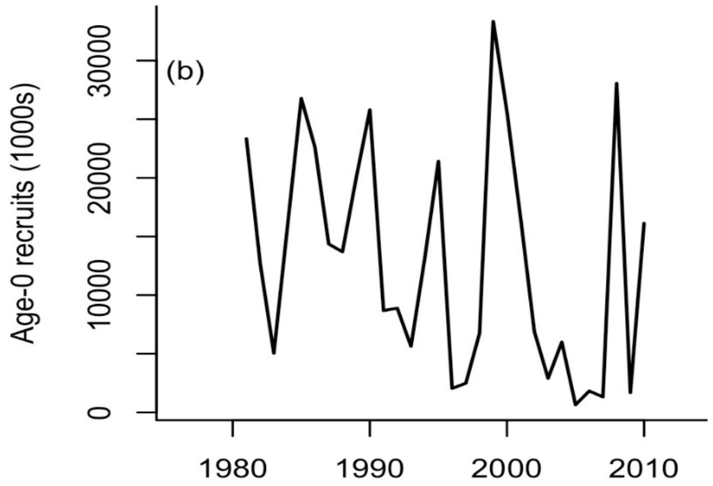
Agenda Item F.2.a
Supplemental NMFS PowerPoint (Haltuch)
March 2017

Oceanographic drivers sablefish recruitment in the Northern California Current



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NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Applications

Leading recruitment indicator

Now-cast and/or short term forecasting applications for management advice.

Recruitment hindcasting

What could recruitment have looked like during periods without length- and age- composition data?

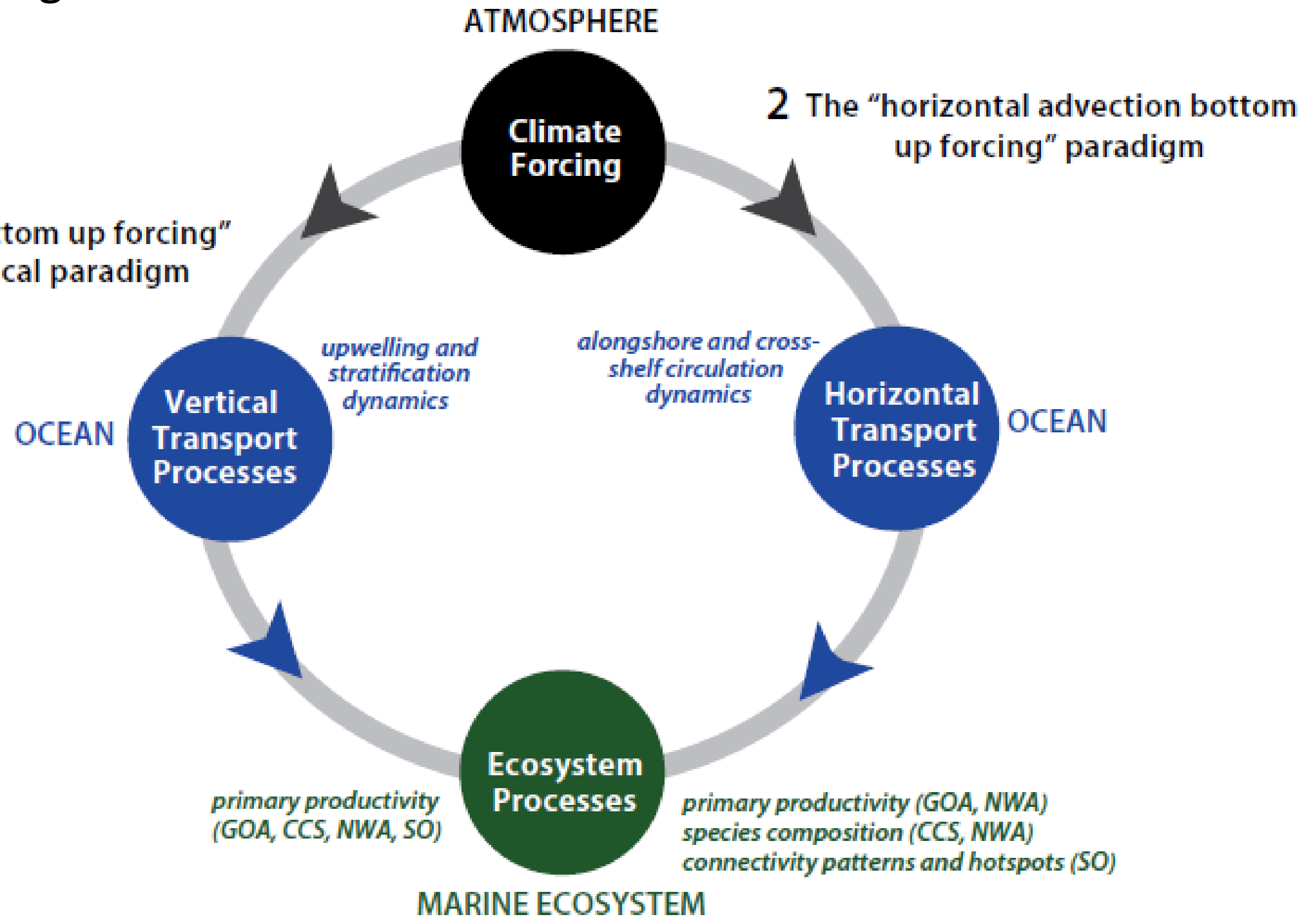
Decrease the uncertainty in estimates of B0 by providing information on past recruitments rather than using recruitments off the stock-recruitment curve.

