Jun 19th, 4:50 PM - 5:30 PM

Development of the Perception of Changes in Position, Swimming Speed and Sounds in Fish and its Influence on Passage

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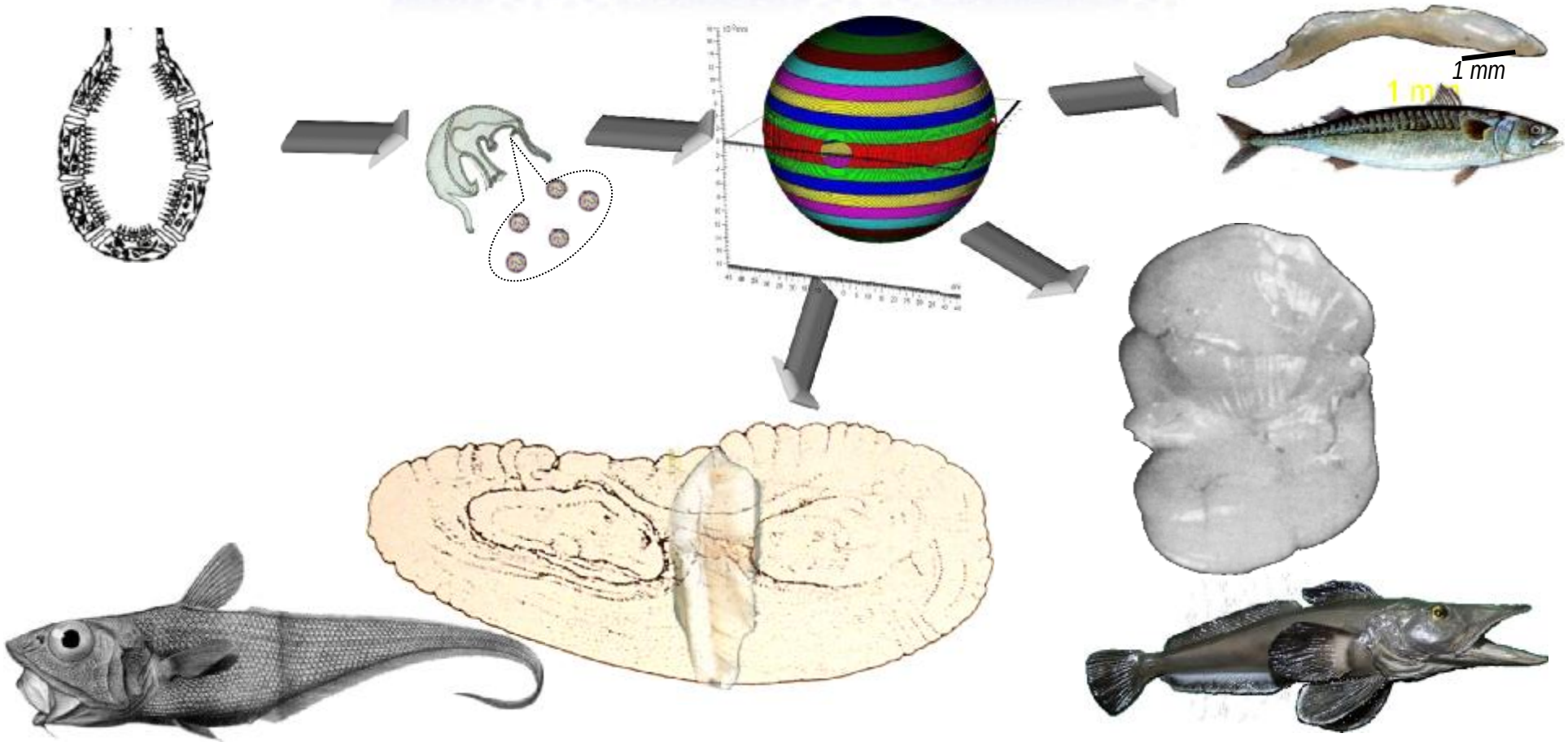
FROM TO

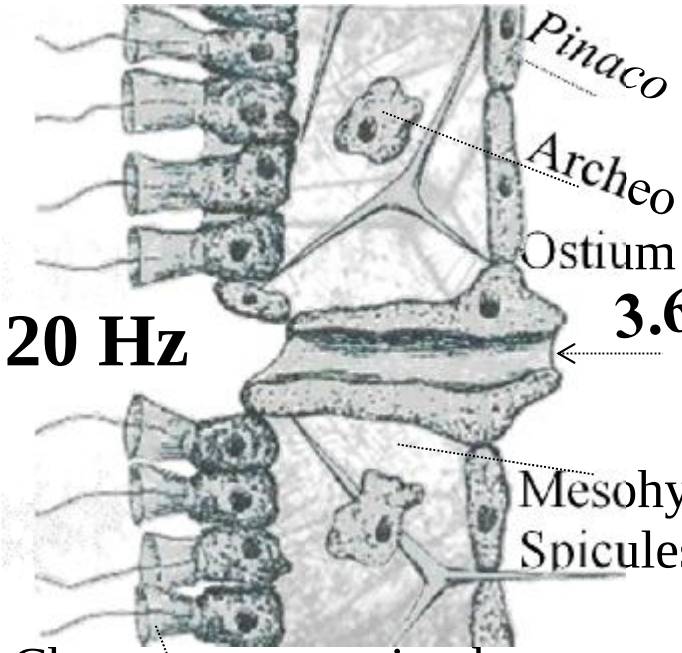
Sesile Body balanced Otolith balanced



The Perception of Changes in Position & oscillation of water transporting informations use even sesile Sponge, & settled polyps of young Scyphozoans from Cnidarians.

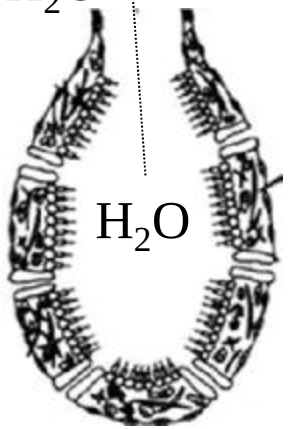
Sesile Sponge

Passage to nervous system

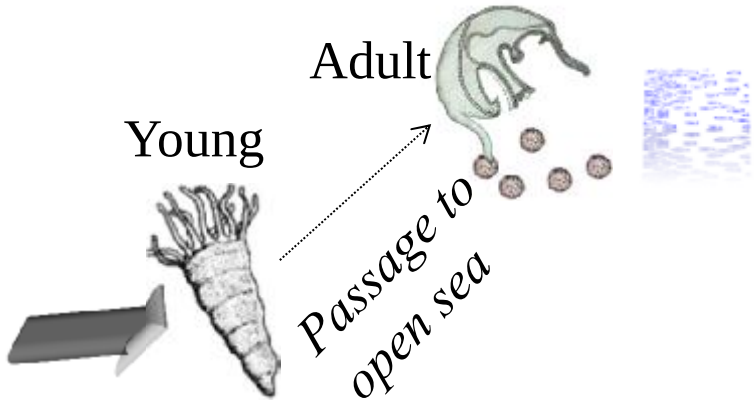


3.6 m ·h^{-1}
H_2O

31 m ·h^{-1}
H_2O



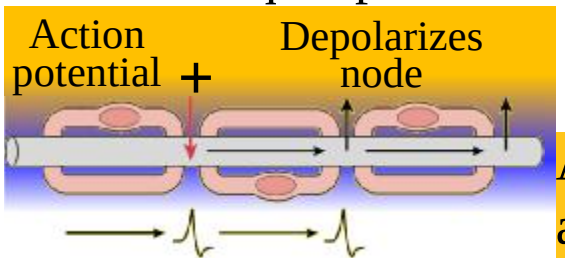
Cnidarians



Scyphozoan
with nervous net

contain spongin fibers arrangeing crystals percept from pressure the change of body position.

Choanocytes waving low pressure pulls food with inflow of water, but wasting out is 10 faster. Unequal pressure is controled by like nerve action propagates on cell membrane electrical signals, rise $[Ca^{+2}]_i$ stop flagellum (Hexactinellids). Flagellum start beat if $[Ca^{+2}]_i$ is pumped out of the choanocyte.

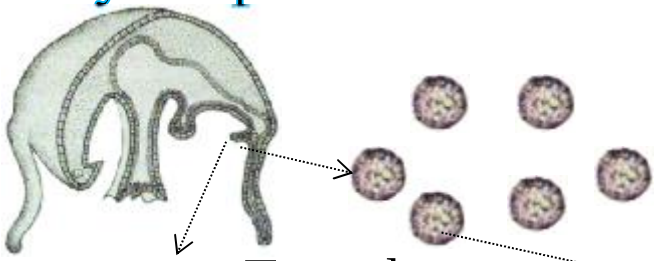


At depolarization, voltage $^+$ sink the hill of axon & depolarize adjacent region that propagates along as acoustic wave.

Medusa

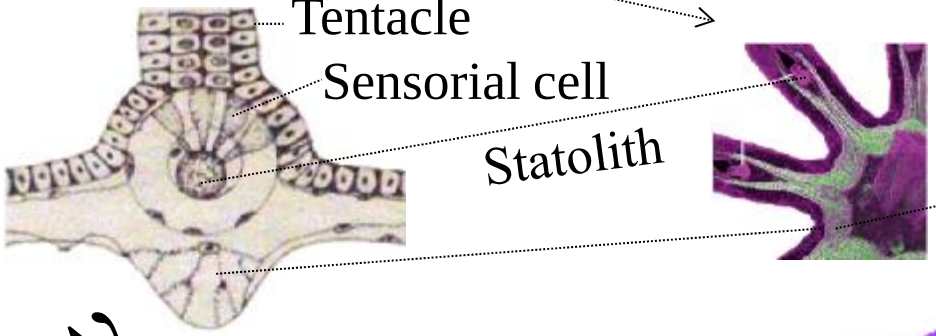
High efficiency using low pressure, the changes work on body shape & statolith localizations – passage to pelagic

Body shape balanced



Radiant symmetry hold balance
Spherical statocysts at edge manage every side

Statocyst



Ring of neural net thickens at statocysts

Swimming strategy

Hydrodynamic resistance, $R_{a,h}$

Push body to low R (spherical side)

Stop & jump at great R (concave)

Speed of swimming

2 - 19 $cm \cdot s^{-1}$ = 0.004 – 0.07 $km \cdot h^{-1}$, generate 1 – 0.5 Hz

Ctenophora

To high deep

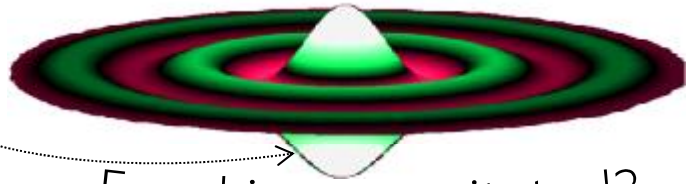
Body shape: biradial

balanced

3× faster due to smaller resistance from elongation.

1 statolite hold perception on all around.

Combs beat generate waves

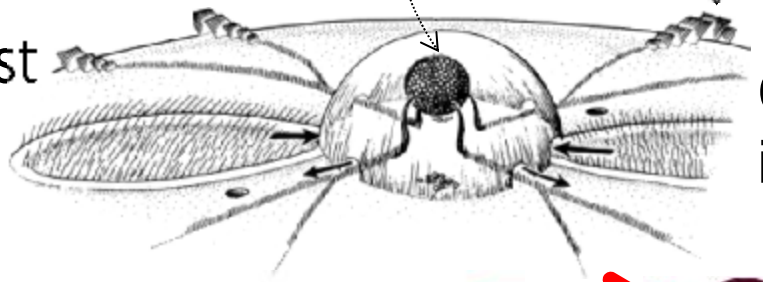


Food is regurgitated?

Passage for food digestion

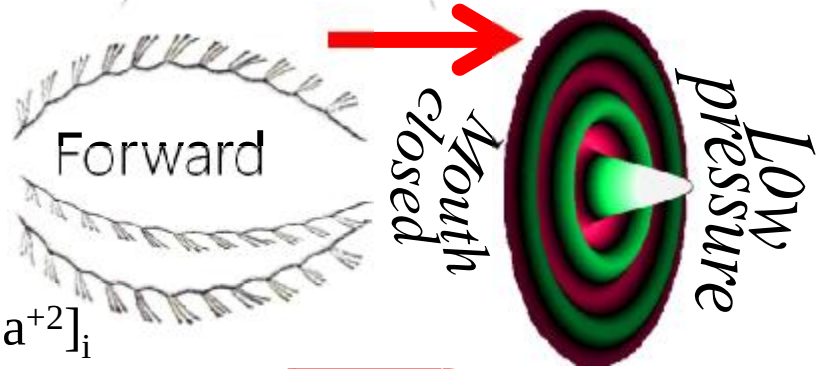
Statocyst

1



Centralizes all: nerve ring, swimming, information, feeding & waist

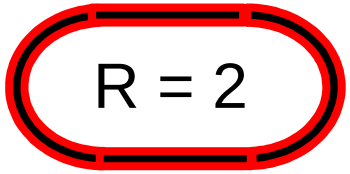
New swimming strategy

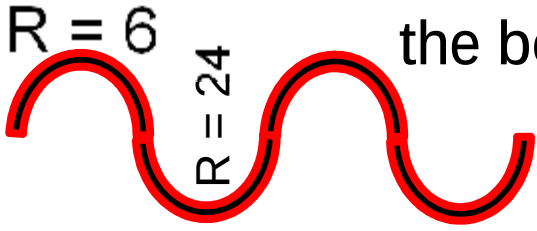


backward $[Ca^{+2}]_i$

Cestida, waving of the body.

