

Ocean-Climate Effects on Fish



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Erasmus+
Intl. School of Hellerup
Grades 7-8
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Outline

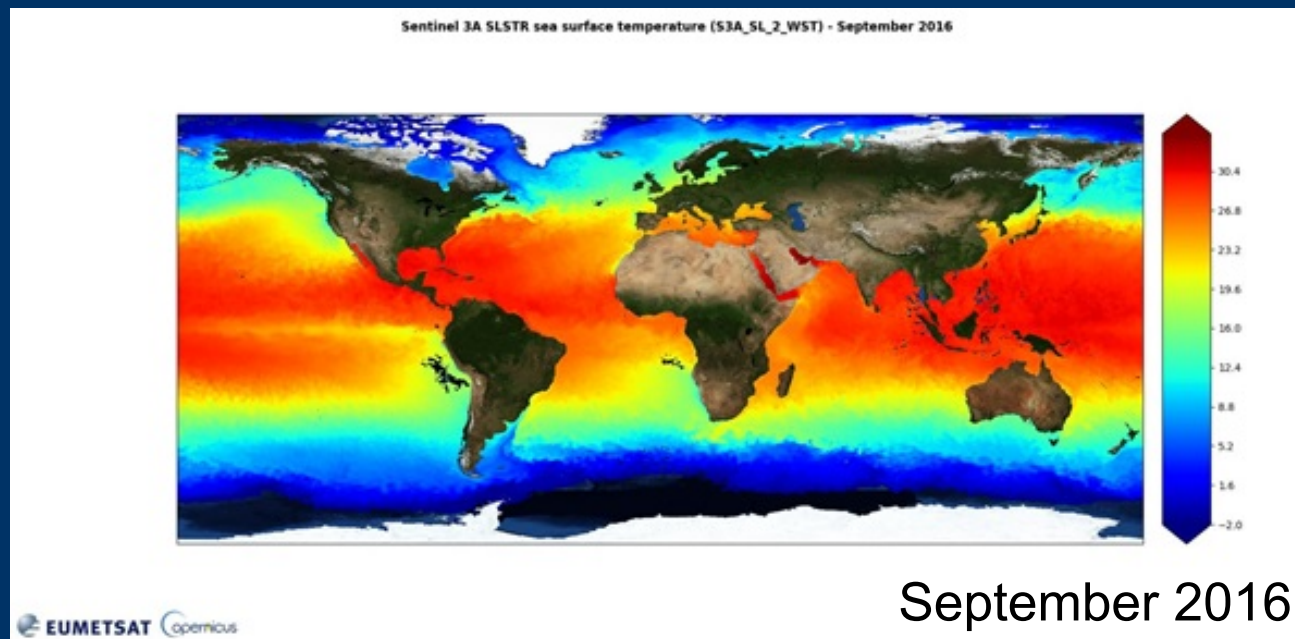
-life conditions in the ocean – major properties of sea water; global spatial distributions of ocean conditions

-where fish live (their habitats), and why they live where they do

-geographic comparisons of fish habitats – North Sea, Baltic Sea, Black Sea

-how climate change is affecting fish distributions and diversity of fish species

Spatial Differences in Ocean Temperature

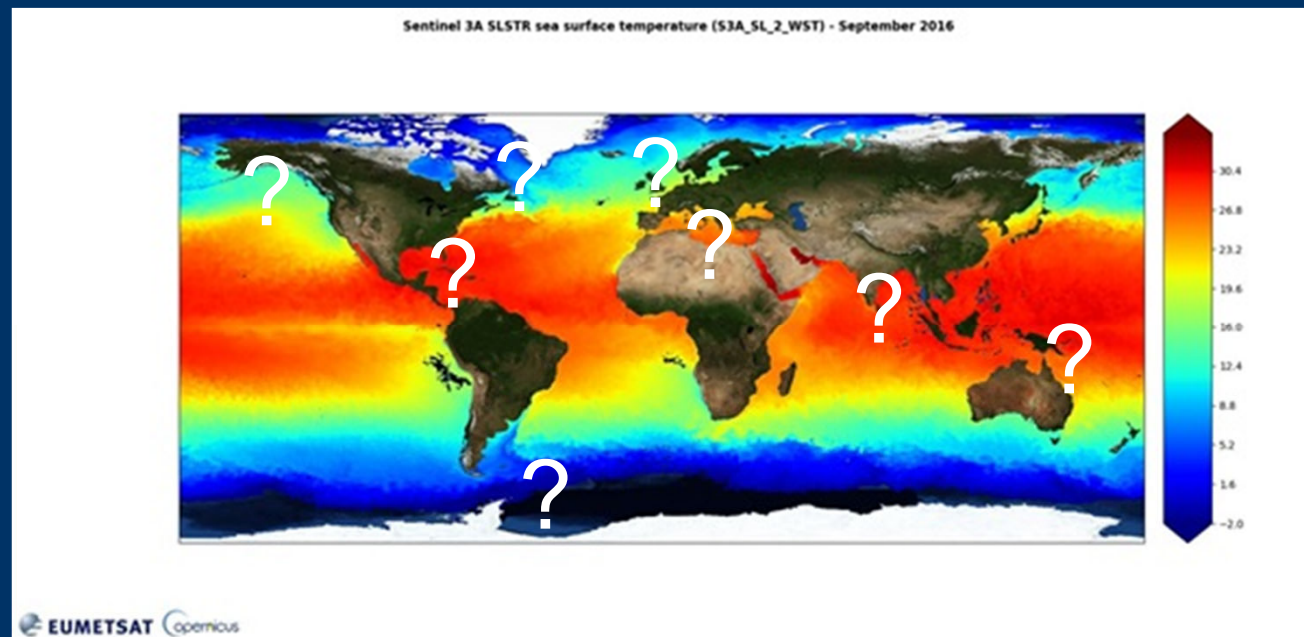
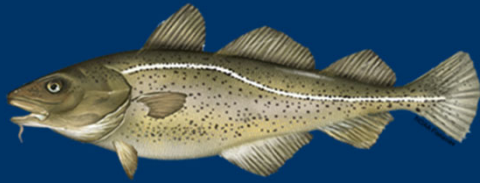


Source: SST data from Copernicus

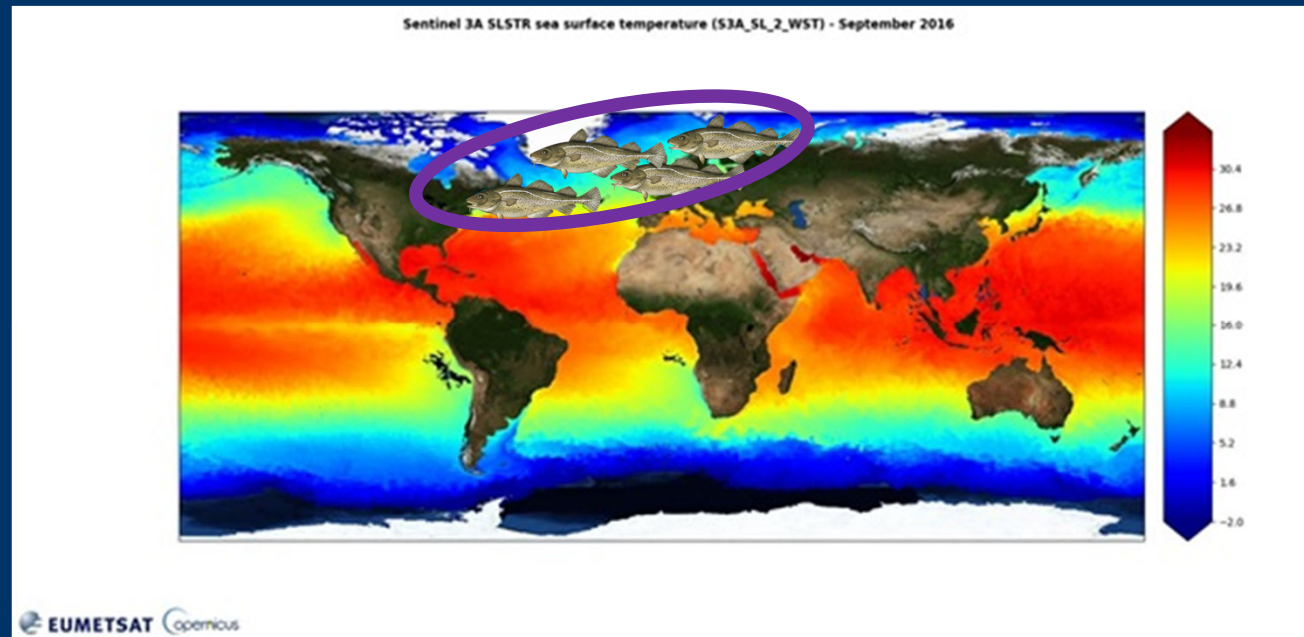
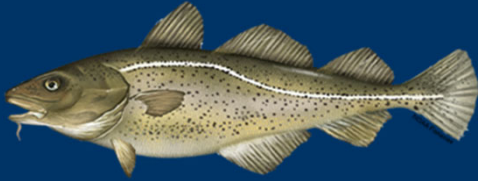
What Fish Species is This?



