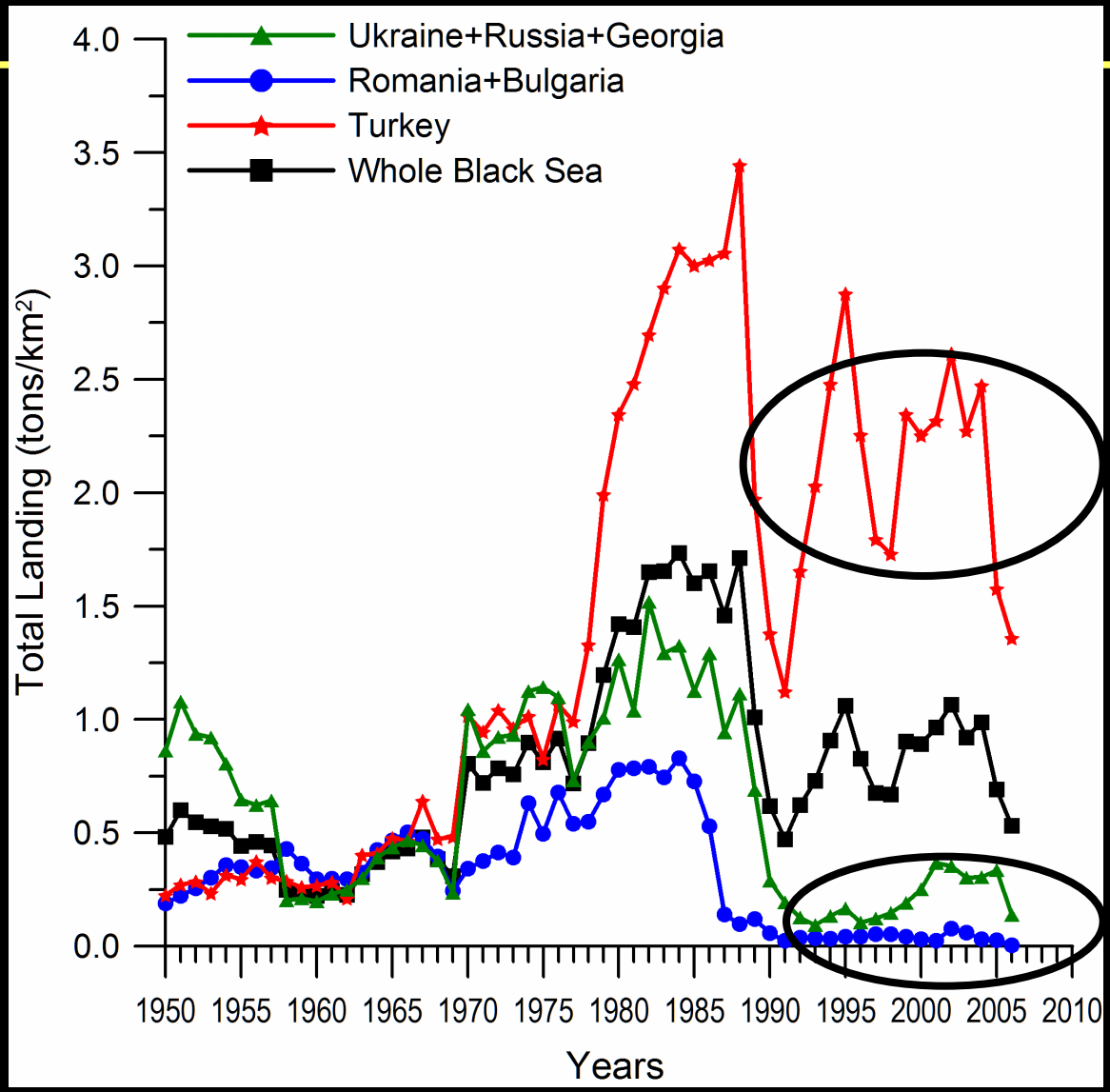
Fueling phytoplankton production by ageostrophic frontal processes in the Black Sea