Hydrodynamic resistance, $R_{a,h}$



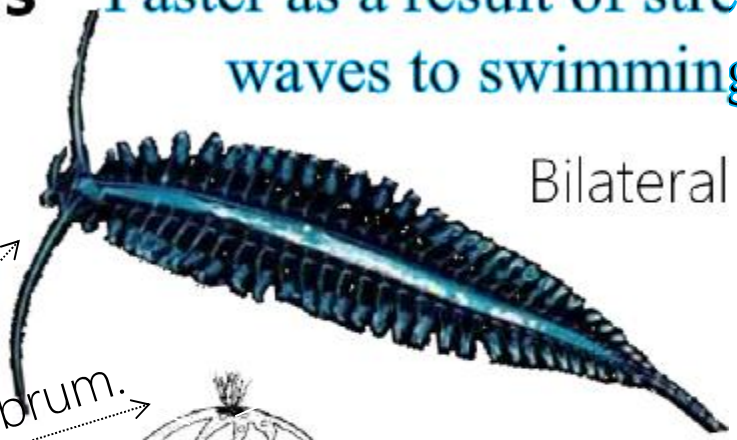


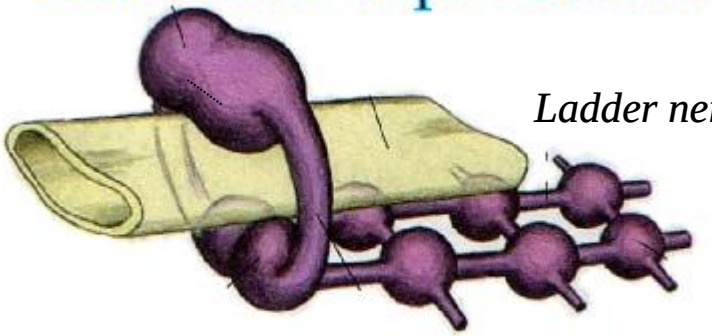
Speed of swimming 0.009 $km \cdot h^{-1}$; 3- 5 Hz

Annelids

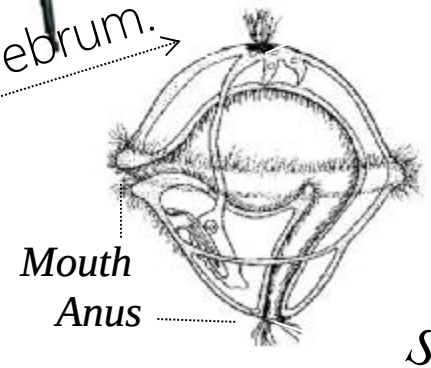
Faster as a result of streamlined shape & use transverse waves to swimming. Wider interpretations through hind- mid- & part forebrain.

Body shape

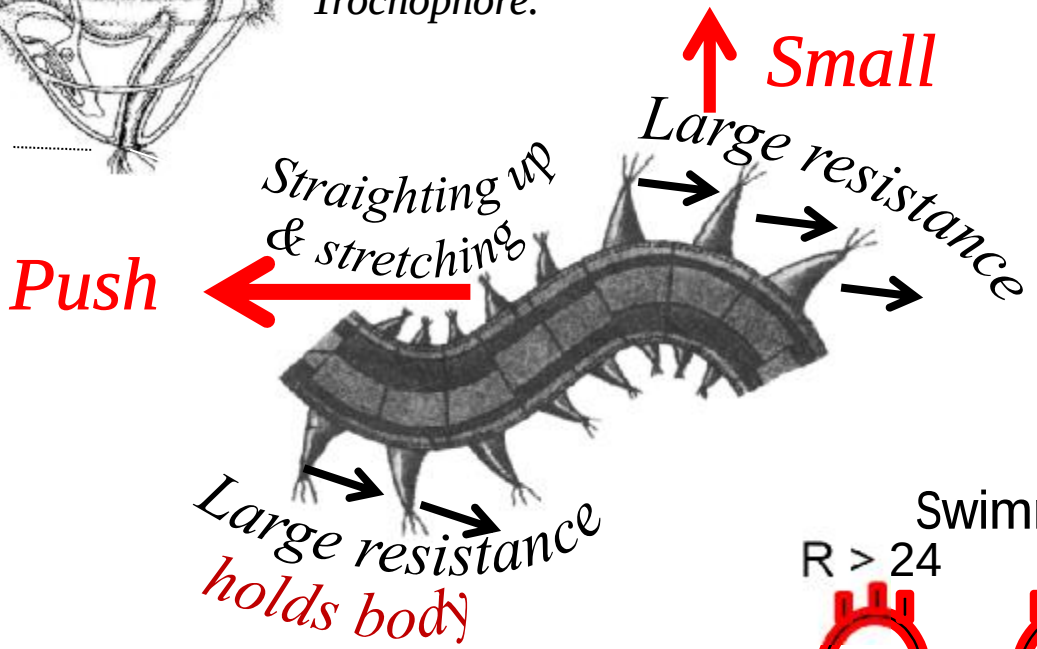




1 Statocyst in cerebrum.



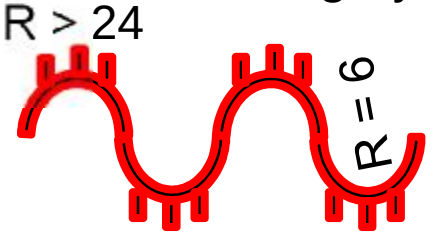
New Swimming strategy



As climbing the ladder

Hydrodynamic resistance, $R_{a,h}$

Swimming by transverse waves



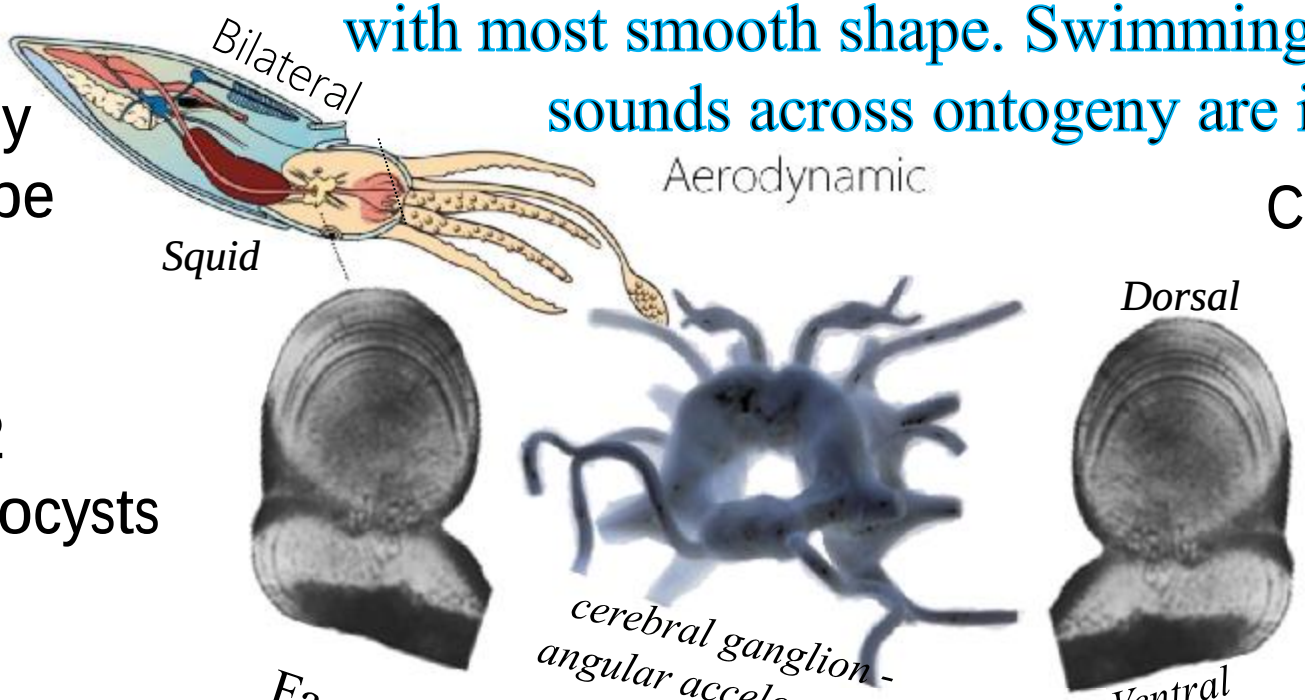
Speed of swimming 0.01 km·h^{-1};

Low Hz faster swimming.

Mollusca

Biggest body (10 m squids) & speed among protostome with most smooth shape. Swimming is pulsation & its sounds across ontogeny are in otolith recorded

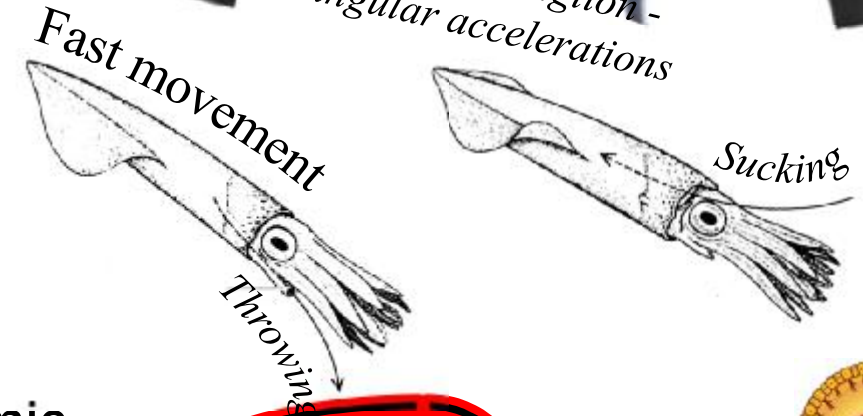
Body shape



Circular center? slow swimming larvae

2 Statocysts

New Swimming strategy



Hydrodynamic resistance, $R_{a,h}$

Speed of swimming 1 km·h^{-1};

Snail otolith

High otolith? large vertical migration

Arthropods

The passage to gain communication and gain new space: air for flying

Class Insecta

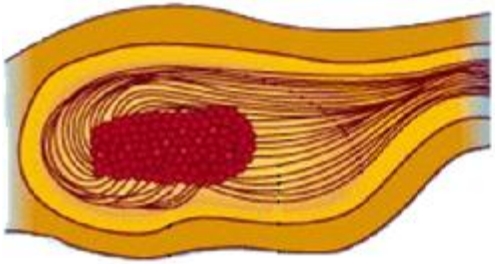
Body shape

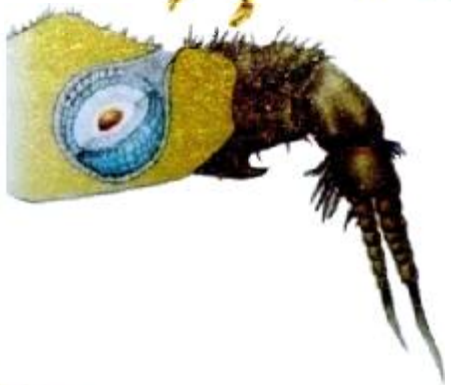
Krill, *E. superba*

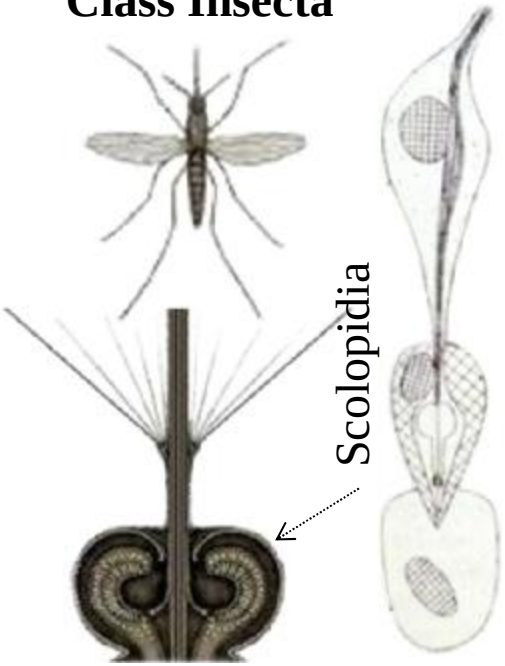
Beating

Crayfish

2 Statocysts

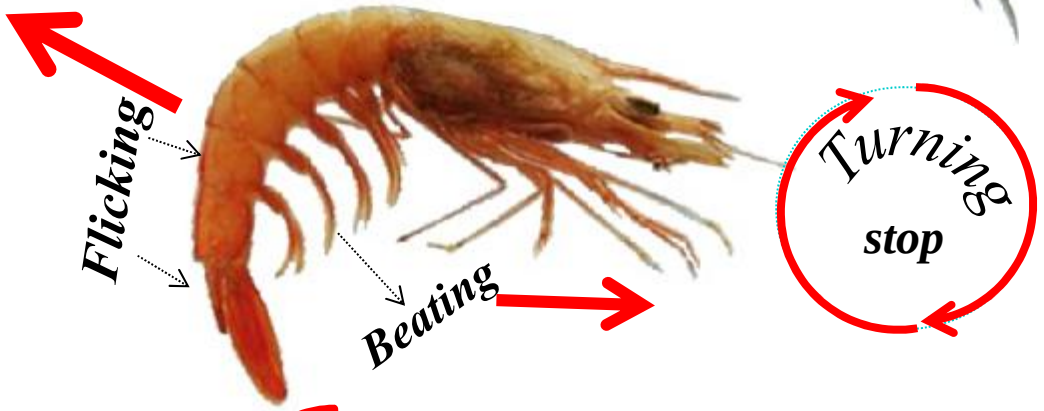






Scolopidia

New Swimming strategy



Flicking

Beating

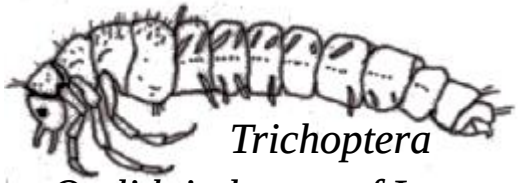
Turning

stop

Johnston's organ, 480 neurons

Percept gravitational, mechanical & acoustic oscillation, 50 – 70 Hz

Hydrodynamic resistance, $R_{a,h}$



Trichoptera

Otolith in larvae of Insects

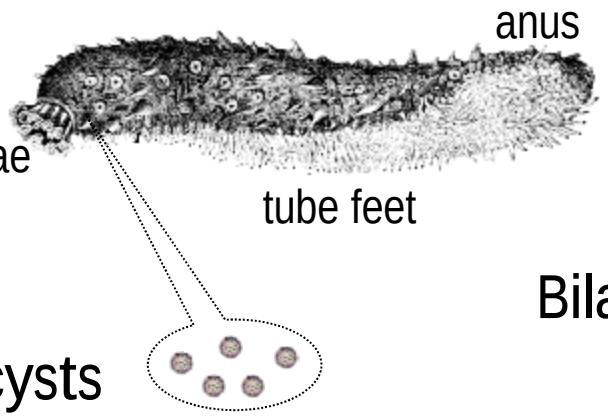
Speed of swimming 3.6 - 29 m·h^{-1}; 3.3-4.3 Hz

33 – 97 km·h^{-1}; 27 Hz

Echinoderms

In the new phase of evolution, animals gain new opportunities. Their development require more secure lifestyle at the bottom.