Management Strategy Evaluation

Evaluate control rule performance to potential long-term changes productivity

US GLOBEC:
The horizontal-advection bottom-up forcing paradigm

Large-scale climate forcing drives regional changes in alongshore and cross-shelf ocean transport, directly impacting the transport of nutrients, water masses, and organisms.



Di Lorenzo, et al. 2013. *Oceanography* 26(4):22–33.

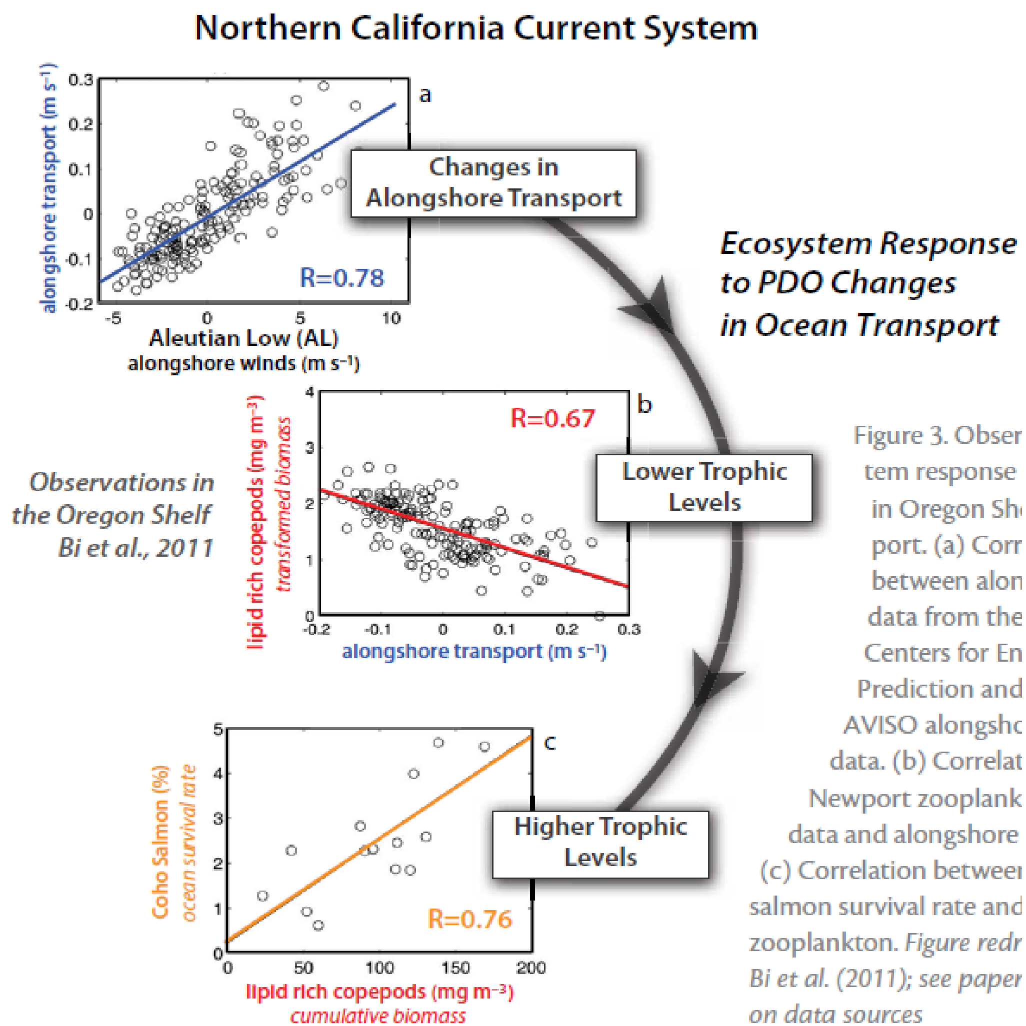
US GLOBEC:
The horizontal-advection bottom-up forcing paradigm