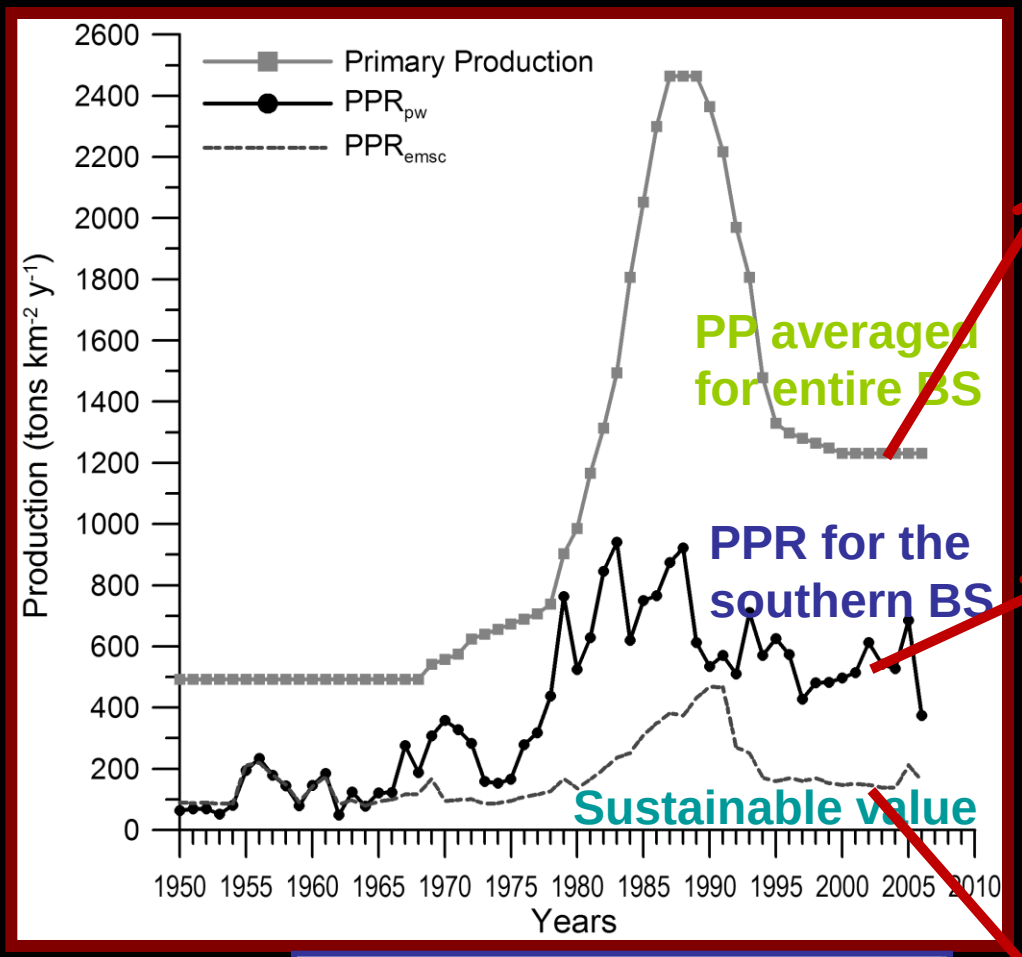
T. Oguz

Institue of Marine Sciences,
METU, Erdemli, Turkey

This study is motivated by
high level of fish catch has ben continuing for decades in the southeastern Black Sea albeit its over-exploitation.

WHY?





After the early 1990s, PP decreased twice, and thus its capability of supporting HTLs reduced considerably over the entire BS.

On the other hand, the PPR is maintained around 75% of its former level of the 1980s in the southern Black Sea.

The sustainable level of PPR is roughly 30-40% of the present catch levels.

Primary Production Required

$$PPR = \sum_{i=1}^{m} \left[Y_i \cdot \left(\frac{1}{TE} \right)^{\pi_i - 1} \right]$$

Ecological cost of the Catch expressed in the units of production

How can the southern BS maintain such a high catch ? when

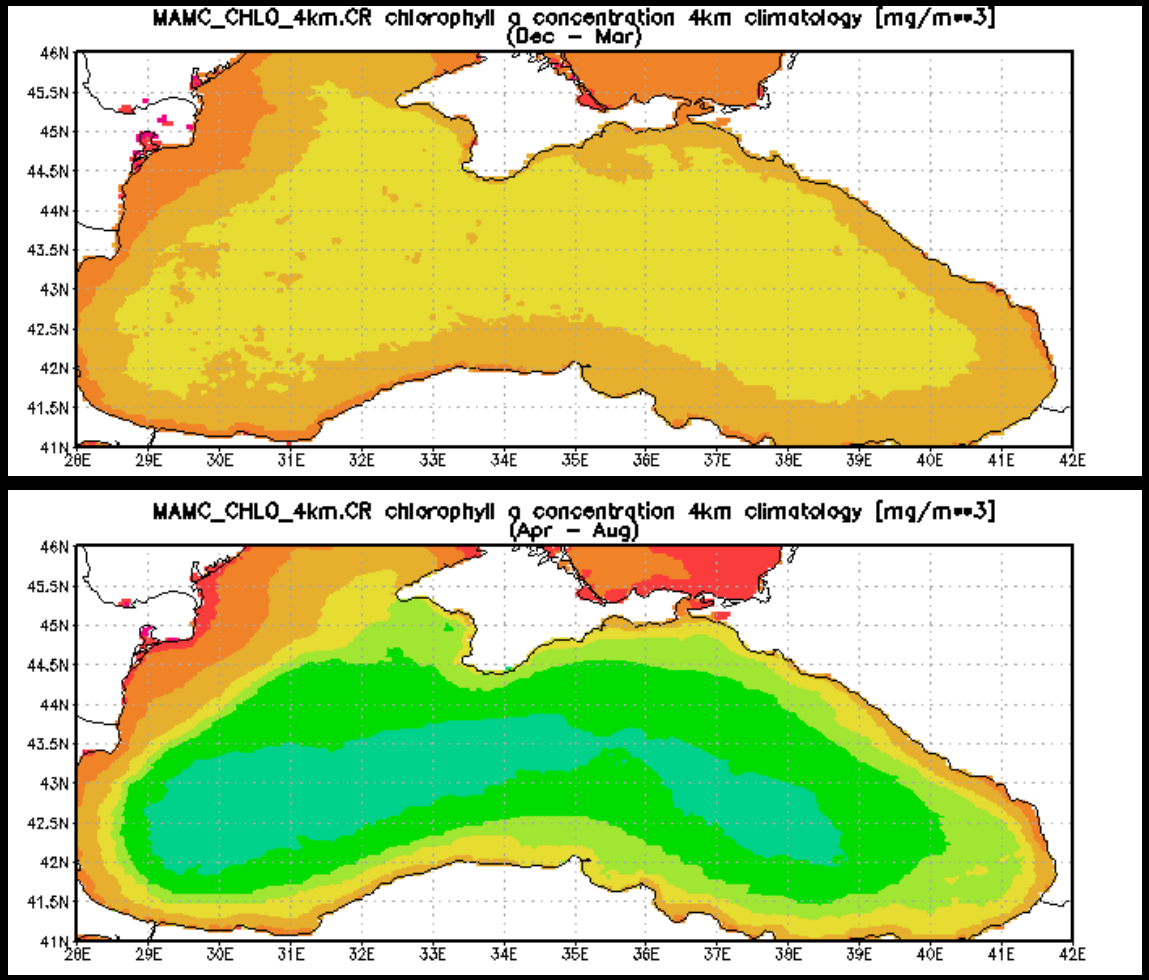
- there is a major reduction in PP over the basin,
- high exploitation rates of the stocks, and
- all the other regions have collapsed fishery ! ! !

