Using bioenergetics models to estimate sensitivity of California Current groundfish to temperature anomalies

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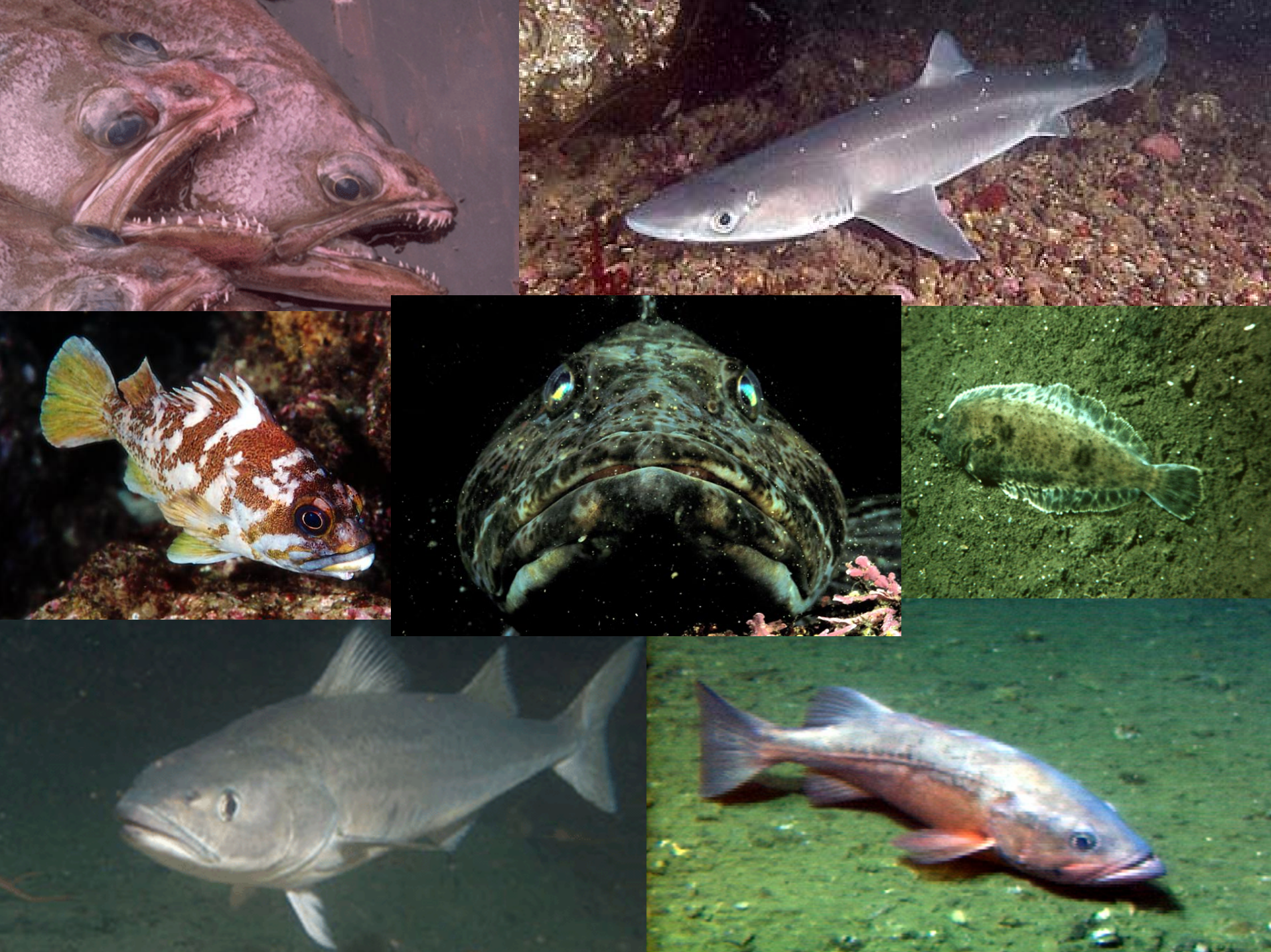
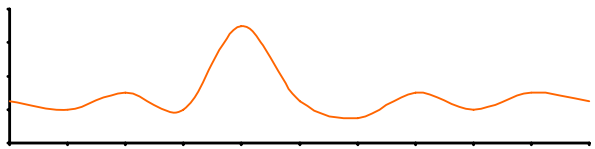
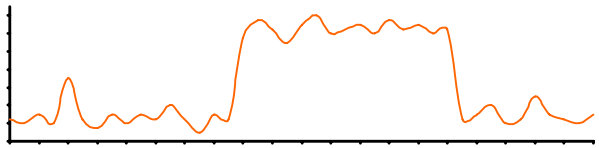