Climate variability alters sea surface height (SSH), zooplankton community structure, and sablefish recruitment

SSH explains ~35-40% of the variance in recruitment (Schirripa)

Problem: needs to explain >50% of the variability in recruitment to inform stock assessment

Goal: develop stronger environmental index of recruitment



Di Lorenzo, et al. 2013. *Oceanography* 26(4):22–33.

Oceanographic drivers of sablefish recruitment

Conceptual life-history

↓

Make hypotheses

↓

Fit a bunch of models (glms)

↓

↓

Model selection with AICc

↓

Model testing

Literature search

Oceanographic drivers of sablefish recruitment

Conceptual life-history

↓

Make hypotheses

↓

Fit a bunch of models (glms)

↓

Residuals = Intercept + various predictors

↓

Model selection with AICc

↓

Model testing

Make stage specific & spatially specific hypotheses

- Do not use generalized climate indices like NOI or PDO
- Use ROMS output for oceanic drivers
- Include some biological drivers
    - Predator and prey density
- Include Sea surface height (SSH)
- ***NO*** Spawning stock biomass (SSB)

Oceanographic drivers of sablefish recruitment

Conceptual life-history

↓

Make hypotheses

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Fit a bunch of models (glms)

↓

Residuals = Intercept + various predictors

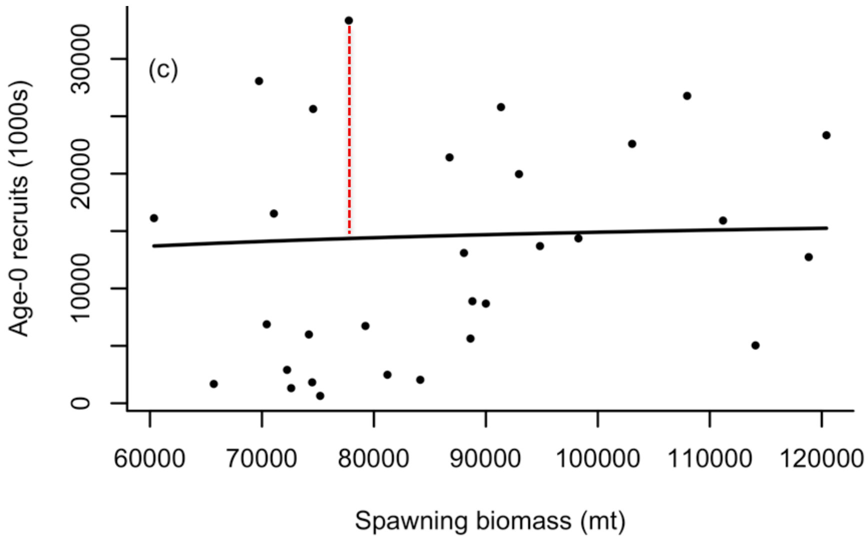
↓

Model selection with AICc

↓

Model testing

Remove known Beverton-Holt stock recruitment relationship from assessment



Asserted Stock-recruitment relationship in the assessment

Oceanographic drivers of sablefish recruitment

Conceptual life-history

↓

Make hypotheses

↓

Fit a bunch of models (glms)