Where Does this Fish Species Live?

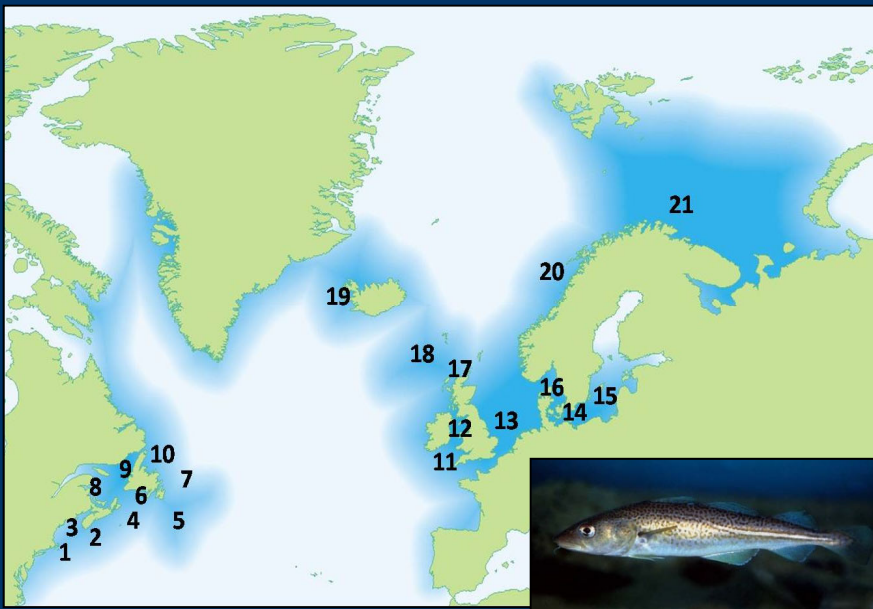


Where Does this Fish Species Live?



