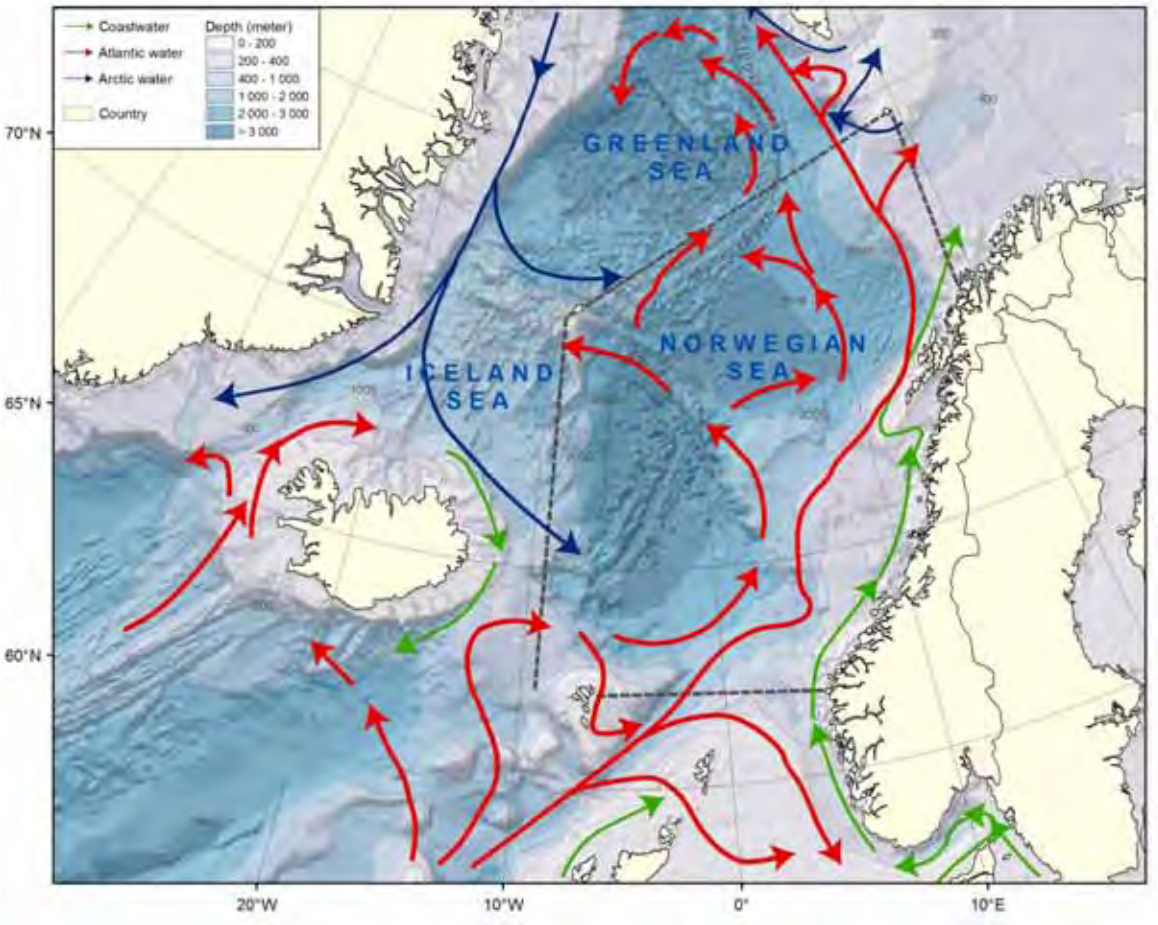
Towards spatially explicit fish representation in end-to-end models

Kjell Rong Utne & Geir Huse

The Norwegian Sea



The species and their position in the water column during the feeding period

0-50 m

10-300 m

50-500 m

Mackerel

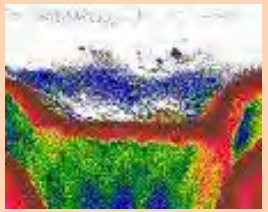
Herring

Blue whiting

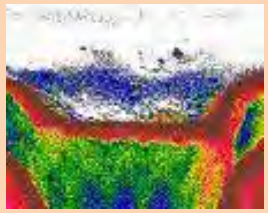
Calanus finmarchicus

Study overview

1. Acoustics
- Horizontal distribution
- Temperature
- Overlap




2. Acoustics
- Vertical distribution
- Interactions




3. Modelling
- Simulate feeding migrations
- Horizontal overlap


4. Modelling
- Simulate feeding pressure on zooplankton
- Interactions fish species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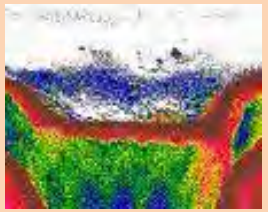


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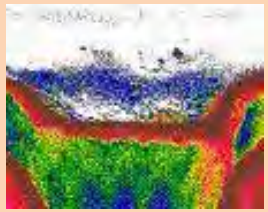


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Modelling fish migrations without zooplankton

Aim:

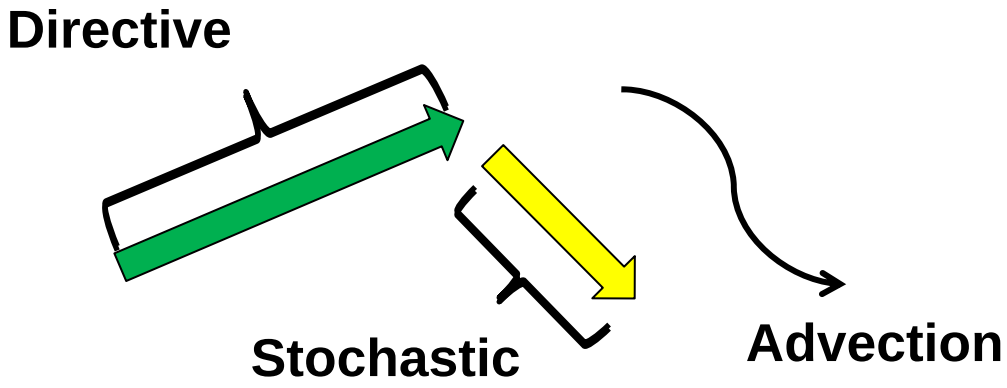
- Simulate feeding migrations
- Know the spatial distribution during the feeding period
- Quantify the daily horizontal overlap

