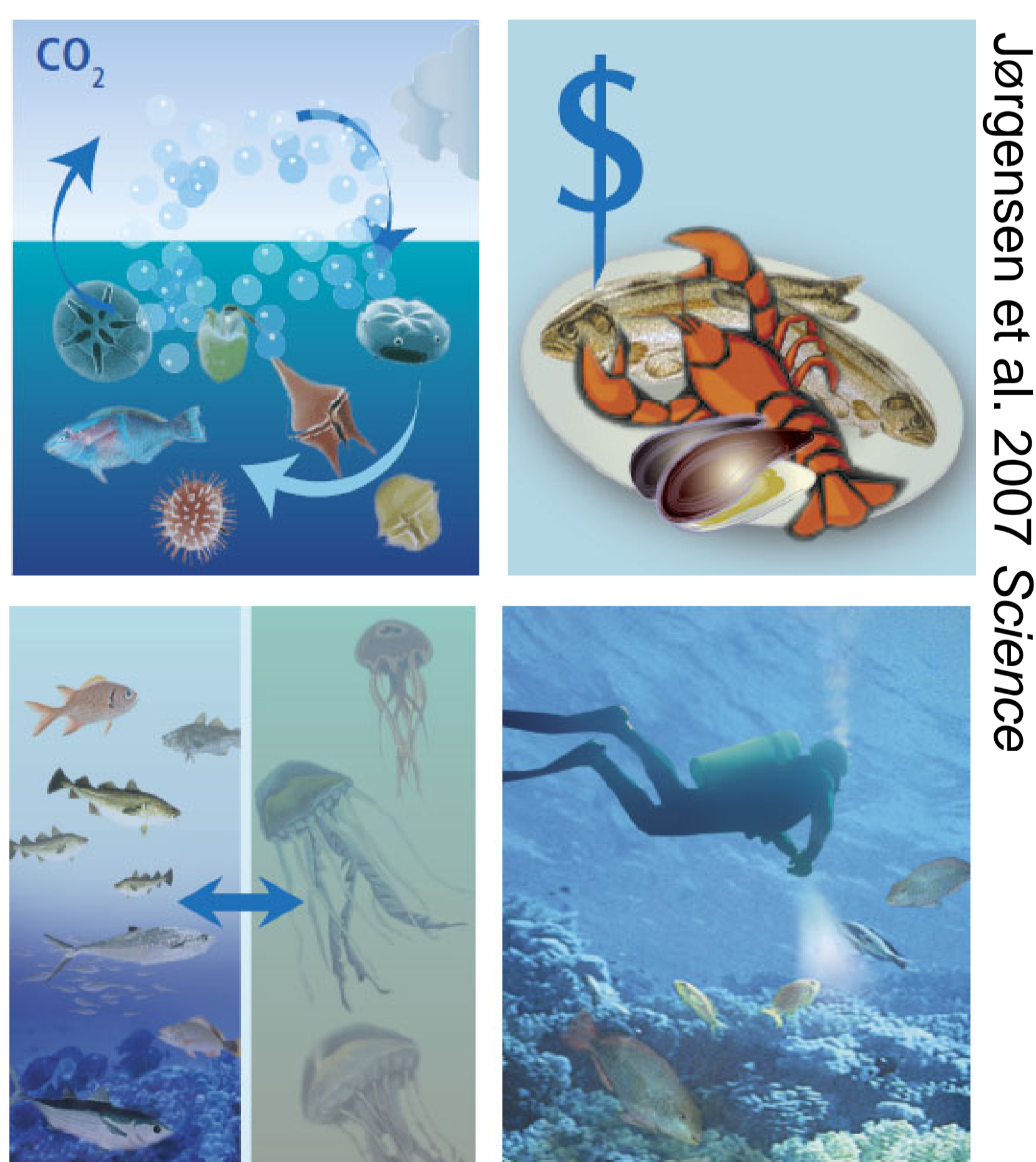
- ✓ Trends towards earlier maturation are ubiquitous in heavily exploited fish stocks
 - In agreement with predicted fisheries-induced evolution
 - Other explanations are possible
- ✓ Method developed at IIASA helps to disentangle explanations (Heino et al. 2002)
 - Applied now in 13 species, representing >30 cases
 - Most cases suggest that fisheries-induced evolution has occurred

Consequences

- ✓ Fish adapted to fishing:
 - ☺ tolerate more overfishing
 - ☹ may be more sensitive to long-term fluctuations?
 - ☹ are less productive
 - ☹ are on average smaller
- Fisheries-induced evolution can diminish the value of fish as a resource

Evolutionary Impact Assessment

- ✓ We need to assess costs and benefits:
 - ongoing fisheries-induced evolution
 - mitigating actions
- ✓ New framework: the Evolutionary Impact Assessment (EvoIA)
 - **Quantify** the consequences of fisheries-induced evolution on **utility** of a fish population under alternative management **actions**, including the status quo
 - ☞ Jørgensen et al. 2007, Laugen et al. 2012



Fisheries-induced evolution

→ ecosystem services

- Supporting services
- Provisioning services
- Regulating services
- Cultural services

References

Heino, M., Dieckmann, U., and Godø, O. R. 2002. Measuring probabilistic reaction norms for age and size at maturation. *Evolution* 56: 669–678.

Jørgensen, C., Enberg, K., Dunlop, E. S., et al. 2007. Managing evolving fish stocks. *Science* 318: 1247–1248.

Laugen, A. T., Engelhard, G. H., Whitlock, R., et al. 2012. Evolutionary impact assessment: Accounting for evolutionary consequences of fishing in an ecosystem approach to fisheries management. *Fish and Fisheries*, in press

Olsen, E. M., Heino, M., Lilly, G. R., et al. 2004. Maturation trends indicative of rapid evolution preceded the collapse of northern cod. *Nature* 428: 932–935.

