» SEASONAL AND SPATIAL CHANGES IN LARVAL FISH ASSEMBLAGES ALONG THE DUTCH COAST, SOUTHERN NORTH SEA

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» LARVAL ASSEMBLAGES: Dutch Coast

Maasvlakte 2 Land Reclamation

- Total area ca 2,000 hectares , 13 km of quay walls & 12 km sea defences
- Total capacity container throughput 17 million annually
- Sand, 1st phase construction by 2013, 240 million m^3, 365 million m^3 (by 2033)
- Trailing Suction Hopper Dredgers extract sand form offshore sites (7 to 20 km off the coast)
- Navigation channel 10 nautical miles, and up to 20 meter deep

Start, Jan 2009

Oct. 2009

April 2010

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Impacts on the receiving marine ecology?

Water Framework Directive (EU WFD; 2000/60/EC)
Marine Strategy Framework Directive (EU MSFD; 2008/56/EC)

Ecosystem integrity assessment

could larval fish be a sensitive measure of ecological integrity and impacts?

Effects on larval assemblages from ...

1. disruptive pressure on spawning habitat /spawning stock biomass
2. direct effects on larval fish survival
3. indirect effects on survival -food availability, predation

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» LARVAL ASSEMBLAGES: Dutch Coast

Ecosystem integrity assessment

Biological elements response -indicators

- sensitivity to pressure (calibration)
- reference conditions
- accurate and robust indication
- technically feasible
- bound by time and budget constraints
- easy interpretation by non-specialists

1. Reference conditions of larval fish assemblages (time & space)
2. Optimization of effort

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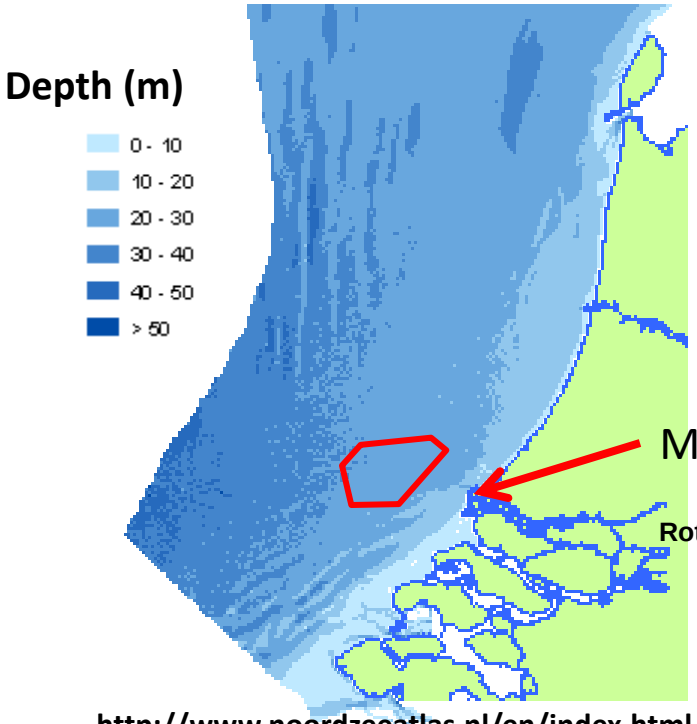
» LARVAL ASSEMBLAGES: Dutch Coast

The study area



http://www.noordzeeatlas.nl/en/index.html

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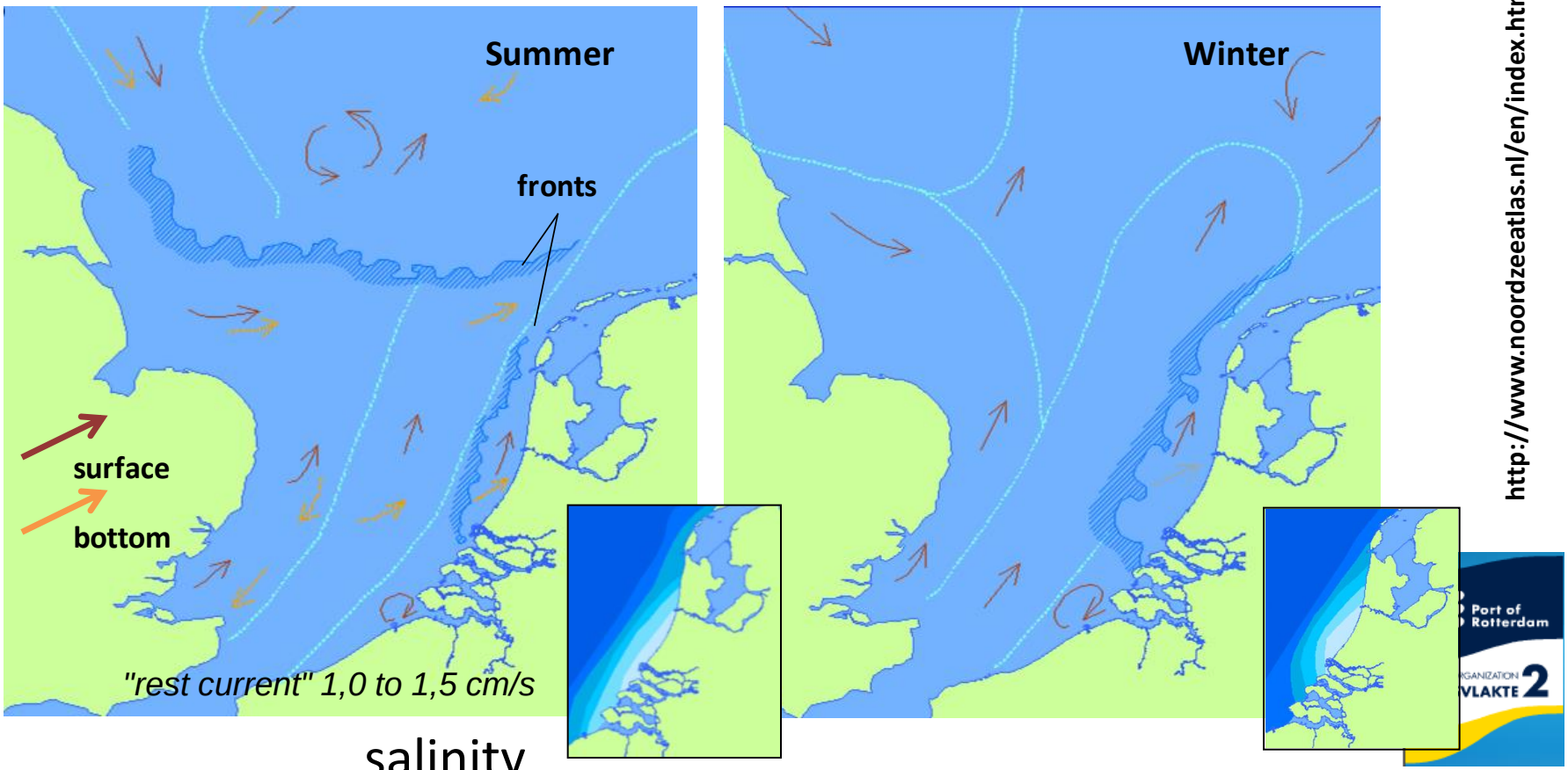
» LARVAL ASSEMBLAGES: Dutch Coast