Cod as a Species Has Many Populations in the North Atlantic

Cod Populations

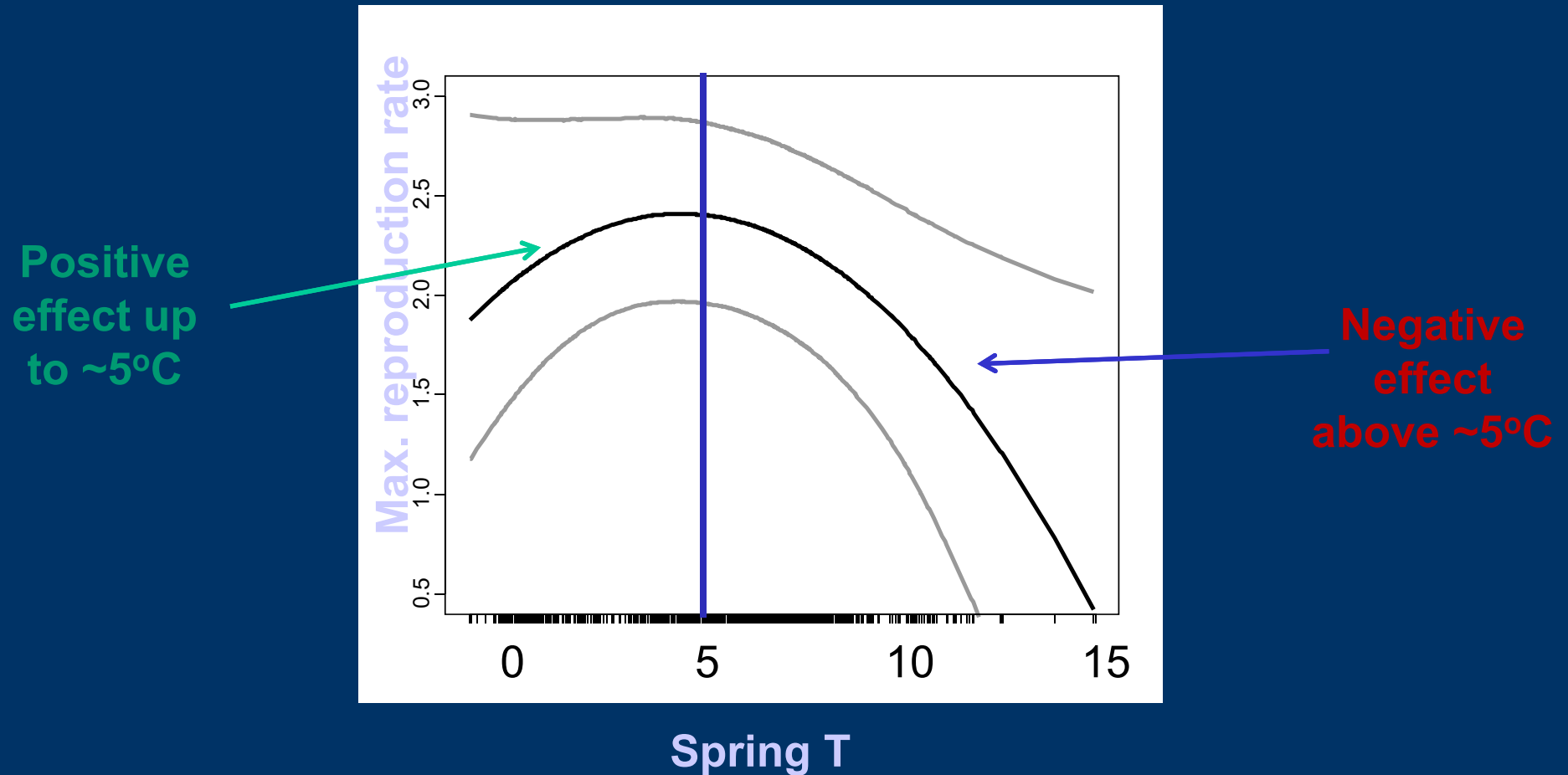


-some live in northern (cold) areas

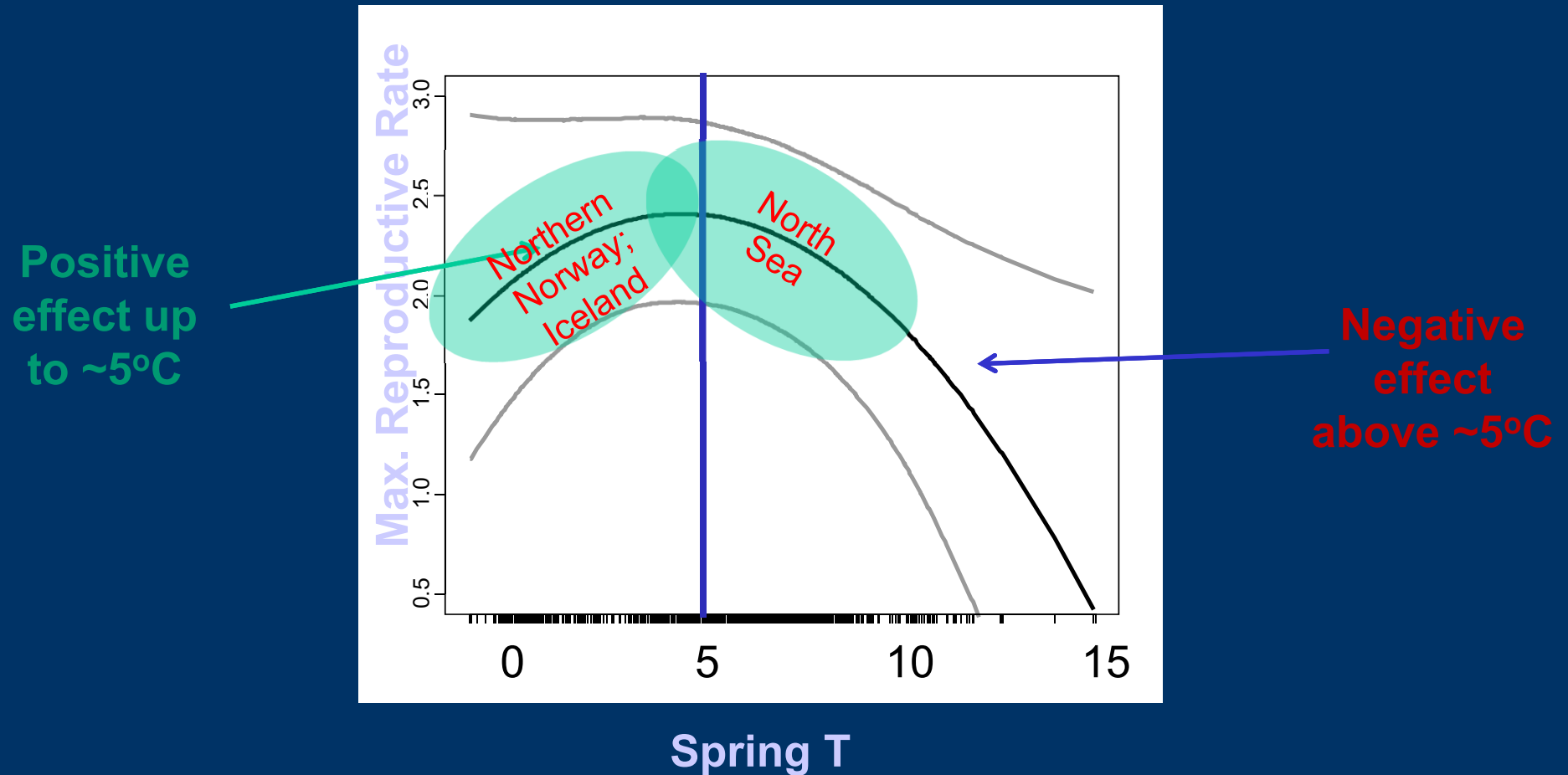
-some live in southern (warm) areas

Do they all produce same number of offspring each year?

Effects of Temperature on Max. Reproductive Rate in 20 Cod Populations



Effects of Temperature on Max. Reproductive Rate in 20 Cod Pops.

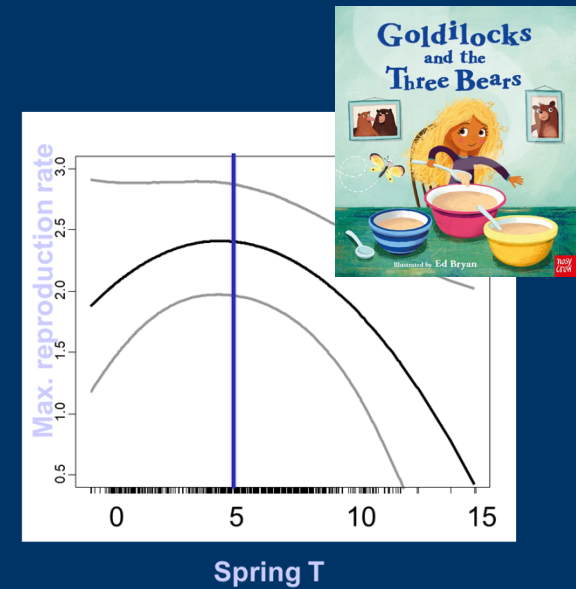


Temperature Effect on Cod Population Growth Rate

-highest rate at "medium" temperatures

-if T is too warm or too cold, then the rate decreases

→ "Goldilocks" response –
not too warm, not too cold is best for cod.



Temperature Responses in Different Populations of Same Species

Is cod the only species that reacts in the "Goldilocks" way?

Let's check with another species:

-sprat (herring relative)

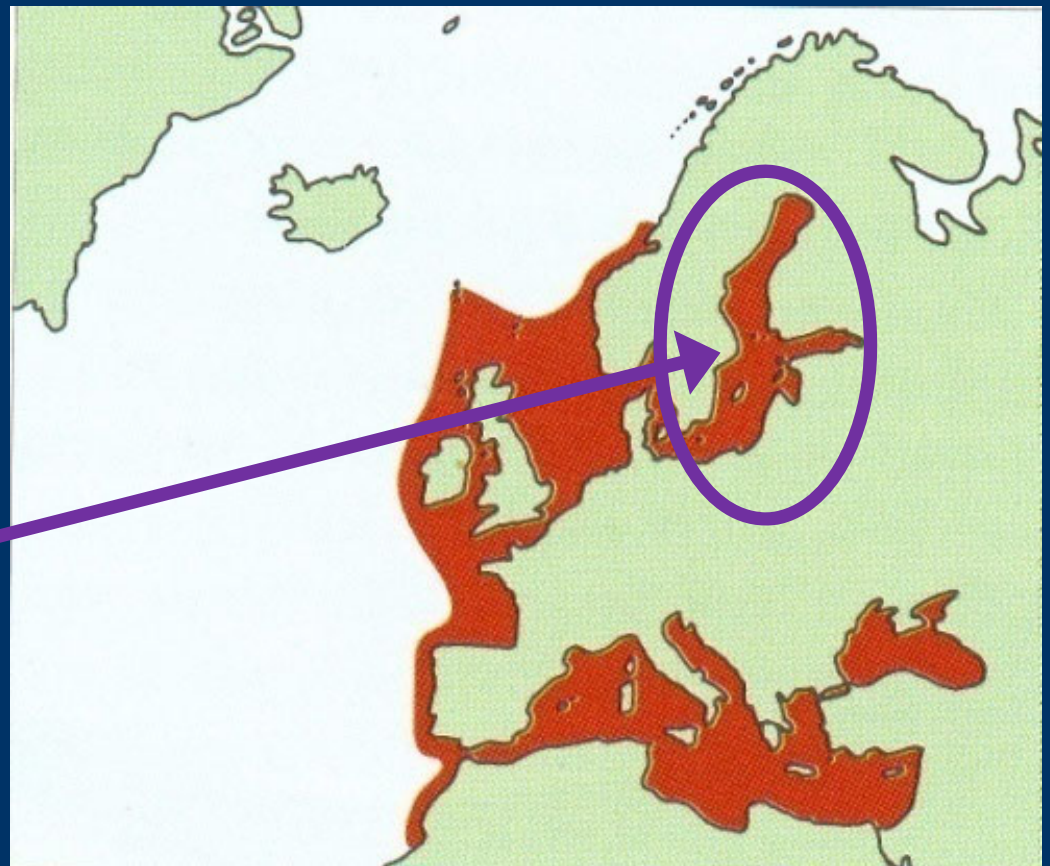


Sprat Distribution Range



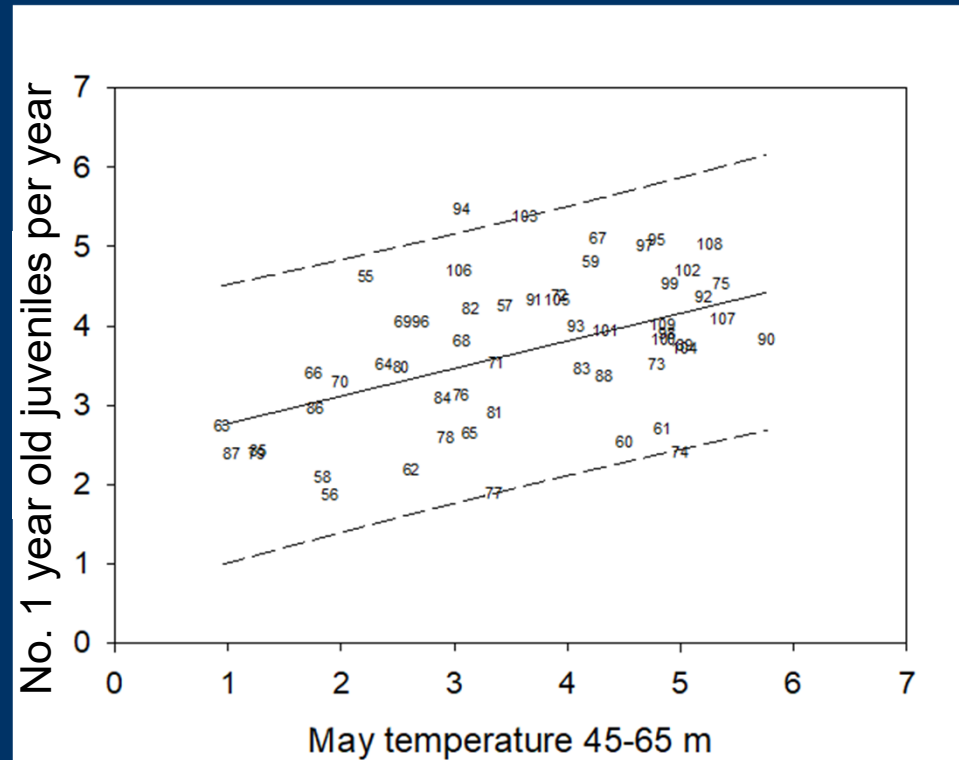
Here is where sprat lives...