↓

Residuals = Intercept + various predictors

↓

Model selection with AICc

↓

Model testing

Models

Basic glms

- Identity link
- Normal distribution

- Min predictors = 0
- Max predictors = 5
- Covariates with $r > 0.75$ excluded from the same model

Conceptual life-history model:

Preconditioning to benthic juveniles

Lat: 40-50 ^{o}N
Years: 1980-2010

Life-history stage	Time period	Depth	Sablefish location
Preconditioning	Jun - Dec (Yr 0)	50-1200m with highest occurrence between 150 - 400 m	Bottom
Spawning	Dec (Yr 0)- Mar (Yr 1)	300-500 m	Bottom
Eggs	Jan-Apr	200-825 m with highest occurrence between 240 and 480 m, may rise has high as 200-300 m	Open water
Early Development	Feb-May	1000-1200 m	Open water
Larvae (start feeding)	Feb-May	Surface waters	Open water
Pelagic juveniles	Apr-Nov	Surface waters	Open water
Benthic Juvenile (Age-0)	Aug-Nov	0 - 250 m	Bottom

Conceptual life-history model:

Preconditioning to benthic juveniles

Life-history stage	Time period	Depth	Sablefish location
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Early Development			Open water
Larvae (start feeding)			Open water
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Look at one stage

Conceptual life-history model:

Preconditioning to benthic juveniles

Lat:	40-50 ^{o}N
Years:	1980-2010

Life-history stage	Time period	Depth	Sablefish location
Pelagic juveniles	Apr-Nov	Surface waters	Open water

Hypothesis	Covariates	Depth extent	Longitudinal extent	Data source
Transport to settlement habitat affects recruitment	Net long-shore transport	Surface waters	0-150 nautical nmi	ROMS
Transport to settlement habitat affects recruitment	Net cross-shelf transport	Surface waters	0-150 nautical nmi	ROMS
Growth/Predation hypothesis: Growth rate is faster in warm water leading to reduced time vulnerable to predators etc	Degree days	Surface waters	0-150 nautical nmi	ROMS