The study area

residual currents & water masses



salinity

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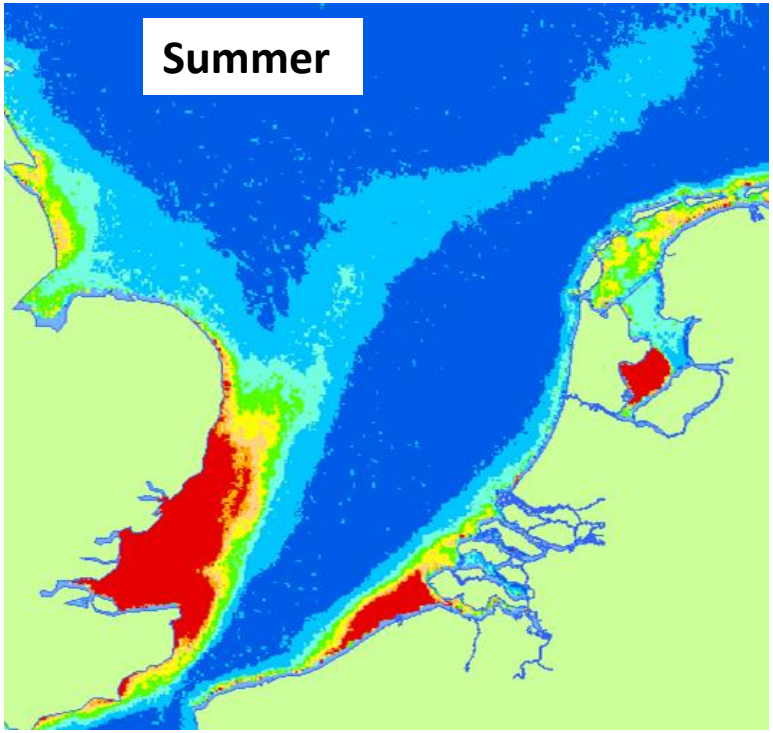
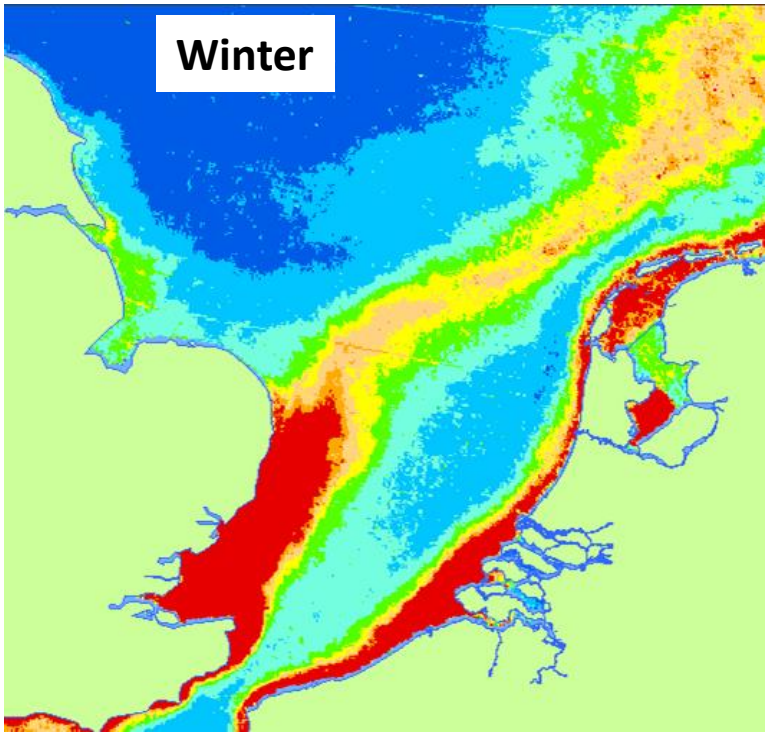
» LARVAL ASSEMBLAGES: Dutch Coast

The study area:

Total Suspended Solids





Red = high
Blue = low

http://www.noordzeeatlas.nl/en/index.html

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» LARVAL ASSEMBLAGES: Dutch Coast

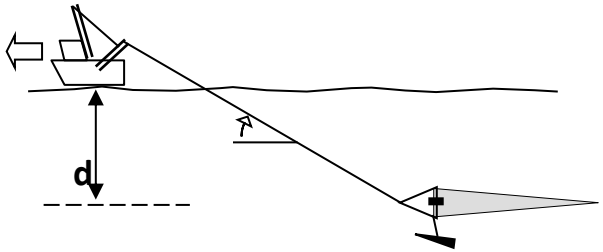
Methods Field:

Gear

Night time MIK trawls

2m Ø 1500µm body & 500µm codend

10-15’ tows & approx. 3200m^{-3} samples



Water Quality parameters

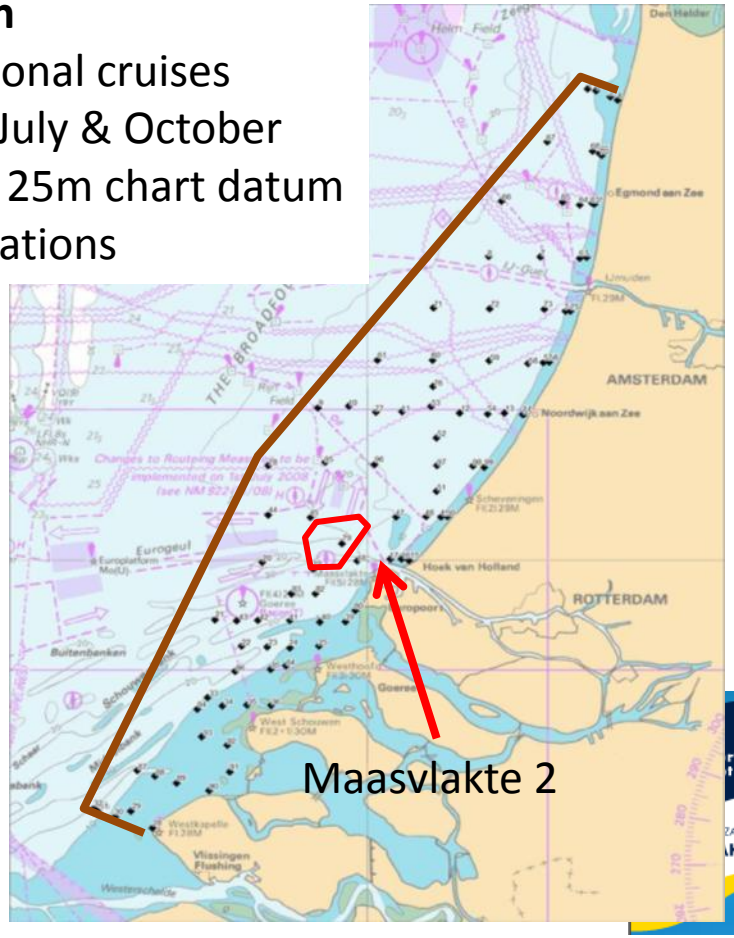
Design

3 seasonal cruises

April, July & October

5m to 25m chart datum

100 stations



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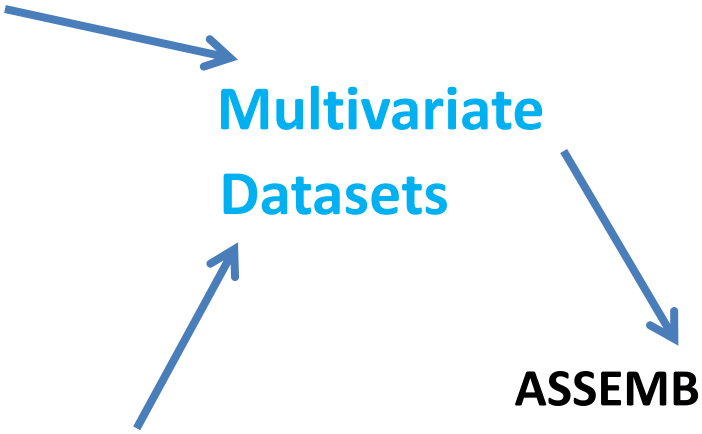
» LARVAL ASSEMBLAGES: Dutch Coast

MIK SAMPLE PARAMETERS

Larval density (ind./1000 m^3) by species
Standard length
Stomach content analysis (n=108)

ENVIRONMENTAL VARIABLES

Temperature
Salinity
Chlorophyll
% silt (bottom)
Total Suspended Matter
Station depth
Latitude
Cruise (degree day)



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» LARVAL ASSEMBLAGES: Dutch Coast

Results: Sampling effort & larval assemblage

Cruise APRIL

100 stations			33 stations	
no/1000m^3	Species	Rank	no/1000m^3	Species
180.4	***Clupea harengus***	1	167.4	***Clupea harengus***
24.7	***Platichthys flesus***	2	14.9	***Platichthys flesus***
18.1	***Limanda limanda***	3	14.3	***Limanda limanda***
7.3	*Arnoglossus laterna*	4	5.0	*Ammodytes marinus*
4.0	*Ammodytes marinus*	5	4.7	*Arnoglossus laterna*
3.3	*Solea solea*	6	4.2	*Solea solea*
2.1	*Pleuronectes platessa*	7	1.5	*Pleuronectes platessa*
1.1	*Sprattus sprattus*	8	0.7	*Merlangius merlangus*
0.5	*Merlangius merlangus* *	9	0.5	*Sprattus sprattus*
0.3	*Liparis liparis* *	10	0.2	*Liparis liparis*
0.1	*Aphia minuta* *	11	0.2	*Pholis gunnellus*
0.1	*Microchirus variegatus**	12	0.1	*Microchirus variegatus*
0.1	*Pholis gunnellus* *	13	0.1	*Aphia minuta* *
<0.1	*Anguilla anguilla* *	14	0.1	Scorpaenidae spp *
<0.1	*Pomatoschistus minutus* *	15		
<0.1	Scorpaenidae spp *	16		
<0.1	*Callionymus lyra* *	17		
<0.1	*Dicentrarchus labrax* *	18		
<0.1	*Hyperoplus lanceolatus* *	19		

99% of total abundance

< 5% of samples

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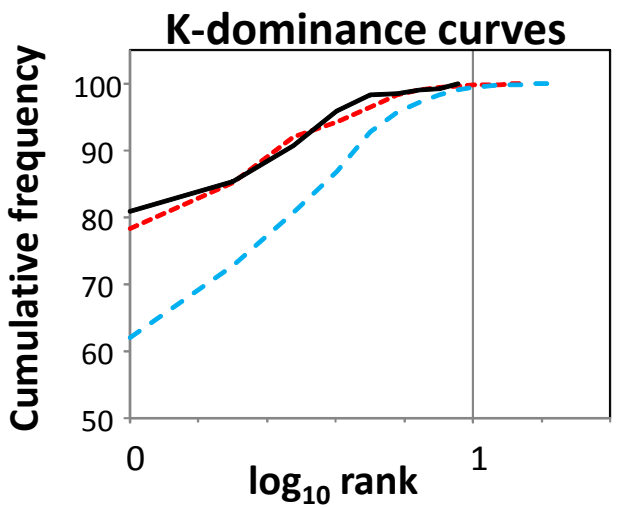
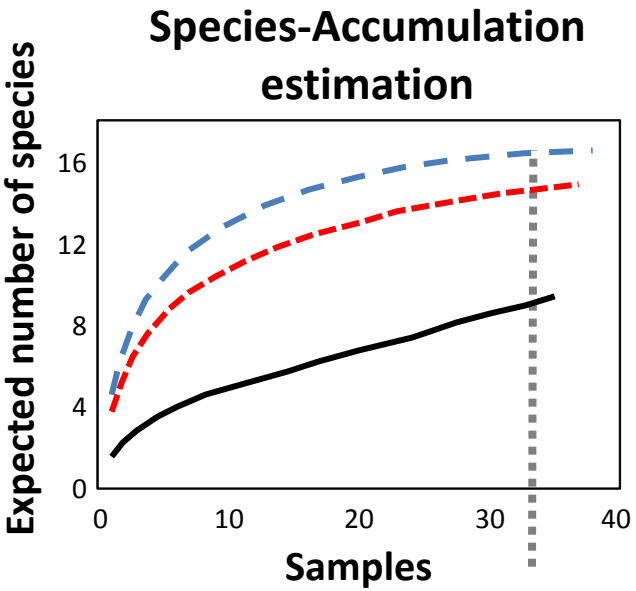
» LARVAL ASSEMBLAGES: Dutch Coast

Results: diversity by season

APRIL ---
JULY - -
OCTOBER —





33 Samples

	April	July	October
No. spp.	14	17	9
No. Unique spp.	10	4	1

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» LARVAL ASSEMBLAGES: Dutch Coast

