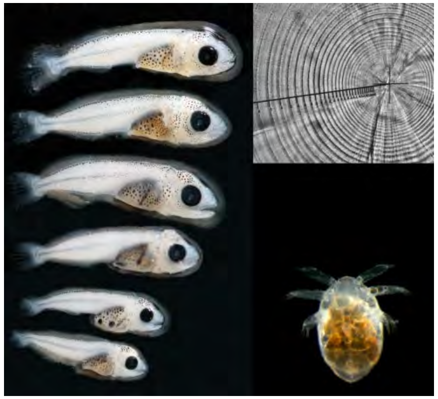
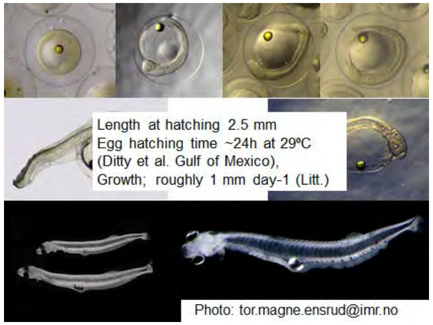
Session 2 – Wrap up

External drivers of change in early life hystory, growth and recruitment processes of small pelagic fishes

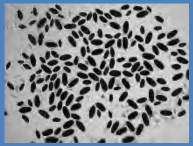


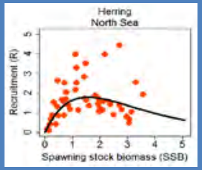


Length at hatching 2.5 mm
Egg hatching time ~24h at 29ºC
(Ditty et al. Gulf of Mexico),
Growth; roughly 1 mm day-1 (Litt.)

Photo: tor.magne.ensrud@imr.no

Population age/size structure





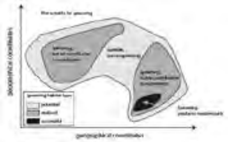
Food resources
Energy reserves

Number & viability of eggs

Abundance of spawners

Density-dependent growth/egg production

Population age/size structure

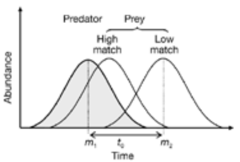


Small pelagic fish recruitment

Timing of spawning

Distribution of spawners

Physical factors



Density-dependent habitat use

Survival of early life stages

Physical & trophodynamic factors

Density-dependent competition for food and space or vulnerability to predators

Somarakis talk

Revealing the link between prey availability during the larval stage and recruitment strength in small pelagic fish

D. Robert, C.J. Wilson, D. Kamada, H.M. Murphy, P. Pepin

International symposium on the drivers of dynamics of small pelagic fish resources

March 6th, 2017

UQAR ISMER

Canada Research Chair in Fisheries Ecology

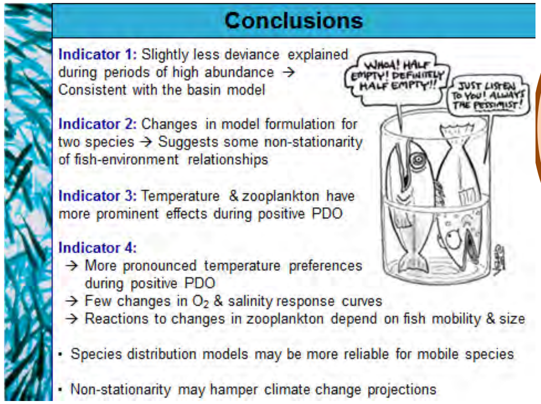
- ➢ **Much like juveniles and adults, larval stages of small pelagic fish exhibit strong prey selectivity, which is apparent from the first-feeding stage when considering prey field and gut content at the species level**
- ➢ **Consideration of preferred prey taxa may allow to reveal links between variability in zooplankton prey supply and variability in vital rates and recruitment (e.g. Atlantic mackerel)**
- ➢ **Growth autocorrelation analysis suggests that there exists massive variability among taxa in the timing of the importance of feeding and growth in driving mortality**