Climate anomalies that affect co-occurring groundfish

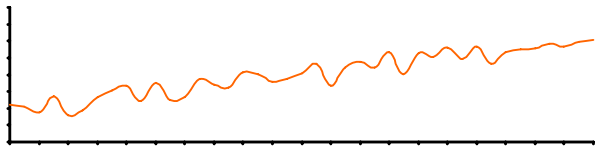
- **Interannual variation (e.g., El Niño)**



- **Interdecadal shifts (e.g., PDO)**

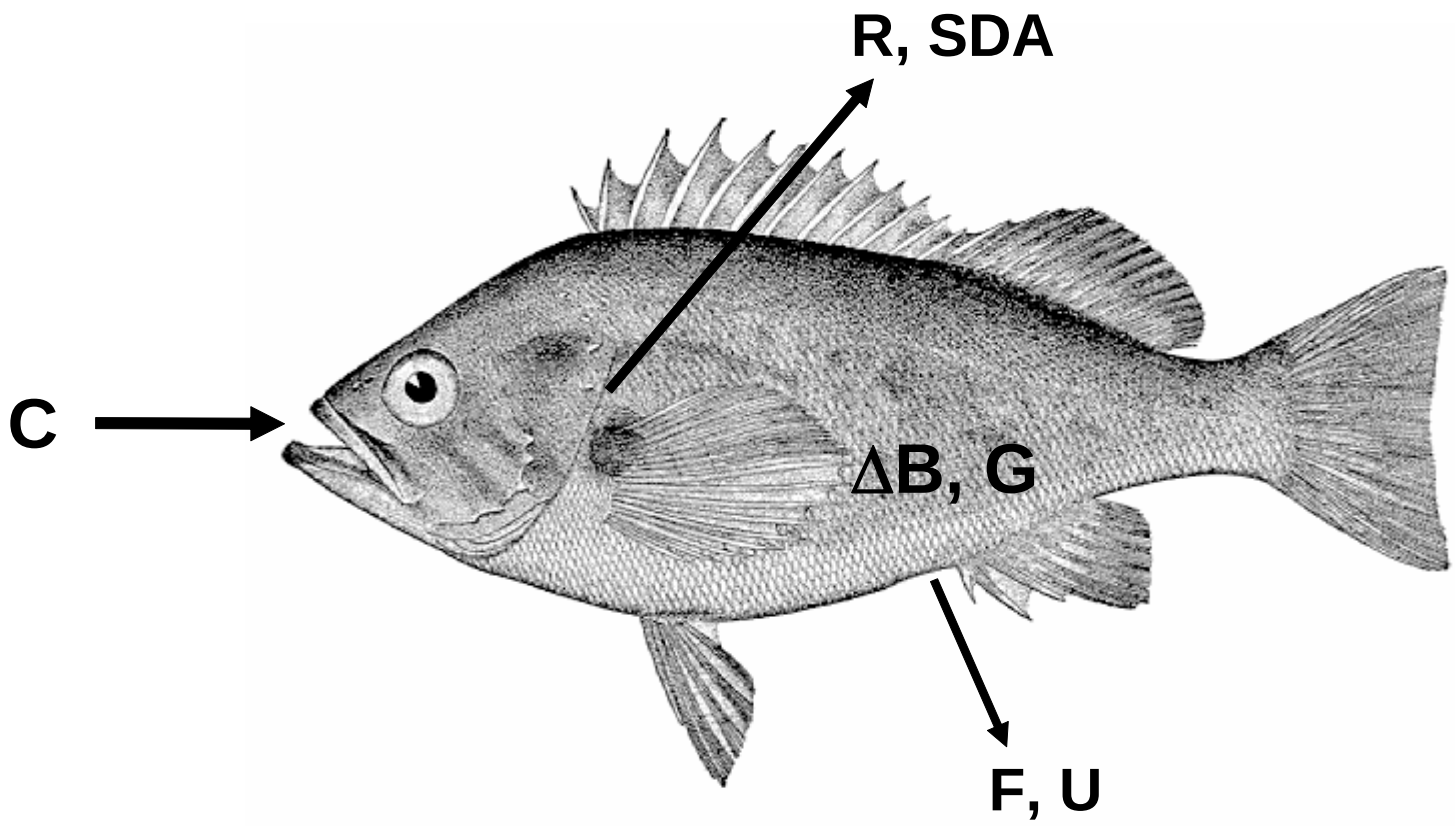


- **Long-term trends (e.g., climate change)**



How do groundfish with different life histories respond to these changes?

Core bioenergetics processes:

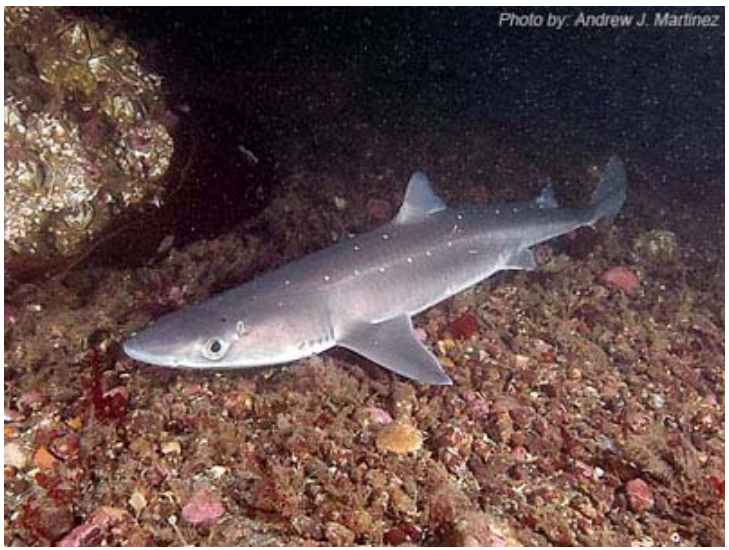


$$\Delta B = C - R - SDA - F - U - G$$

$$\Delta B = CA \cdot W^{CB} \cdot CV^{CX} \cdot e^{(CX \cdot (1 - CV))} - RA \cdot W^{RB} \cdot RV^{RX} \cdot e^{(RX \cdot (1 - RV))} \cdot ACT \cdot oxycal \cdot ED - (SDA + U) \cdot (C - F) - F - W \cdot (GSI_{max} - GSI_{min})$$

English sole, *Parophrys vetulus*
(photo: Wes Nicholson)

Sablefish, *Anoplopoma fimbria*
(photo: Wade D. Smith)



Spiny dogfish, *Squalus acanthias*
(photo: Andrew J. Martinez)

Yelloweye rockfish, *Sebastes ruberrimus*
(photo: Victoria O'Connell)

Species characteristics

	L_∞ (cm)	Max age	Age 50%$_M$	Fecundity	Est. B/B_0
 English sole	39	20	3.5	150,000 to 2,000,000 eggs / yr	~0.9
 Yelloweye rockfish	60	120	14	100,000 to 2,000,000 larvae / yr	~0.18
 Sablefish	66	55	5.5	75,000 to 450,000 eggs / yr	~0.35
 Spiny dogfish	153	75	21	1 to 20 pups / 2 yr	?