Assemblages:
Redundancy Analysis (RDA) Brodgar

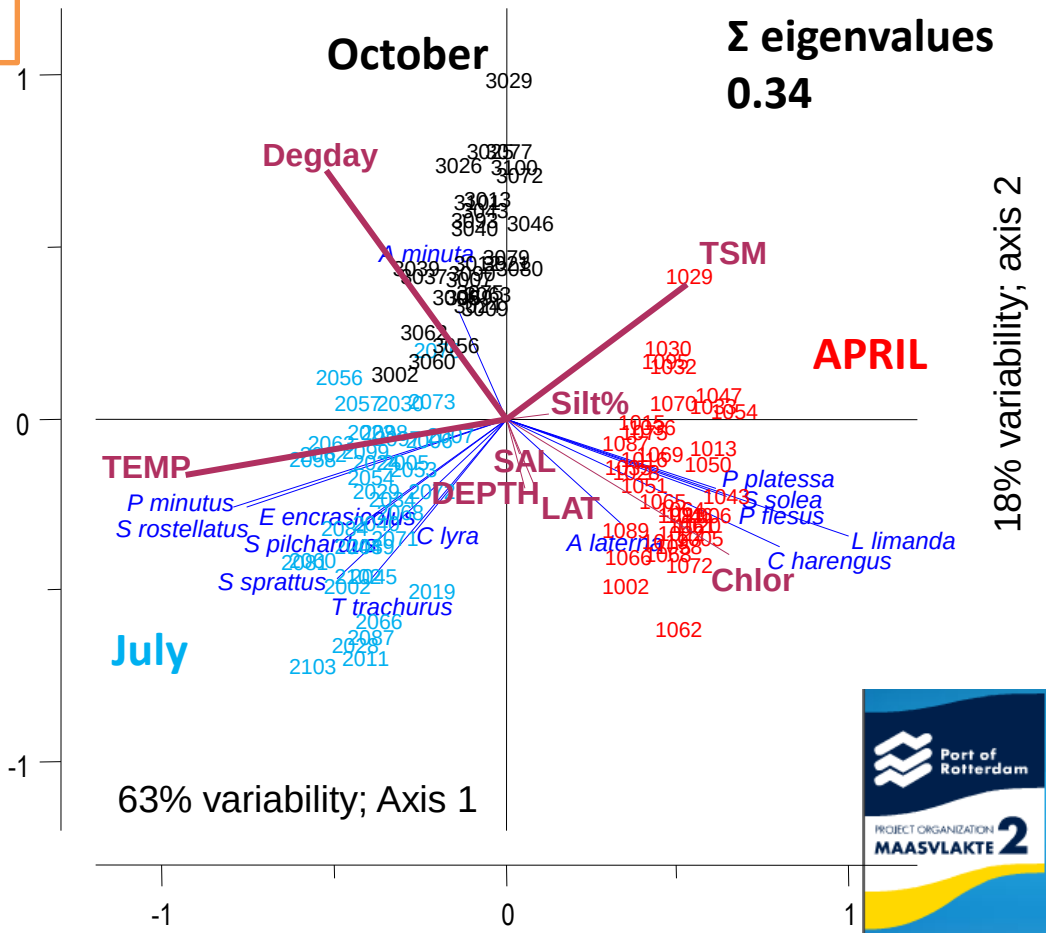
-Strong seasonal effect

-Flatfish dominated in April (local source of larvae?)

-Peak diversity in Summer

-Model: **TEMP : Degday : TSM**
79% explained variance

-TSM relevant?



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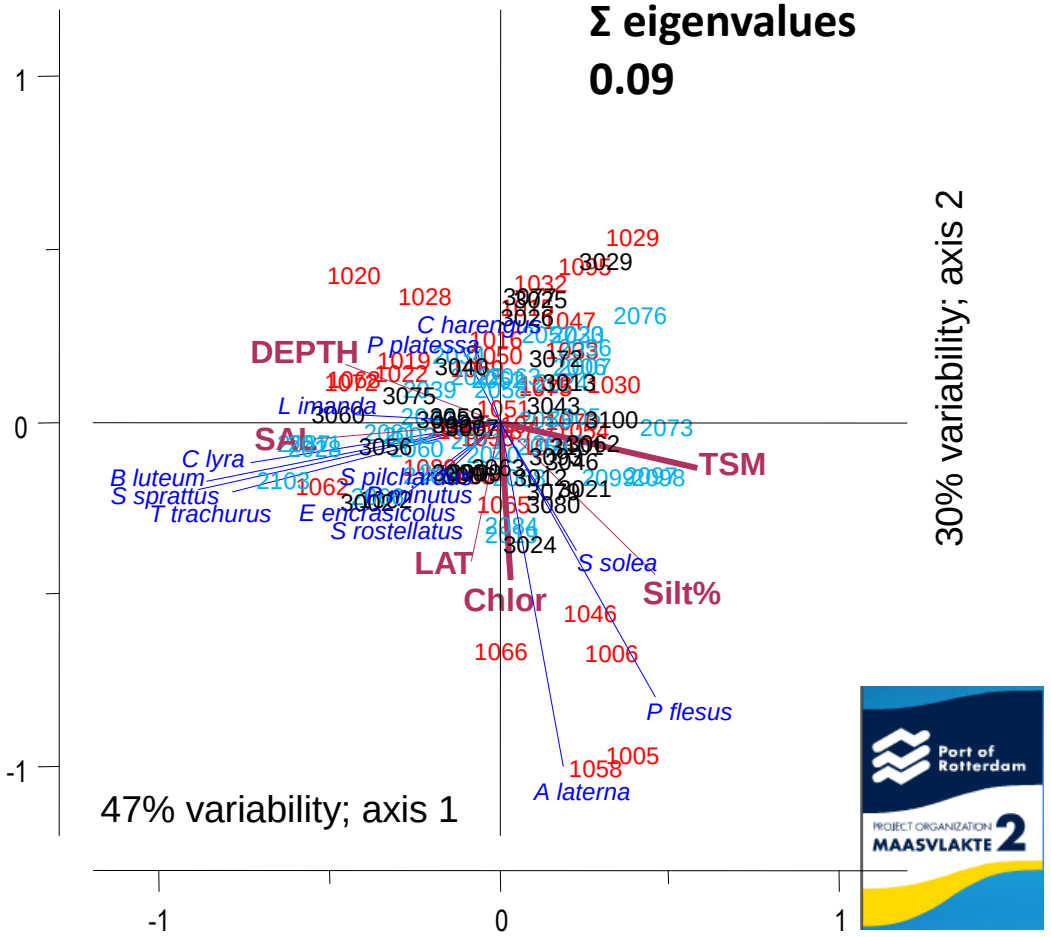
» LARVAL ASSEMBLAGES: Dutch Coast

Assemblages: partial RDA
Covariates TEMP + Degday

- Model: **TSM : Chlor**
21.2% explained variance, but very low predictive power

is TSM variability driving the assemblage or are they linked by a 3rd unknown variable?

… most explanatory power in the seasonal effect



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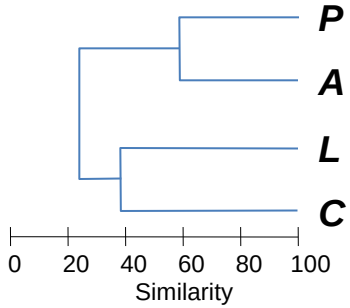
» LARVAL ASSEMBLAGES: Dutch Coast

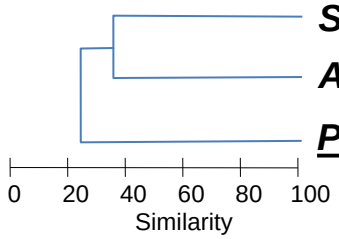
Species assemblages & abundance

April



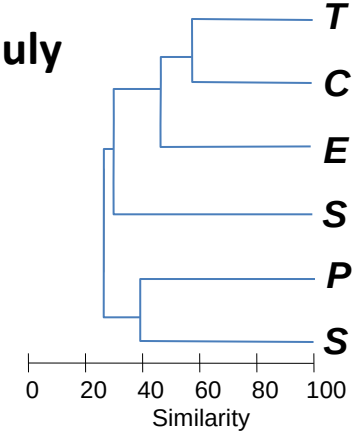
	A1	A2
P flesus	-	4.3 (ind/1000m³)
A laterna	-	2.2
L limanda	3.3	1.3
C harengus	14.0	4.1