Contents

	Field	**Laboratory**	**Modelling**	**Combination**	**TOTAL**
correlation of distribution/abundance/ recruitment strength with environmental data	3		10	3	**16**
growth and condition	4	1	2	2	**6**
trophic ecology	4	1	1	1	**10**
reproductive traits	2	1	2		**5**
diseases	1				**1**
TOTAL	**14**	**3**	**15**	**6**	

40 oral presentations, 14 posters

Clupea harengus	9
Engraulis ringens	5
Sardina pilchardus	4
Engraulis encrasicolus	4
Engraulis mordax	3
Engraulis japonicus	3
Clupea palasii	2
Scomber scombrus	2
Mallotus villosus	2
Sardinops sagax	2
Sprattus sprattus	1
Strangomera bentincki	1
Trachurus murphyi	1
Sardinella aurita	1
Sardinops melanostictus	1
Scomber japonicus	1



Conclusions

Indicator 1: Slightly less deviance explained during periods of high abundance → Consistent with the basin model

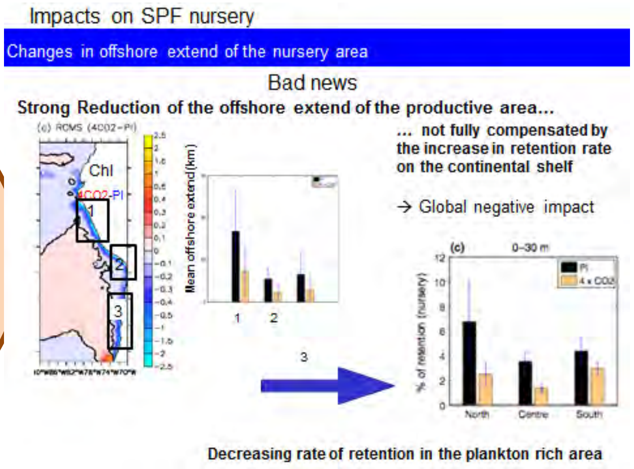
Indicator 2: Changes in model formulation for two species → Suggests some non-stationarity of fish-environment relationships

Indicator 3: Temperature & zooplankton have more prominent effects during positive PDO

Indicator 4:
- → More pronounced temperature preferences during positive PDO
- → Few changes in O_2 & salinity response curves
- → Reactions to changes in zooplankton depend on fish mobility & size

- Species distribution models may be more reliable for mobile species
- Non-stationarity may hamper climate change projections

correlation of distribution/abundance/ recruitment strength with environmental data



Impacts on SPF nursery

Changes in offshore extend of the nursery area

Bad news

Strong Reduction of the offshore extend of the productive area…

… not fully compensated by the increase in retention rate on the continental shelf

→ Global negative impact

Decreasing rate of retention in the plankton rich area

Significant variables:

Temperature
Salinity
Oxygen
Food availability (composition, size and abundance)
Density-dependence
Freshwater input
Wind
Climate change scenarios

Non-stationary relationship between SPF and oceanographic variables

Growth and condition

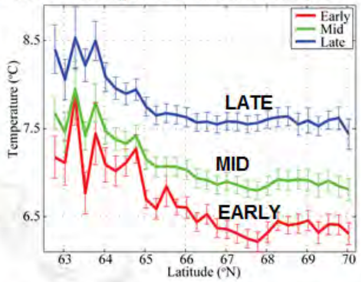
Otolith microstructure
RNA/DNA
Stable isotopic analysis
Heart rate (thermal optimal and aerobic scope)