One model with ΔAICc < 2.0

Model						R2	ΔAIC
Model 1	DD_{pre}	CST_{egg}	DD_{egg}	LST_{ed}	DD_{larv}	0.57	0

One model with ΔAICc < 2.0 $r^2 = 0.57$

Degree days – preconditioning — bottom, 150 – 400 m

Cross-shelf transport – egg stage — 500 m off shore to 170 nmi
300-825 m

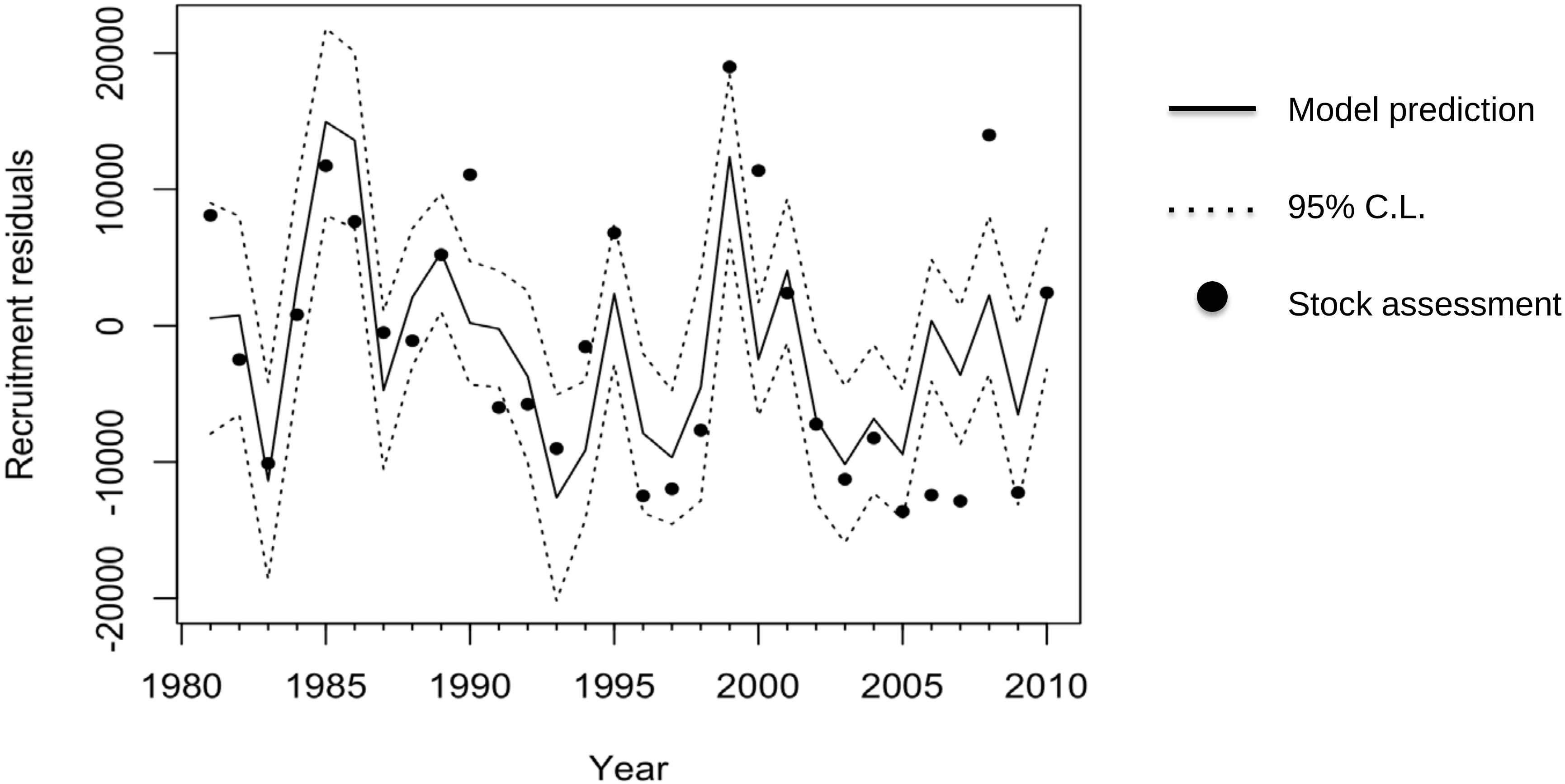
Degree days – egg stage — 500 m off shore to 170 nmi
300-825 m

Long-shelf transport – early development — 1000 m off shore to 170 nmi
1000 – 1200 m