October



S rostellatus	0.5
A minuta	0.4
P minutus	2.8

July



	J1	J2	J3	J4
T trachurus	-	-	5.5	1.3
C lyra	-	-	7.4	-
E encrasicolus	-	-	7.6	1.1
S sprattus	3.9	-	10.3	0.7
P minutus	7.7	10.4	25.8	1.4
S pilchardus	-	6.5	-	-

Assemblages:
Cluster analysis (Bray-Curtis similarity and SIMPROF test) Primer v6

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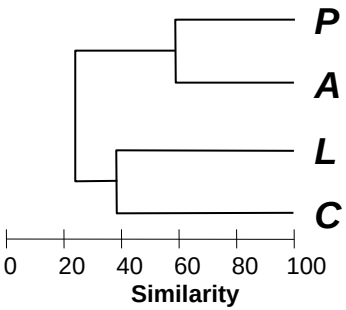
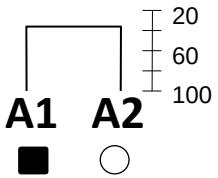
(a) April





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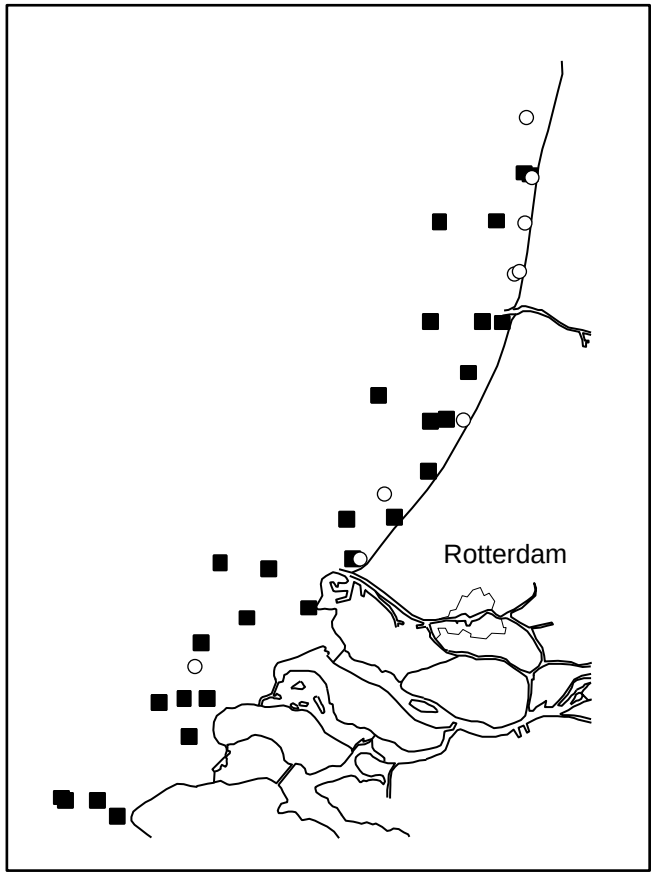
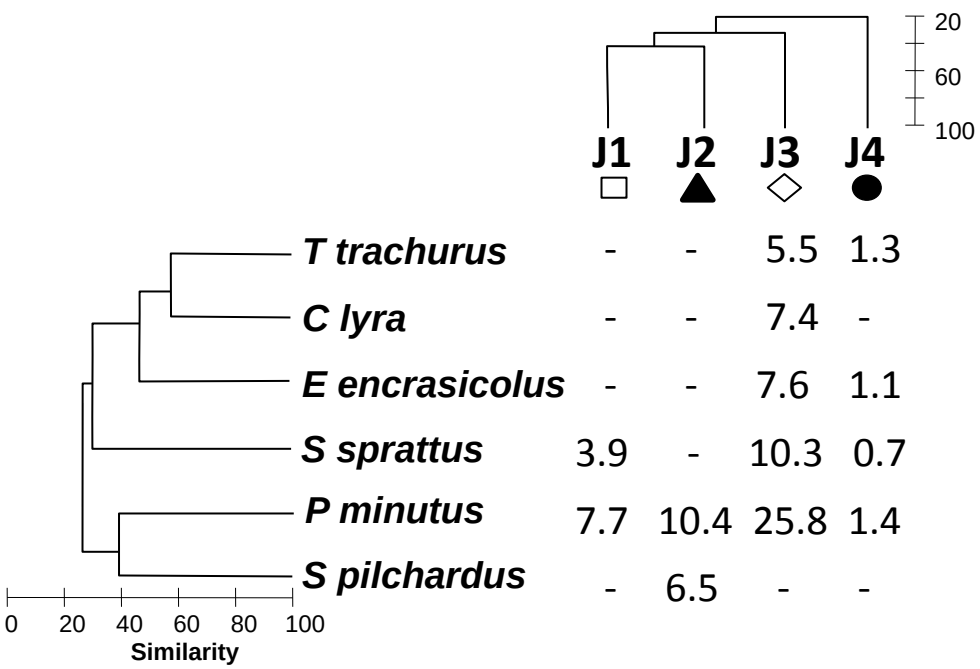
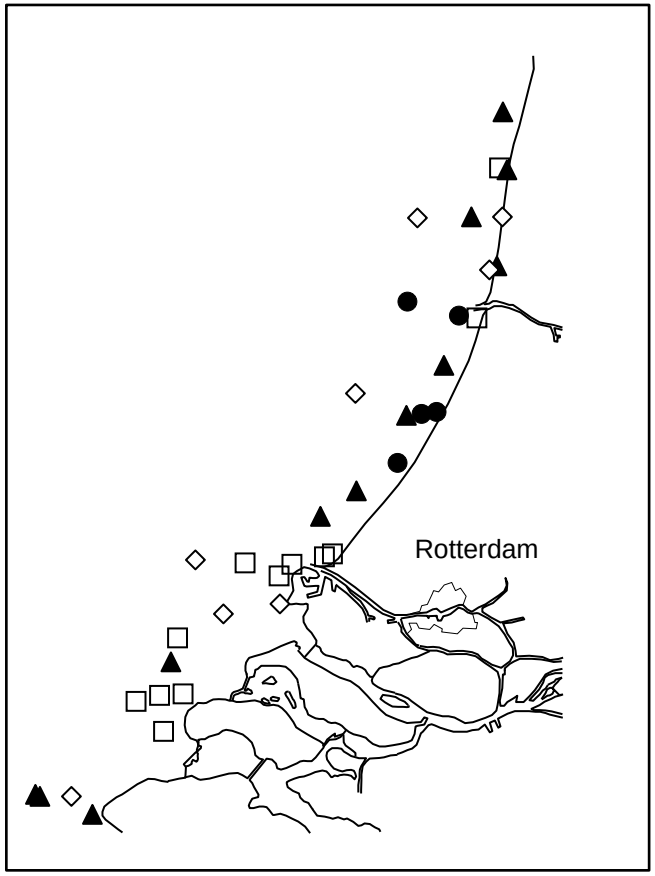