Approach:

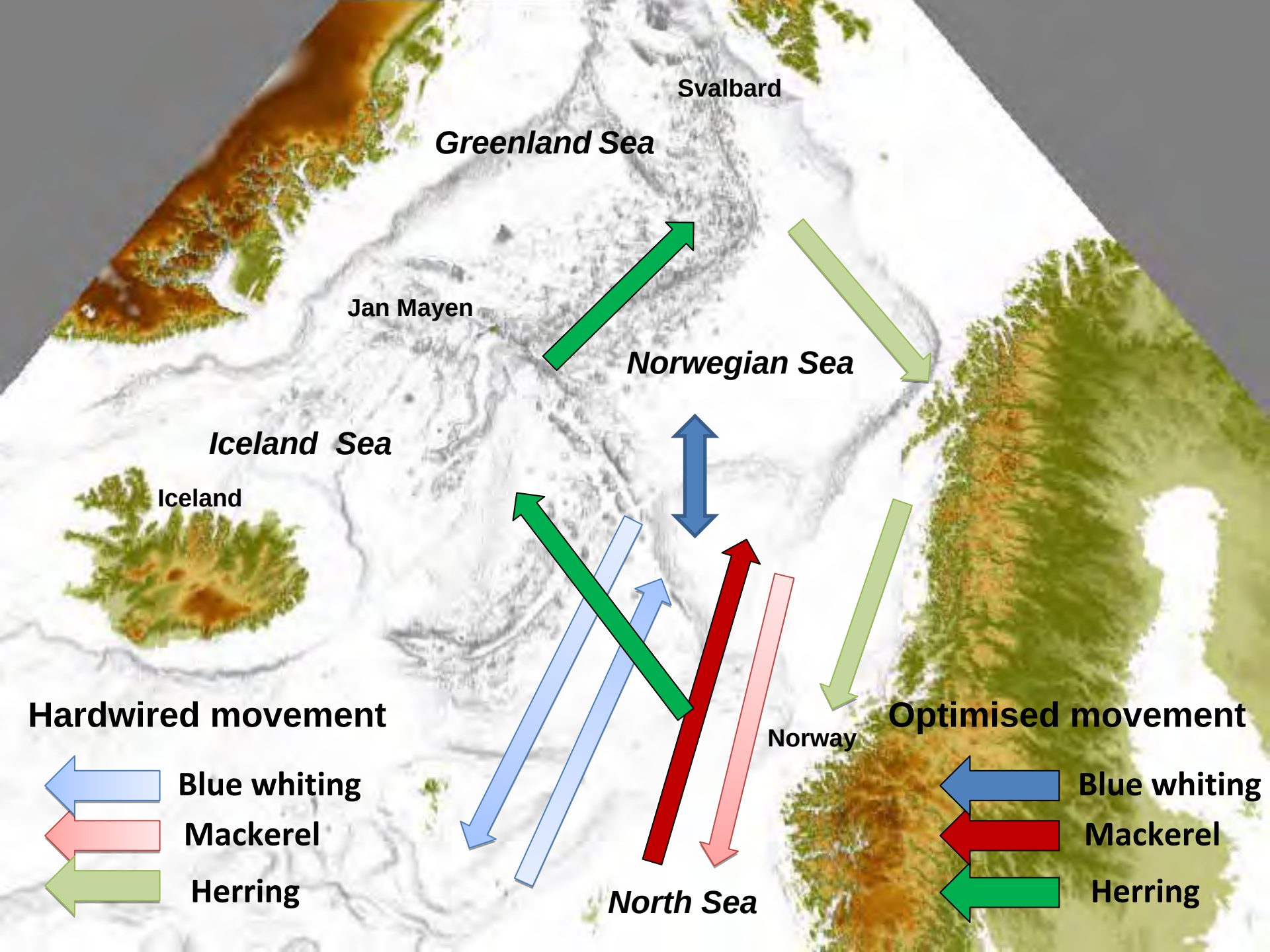
- Individual based models
- Genetic algorithm to optimize migration parameters
- Validated with survey observations (early and late summer)
  - Herring and blue whiting – echo sounder
  - Mackerel - trawl catches