Start with Baltic Sea



Muus & Nielsen 1999

Effect of Temperature on Sprat Reproduction Rate in Baltic Sea 1960-2009



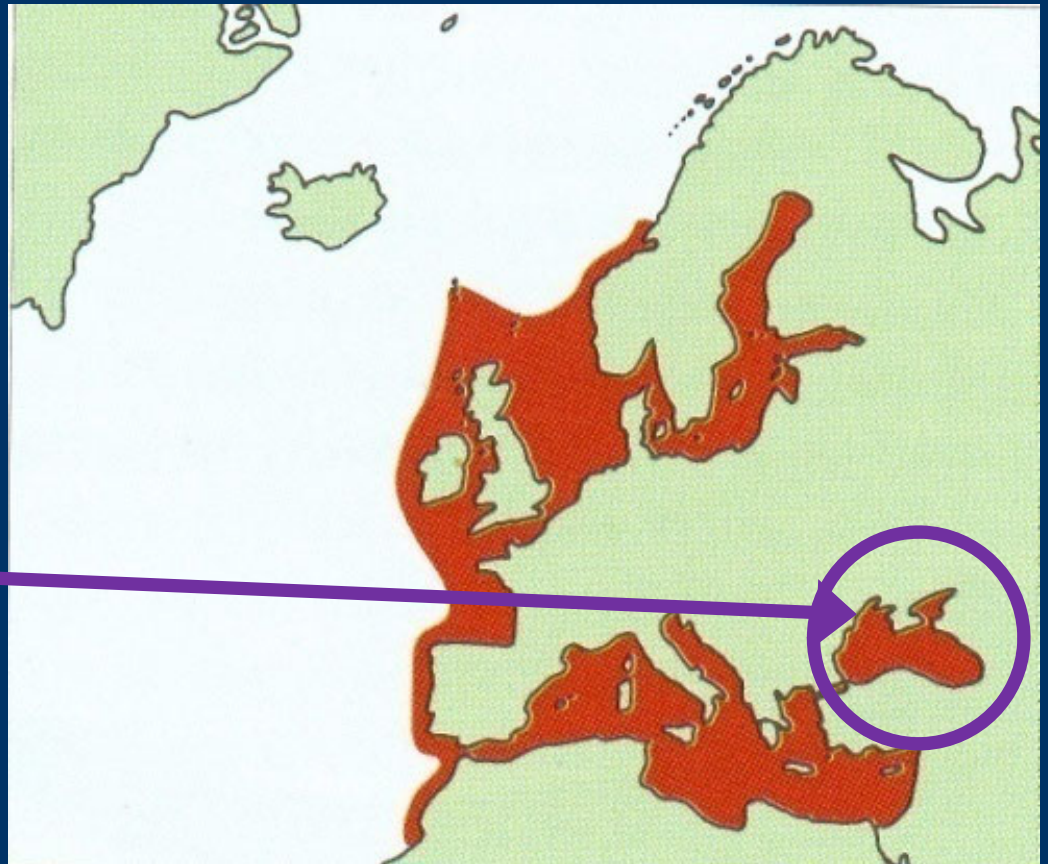
-sprat eggs and juveniles survive better in warm years

Sprat Distribution Range



Here is where sprat lives...

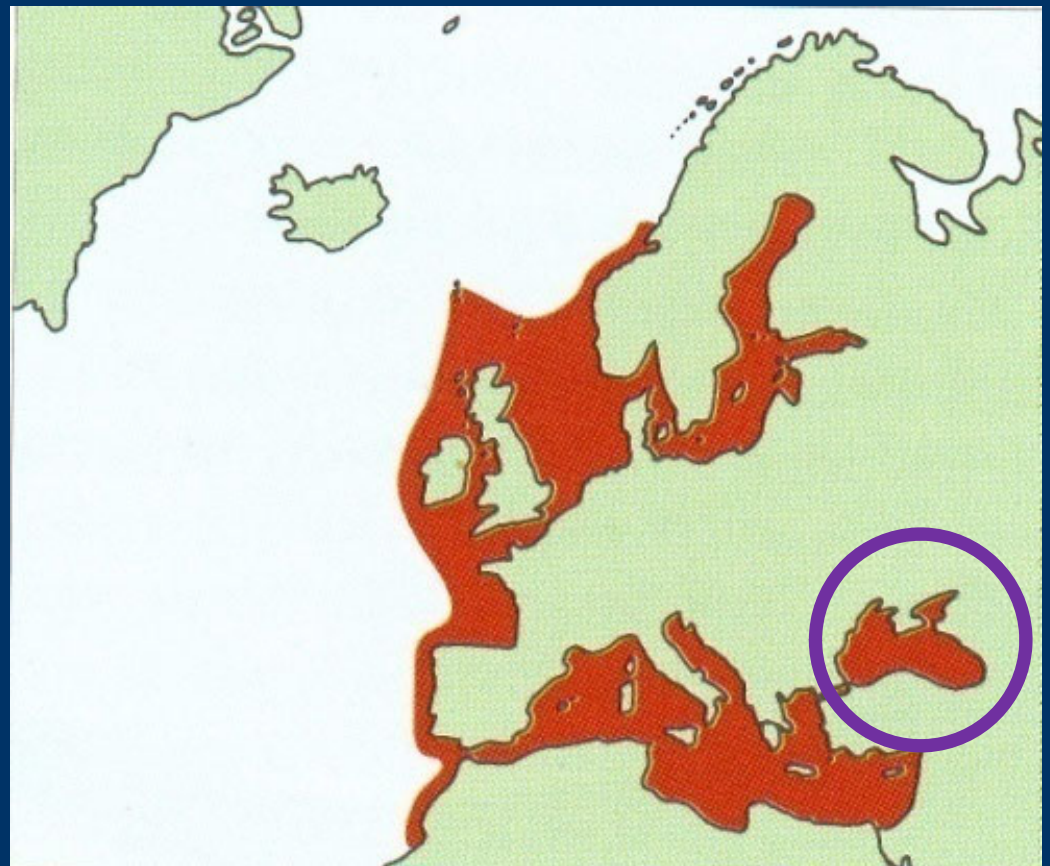
Now test with Black Sea



Sprat Distribution Range

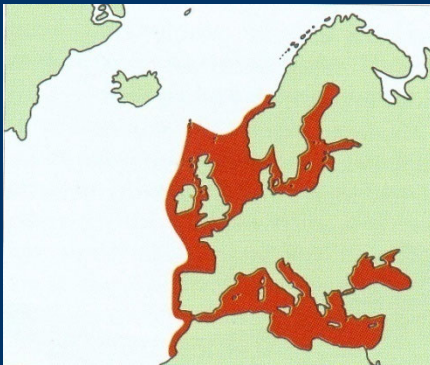
How do you think T affect
reproduction rate
In the Black Sea?

-same way as in Baltic Sea?