Degree days – larvae — surface waters out to 150 nmi

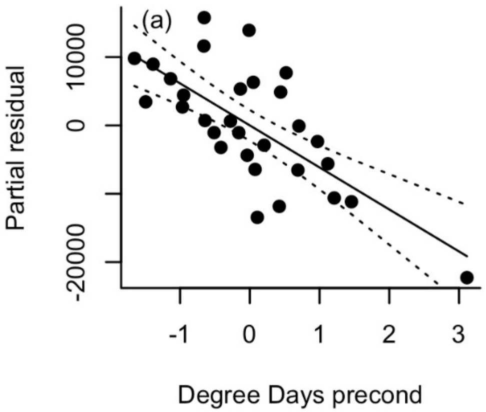
One model with ΔAICc < 2.0

Model						R2	ΔAIC
Model 1	DD_{pre}	CST_{egg}	DD_{egg}	LST_{ed}	DD_{larv}	0.57	0



Partial residual plots

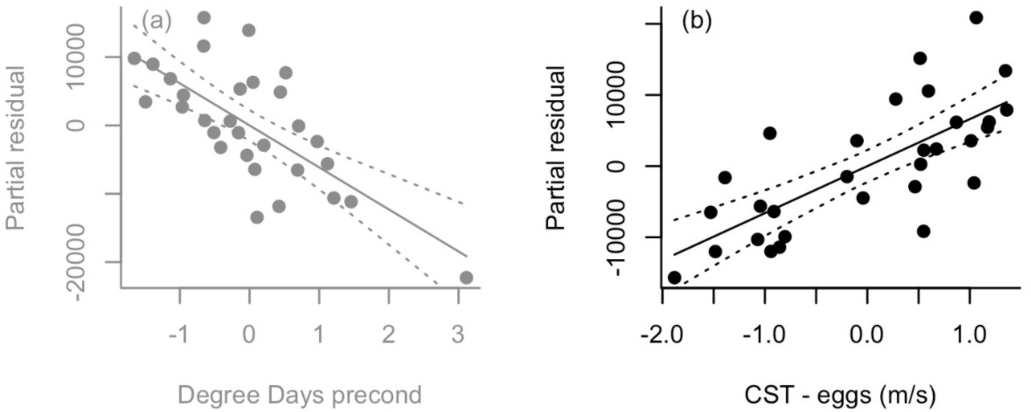
(-) DD_{pre}– cold water = more food; lower metabolic costs and more energy for reproduction



Partial residual plots

(-) DD_{pre}– cold water = more food; lower metabolic costs and more energy for reproduction

(+) CST_{edev}– onshore transport = retention near settlement habitat

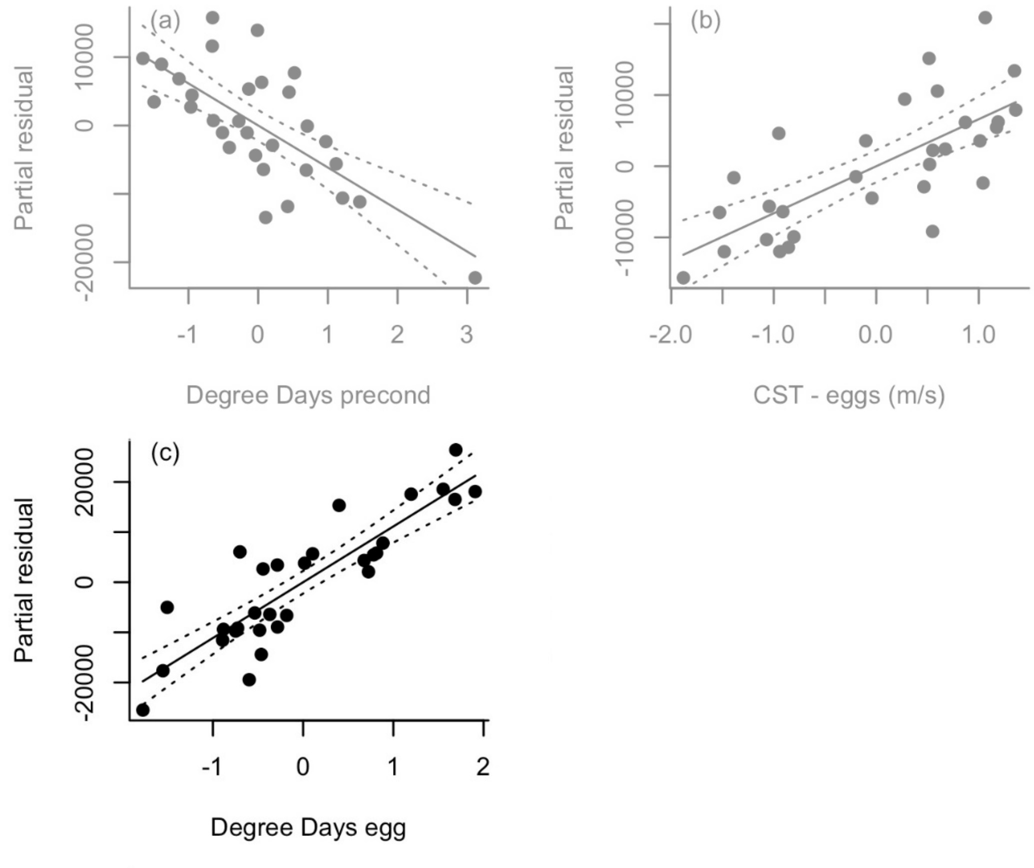


Partial residual plots

(-) DD_{pre}– cold water = more food; lower metabolic costs and more energy for reproduction