Which species are most sensitive to temperature in terms of…

most → least

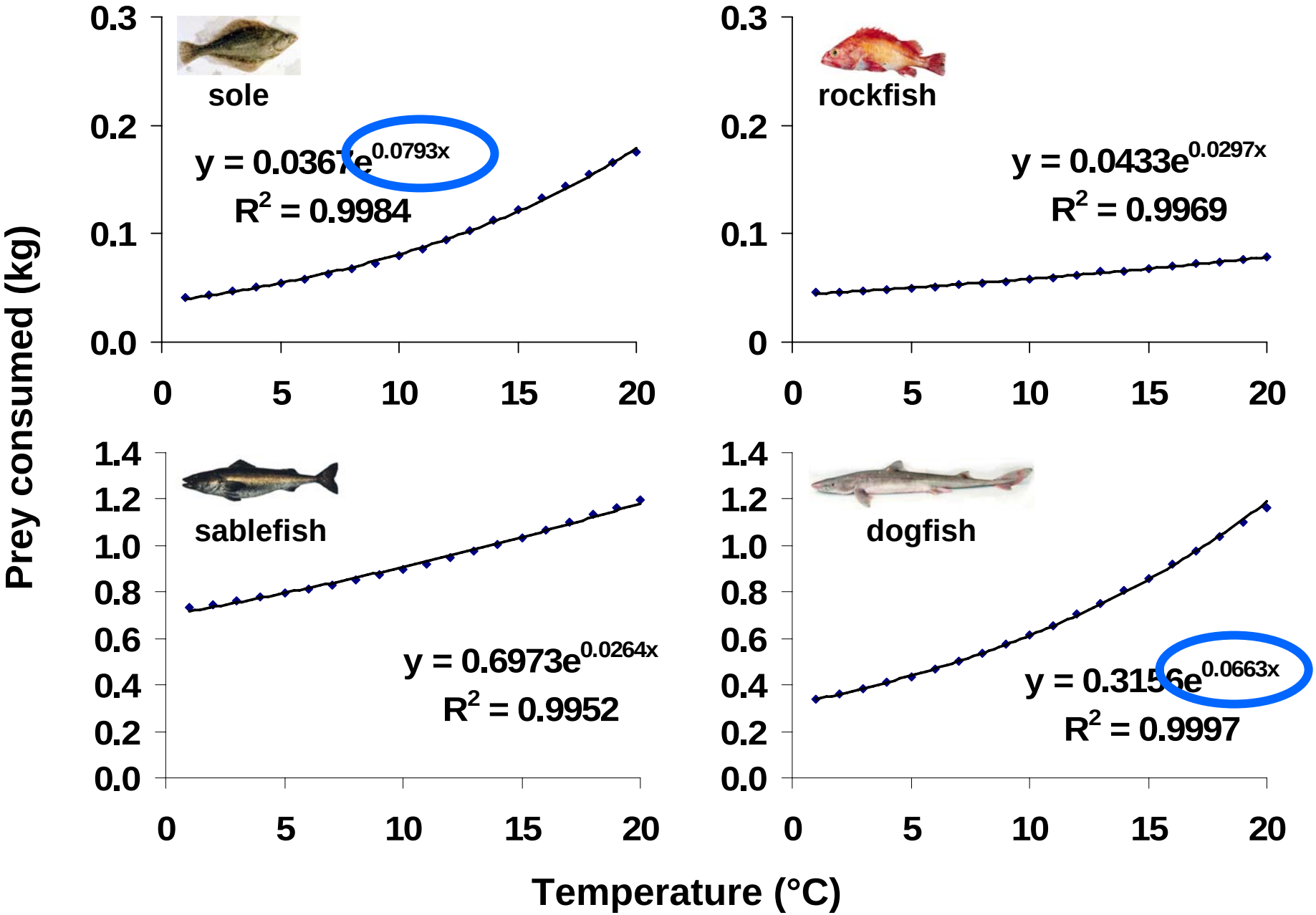
…first year consumption?

…lifetime consumption?

…age at 50% maturity?

…lifetime egg production?

Consumption required to reach observed size at age 1



Which species are most sensitive to temperature in terms of…

most → least

…first year consumption?