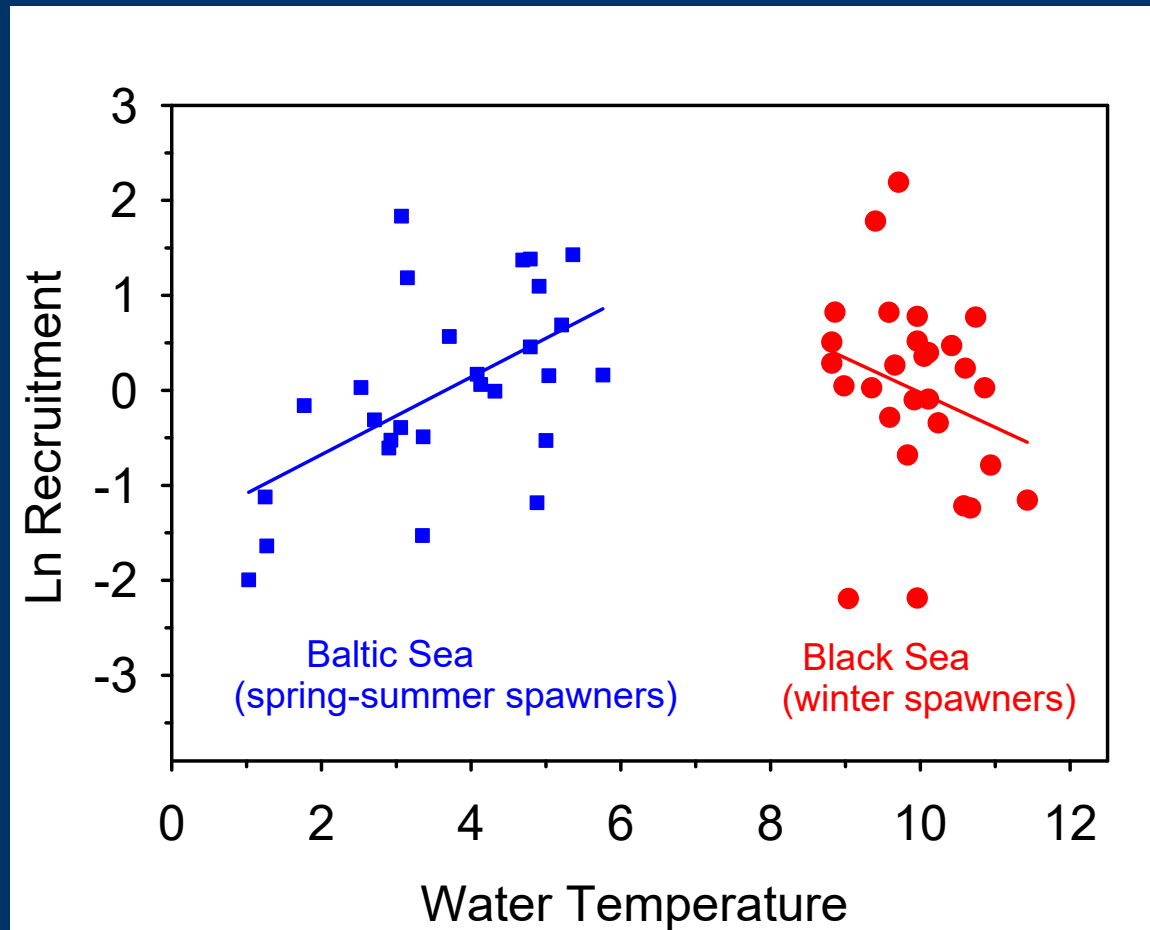


Muus & Nielsen 1999

Temperature-Reproduction Rates for Sprat in Different Regions



Muus & Nielsen 1999



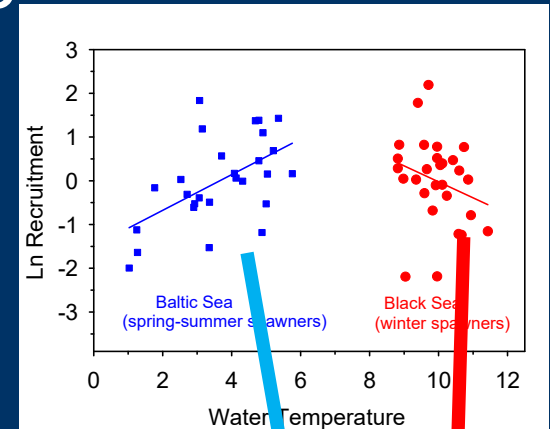
Temperature-Reproduction Relationships for Sprat in Different Regions

Responses differ between regions:

Rate increases when T increases in colder (northern) area.
-cold years are bad for reproduction

Rate decreases when T increases in warmer (southern) area
-warm years are bad for reproduction

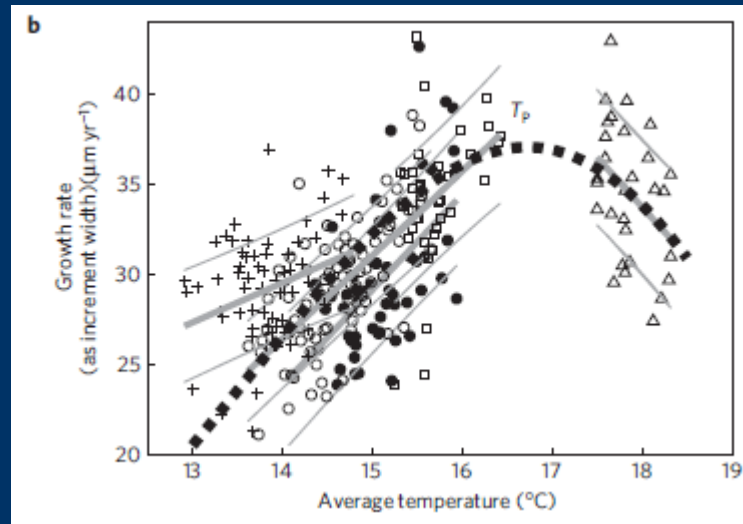
Highest rate in "medium" temperatures
→ Goldilocks effect again!



Muus & Nielsen 1999

Effects of Temperature on **Growth** Differ Throughout Species Range

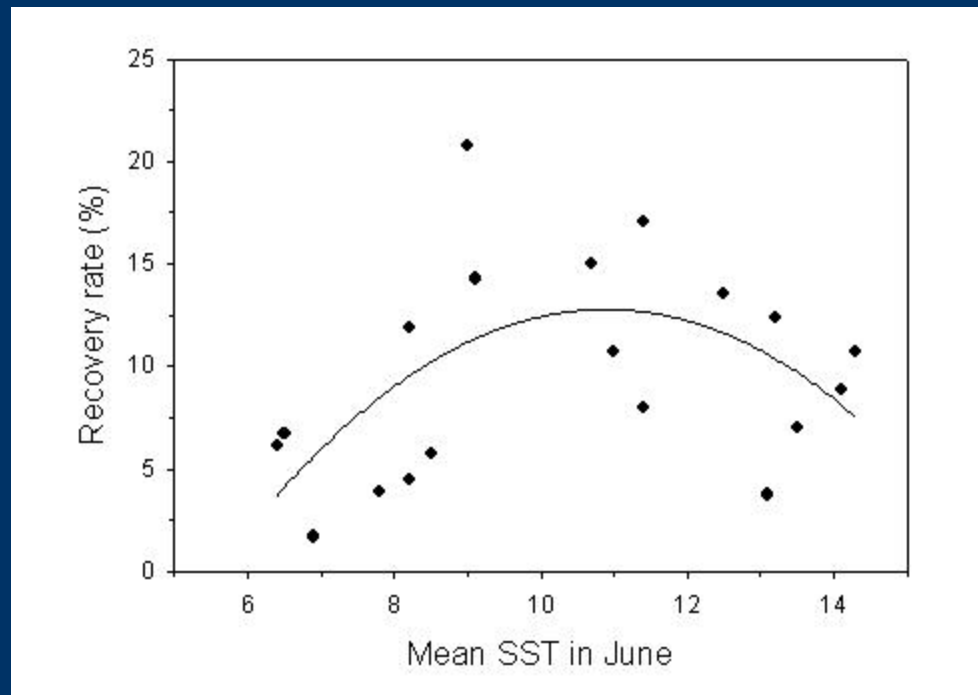
Banded morwong
Or red moki
(Australia;
New Zealand)



-highest growth rates at intermediate temperatures

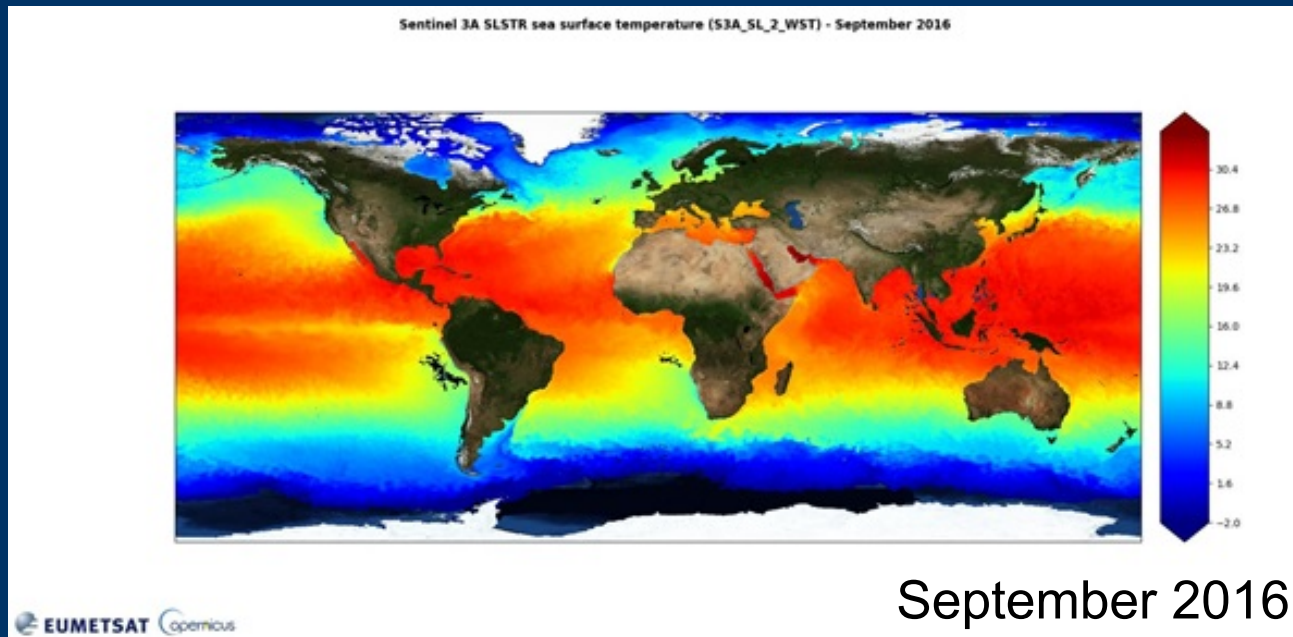
Neuheimer et al. 2011
Nat. Cl. Ch.