Migration model

Individual movement – own decision and currents

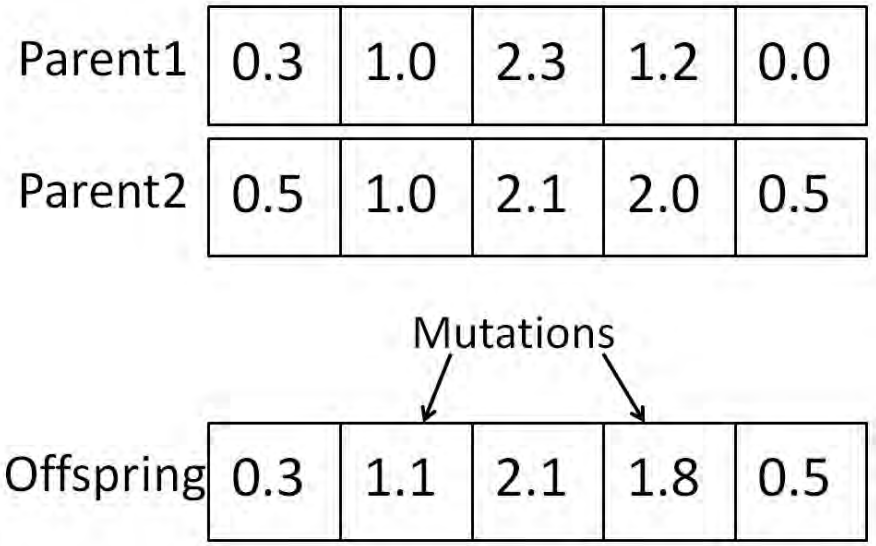


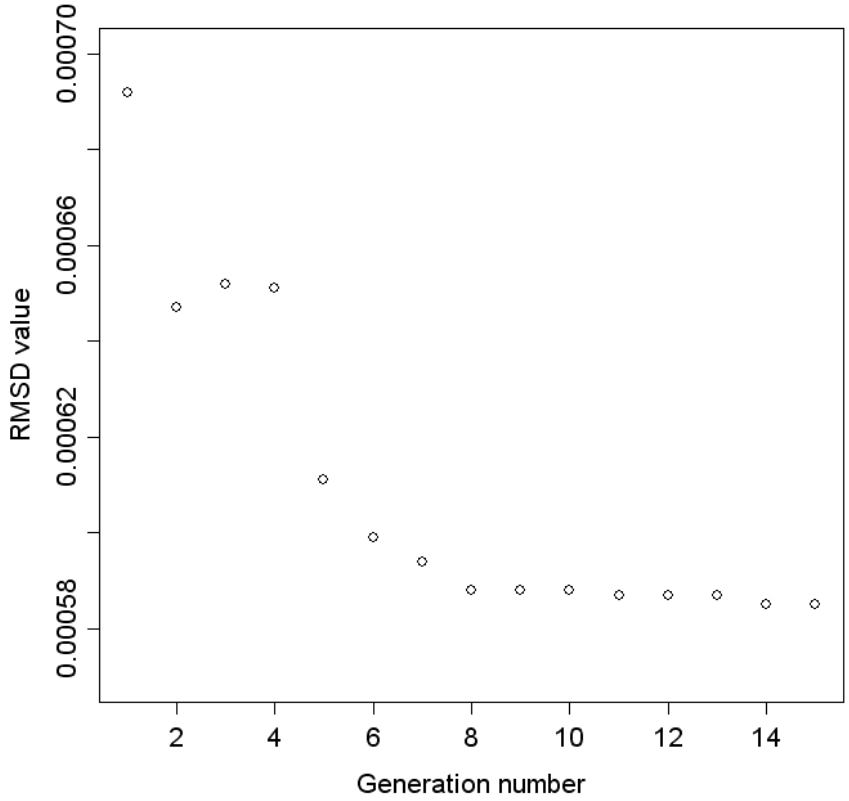
•The fish cannot migrate into water masses colder than 2 (her and bw) or 8° C (mac).
•The simulations are a combination of modelling fish movement and hardwired movement.


Svalbard
Greenland Sea
Jan Mayen
Norwegian Sea
Iceland Sea
Iceland
Hardwired movement
Blue whiting
Mackerel
Herring
Norway
North Sea
Optimised movement
Blue whiting
Mackerel
Herring