sole

dogfish

rockfish

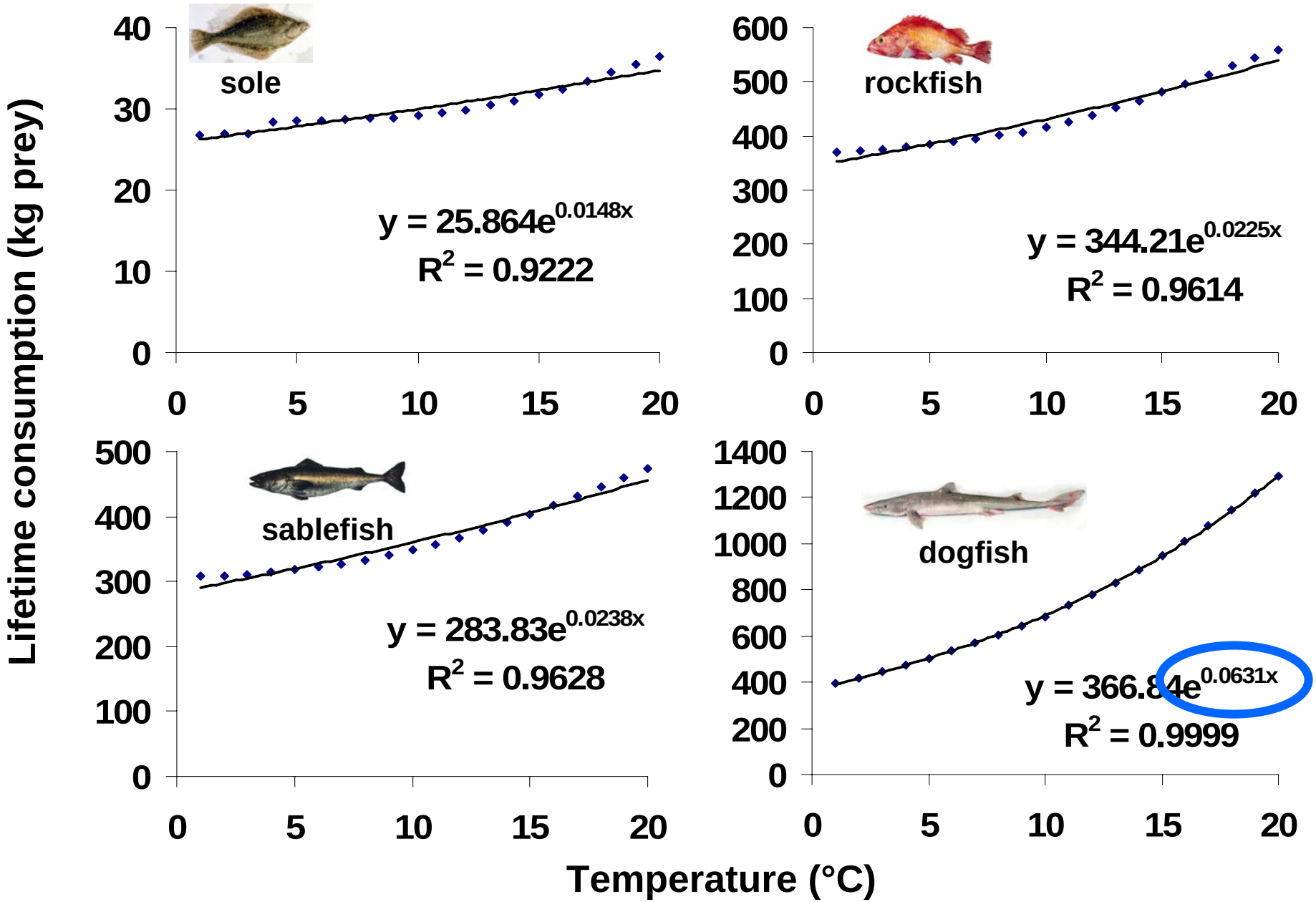
sablefish

…lifetime consumption?

…age at 50% maturity?

…lifetime egg production?

Lifetime cumulative consumption (assuming VBGF)



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most → least

…first year consumption?


sole


dogfish


rockfish


sablefish

…lifetime consumption?