Lipid analysis

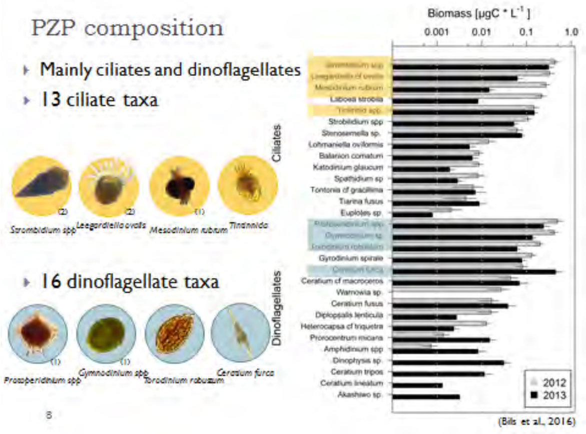
Validation exercices of age reading of several SPF (daily and annual)
Patterns of growth in relation to spatial occupancy
Not always fast-growers are selected (norwegian herring)
Not only important early survival (growth of post-larvae sprat & year class strength)

Modelled ambient temperature during 60 days of larval drift (*Vikebø et al. 2010*)

Effects of hatching time and northward driftspeed?



Indicate that survivors until 0-group originate from early hatching with rapid drift, low ambient temperature and low growth rate

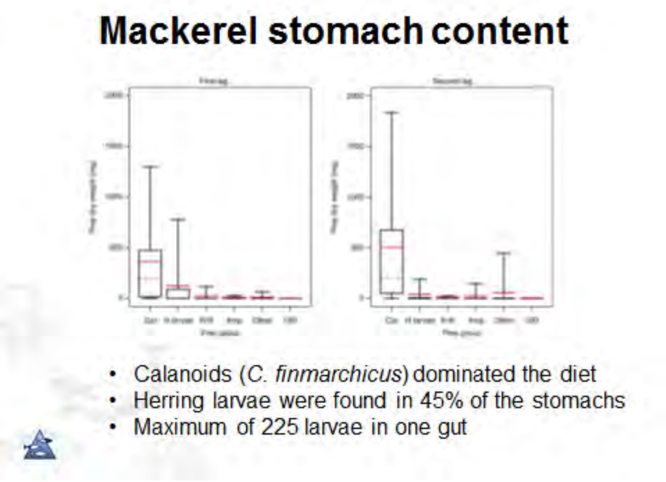


PZP composition

- Mainly ciliates and dinoflagellates
- 13 ciliate taxa
- 16 dinoflagellate taxa

(Bils et al., 2016)

Trophic Ecology



Mackerel stomach content

- Calanoids (*C. finmarchicus*) dominated the diet
- Herring larvae were found in 45% of the stomachs
- Maximum of 225 larvae in one gut

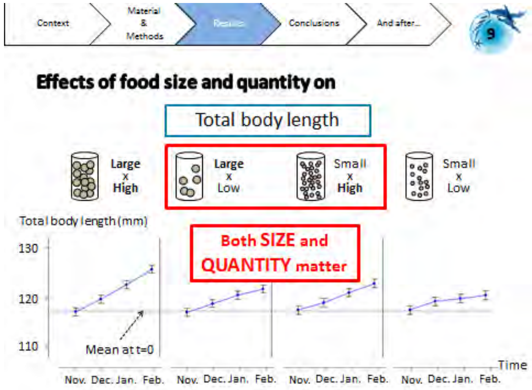
Robert: Important to know species-specific prey types of the larvae

Also important: Prey size

Complementary molecular tools to identify larval diets

Sharp increase in the trophic level of larvae with ontogeny (δ15N).

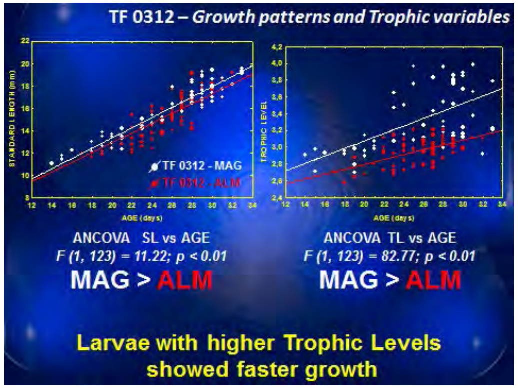
Importance of protozooplankton for herring larvae