One possibility is the fact that

- the southern BS may sustain much higher PP as compared to other regions (except the NWS),
- this energy propogates efficiently into HTLs without much loss to the jelly food web.

Then, the question

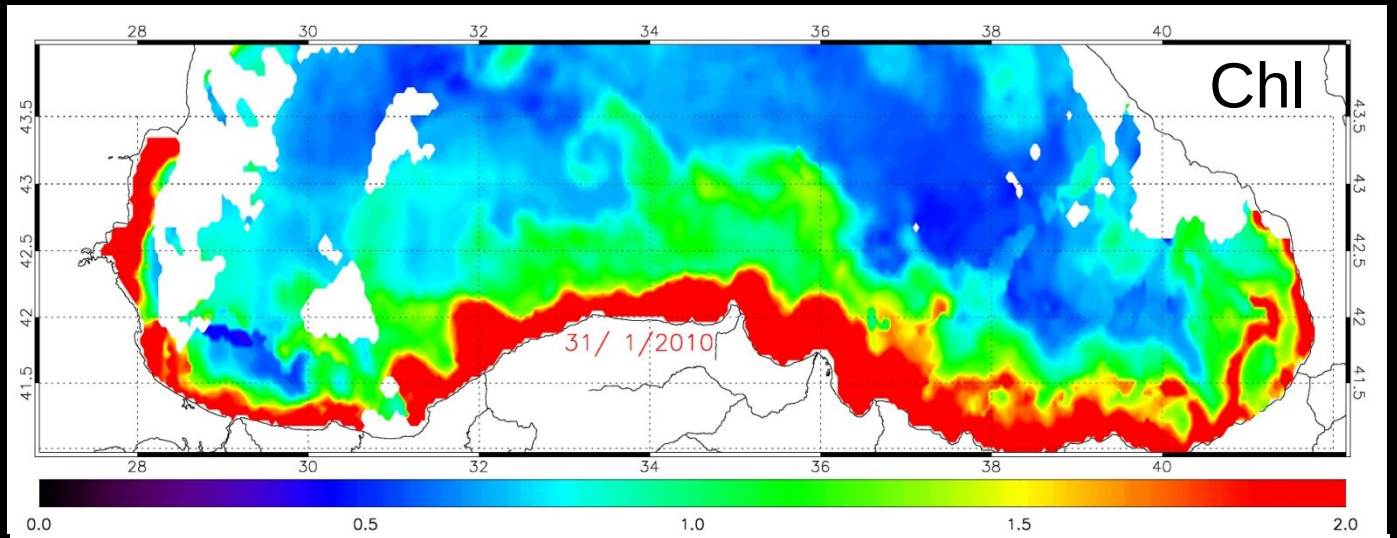
is the southern BS really maintaining high PP ?