dogfish


sablefish

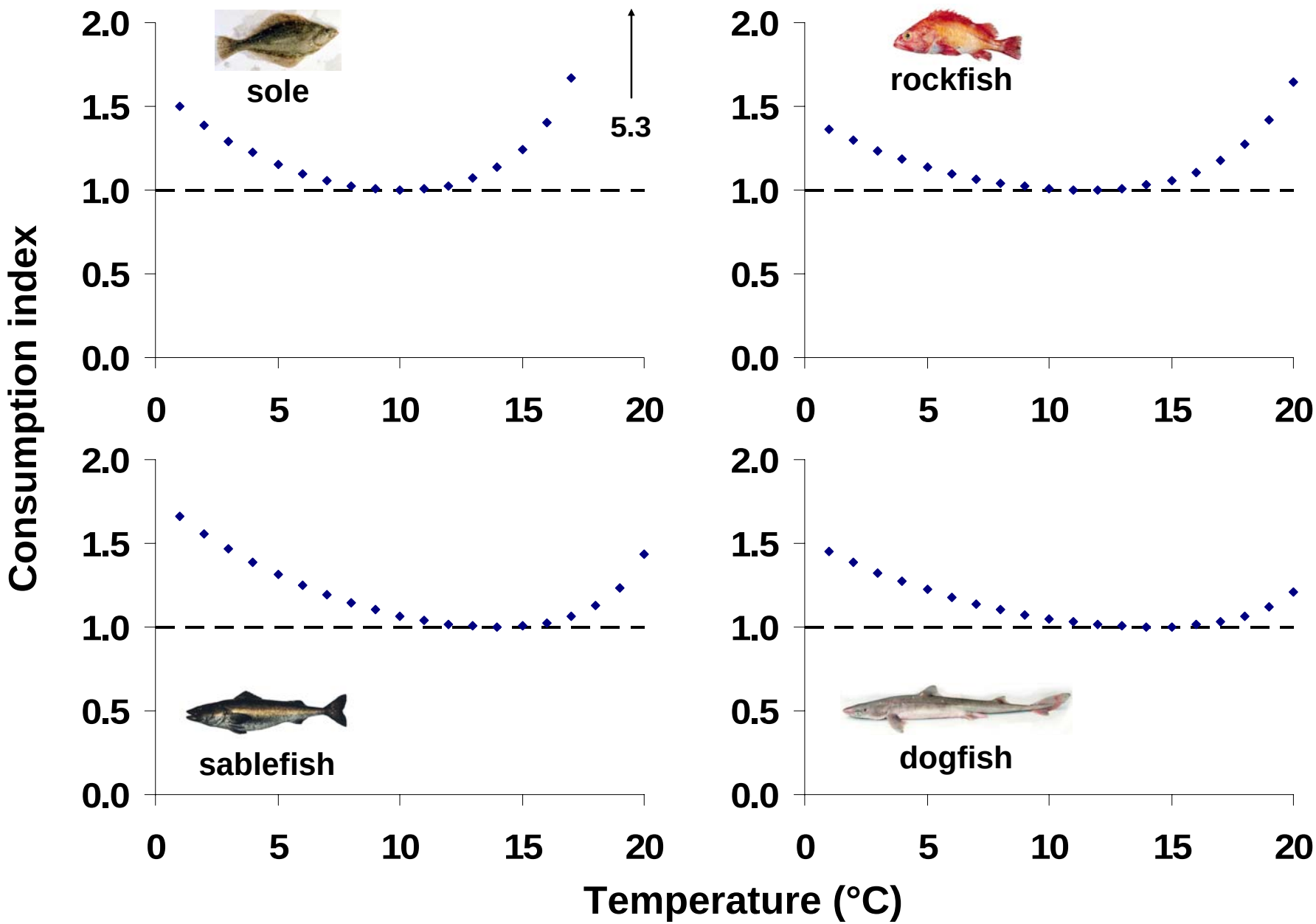

rockfish


sole

…age at 50% maturity?

…lifetime egg production?

Index of relative consumption to reach $t_{50\%M}$



Which species are most sensitive to temperature in terms of…

most → least

…first year consumption?


sole


dogfish


rockfish


sablefish

…lifetime consumption?


dogfish


sablefish


rockfish


sole

…age at 50% maturity?