Body shape



5 Statocysts

Bilateral swimming larvae

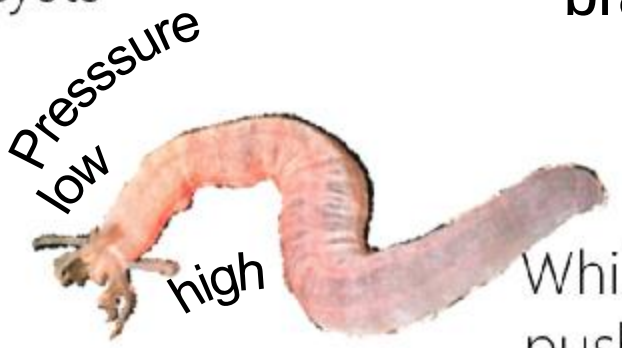
5 statocysts

Radial adults

Lose statocysts & brain

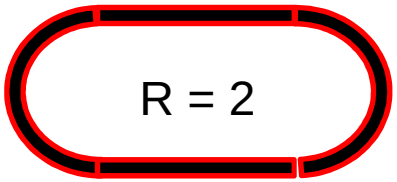
Swimming strategy

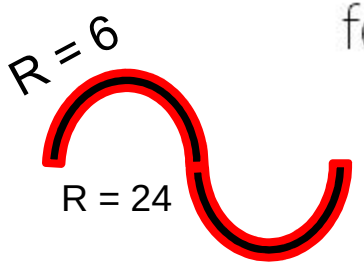
Crawling at the bottom



While bending push the body forward to lesser resistance.

Hydrodynamic resistance, $R_{a,h}$

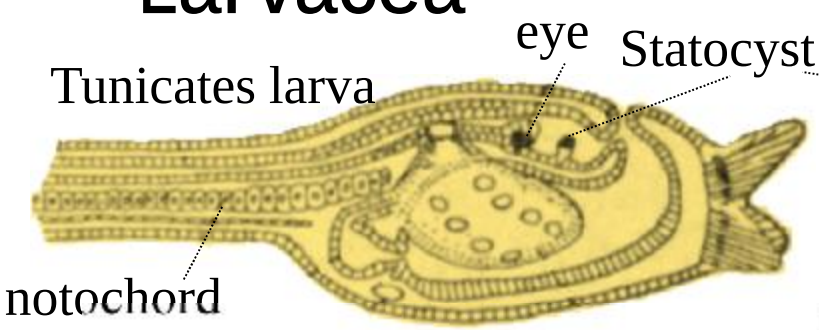
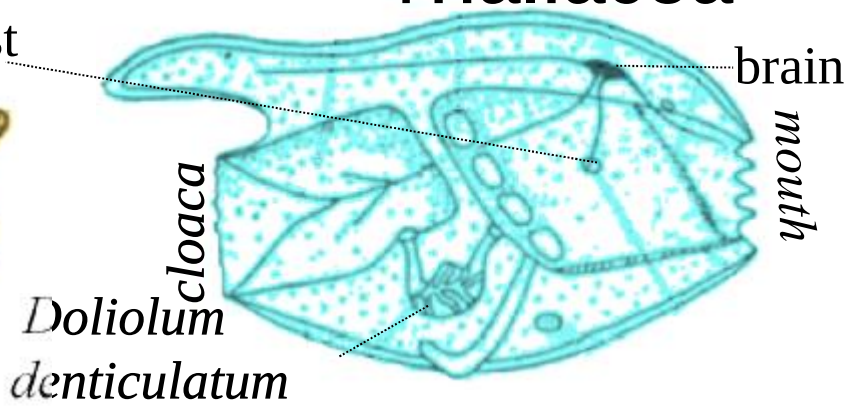
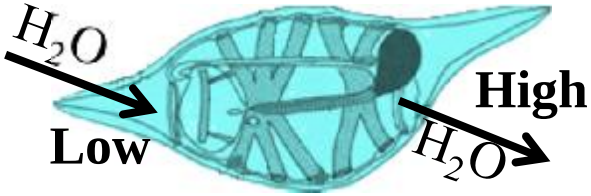
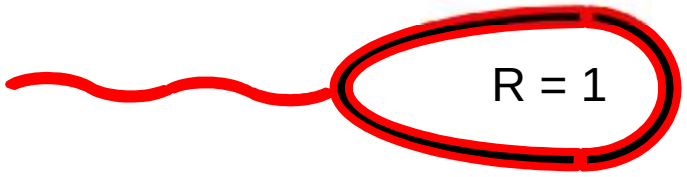
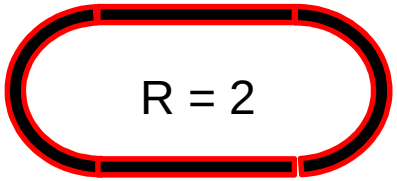


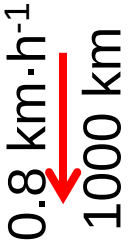


Speed of swimming 0.0011 $km \cdot h^{-1}$;

Chordates
Tunicates

Back to centralizing the perception of oscillation with their interpreting brain development

	Larvacea	Thaliacea
Body shape		
1 Statocyst	Central in brain central cavity	In the vicinity of ganglia
New Swimming strategy	 The larva Ascidiacea is more advanced carried in current, get quick sex & sesile	 Salp pumping generate low pressure to which it pulls its body
Hydrodynamic resistance, $R_{a,h}$		
Speed of swimming	1.6 km·h^{-1}	0.2 – 0.6 km·h^{-1}; 0.5 – 1.2 Hz



Jawless

Passage to be fast & conquer. Lymph oscillation extended on circular canals better measure fast turning of loosely body

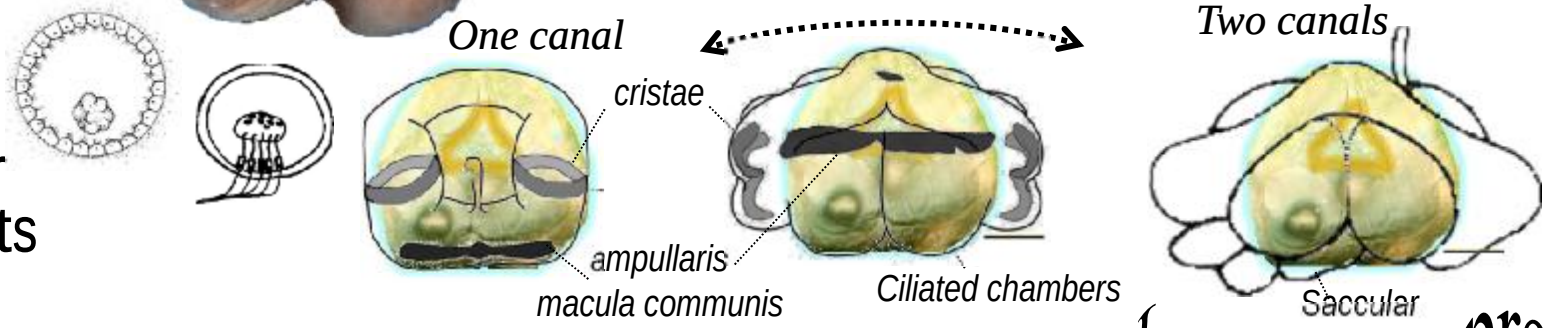
Body shape

Myxini

Phylo- & ontogene

Petromyzontiformes

2 circular Statocysts



New Swimming strategy

Hydrodynamic resistance, $R_{a,h}$

Speed of swimming 1.6 km·h^{-1} 66 - 132 Hz

7-22 km·h^{-1}, 1.5 Hz

Chordates

Development various movement strategies to fullfil use all environment resources at different habits in time & space