Effects of food size and quantity on

Total body length

Both SIZE and QUANTITY matter

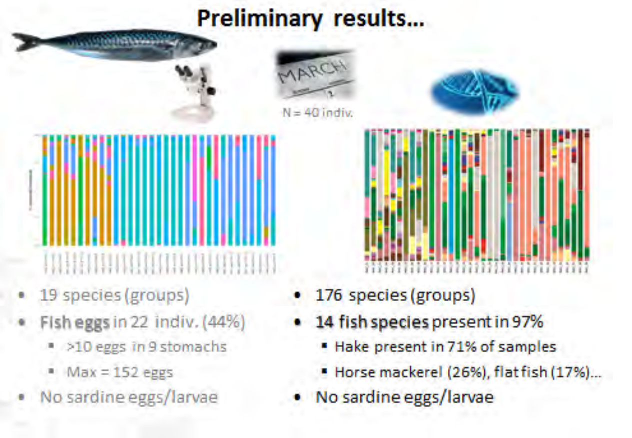


TF 0312 – *Growth patterns and Trophic variables*

ANCOVA SL vs AGE
$F(1, 123) = 11.22$; $p < 0.01$
MAG > ALM

ANCOVA TL vs AGE
$F(1, 123) = 82.77$; $p < 0.01$
MAG > ALM

Larvae with higher Trophic Levels showed faster growth

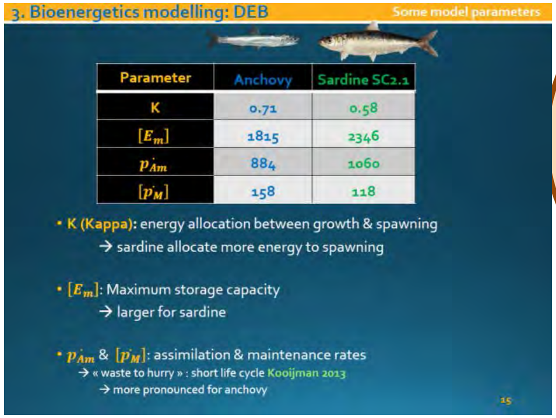


Preliminary results...

N = 40 indiv.

- 19 species (groups)
- **Fish eggs** in 22 indiv. (44%)
  - >10 eggs in 9 stomachs
  - Max = 152 eggs
- No sardine eggs/larvae

- 176 species (groups)
- **14 fish species** present in 97%
  - Hake present in 71% of samples
  - Horse mackerel (26%), flat fish (17%)...
- No sardine eggs/larvae



3. Bioenergetics modelling: DEB Some model parameters

Parameter	Anchovy	Sardine SC2.1
K	0.71	0.58
$[E_m]$	1815	2346
$\dot{p}_{Am}$	884	1060
$[\dot{p}_M]$	158	118

- K (Kappa): energy allocation between growth & spawning
  → sardine allocate more energy to spawning
- $[E_m]$: Maximum storage capacity
  → larger for sardine
- $\dot{p}_{Am}$ & $[\dot{p}_M]$: assimilation & maintenance rates
  → « waste to hurry » : short life cycle Kooijman 2013
  → more pronounced for anchovy

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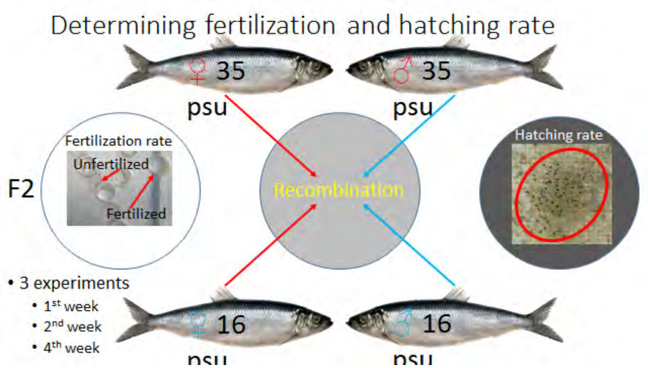
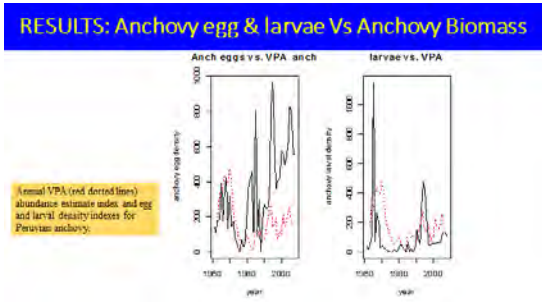
Reproductive traits