sole

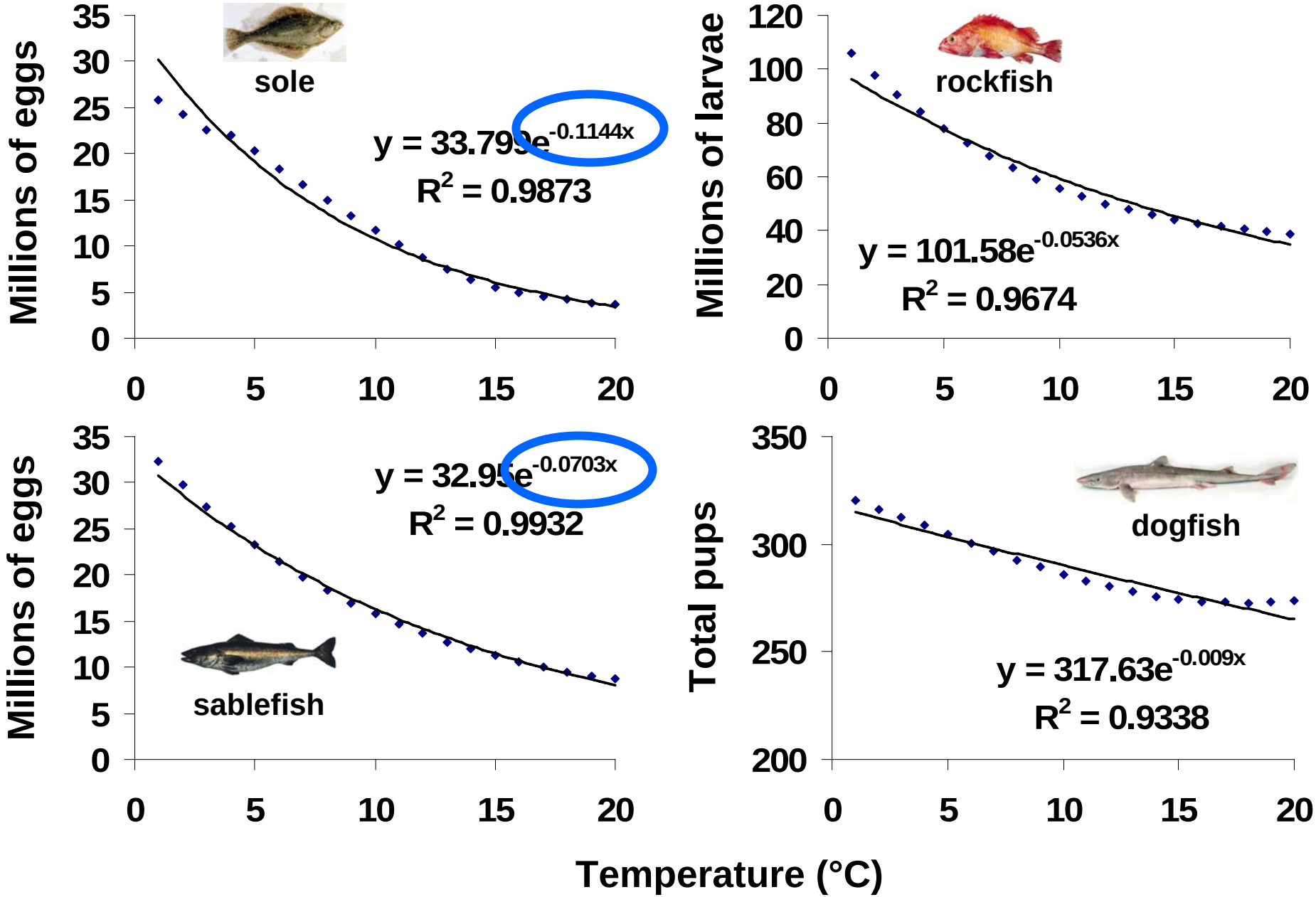

sablefish


rockfish


dogfish

…lifetime egg production?

Lifetime egg production by average female



Which species are most sensitive to temperature in terms of…

most → least

…first year consumption?

sole dogfish rockfish sablefish

…lifetime consumption?