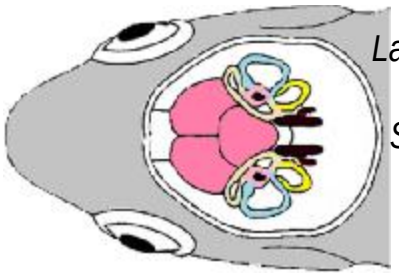
Body shape

Ps. georgianus

S. japonicus

2 statocysts

Not circular



3 pairs otolits

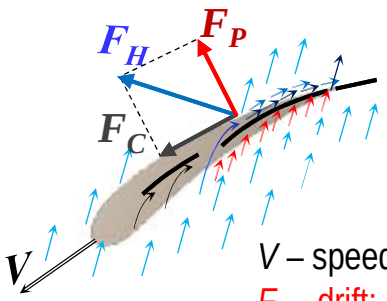
Vertical migrations

Not circular

Horizontal migrations

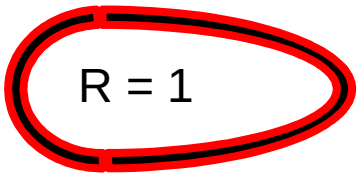
Swimming strategy

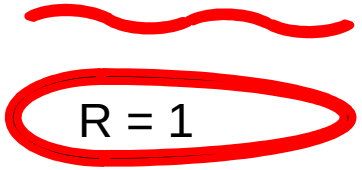
pectoral fin



V – speed; F_C – drive power;
F_P - drift; F_H – hydrodyn. force

Hydrodynamic resistance, $R_{a,h}$

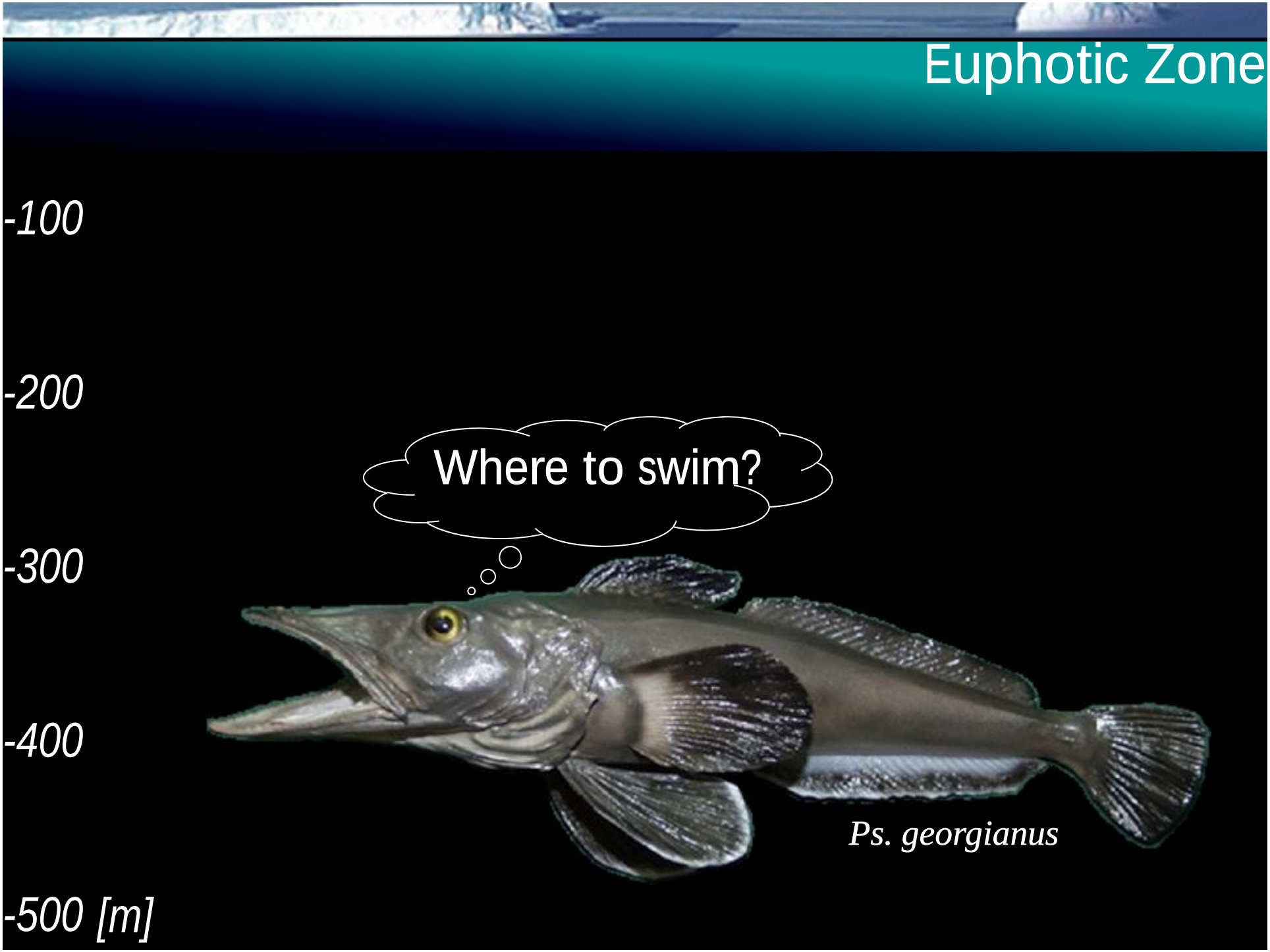


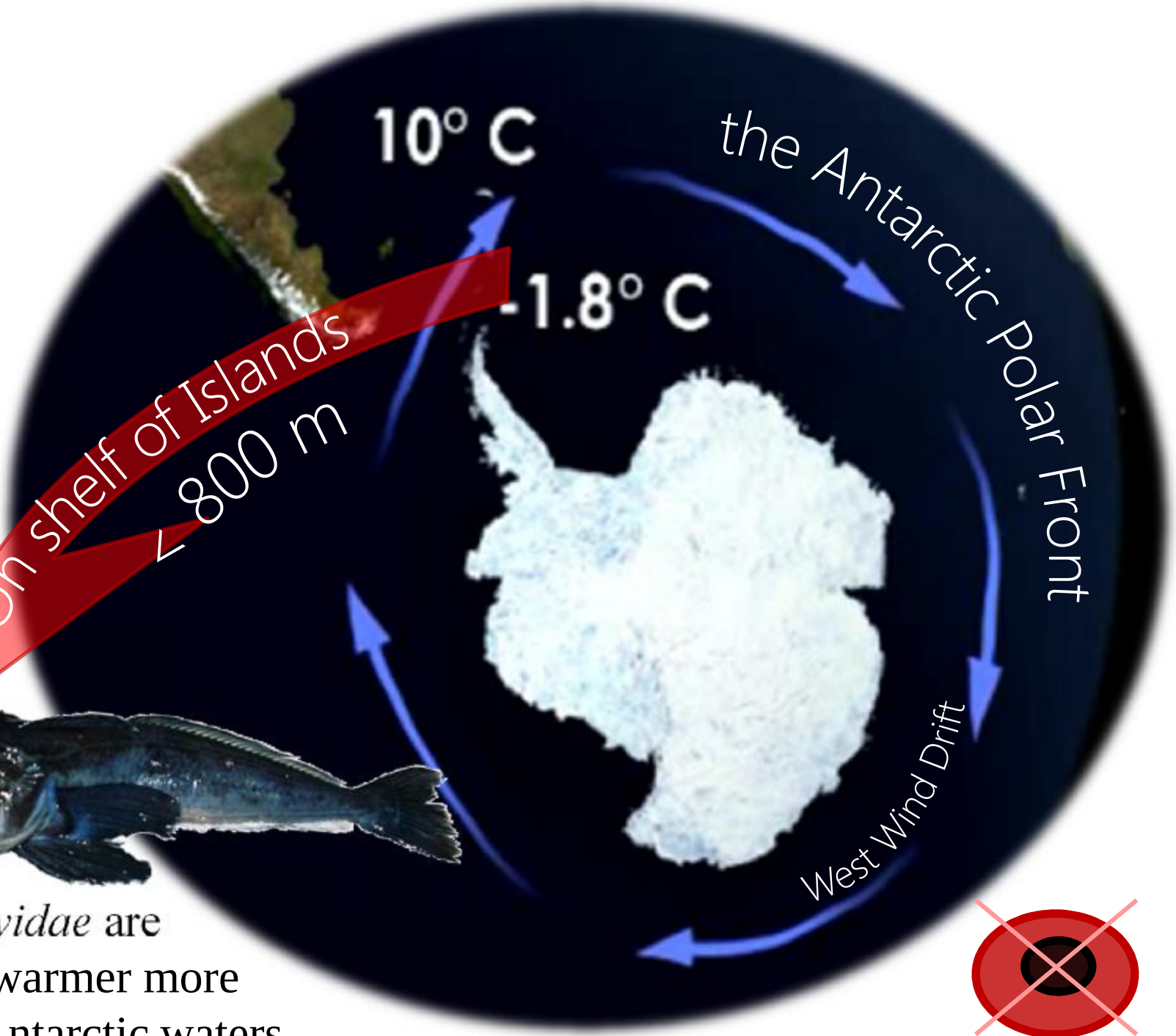


Speed of swimming

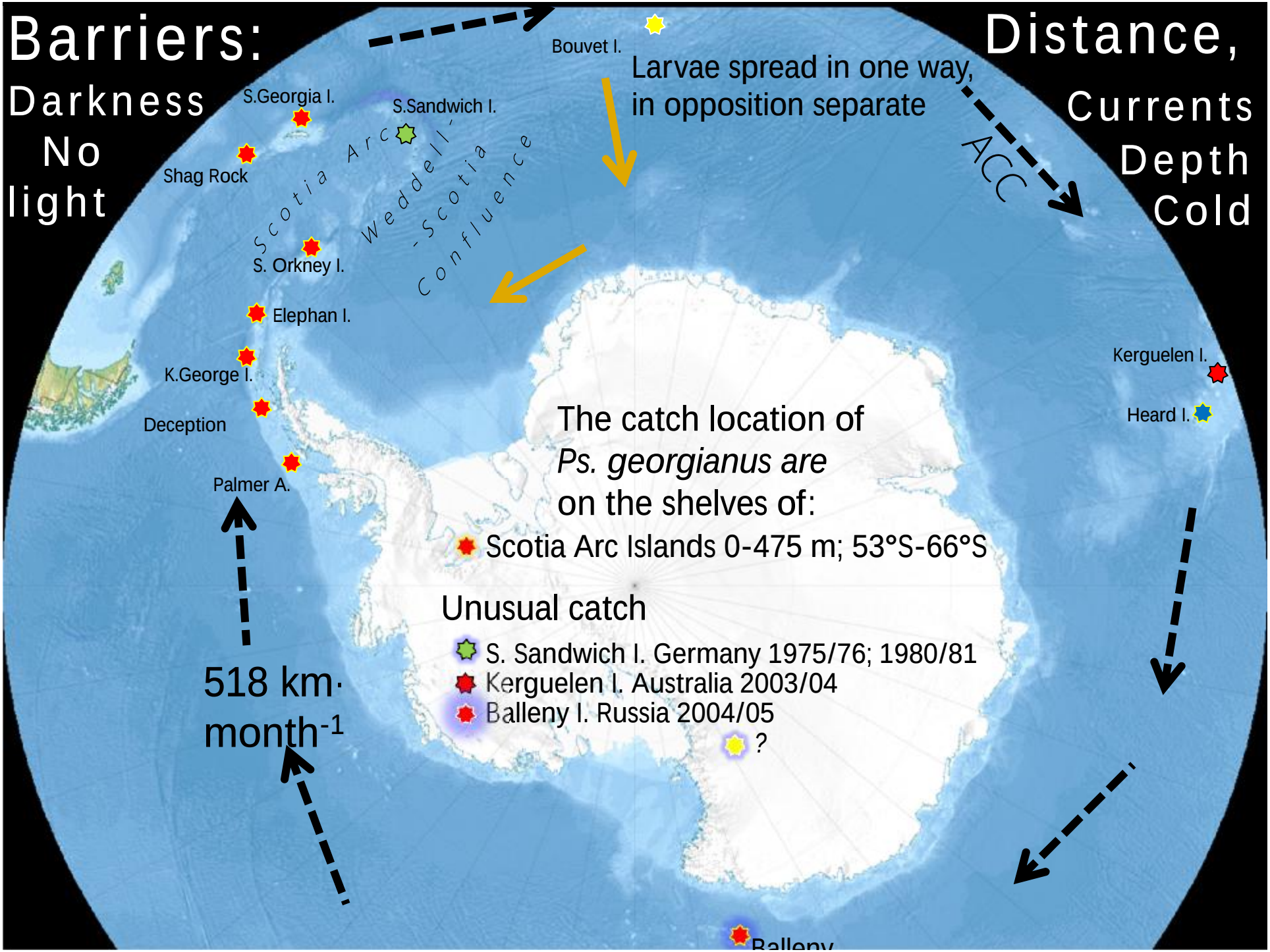
1.6 km·h^{-1}, 0.9 Hz

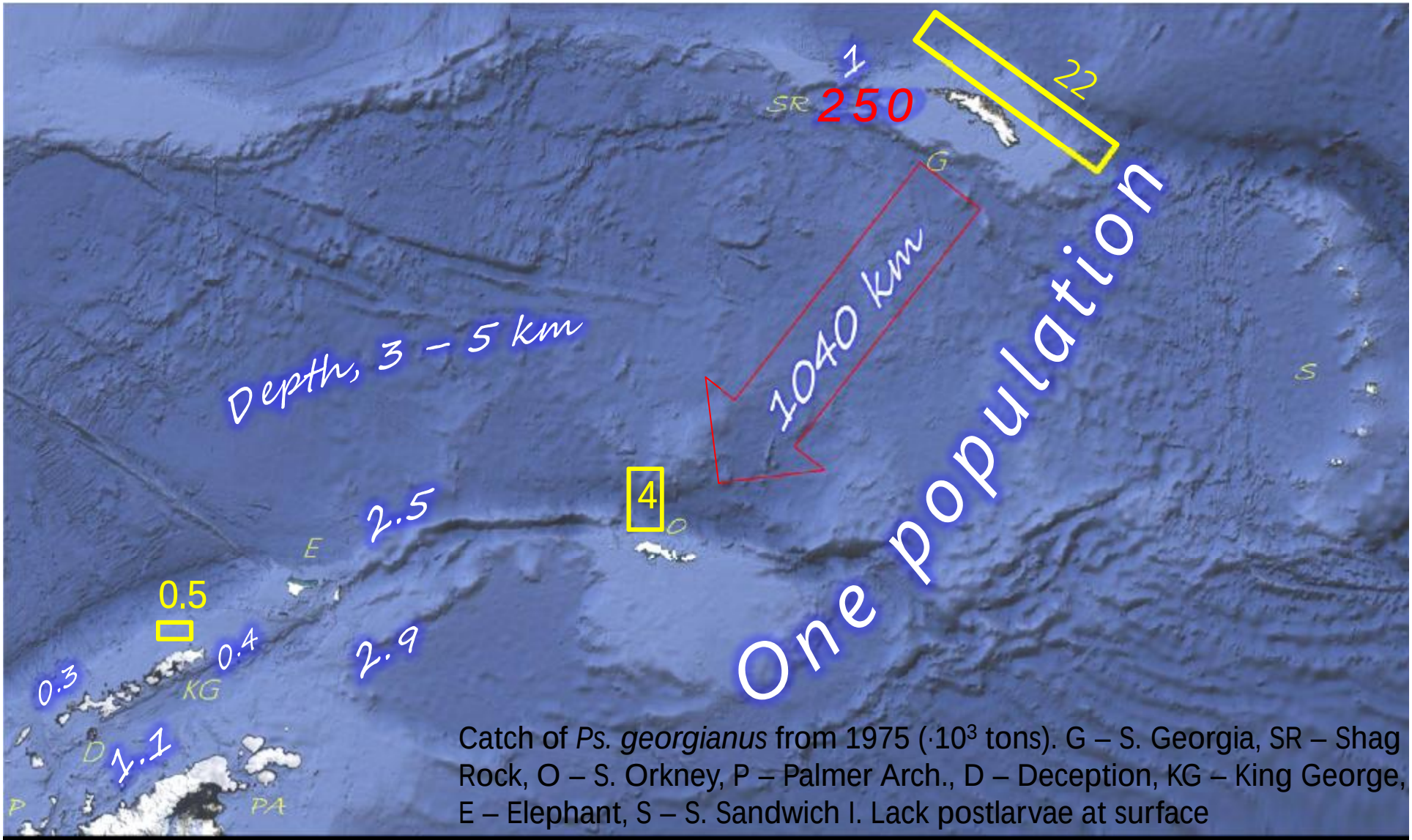
21 km·h^{-1}, 2.5 Hz


Euphotic Zone
-100
-200
-300
-400
-500 [m]
Where to swim?
Ps. georgianus



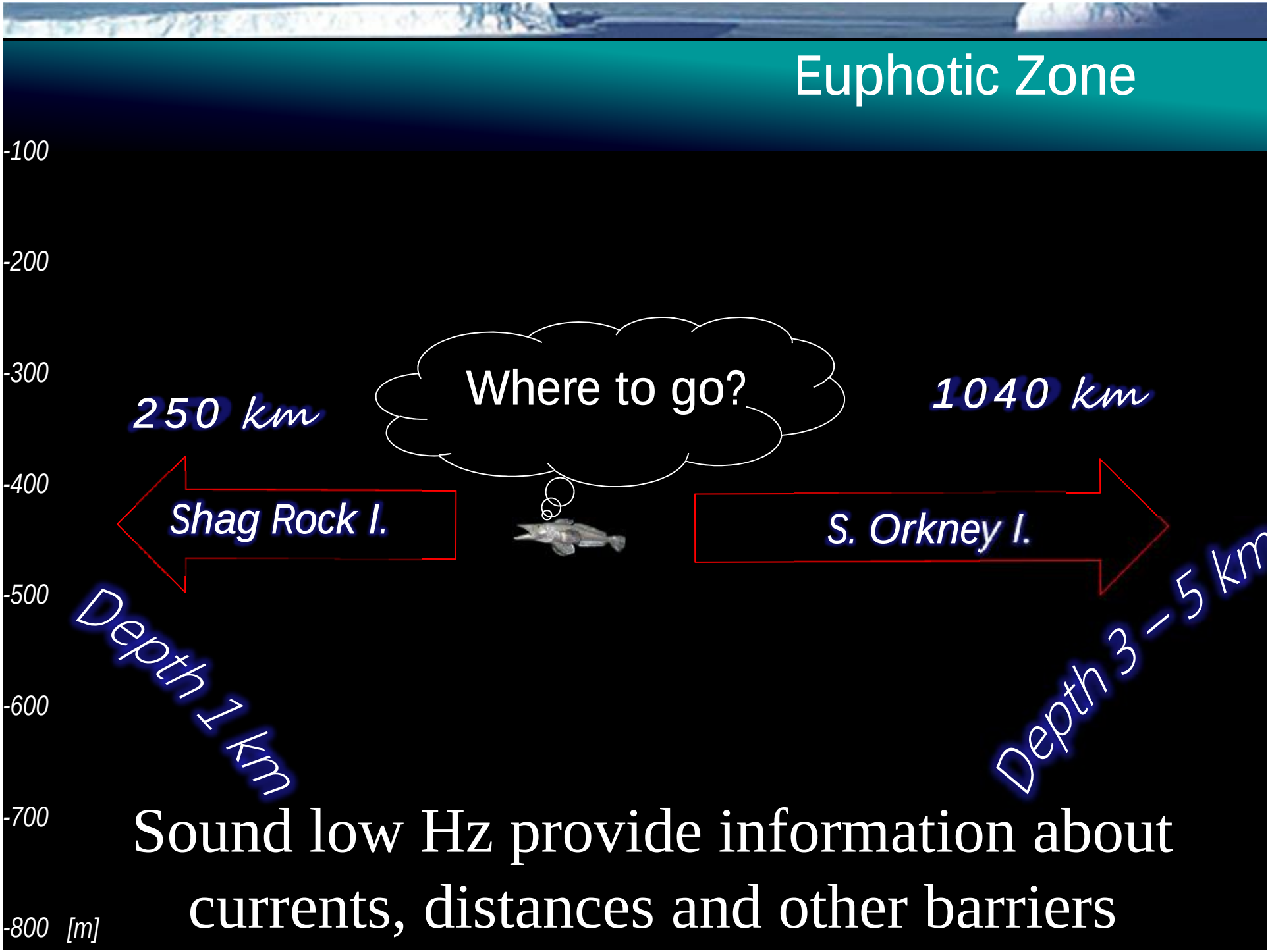
Channichthyidae are isolated by warmer more saline sub-Antarctic waters.