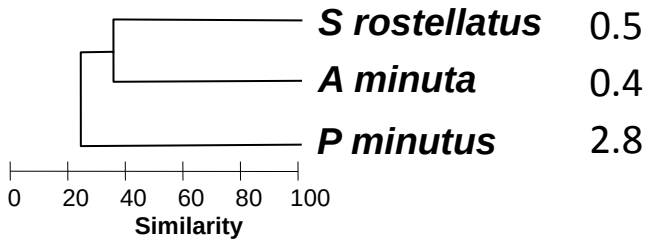
(b) July


20
60
100
J1
J2
J3
J4
T trachurus - - 5.5 1.3
C lyra - - 7.4 -
E encrasicolus - - 7.6 1.1
S sprattus 3.9 - 10.3 0.7
P minutus 7.7 10.4 25.8 1.4
S pilchardus - 6.5 - -
0 20 40 60 80 100
Similarity


Rotterdam

(b) July

(c) October



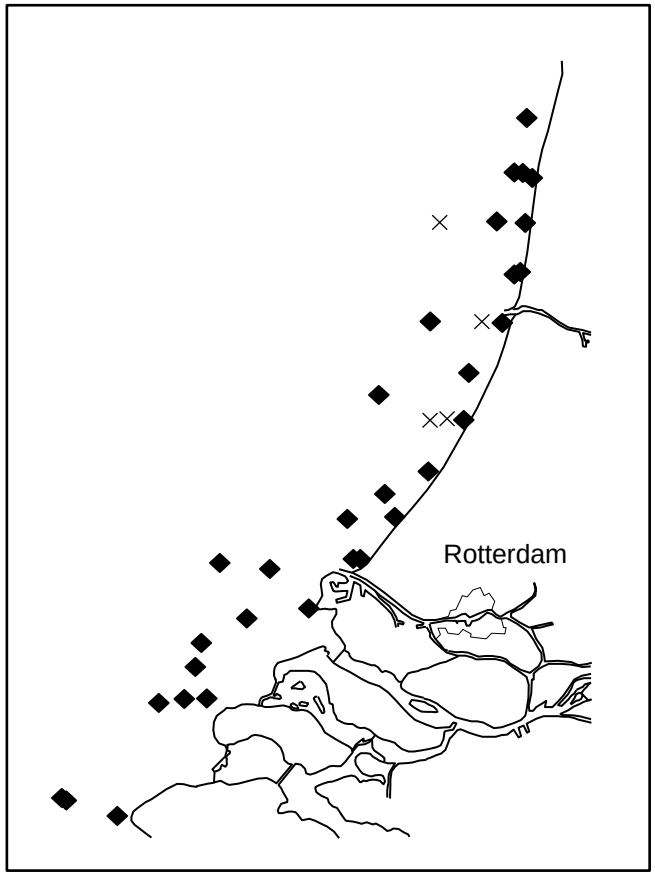
O1

◆

0.5

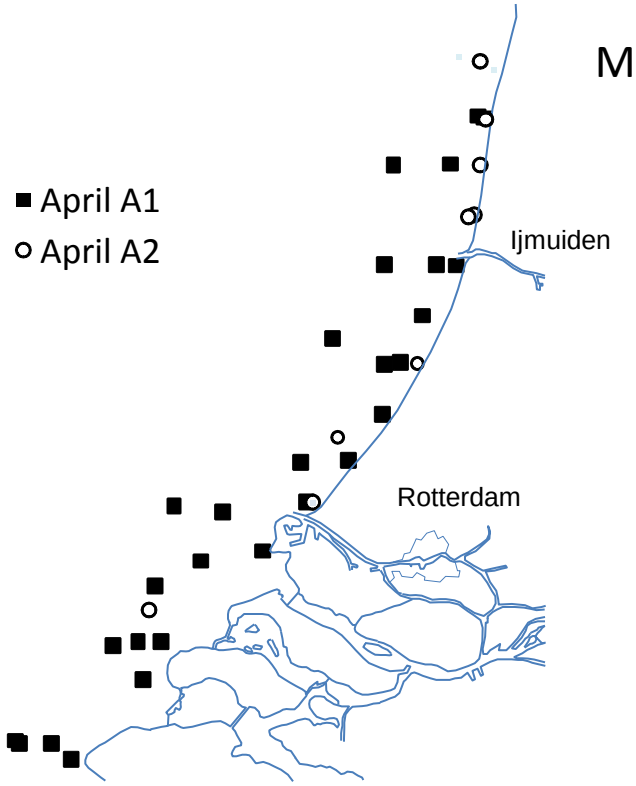
0.4

2.8



» LARVAL ASSEMBLAGES: Dutch Coast

Assemblages: spatial location



Mean length ± standard deviation (mm); (sample size)

APRIL	April A1	April A2	*p*-value
C harengus	22.5±4.6 (972) [1]	23.9±5.1 (44) [1]	ns
L limanda	11.3±1.8 (258) [1]	11.7±1.6 (25) [1]	ns
P flesus	7.0±1.0 (74) [1]	7.3±0.8 (110) [1]	0.03 ✓
A laterna	7.7±0.9 (19) [1]	7.3±0.8 (34) [1]	ns

- Significant spatial segregation $p<0.05$ (PERMANOVA)
- Uniform conditions,
- Local source of flatfish larvae?

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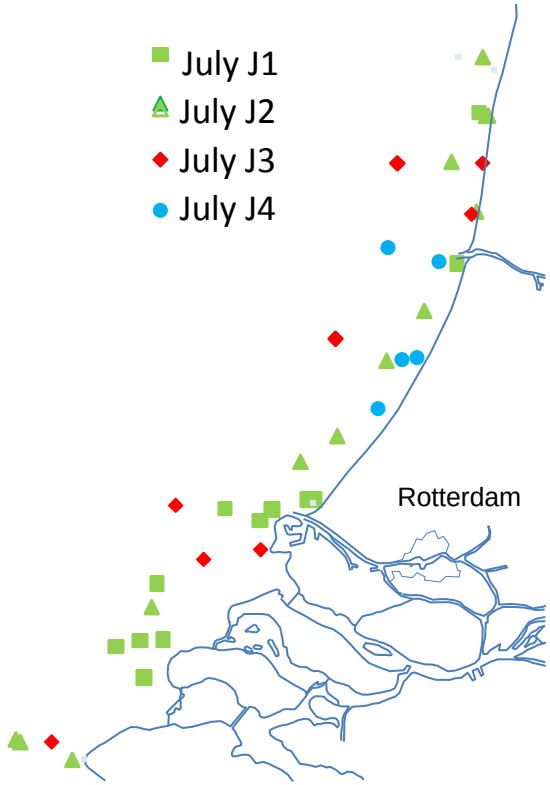
» LARVAL ASSEMBLAGES: Dutch Coast

Assemblages: spatial location



Mean length ± standard deviation (mm); (sample size)

JULY	July J1	July J2	July J3	July J4	*p*-value	
P minutus	14.1±5.0 (237)[1]	13.1±3.4 (265)[1]	10.9±3.4 (220)[2]	11.0±3.4 (19)[1,2]	<0.01	✓
S sprattus	18.0±5.1 (128)[1]	-	13.9±4.8 (127)[2]	-	<0.01	✓
S pilchardus	-	18.0±5.2 (190)[1]	14.7±2.4 (36)[2]	-	<0.01	✓
E encrasicolus	16.9±2.1 (8)[1]	13.9±3.4 (47)[2]	13.0±4.0 (110)[2]	12.6±2.8 (21)[2]	<0.01	✓
T trachurus	-	-	5.3±2.1 (92)[1]	8.7±3.0 (29)[2]	<0.01	✓
S rostellatus	22.7±7.1 (34)[1]	25.9±9.0 (23)[1,2]	19.4±8.0 (20)[2]	-	0.02	
H lanceolatus	-	25.2±4.3 (10)[1]	18.7±6.3 (31)[2]	-	<0.01	✓

- Diverse assemblage composition
- Spatial segregation non significant but
  … size differences significant (K-W & K-S tests)
- Suggest segregation into cohorts & more heterogeneous conditions in summer … transport? predation?