Survival of Baltic Salmon and Temperature



- highest survival at intermediate temperatures (1972-1999)
- lower survival in future, warmer Baltic?

Spatial Differences in Ocean Temperature



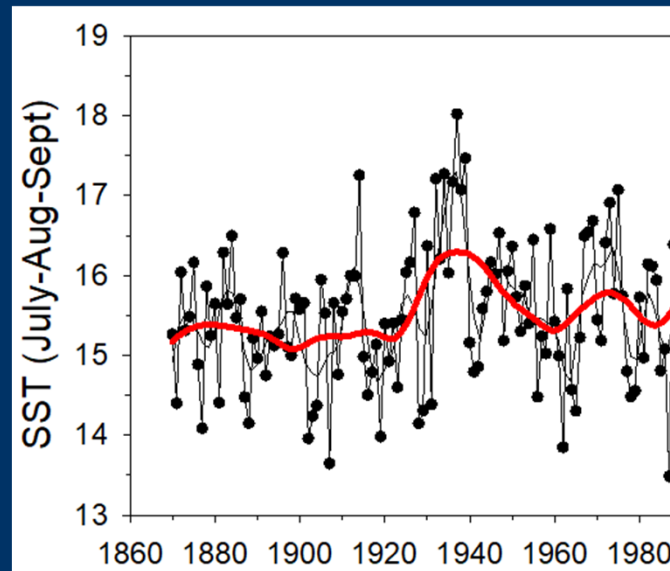
-snapshot in time

-how is it changing from year to year?

Source: SST data from Copernicus

Temperatures Since 1880-1990

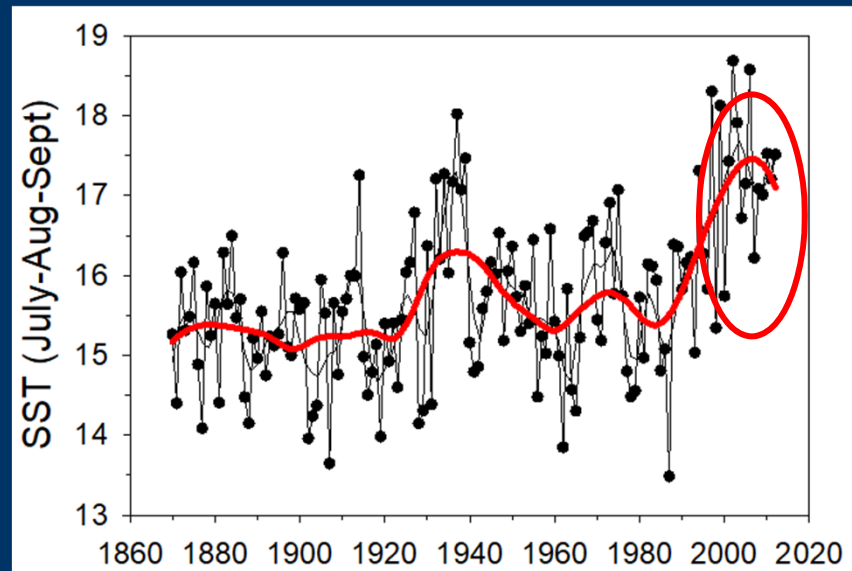
Summer Sea Surface Temp. 1880-1990



-temperatures relatively stable but no overall trend

Temperatures Have Increased Since ca. 1990

Summer Sea Surface Temp. 1880-2012



-temperatures during 1990s-2000s are warmest since
measurements began in 1860s-1880s

Fish Communities Near Denmark

Boreal-temperate



Common species:

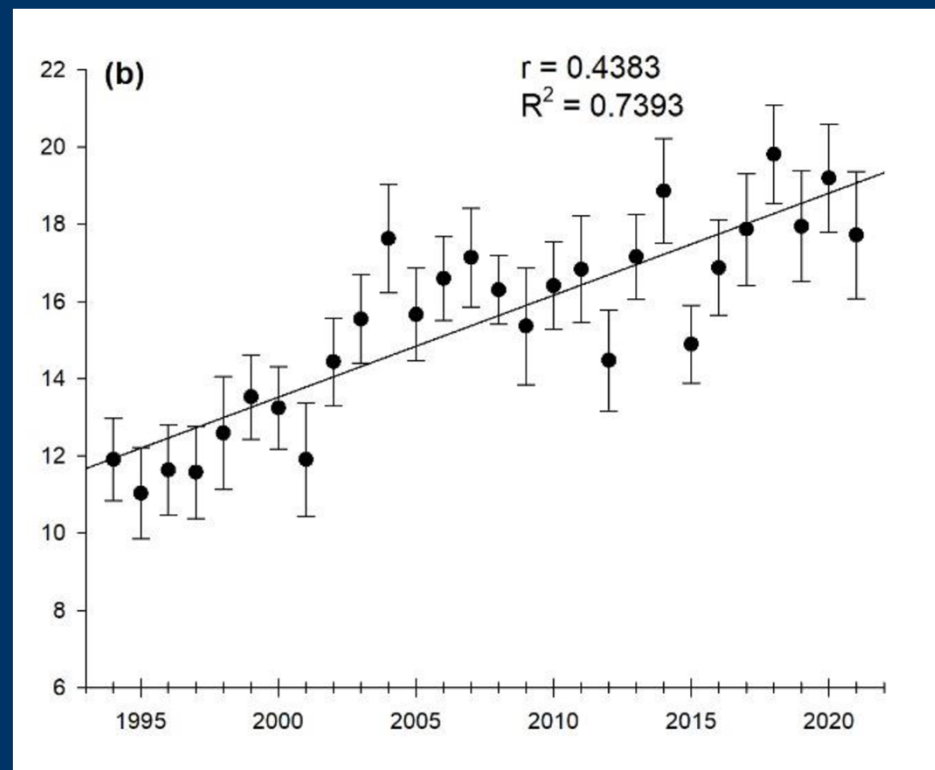
-cod, mackerel, plaice, herring, sprat

20th Cent.

How Are Danish Fish Communities Reacting to Warmer Temperatures?

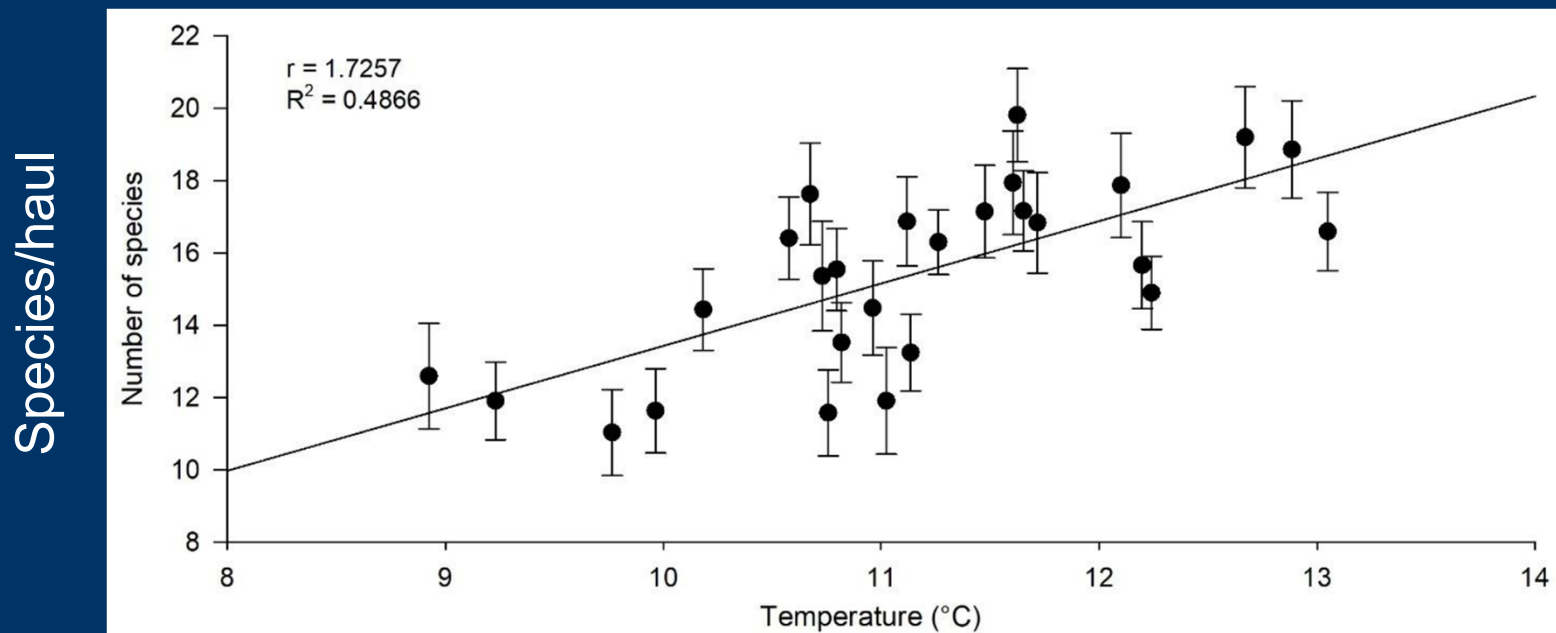
Temporal Trends in Number of Species in Kattegat-Belt Sea 1994-2020

No. Species/haul \pm 2 Se



→ ca. 50% increase in no. of species (richness)

Number of Species is Higher in Warmer Years in Kattegat



-richness is higher in warmer years

Fish Communities Near Denmark Are Shifting to Warmer-Adapted Species

Boreal-temperate

Temperate-Lusitanian



20th Cent.