(+) CST_{edev}– onshore transport = retention near settlement habitat

(+) DD_{egg}– warm water = faster development



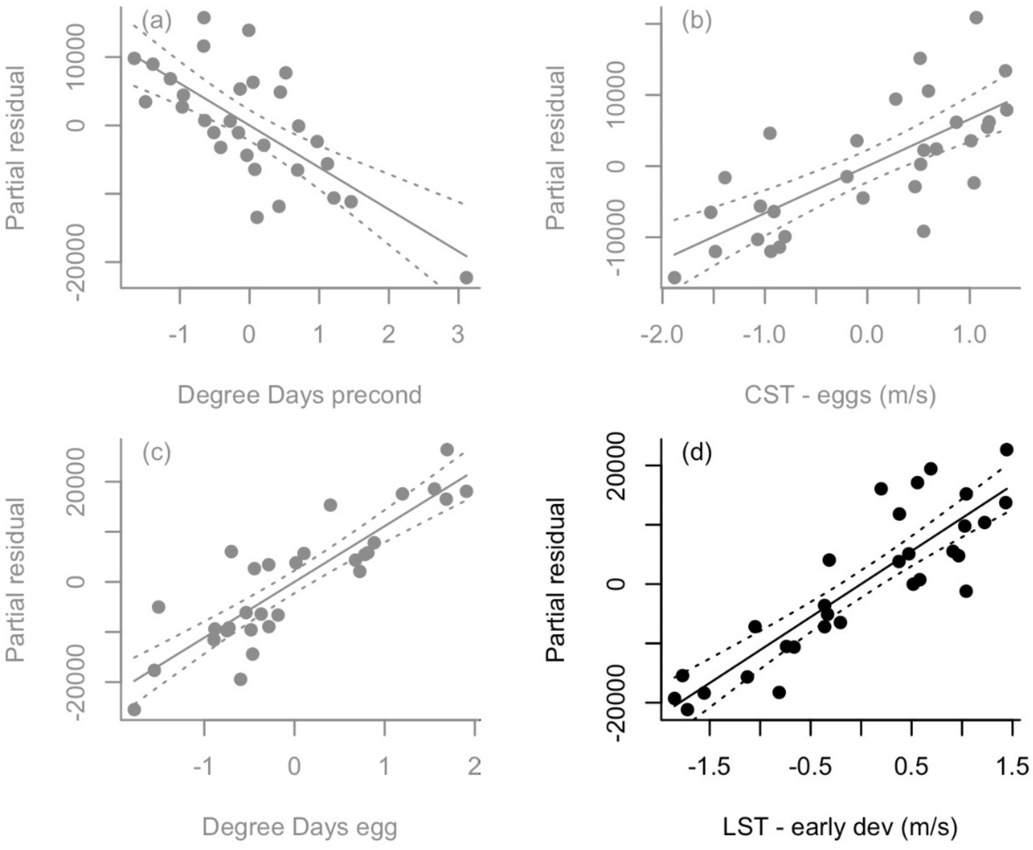
Partial residual plots

(-) DD_{pre} – cold water = more food; lower metabolic costs and more energy for reproduction