dogfish sablefish rockfish sole

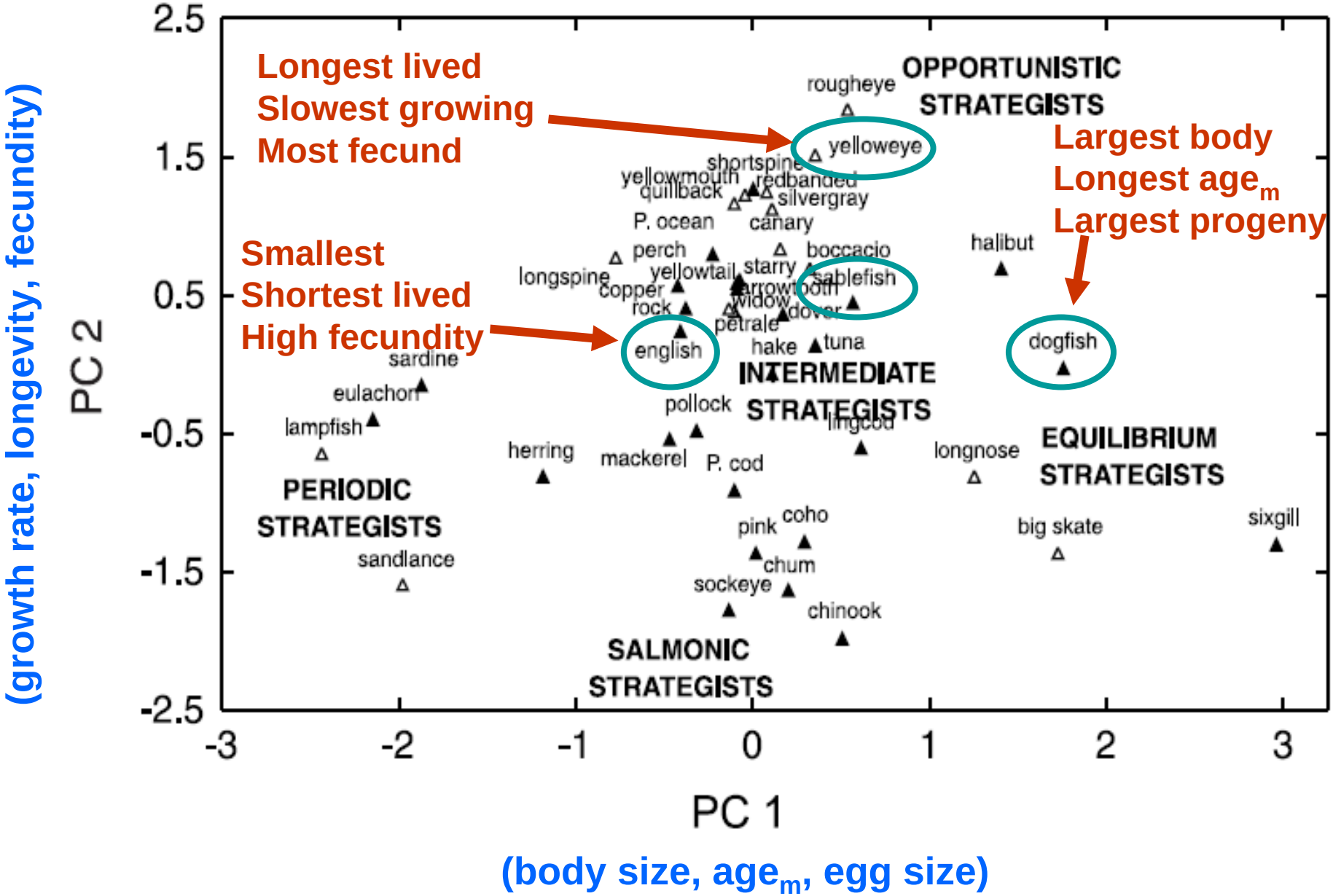
…age at 50% maturity?

sole sablefish rockfish dogfish

…lifetime egg production?

sole sablefish rockfish dogfish

Life history strategies of some Pacific fishes (King and MacFarlane 2003)



How might groundfish express sensitivity?

- Changes in growth rates
- Changes in feeding rates (depletion, release, competition)
- Changes in foraging time (= changes in predation risk)
- Move to more optimal temperatures (depth, latitude)
- Recruitment peaks/drops
- Compensatory changes in life history parameters
- Changes in population size

- It may depend on the actual extent of the anomaly…

Possible future direction:
Maps of groundfish growth and reproduction sensitivity?

Depth specific temperature ranges

+ Age specific depth distributions

+ Age specific sensitivities to temperature

= Diagnostic map of sensitivity across a species' life history

We could then overlay those maps spatially with where source/sinks are thought to be; overlay them temporally with when good/bad recruitment occurred...