Late 21st Cent.?

Oceans and Lakes



Both can be beautiful.

What is the difference...from a fish perspective?

Salt!

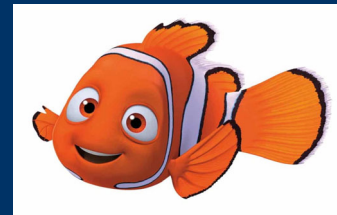


Ocean water is ca. 3.5% salt – i. e., 3.5 g salt / 100 g water or 35 g/litre.

(...and many other differences)

Salt Concentration Affects Where Different Species Live

-some live in salty water (oceans) – Nemo!



-some live in fresh water (lakes) - goldfish



-but some species are a bit more complicated....

Salt Concentration Affects Where Different Species Live

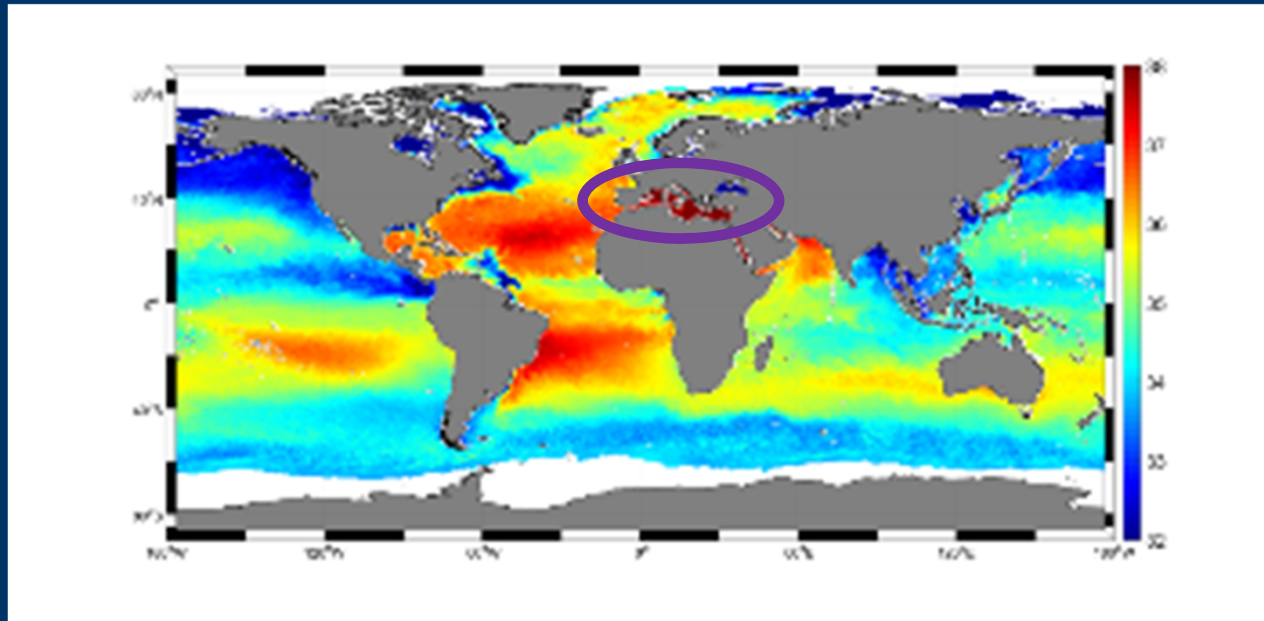
-some live in a mixture of salty and fresh water (*estuaries*) – herring

-some have populations that live in *salt* water and other populations that live in estuaries (salt-fresh mixture) – cod, herring

-some have populations that live in *fresh* water and other populations that live in estuaries (salt-fresh mixture) – trout, pikeperch

-some live in salt *and* freshwater, but at different times of their lives
- salmon, eels (migrate between salt and freshwater)

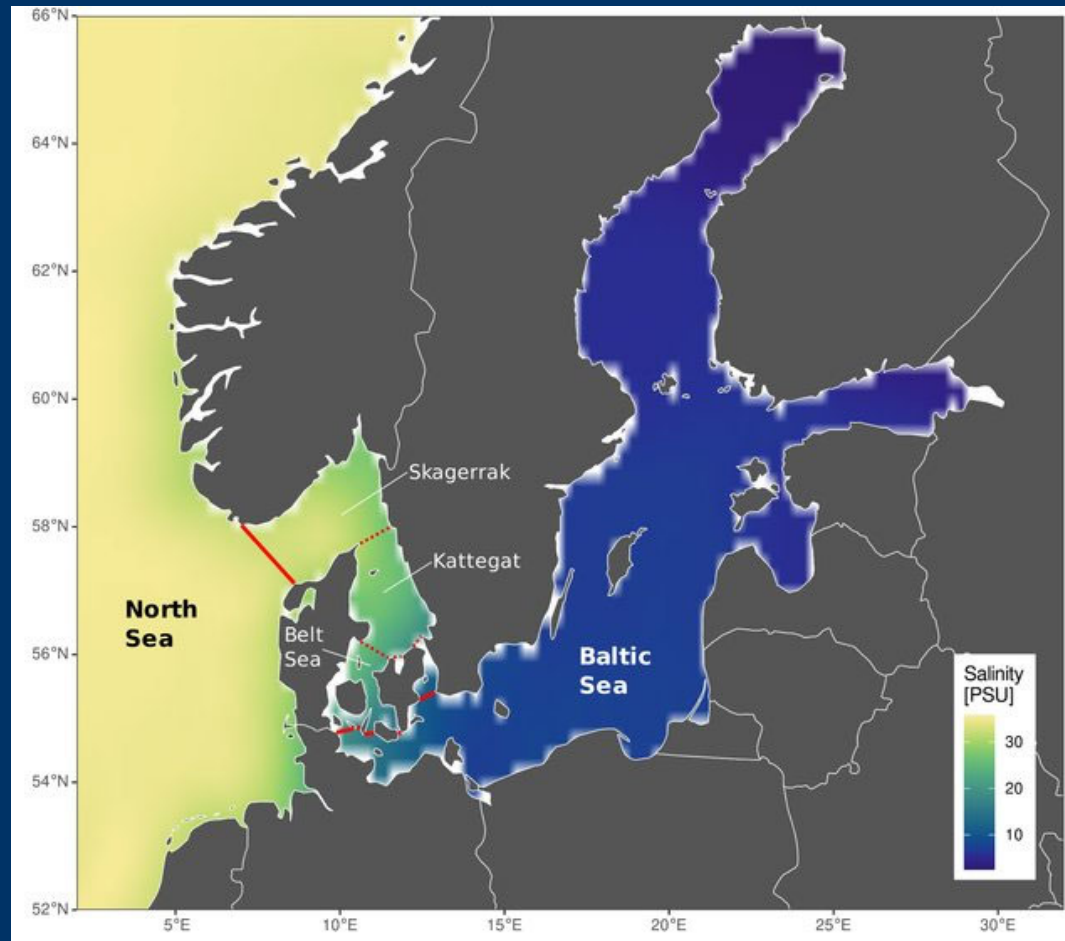
Spatial Differences in Salt Concentration (Salinity)



Mediterranean much saltier than other parts of the world's ocean.
Why??