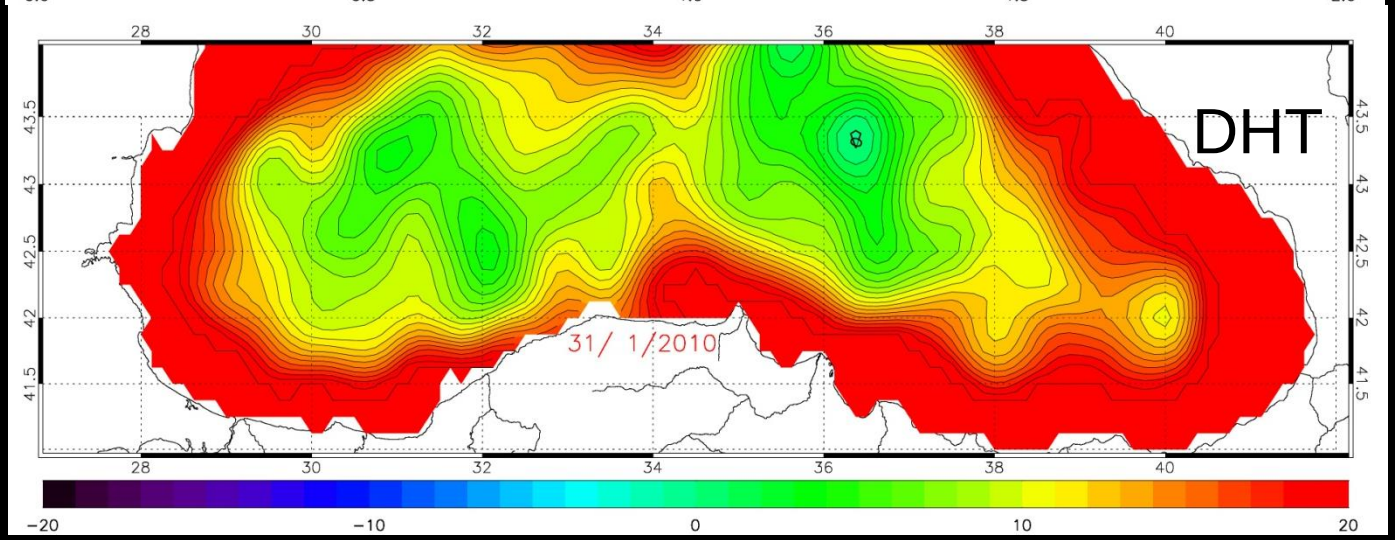


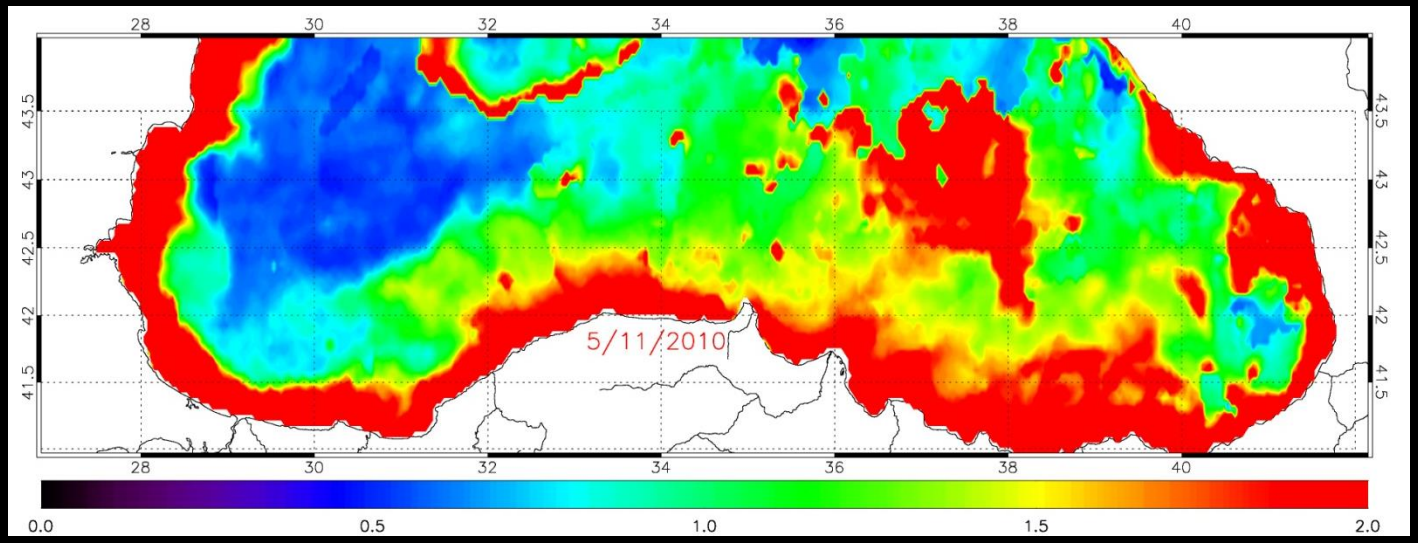
Higher Chl concentrations around the periphery wrto interior basin

The next question:

What mechanisms play role for maintaining high PP in the southern BS ?