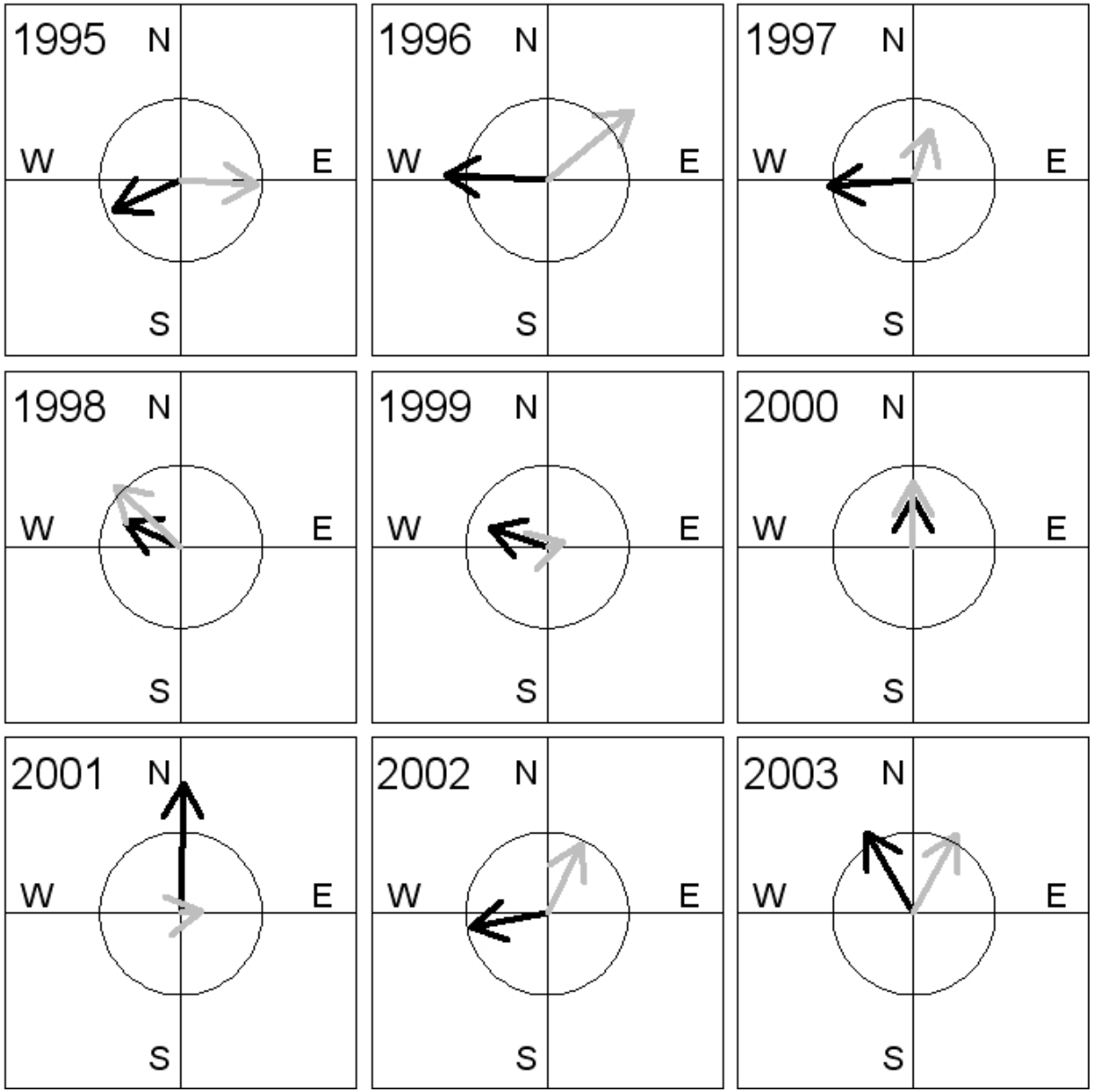
Optimize migrations parameters

- Migration speed, direction and randomness
- Survey observations
- Genetic Algorithm (GA)
- 10 simulations, keep 2, 30 generations