Barriers:
Darkness
No light
Distance,
Currents
Depth
Cold
Bouvet I.
Larvae spread in one way, in opposition separate
ACC
S.Georgia I.
S.Sandwich I.
Shag Rock
Scotia Arc
Weddell-Scotia Confluence
S. Orkney I.
Elephan I.
K.George I.
Deception
Palmer A.
Kerguelen I.
Heard I.
The catch location of
Ps. georgianus are
on the shelves of:
Scotia Arc Islands 0-475 m; 53°S-66°S
Unusual catch
S. Sandwich I. Germany 1975/76; 1980/81
Kerguelen I. Australia 2003/04
Balleny I. Russia 2004/05
?
518 km·month-1
Balleny

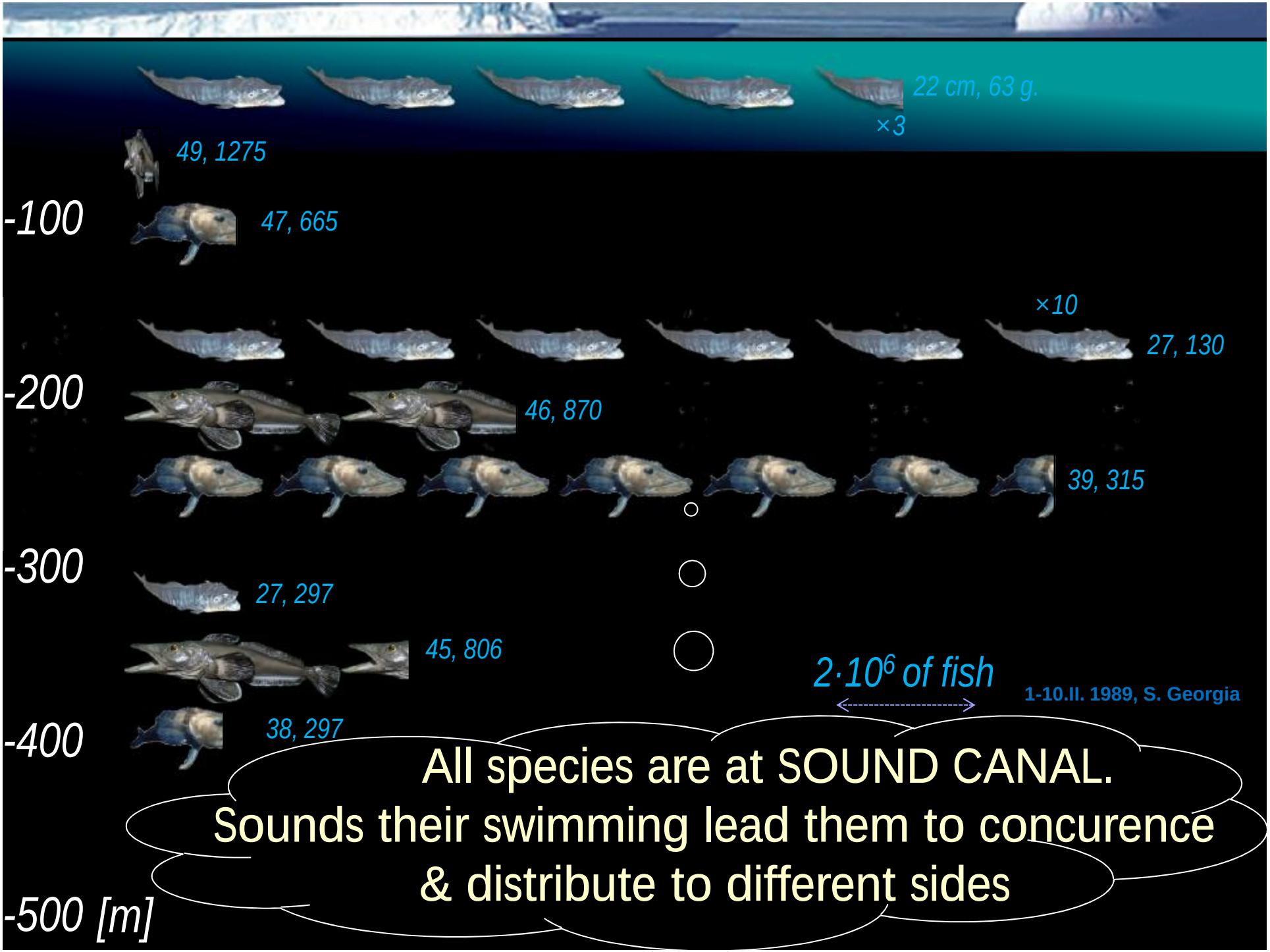


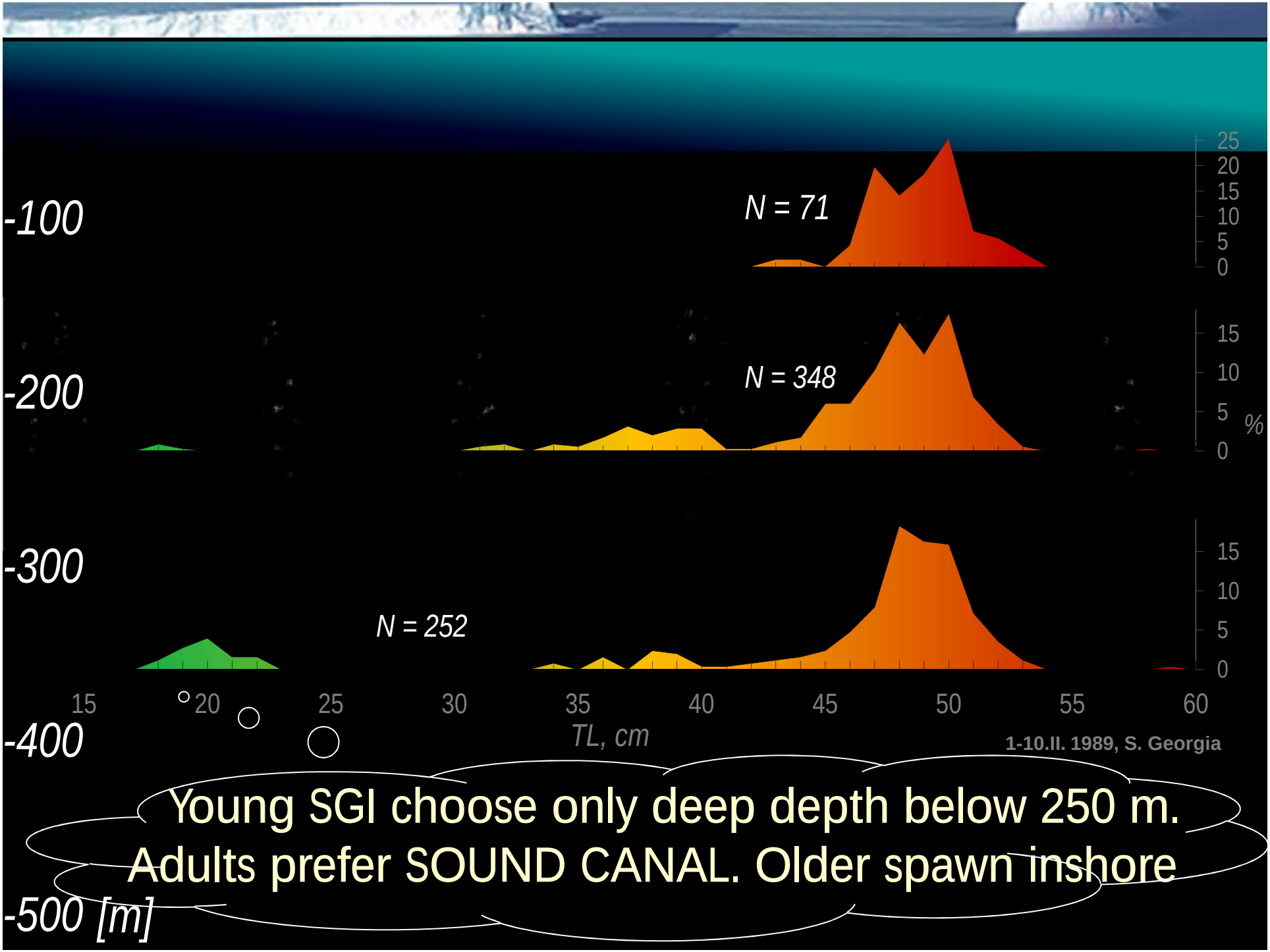
Catch of *Ps. georgianus* from 1975 (·10^3 tons). G – S. Georgia, SR – Shag Rock, O – S. Orkney, P – Palmer Arch., D – Deception, KG – King George, E – Elephant, S – S. Sandwich I. Lack postlarvae at surface

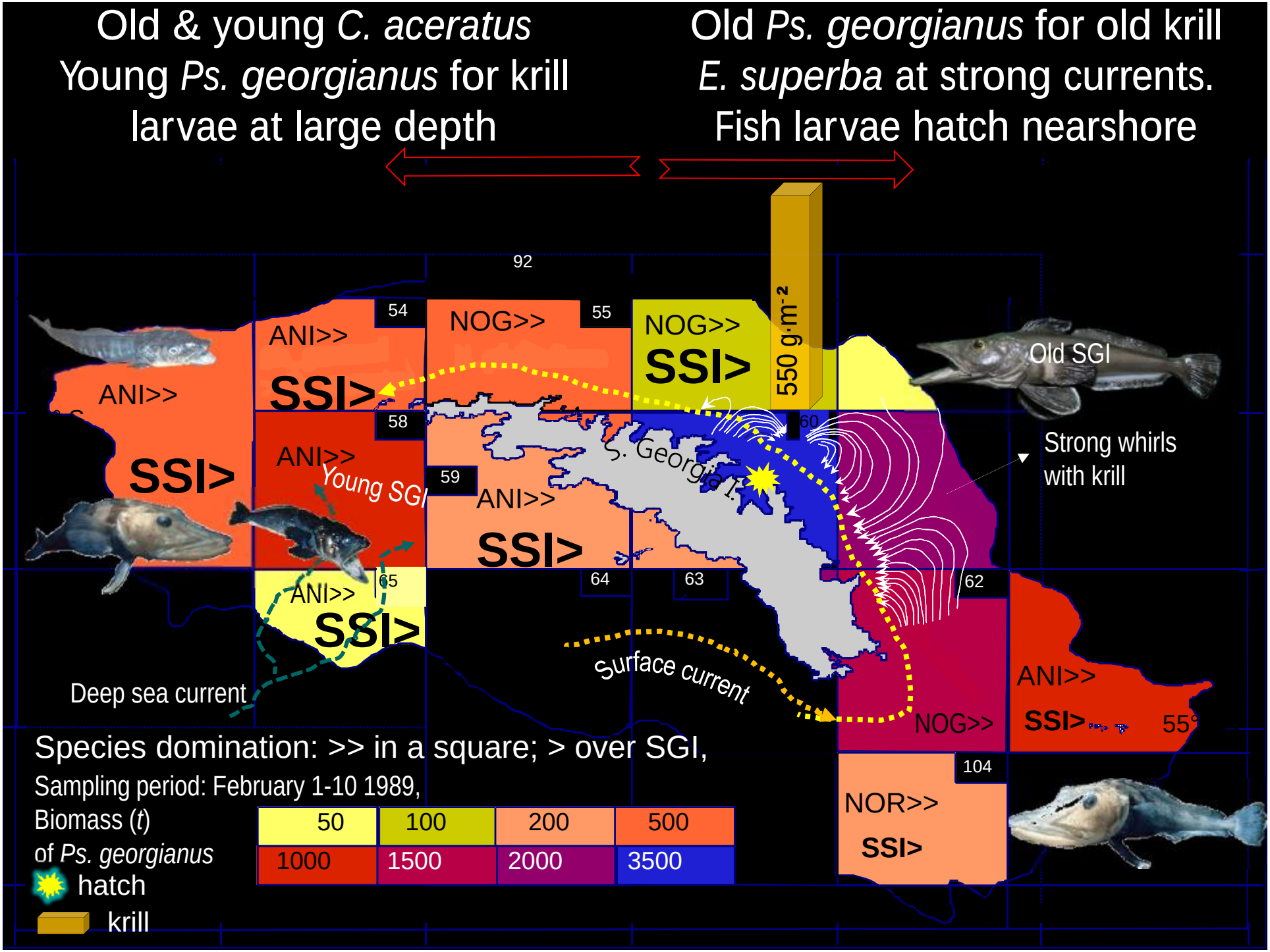
Low genetic differentiation for many Antarctic fish species even benthic suggest their high connectivity between islands


Euphotic Zone
-100
-200
-300
-400
-500
-600
-700
-800 [m]
250 km
Where to go?
1040 km
Shag Rock I.
S. Orkney I.
Depth 1 km
Depth 3 – 5 km
Sound low Hz provide information about currents, distances and other barriers


Informations in low
Hz & high dB
Sounds Canal at 200 m
TRANSPORT < 1200 km
-100
-200
-300
-400
-500 [m]
Vertical sounds canal at whirils
With acoustic perception by otolith
icefish recognize & overgo barriers,
find food & compete!

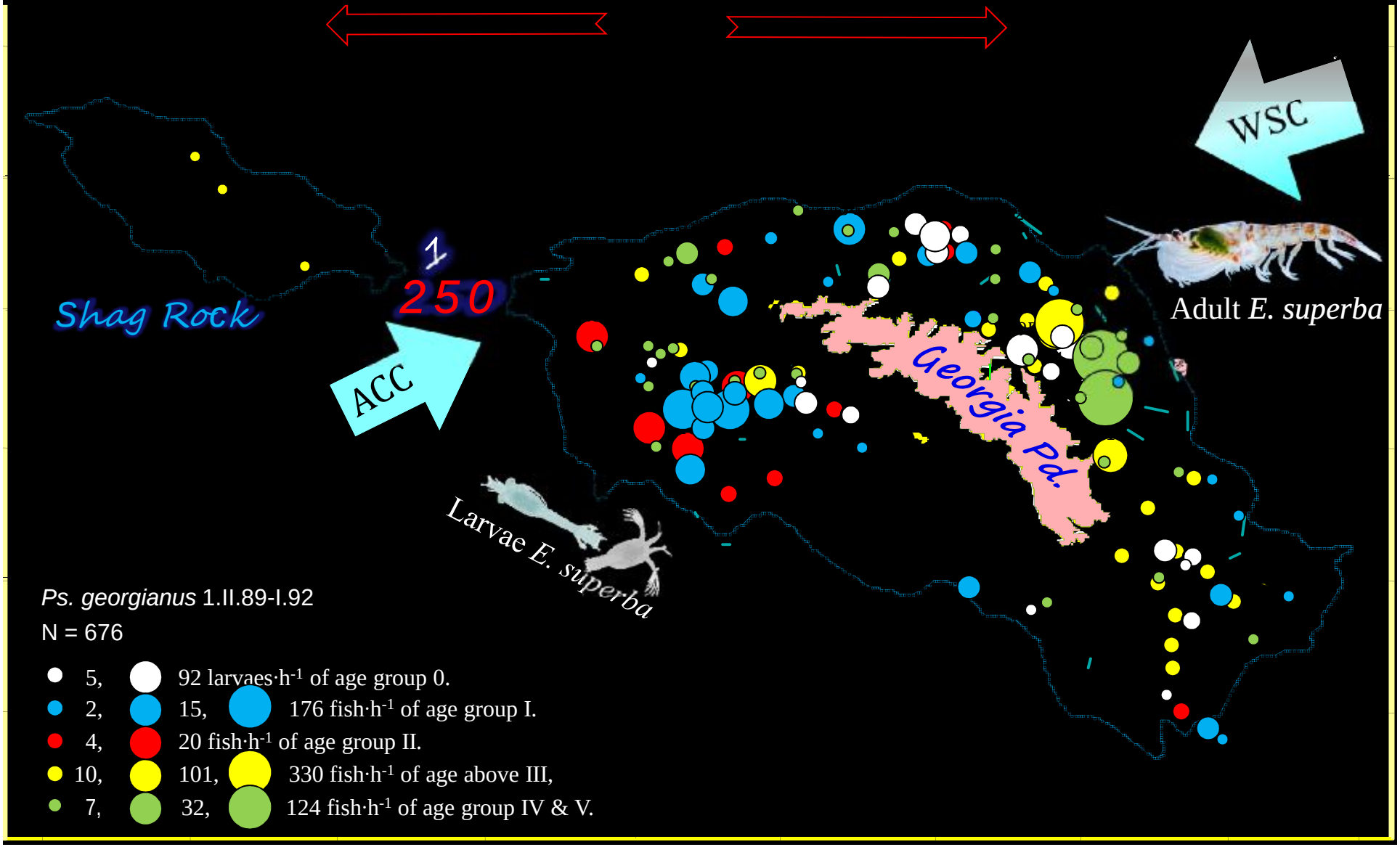

22 cm, 63 g.
×3
49, 1275
-100
47, 665
×10
27, 130
-200
46, 870
39, 315
-300
27, 297
45, 806
2·10^6 of fish
1-10.II. 1989, S. Georgia
-400
38, 297
All species are at SOUND CANAL.
Sounds their swimming lead them to concurence
& distribute to different sides
-500 [m]