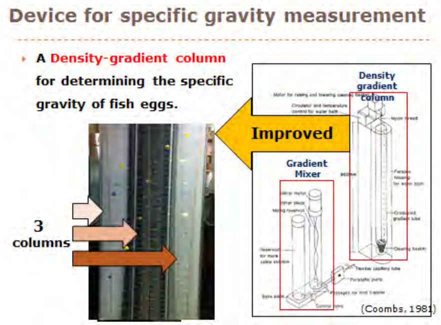

Determining fertilization and hatching rate

- 3 experiments
  - 1st week
  - 2nd week
  - 4th week

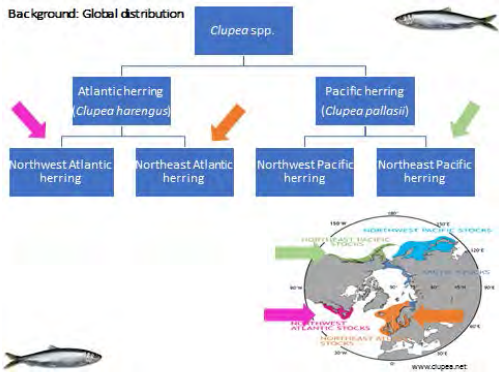
Differences of energy allocation between sardine and anchovy spps (DEB)
Influence of epigenetics and salinity in the reproduction success (herring)
Comparison of reproductive investment between herring populations
Effect of El Niño on the spawning of anchovy populations
Maternal and environmental effects on egg buoyancy & egg buoyancy throughout development
Relationship between egg and larvae abundance and recruitment (Peru)


RESULTS: Anchovy egg & larvae Vs Anchovy Biomass

Annual VPA (red dotted lines) abundance estimate index and egg and larval density indexes for Peruvian anchovy.