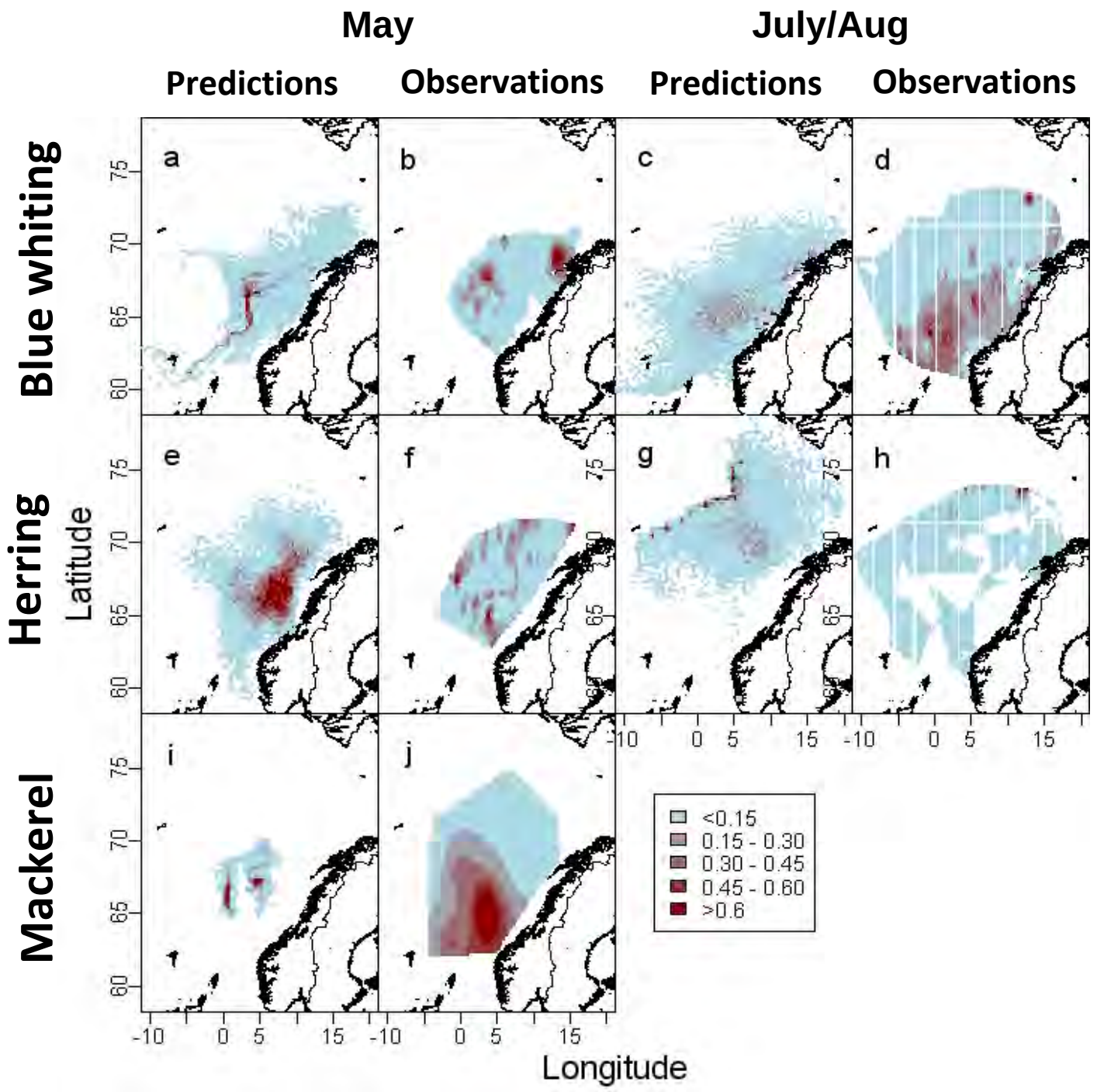


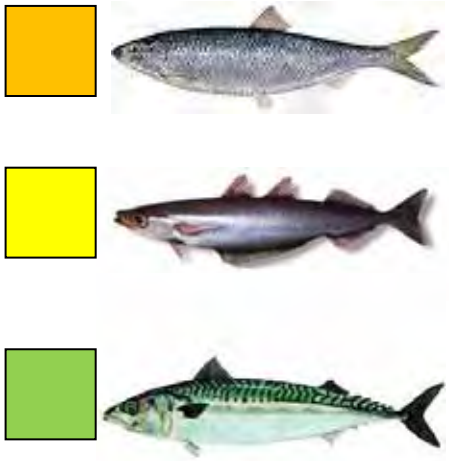
Herring migration vectors



Black arrows
Early summer

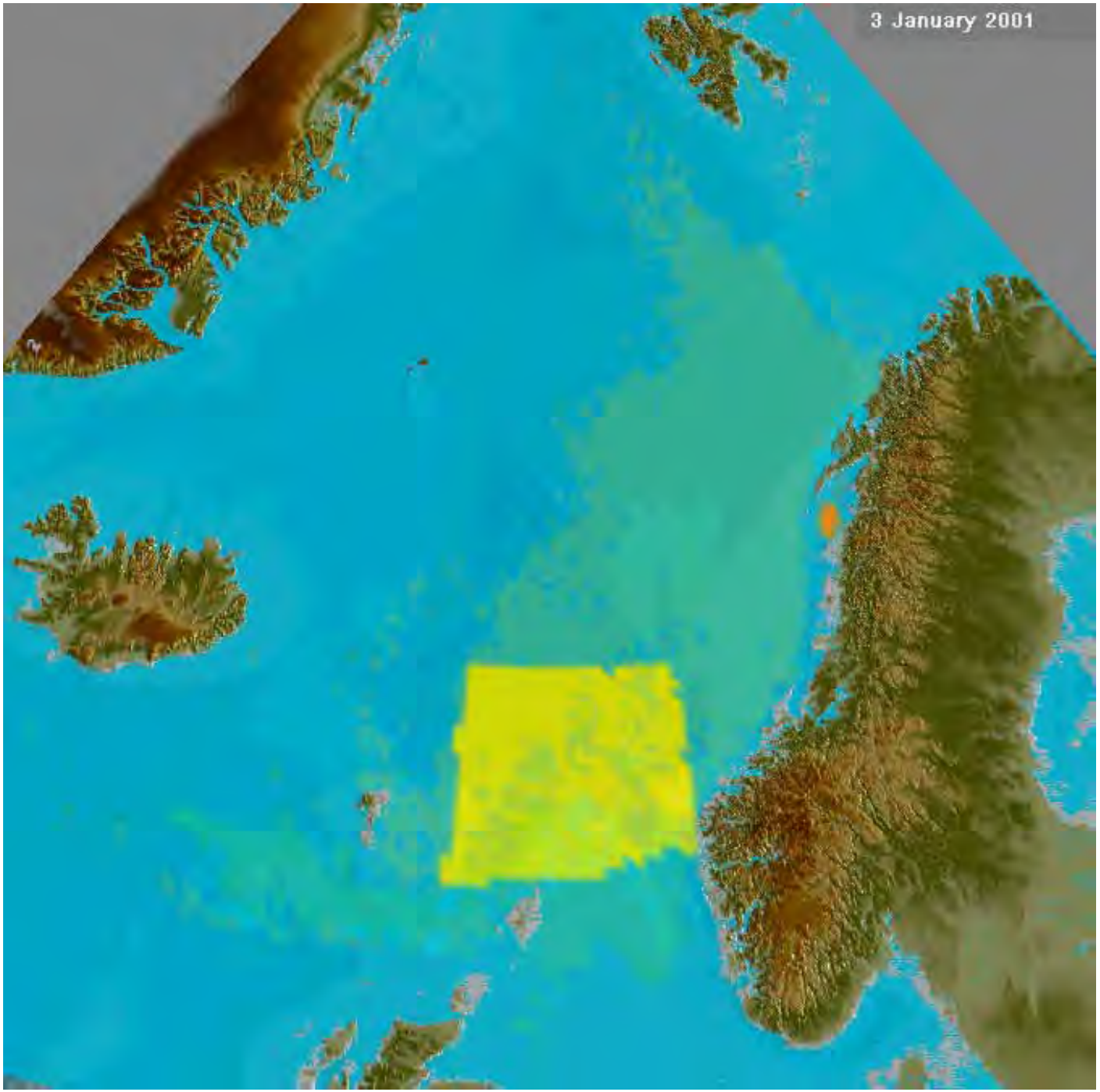
Gray arrows
Late summer

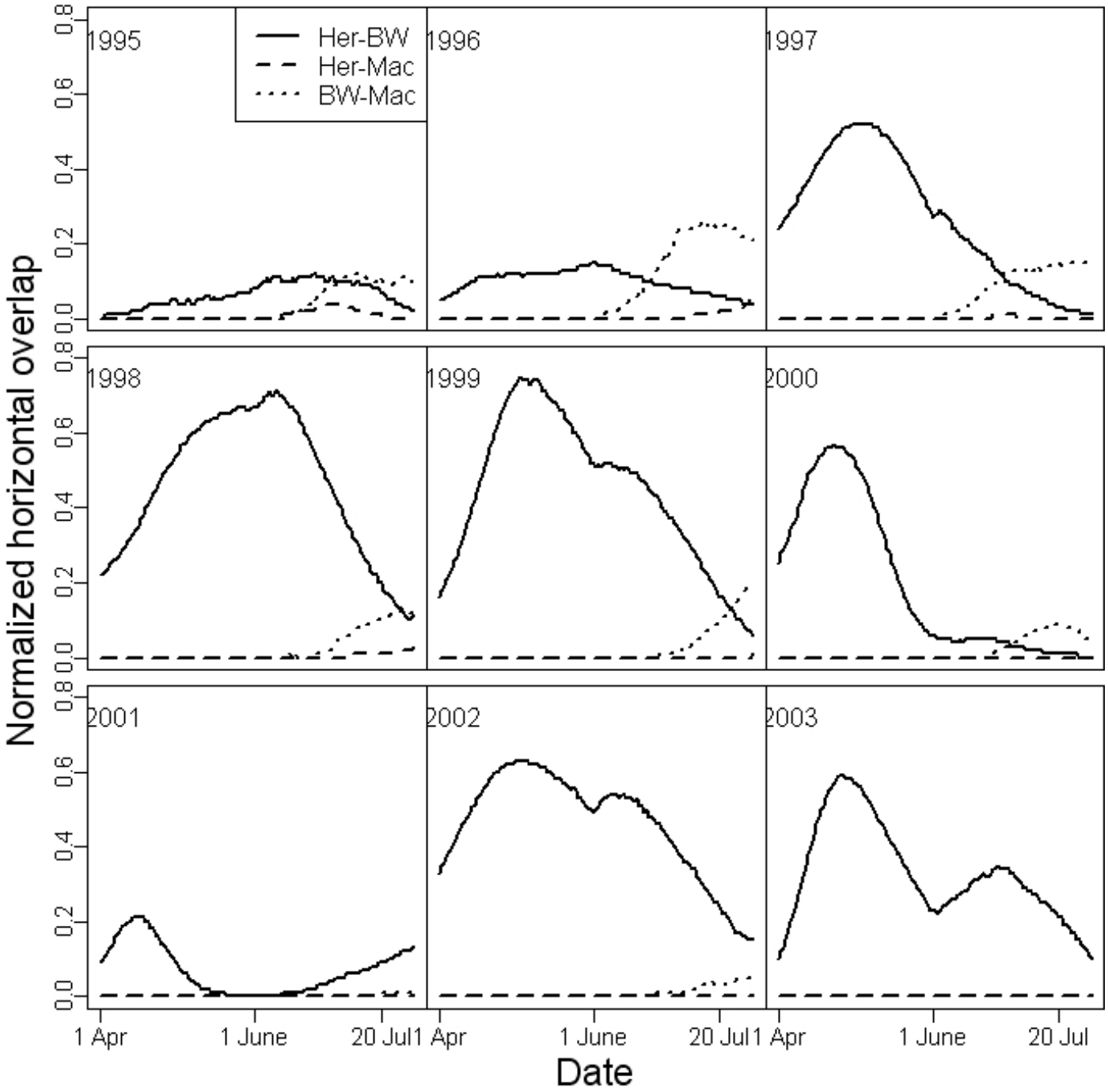

May
July/Aug
Predictions
Observations
Predictions
Observations
Blue whiting
Herring
Mackerel
a
b
c
d
e
f
g
h
i
j
Latitude
Longitude
75
70
65
60
-10
0
5
15
<0.15
0.15 - 0.30
0.30 - 0.45
0.45 - 0.60
>0.6



Overlap between two species

Overlap between three species




Her-BW
Her-Mac
BW-Mac
1995
1996
1997
1998
1999
2000
2001
2002
2003
Normalized horizontal overlap
0.0
0.2
0.4
0.6
0.8
1 Apr
1 June
20 Jul
Date

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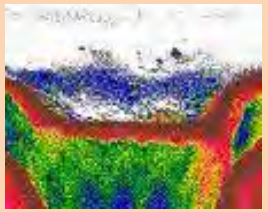


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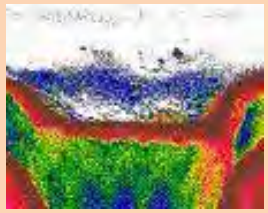