28
30
32
34
36
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42
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5/11/2010
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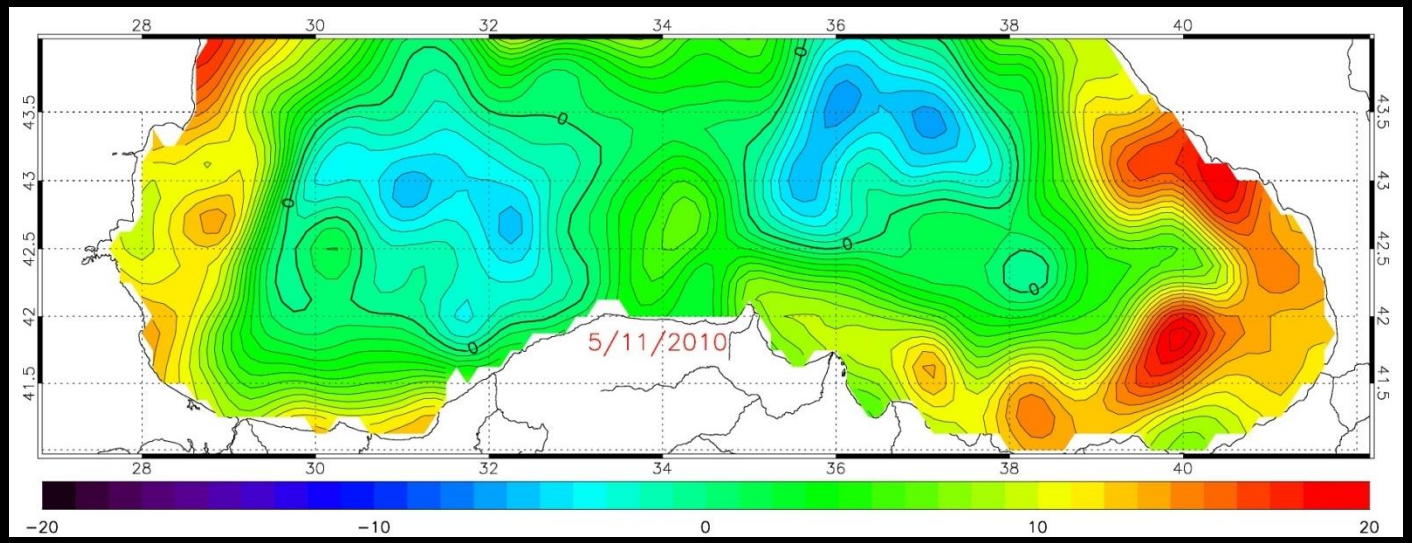
28
30
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40
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42
41.5
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−20
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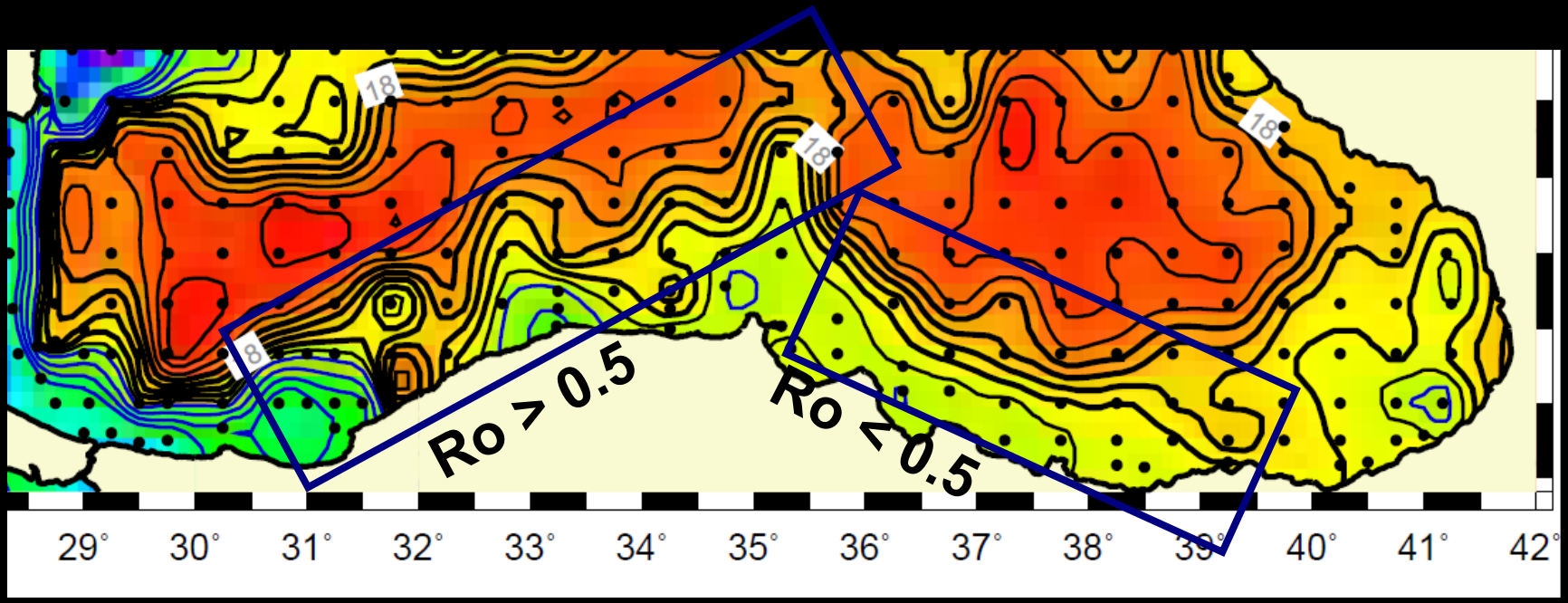
0
10
20

At the first glance, the presence of lower Chl concentrations within the interior basin contradicts with its cyclonic character.
Because, upwelling is expected to supply more nutrients towards surface, whereas the coastal regions with downweling motion depletes nutrients towards deeper levels.

But, this is true for quasi-geostrophic systems i.e. weakly nonlinear systems with Ro ~0.2-0.3 .

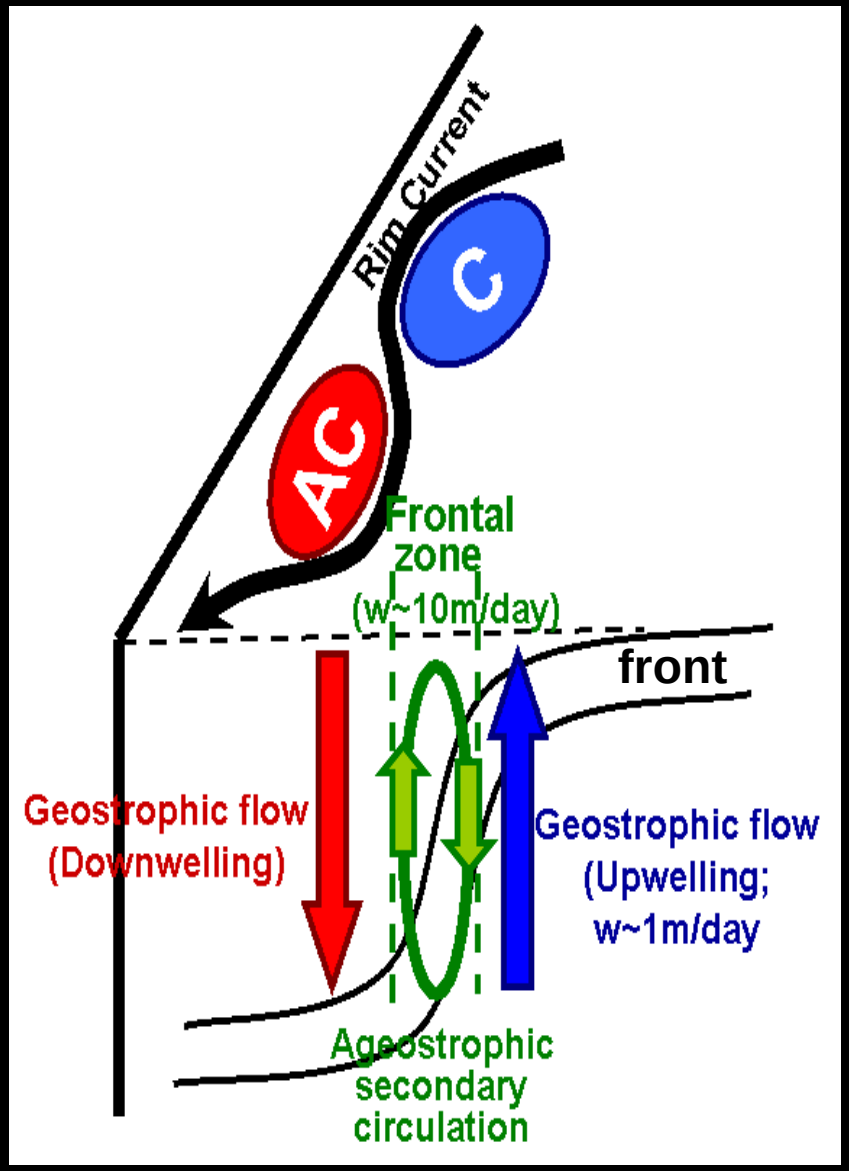
What happens when Ro → 1 ? (Highly nonlinear systems)