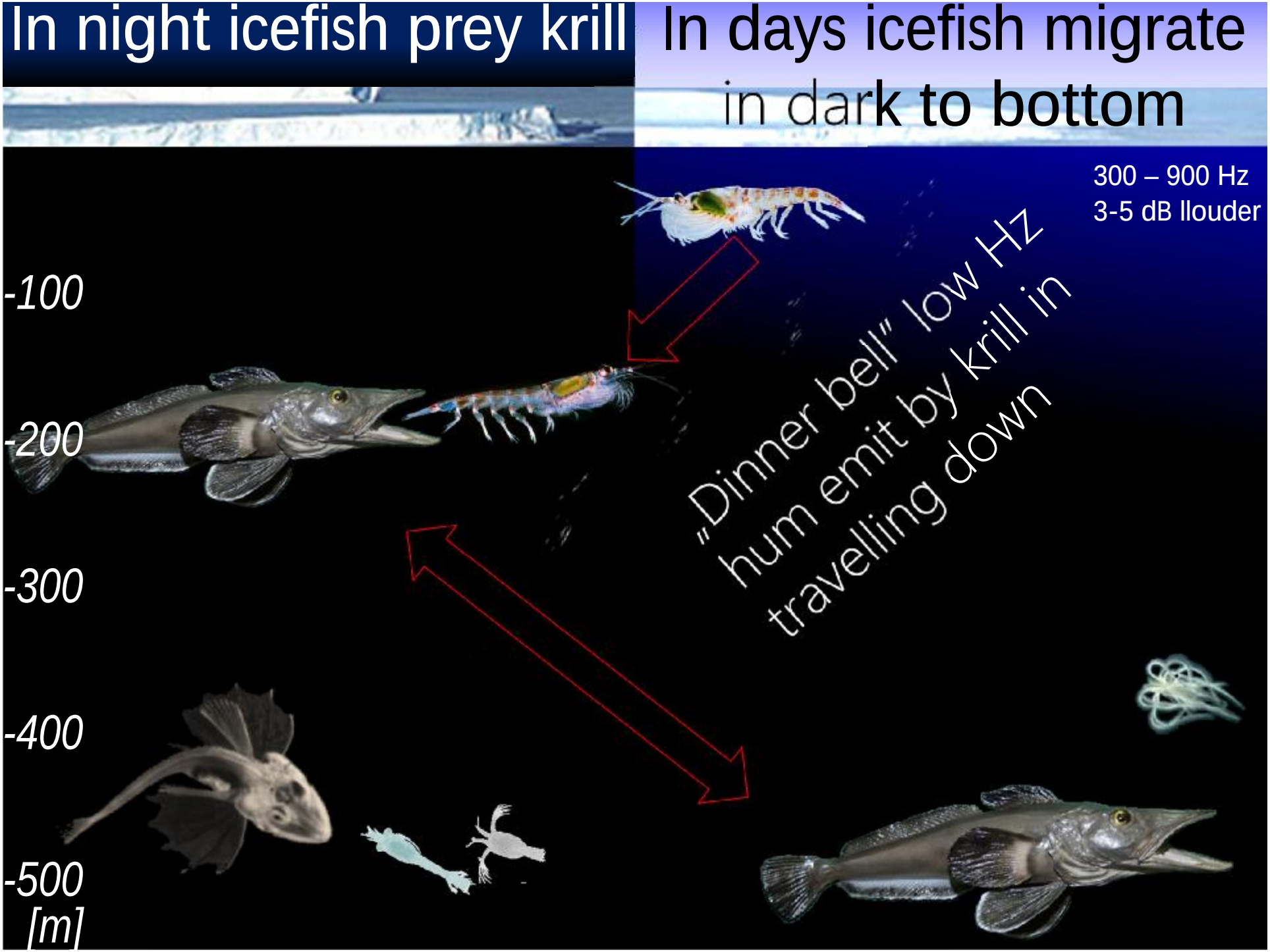

-100
-200
-300
-400
-500 [m]
N = 71
N = 348
N = 252
25
20
15
10
5
0
15
10
5
0
%
15
10
5
0
15
20
25
30
35
40
45
50
55
60
TL, cm
1-10.II. 1989, S. Georgia
Young SGI choose only deep depth below 250 m.
Adults prefer SOUND CANAL. Older spawn inshore

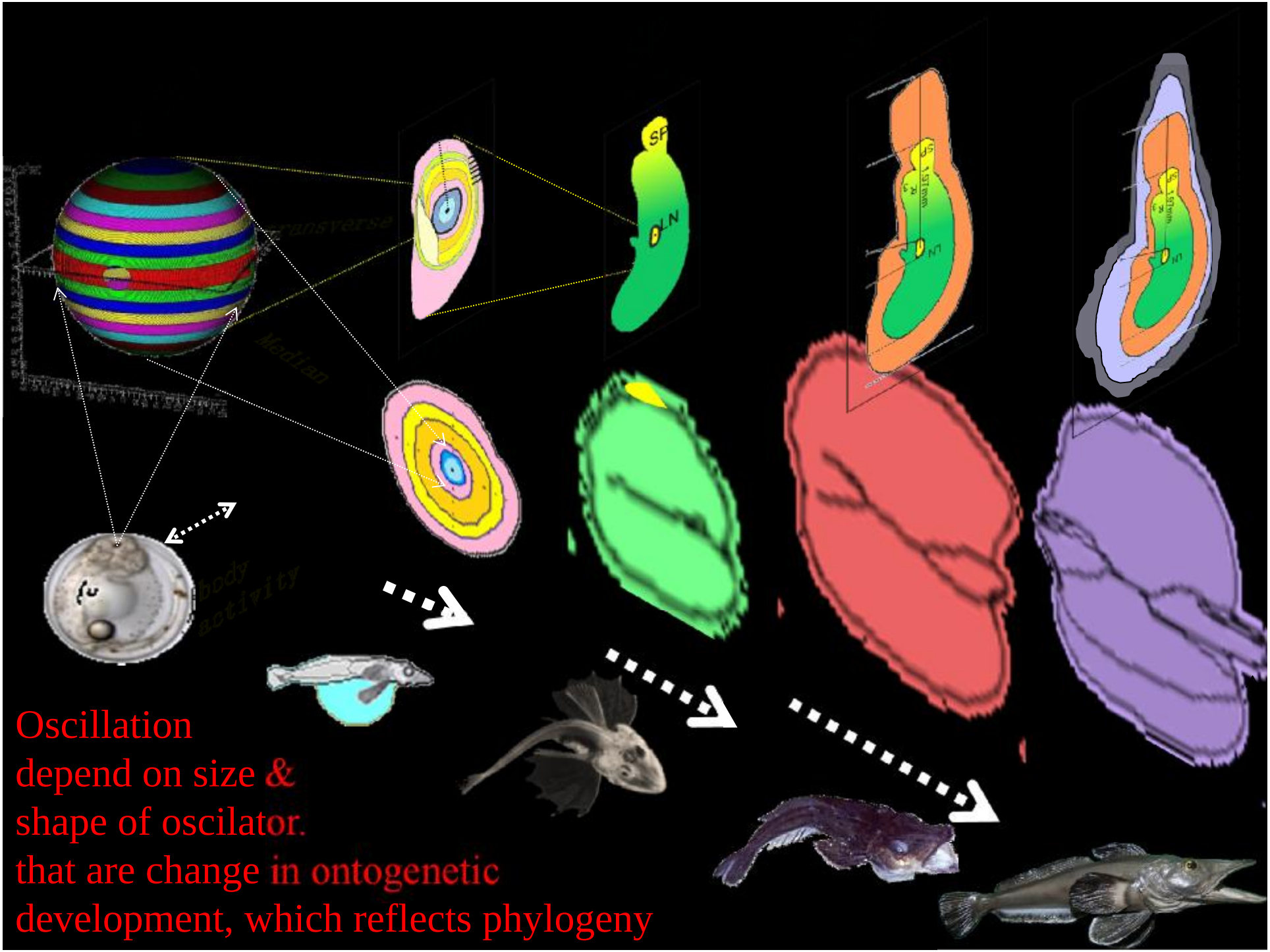

Old & young C. aceratus
Young Ps. georgianus for krill
larvae at large depth
Old Ps. georgianus for old krill
E. superba at strong currents.
Fish larvae hatch nearshore
92
54
55
58
59
60
62
63
64
65
104
ANI>>
SSI>
NOG>>
550 g·m⁻²
Old SGI
Strong whirls
with krill
Young SGI
S. Georgia I.
Surface current
Deep sea current
NOG>>
NOR>>
55°
Species domination: >> in a square; > over SGI,
Sampling period: February 1-10 1989,
Biomass (t)
of Ps. georgianus
hatch
krill
50
100
200
500
1000
1500
2000
3500

Young *Ps. georgianus*
for larvae of krill
Middle age cross 250 km

Old adult *Ps. georgianus*
for adult krill
Larvae near hatch side

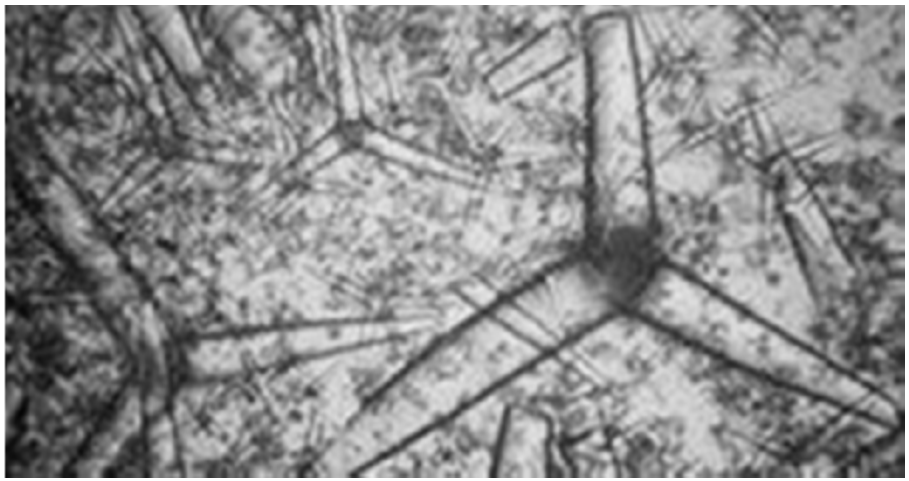


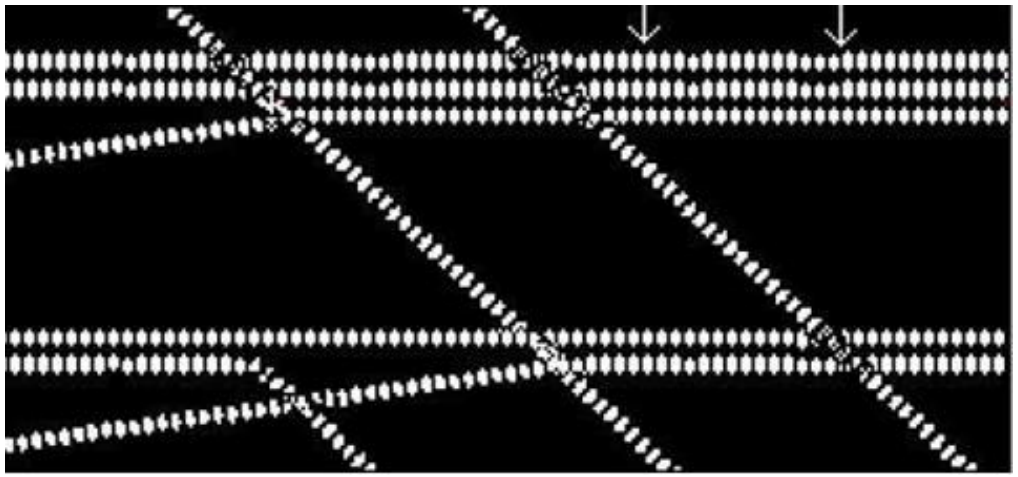

In night icefish prey krill
In days icefish migrate
in dark to bottom
300 – 900 Hz
3-5 dB llouder
-100
-200
-300
-400
-500
[m]
„Dinner bell" low Hz
hum emit by krill in
travelling down


Transverse
Median
SP
DLN
body activity
Oscillation
depend on size &
shape of oscilator.
that are change in ontogenetic
development, which reflects phylogeny

Spongin – is the collagen polymerised fibers in Mesohyl that is between sponge cells.