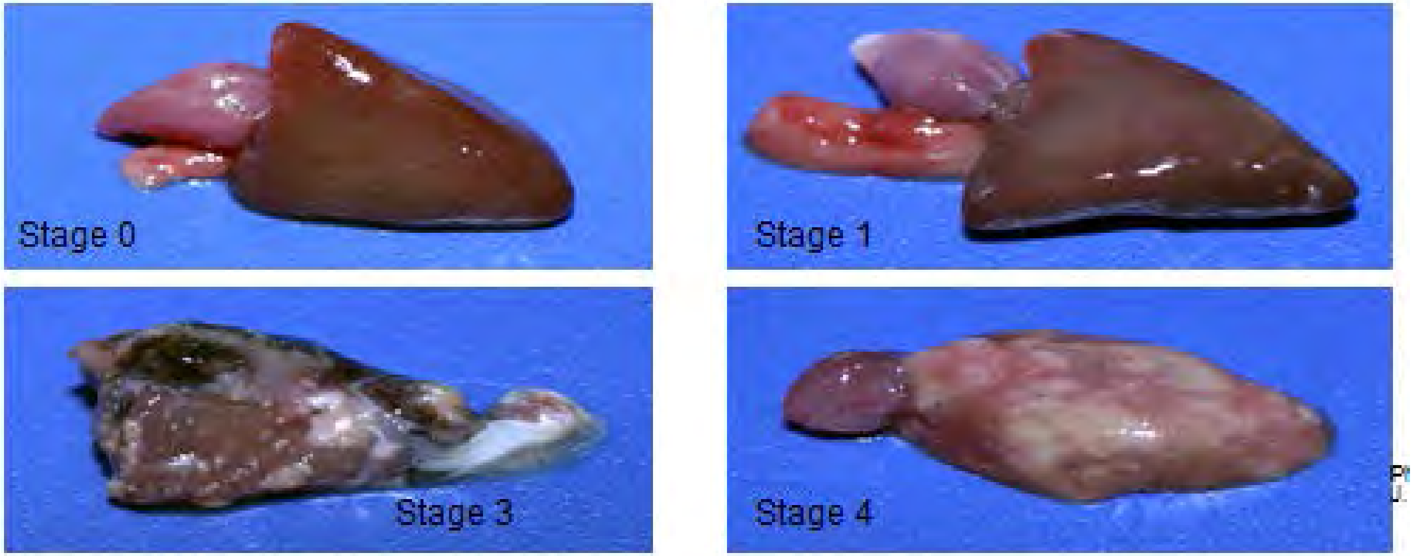

Device for specific gravity measurement

- A Density-gradient column for determining the specific gravity of fish eggs.


Background: Global distribution

Diseases

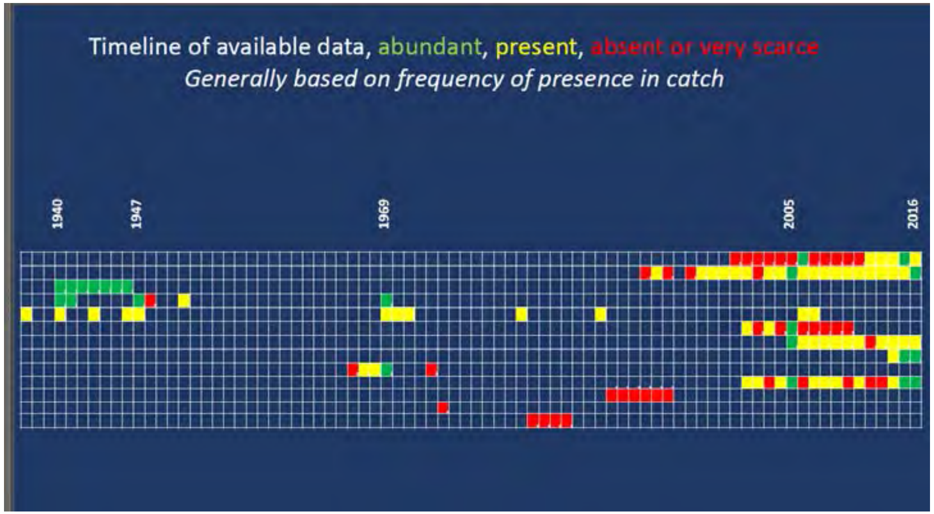
Ichthyophonus sp. outbreak in Icelandic summer-spawning herring



Wrap-up

Broad session, focused on mechanisms
Good conection to W4 and W5

Observed patterns of change: distribution, abundance, recruitment, , growth, length-weight at age and the otoliths.
Most studies formulated hypothesis and then tested those hypothesis.
Hypothesis to explain the patterns: 2 approaches: by statistical testing, by mechanistic experimentation, frequently using both.
Statistical testing: Difficulty and need to assemble long-term data.
Experimental studies: Trophodynamics, genetic cross fertilization, density, physiology.



Wrap-up

Low number of studies considering one driver coming from the physics.

Diverse topics: physiology, energy allocation, prey selectivity, egg buoyancy.

Many drivers of larval dynamics and it is recognized that their importance vary across the years. *Interaction* was a key word.

Big topics: Trophic interactions and physiology (response of species in different environments).

Perspectives

Some factors, such as diseases have received little attention and may deserve more study efforts, particularly if the incidence and vulnerability increases as consequence of climate change.

Ecosystem-wide surveys may be required to generate realistic scenarios of change

More effort is needed on describing prey preferences, prey size-spectrum and prey quality, e.g. FA (link to S3) and then make an effort on trying to construct time-series of relevant parameters.