(+) CST_{edev} – onshore transport = retention near settlement habitat

(+) DD_{egg} – warm water = faster development

(+) LST_{edev} – northerly transport = transported north to food



Partial residual plots

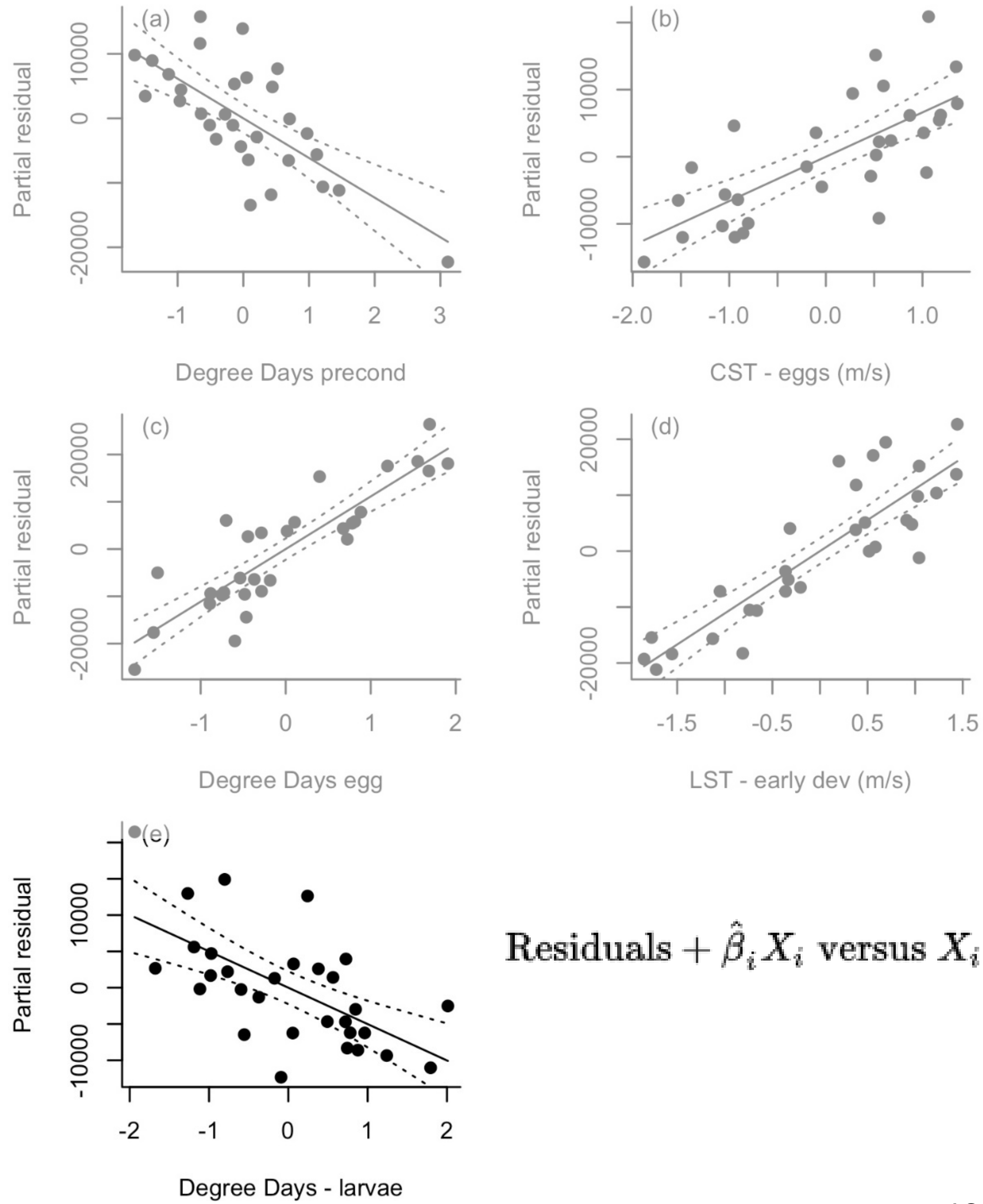
(-) DD_{pre}– cold water = more food; lower metabolic costs and more energy for reproduction

(+) CST_{edev}– onshore transport = retention near settlement habitat

(+) DD_{egg}– warm water = faster development

(+) LST_{edev}– northerly transport = transported north to food

(-) DD_{larv}– warm water = starvation overcomes faster growth rate



$$\text{Residuals} + \hat{\beta}_i X_i \text{ versus } X_i$$

Update with 2011 – 2014 data?

- ➔ **Current data span 1980 – 2010**
- ➔ **2011 – 2014 ROMs data available from a different model**

Oceanographic Modeling Issues

Inconsistent inputs from different products

- Surface forcing (heat flux, wind)
- Ocean boundary conditions

Models are consistent for well observed variables

- SST, SSH, MLD

Not possible to validate many sub-surface predictors between models

New time series are short

Back to Applications

What to do about physical time series?

Need a single reconstruction extending as far back as possible and that can be updated into the future

Leading recruitment indicators

Now-cast based on current year environment

Short-term forecasting depends upon forecasting important covariates - JSCOPE?

Recruitment hindcasting

Depends upon historical oceanographic data

Management Strategy Evaluation

Requires stakeholder input

Assumes stationarity

END