Increasing nonlinearity is possible when the rim current frontal structure becomes unstable and meanders intensely.



Increasing nonlinearity locally intensifies the across-front buoyancy gradient that disrupts the thermal wind balance for the along front flow. Consequently ageostrophic cross-frontal circulation develops.

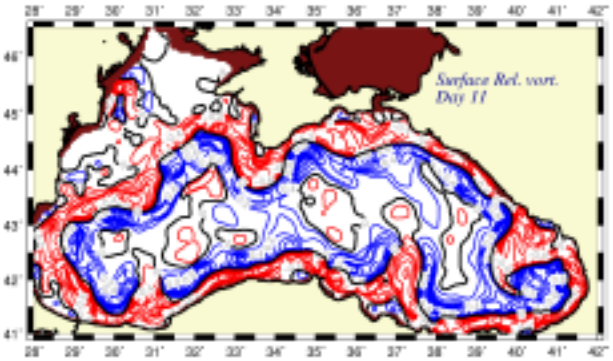
Ageostrophic cross-frontal circulation

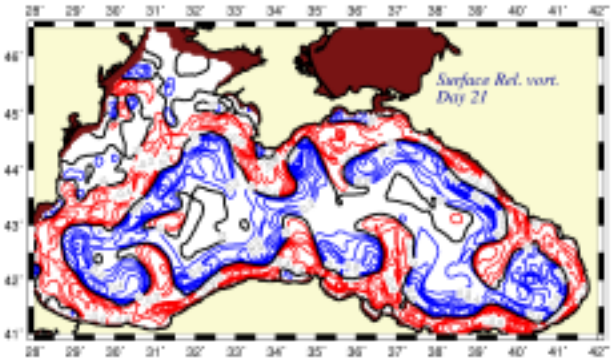


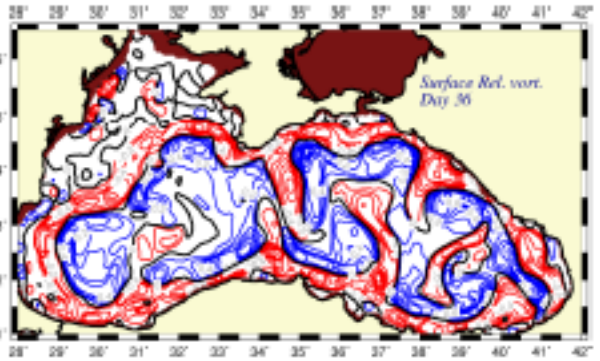
The horizontal secondary flow takes places from light side of the front to its dense side at the surface and the return flow at deeper levels.

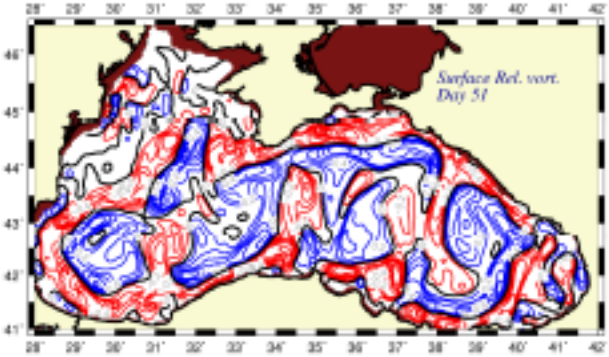
They are accompanied with a strong upward motion on less dense anticyclonic side of the front and an equally strong downward motion (i.e. subduction) on more dense cyclonic side.

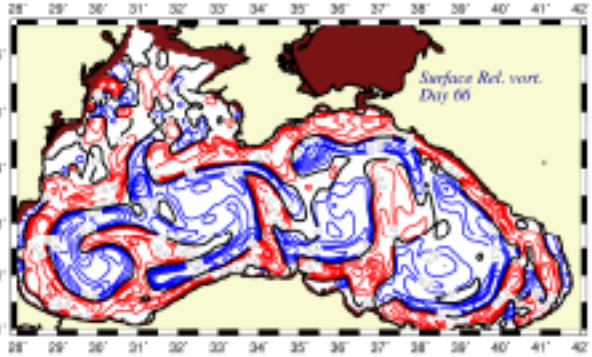
The vertical motion exceeds 10 m/day (up to 100 m/day) as compared to the values around 1 m/day of the quasi-geostrophic motion.