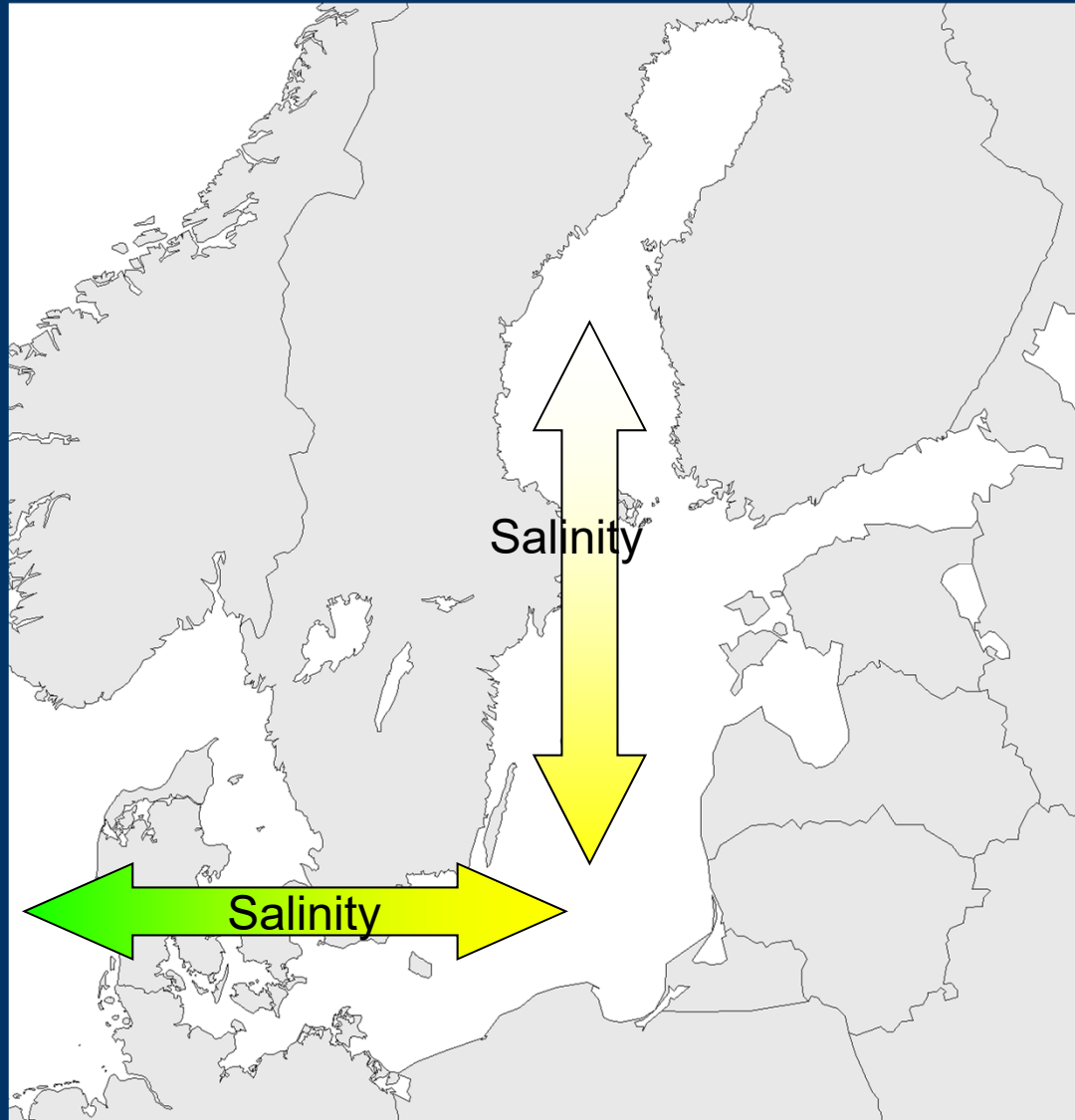
Warm, dry weather causes water to evaporate, leaving salt behind.

Salinity in North Sea-Baltic Sea Region



-Baltic Sea has much *lower* salt concentration than North Sea.

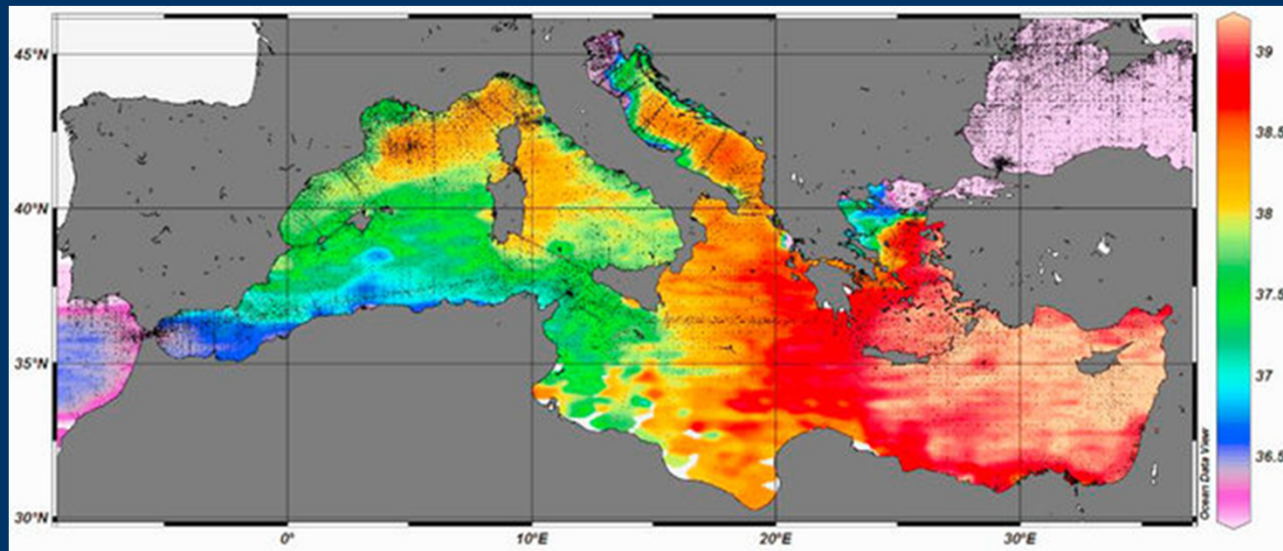
Baltic Sea Salinity Gradient (7-32 PSU) Affects Species Distributions



-relatively few species due to physiological stress

-salinity restricts reproduction by marine species (e. g., cod, sole) and FW species (e. g., perch, pikeperch)

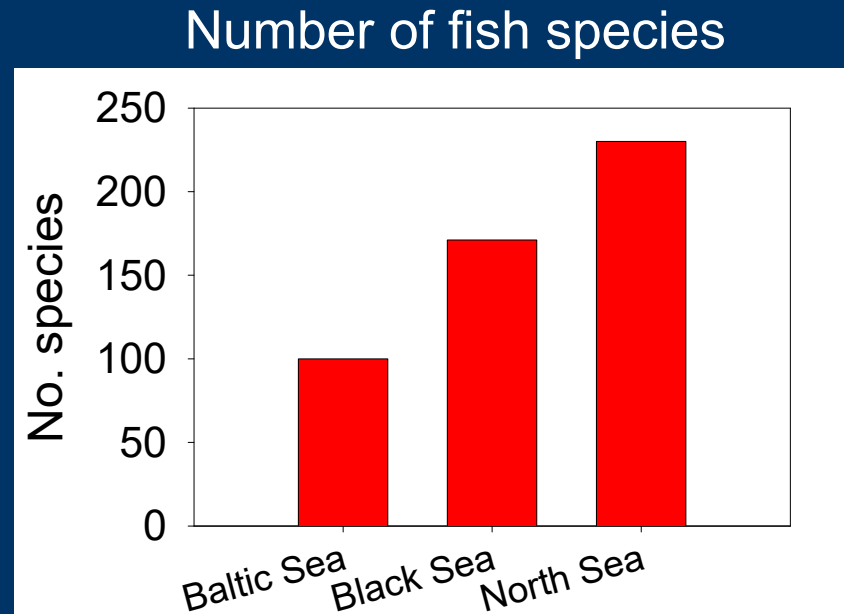
Mediterranean-Black Sea Salinity



-large difference in salinity between Med. And Black Sea

Fish Species Richness in Baltic and Black Seas

-both have relatively few species, compared with other regional seas of similar size (e. g., North Sea):



-marine species are stressed physiologically in low salinities
-grow slower, produce fewer offspring, etc.

Factors Affecting Fish Distributions and Ecology

1. Abiotic environmental conditions
 - T, S, O₂, pollutants in fish habitat impose physiological constraints on distributions
2. Biotic factors
 - food supply, predators, competitors
3. Fishing
 - removal of species, size groups, genotypes
 - targeted and bicatch species
4. Dispersal, introductions and transplantations
 - geological age of habitats

Summary: Ocean-Climate Impacts on Fish

Ranges of species are restricted by both T and S.

Temperature has different effects on different populations within a species.

Ecological responses often highest at intermediate temperatures
(Goldilocks effect)

Salinity affects ranges of distributions – marine species become stressed physiologically at low salinities.

Warming temperature: species are moving towards cooler regions (e. g., to the north or deeper) to reduce exposure to stressful (warmer) temperatures.