… no assemblage differences in October!

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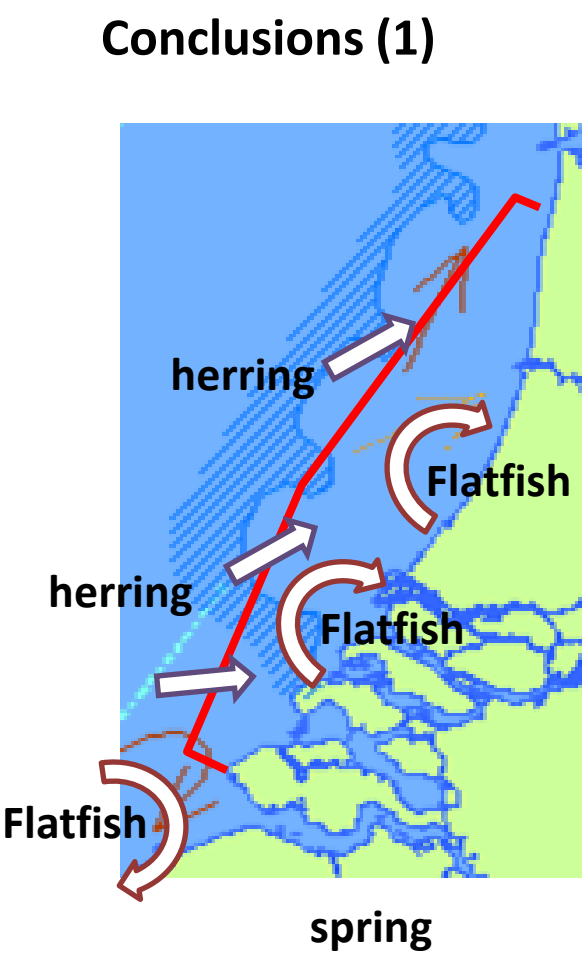
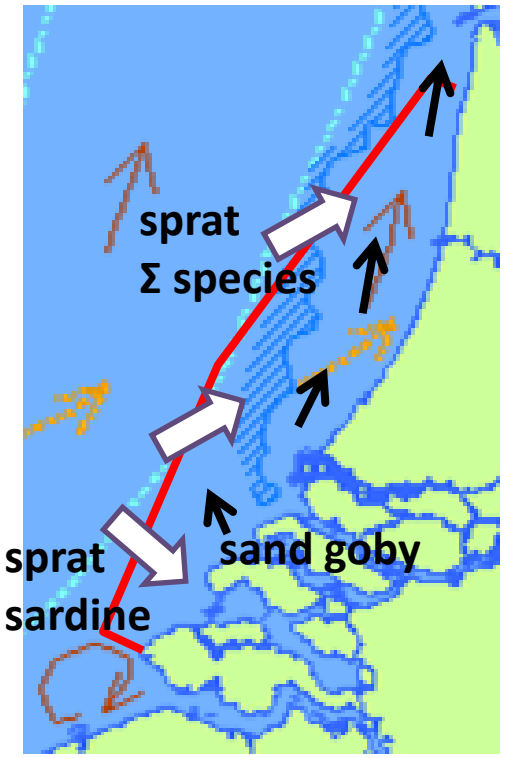
» LARVAL ASSEMBLAGES: Dutch Coast

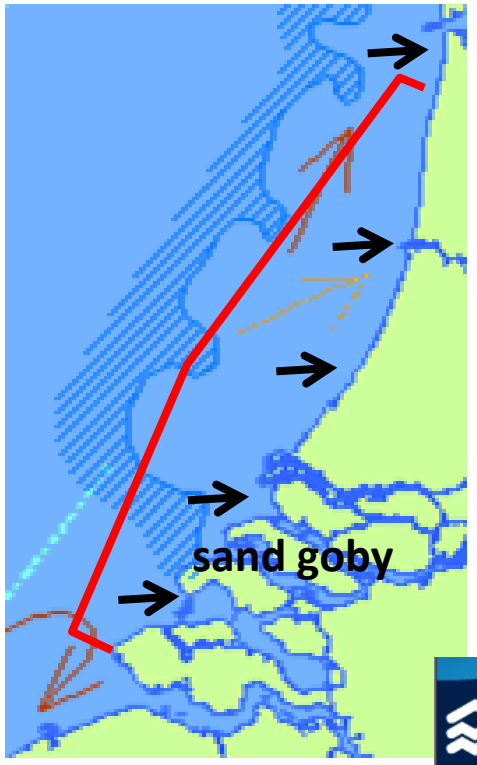
Conclusions (1)



spring



summer



autumn

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» LARVAL ASSEMBLAGES: Dutch Coast

Conclusions (2) and future research:

- Main predictive variables Season and Temperature. Seasonal spawning.
- TSM and Chlorophyll may have structuring roles but with very low predictive power
- species diversity and seasonality best chances for a predictive model

Questions to answer

- Can we derive a reference condition?
- How to improve the models, more sampling or better designs?

Future work

- are the models good enough? Sensitivity analysis
- can we predict, logistic and multinomial logistic regression analysis -probabilities
- are larval fish suitable for biomonitoring and impact assessment?