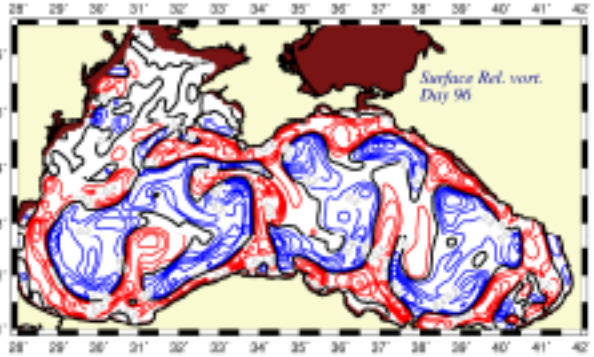

Surface Rel. vort.
Day 11

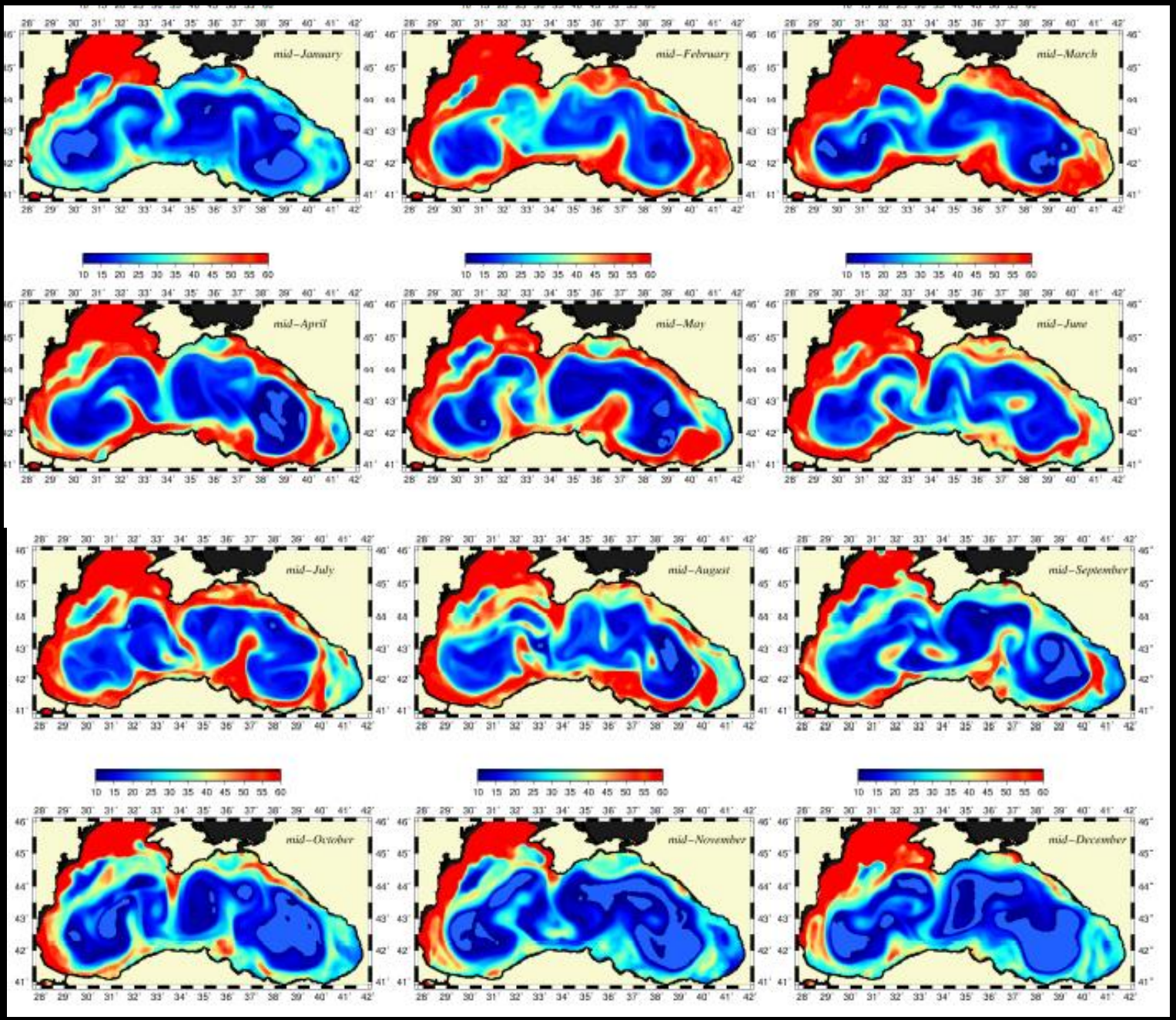

Surface Rel. vort.
Day 21


Surface Rel. vort.
Day 36

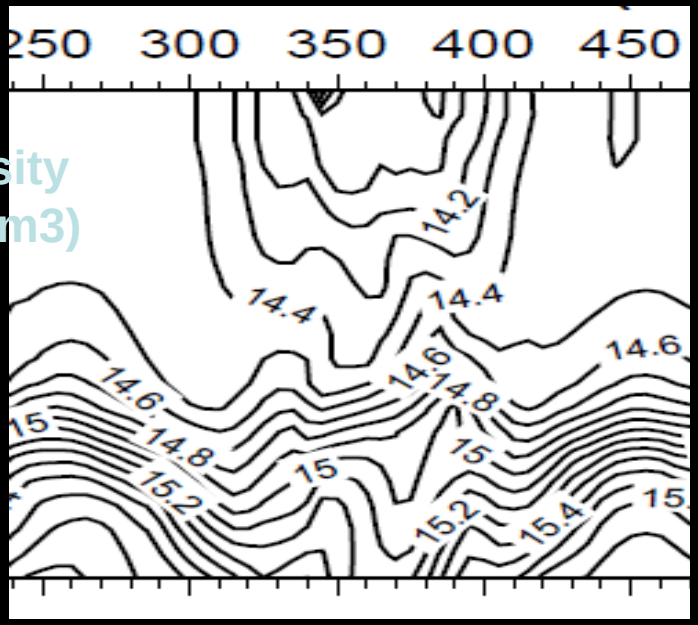

Surface Rel. vort.
Day 51

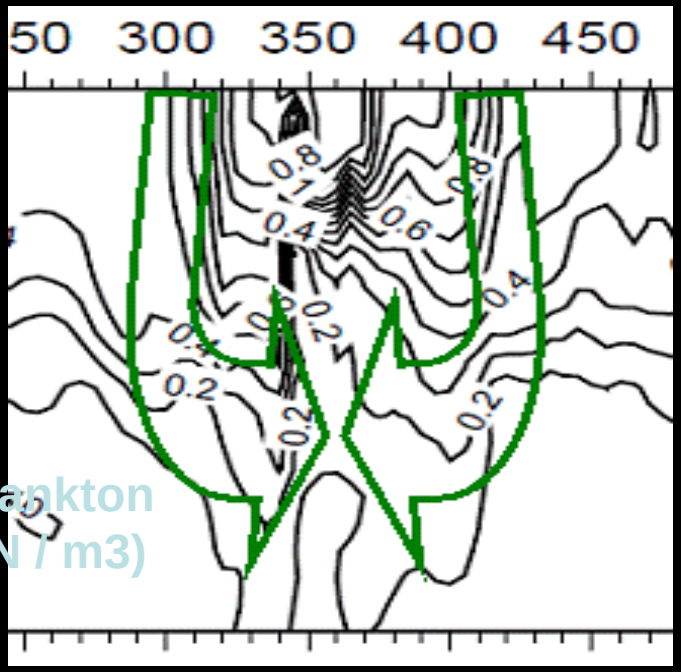

Surface Rel. vort.
Day 66


Surface Rel. vort.
Day 96


mid–January
mid–February
mid–March
mid–April
mid–May