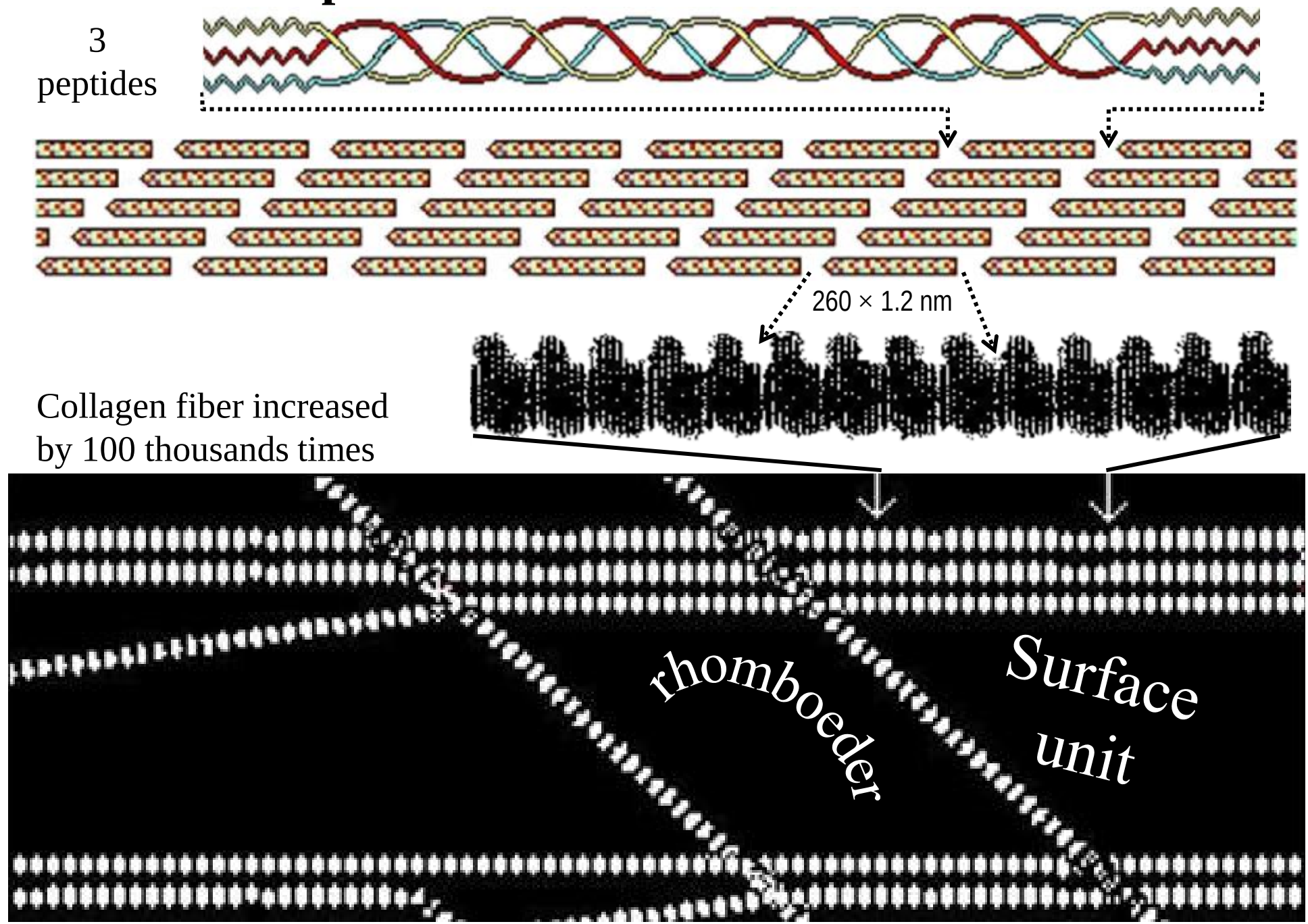
Collagen fibers under magnification of 30 thousands times

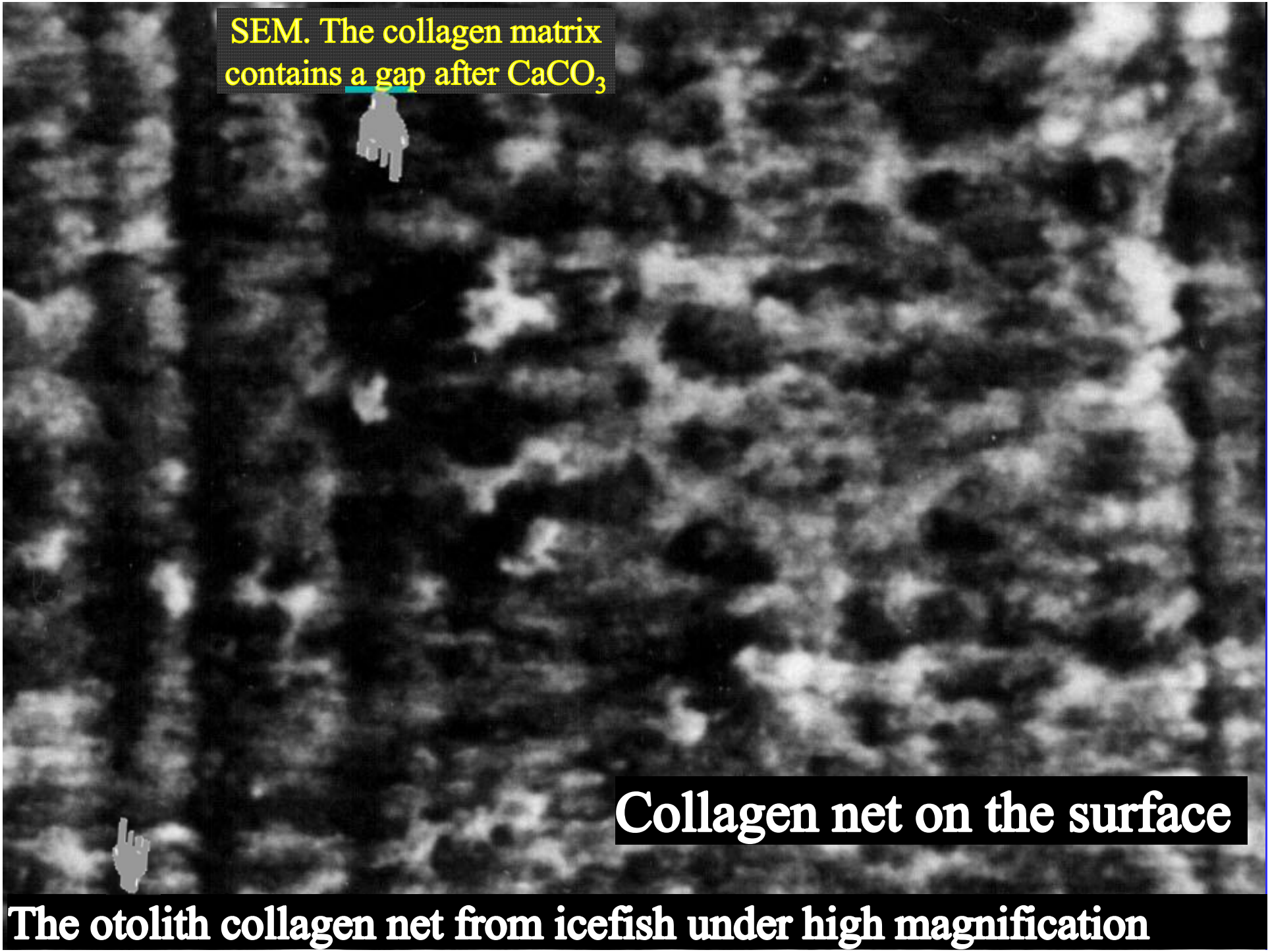




The fish sclerite-protein has conservative structure across evolution (spongin, conchiolin, collagen), and can aggregate and growth in the water.

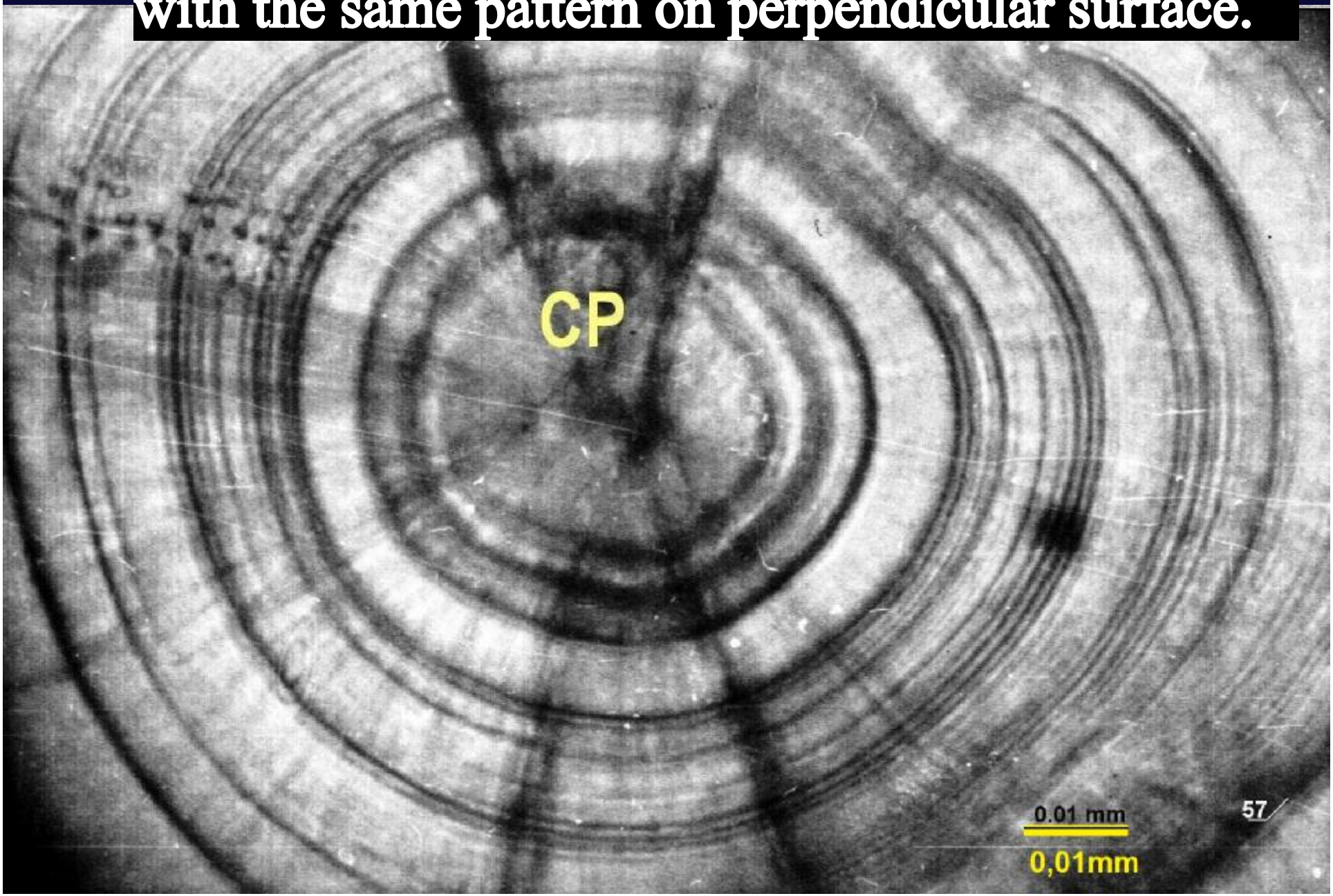
Extracellural process tropocollagen is capable to spontaneous polymerisation





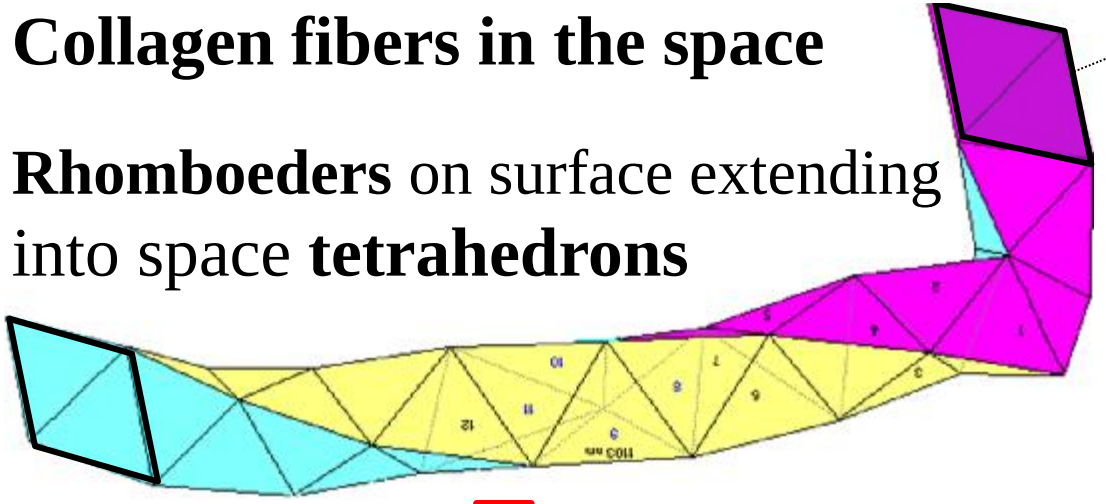
The otolith collagen net from icefish under high magnification

The otolith collagen net under low magnification with the same pattern on perpendicular surface.