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» LARVAL ASSEMBLAGES: Dutch Coast

Title:

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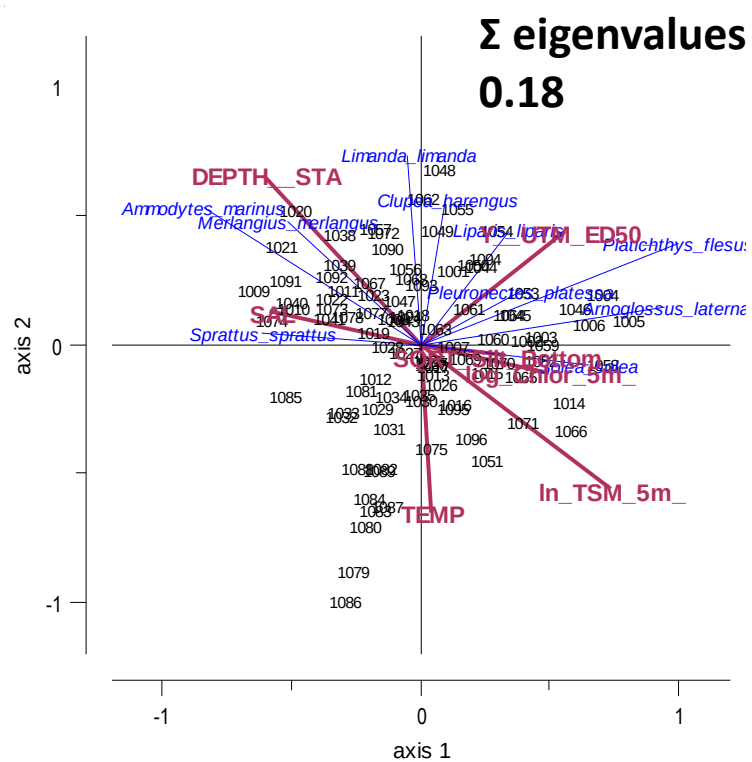
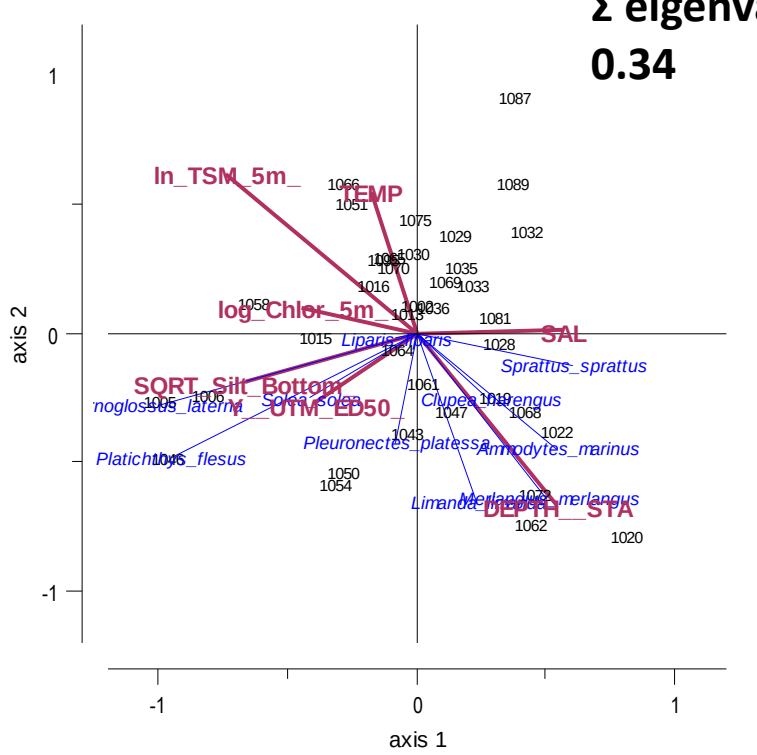
» LARVAL ASSEMBLAGES: Dutch Coast

April 100 samples



Model: **TSM-LAT-TEMP**
(Σ eigenvalues=0.13)

April 33 samples



Model: **TSM - SILT%**
(Σ eigenvalues=0.18)

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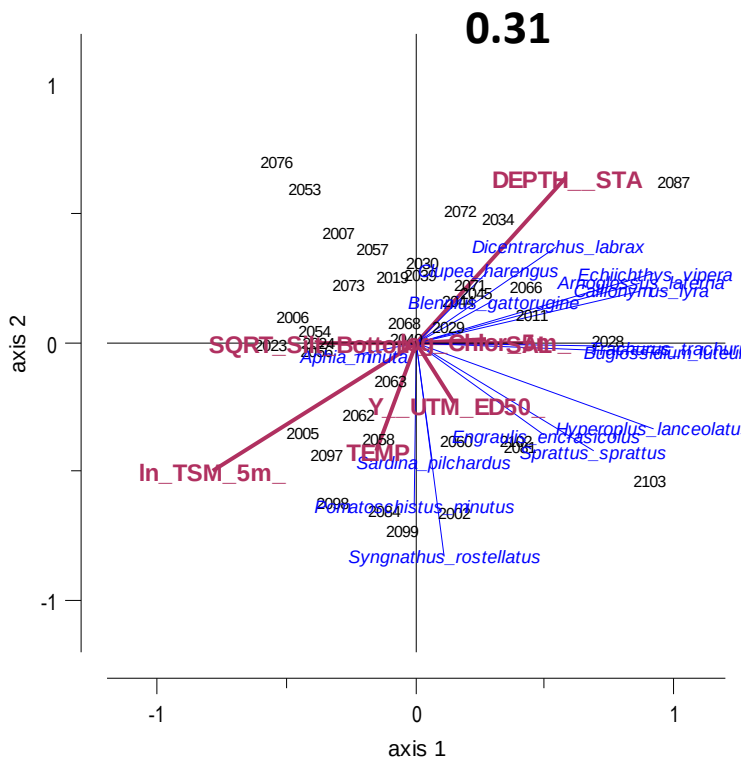
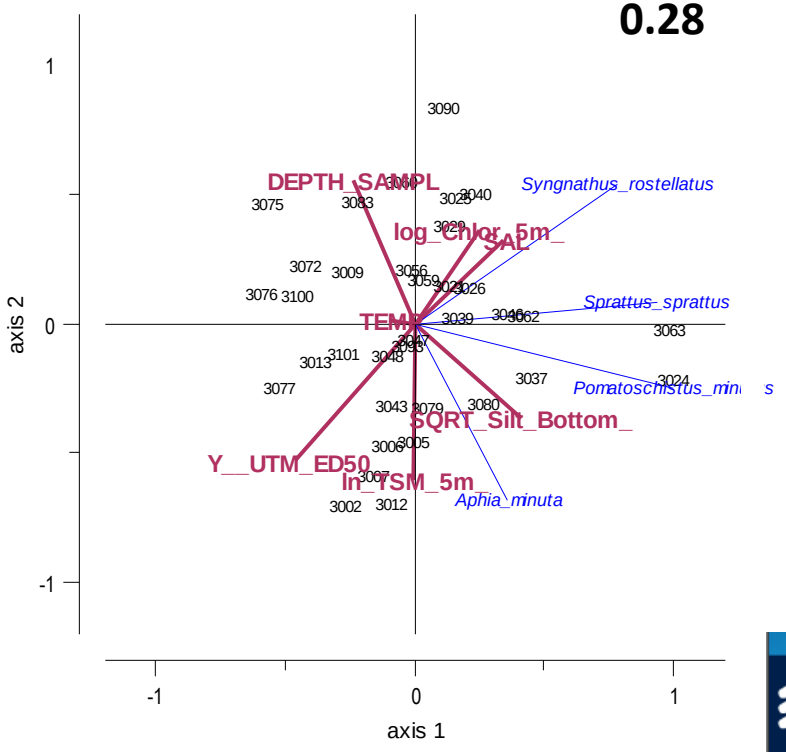
July

Σ eigenvalues 0.31



October

Σ eigenvalues 0.28



Model: **TSM** (Σ eigenvalues=0.13)

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