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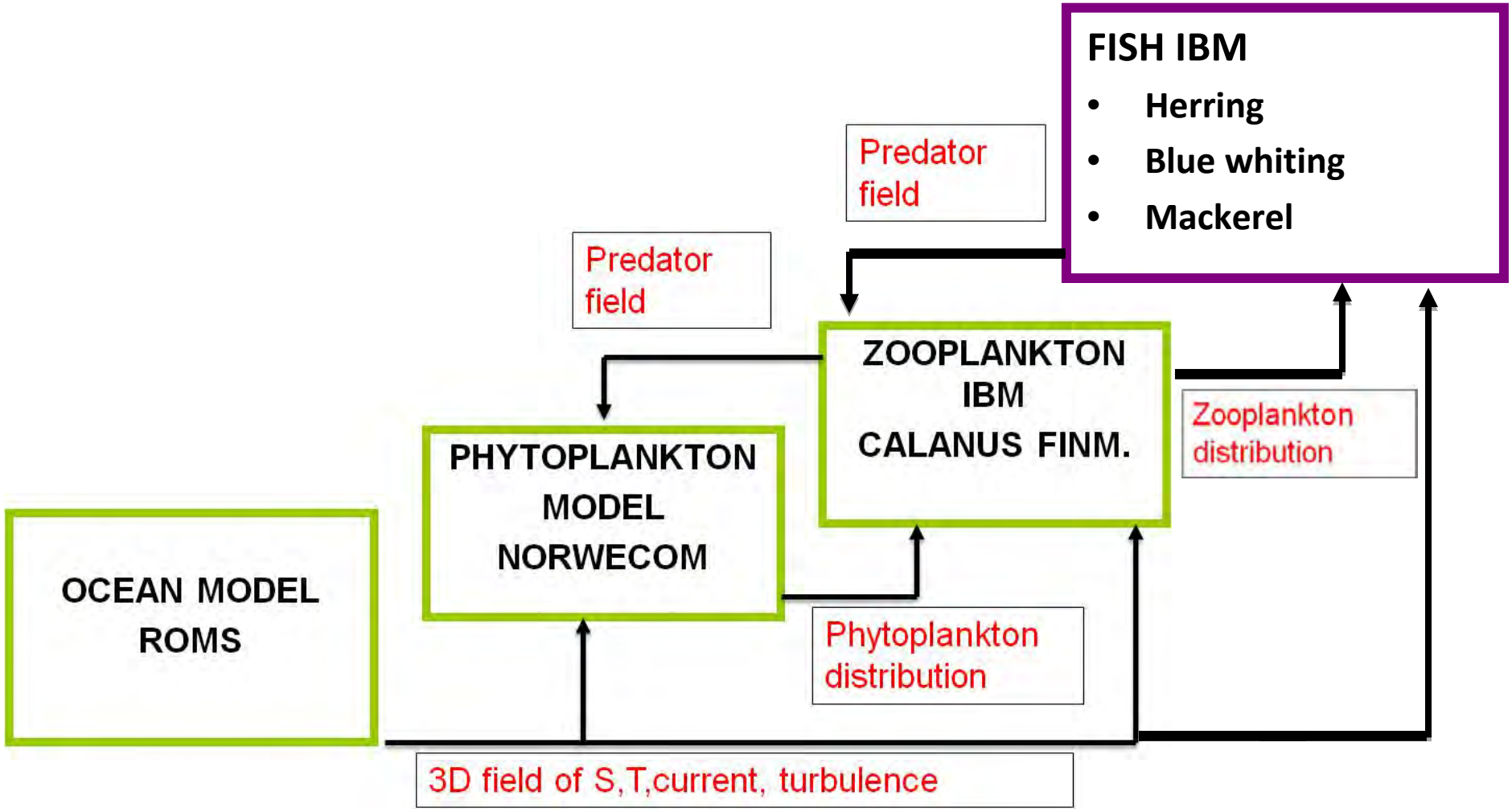
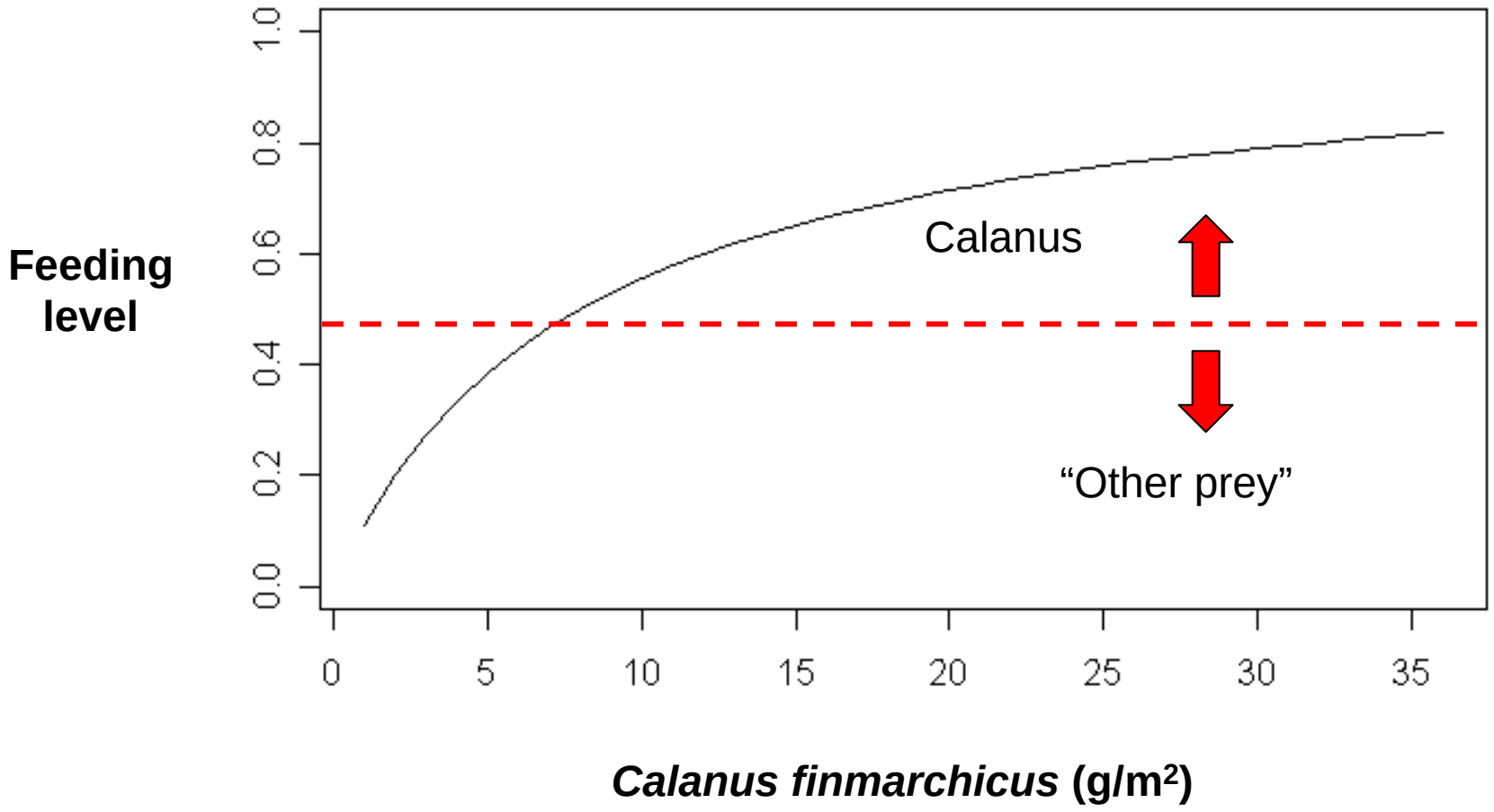
NORWECOM Coupled model system



Feeding behaviour fish

Holling type 2 – functional response



What to do?