mid–June
mid–July
mid–August
mid–September
mid–October
mid–November
mid–December
10 15 20 25 30 35 40 45 50 55 60

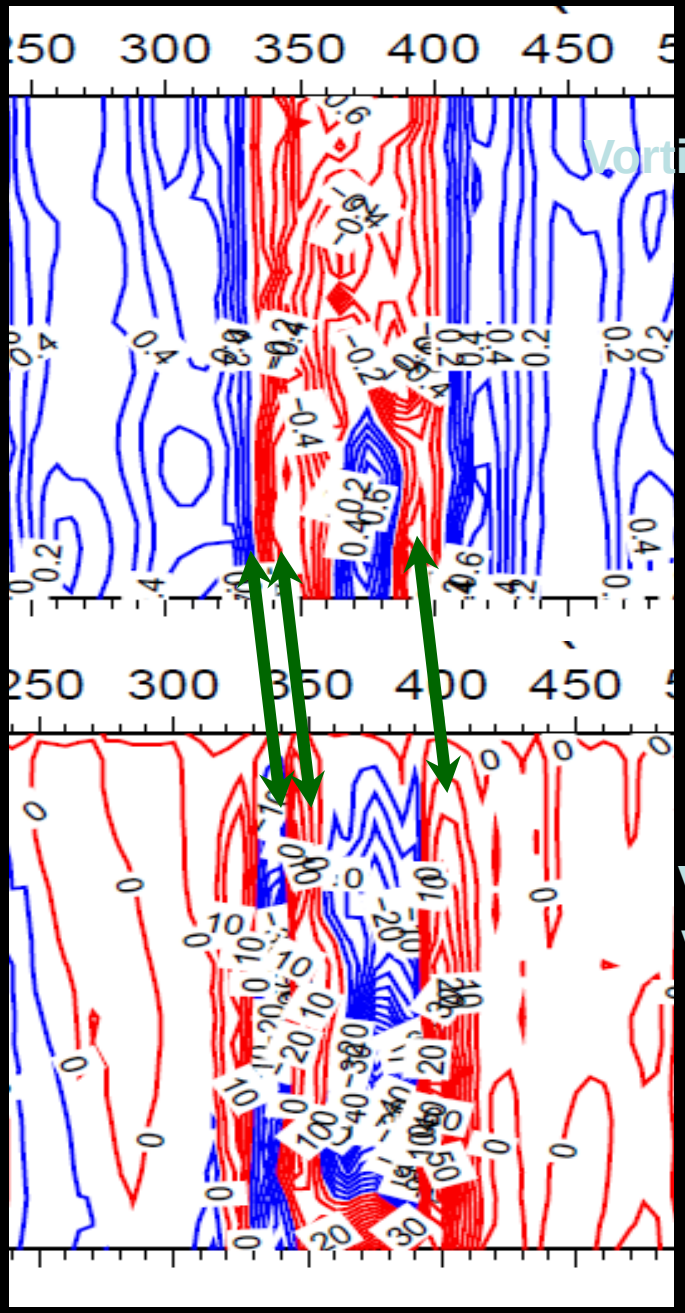
Density
(kg / m3)





Phytoplankton
(mmol N / m3)

Vorticity



Vertical
velocity
(m/day

What is next?

Introduce one more equation to the model for incorporating the interactions with small pelagic fish stocks

Thank you for listening