Date

Spring – spawning
Summer – feeding
Autumn - overwintering

Summer

What to do?

Calanus?

YES -> feed on Calanus
Stay, random walk

NO, feed on “other prey”

Warm enough?

YES

Migrate in predetermined direction
(from the first model approach)

NO. Migrate east

Growth = C – (R+S+F+U)

- C = Consumption (temperature-dependent)
- R = Respiration (energy used for metabolism, temperature-dependent)
- S = SDA (Specific dynamic action)
- F = Feces (Undigested food)
- U = Excretion (Organic waste from metabolism)

Recreate in the model:

- Historic growth including gonads
- Observed diet composition

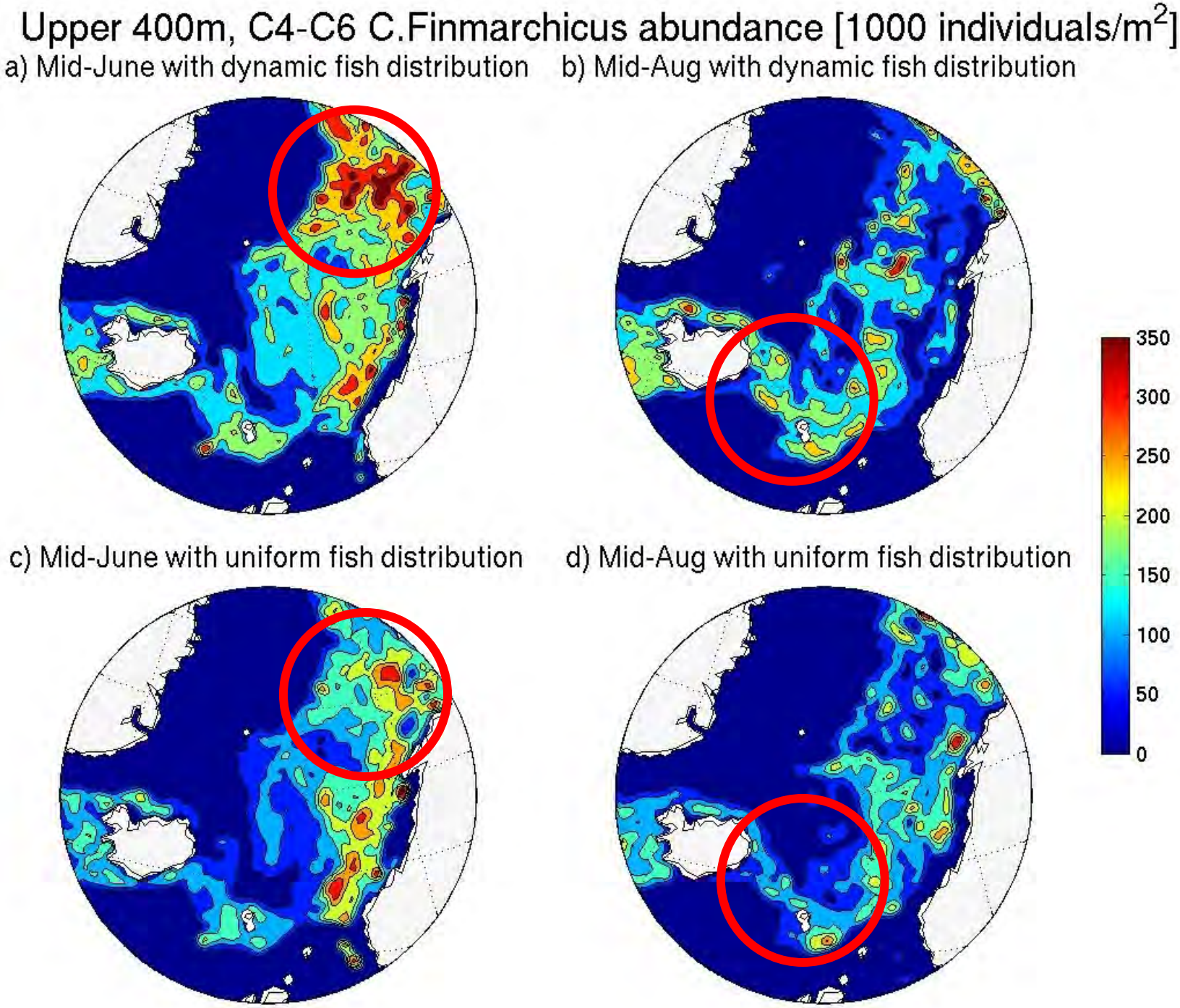
Total consumption in 1997

All numbers in million tonnes

	C finmarchicus	Other prey
Herring	24.5	26
Blue whiting	4	14
Mackerel	6.5	7
Totally	**35**	**47**

Annual zooplankton production is unknown

Rough estimate is 600 million tonnes (Skjoldal et al 2004)


Upper 400m, C4-C6 C.Finmarchicus abundance [1000 individuals/m2]
a) Mid-June with dynamic fish distribution
b) Mid-Aug with dynamic fish distribution
c) Mid-June with uniform fish distribution
d) Mid-Aug with uniform fish distribution
350
300
250
200
150
100
50
0

Historic approaches and thoughts for the future

Substitutes for zooplankton:

Temperature and phytoplankton –> No feedback

One way coupling -> Two way coupling

What is most important during the feeding period?

1. Survive
2. Eat

With dynamic zooplankton fields with feedback, hypothesis about fish migrations can be tested.
More prey species will be included in the model system.

Downside: Simulation time