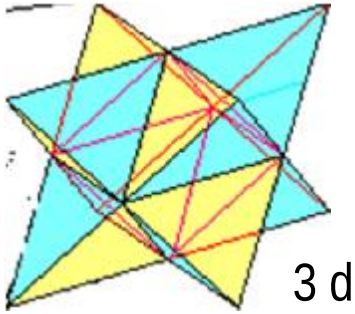


Collagen fibers in the space

Rhomboeders on surface extending into space **tetrahedrons**



Rhomboeder surface unit



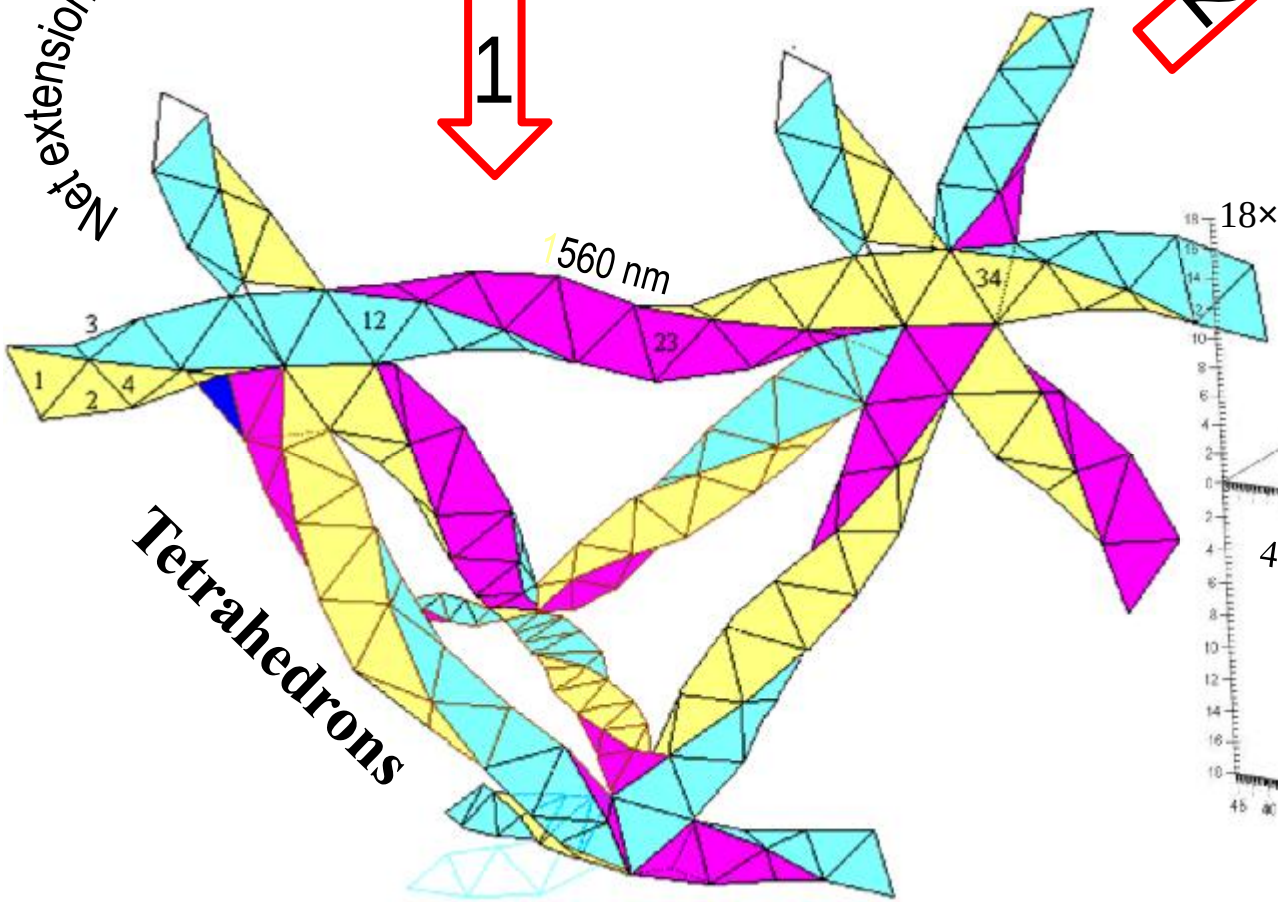
3 dimension space unit

1

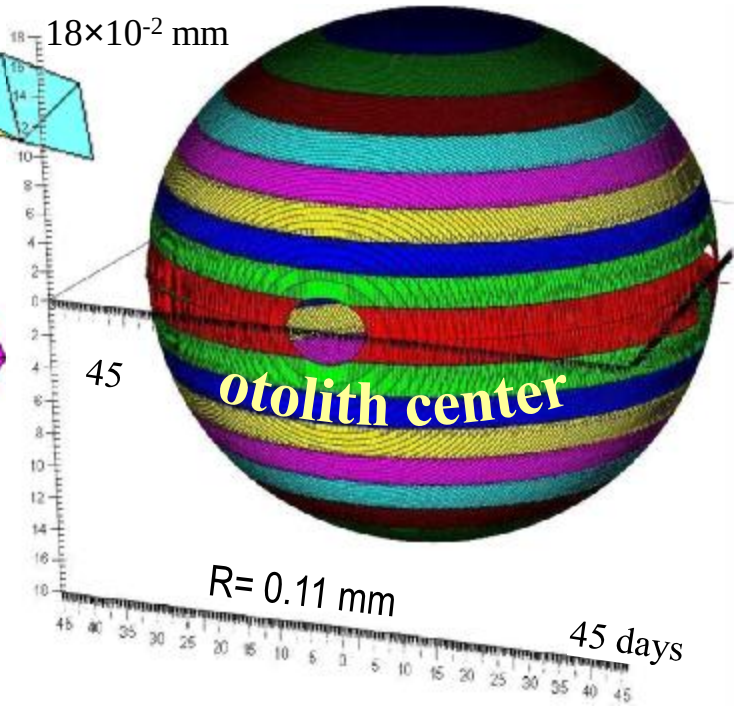
2

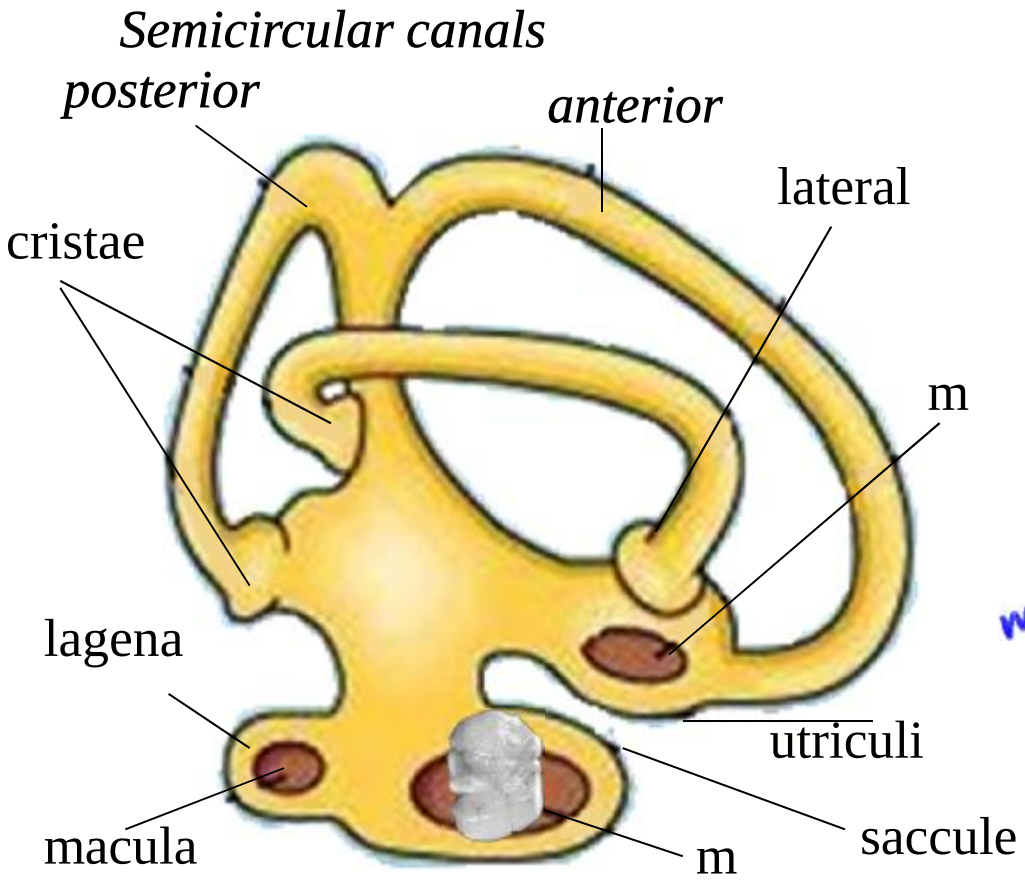
3

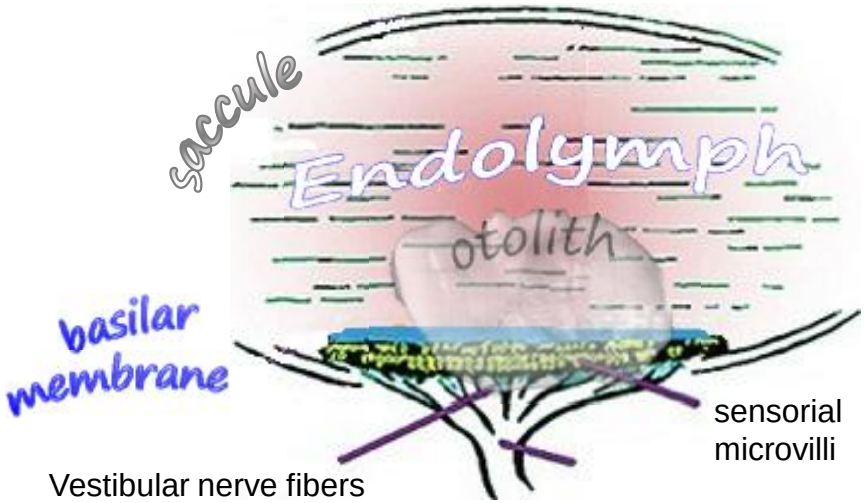
Net extension



Tetrahedrons

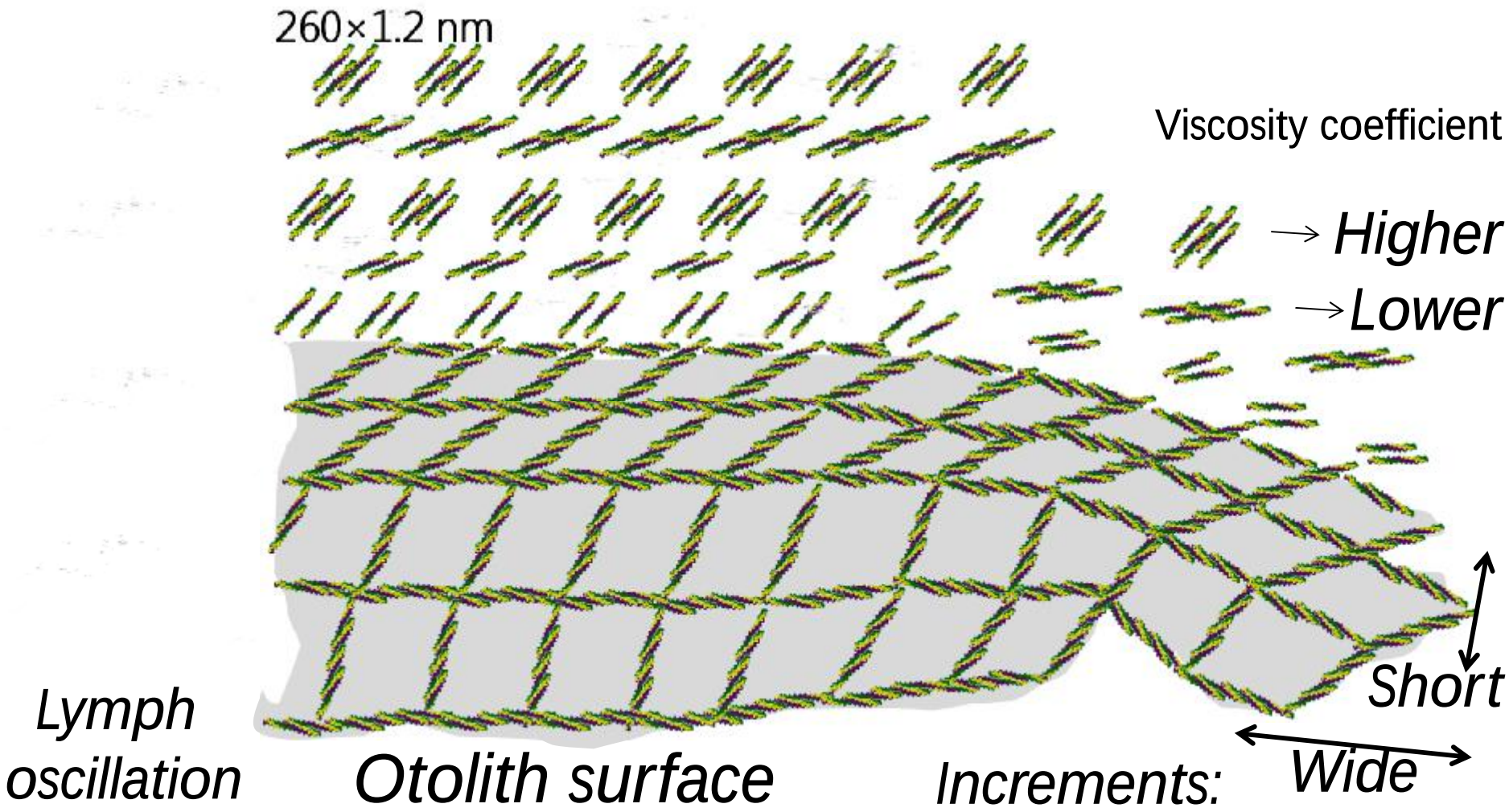






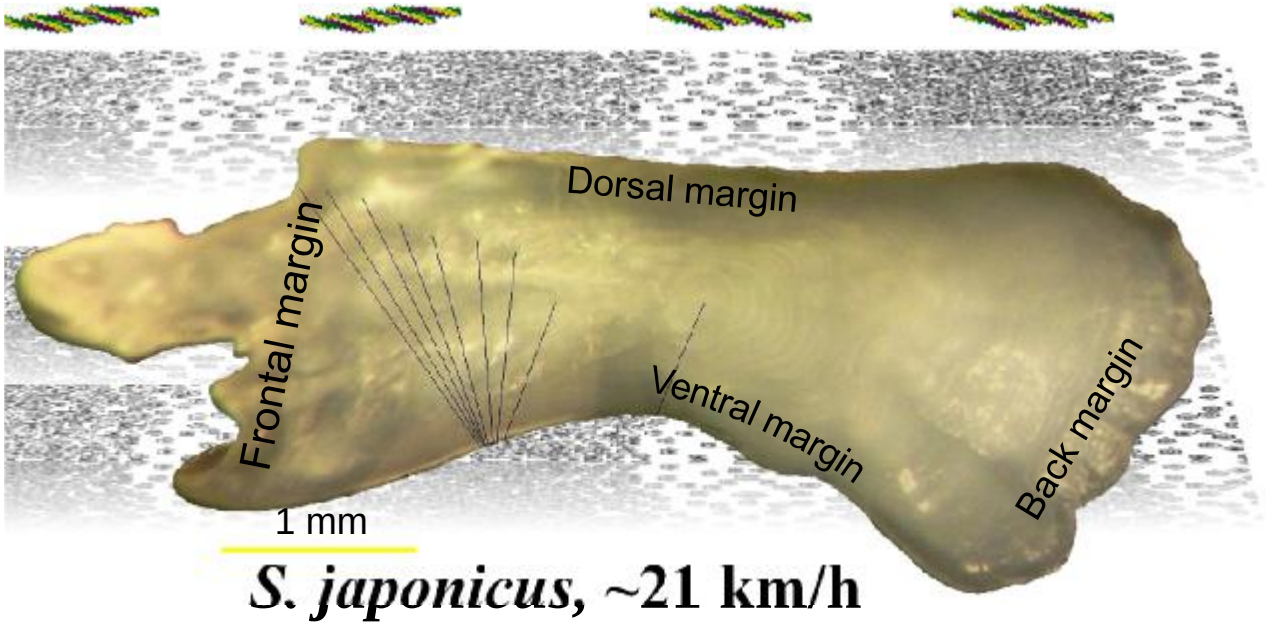
Spherical surfaces of otolith indicate that the crystallization of Aragonite (90%) determine fish sclerite-protein (less than 10%) that is go in endolymph transfering sound waves

Oscillation of endolymph arrange dipoles of tropocollagens. This go for smaller resistance that arrange tropocollages with longer axis along direction of swimming. This give wide increments & elongate otolith in that direction.



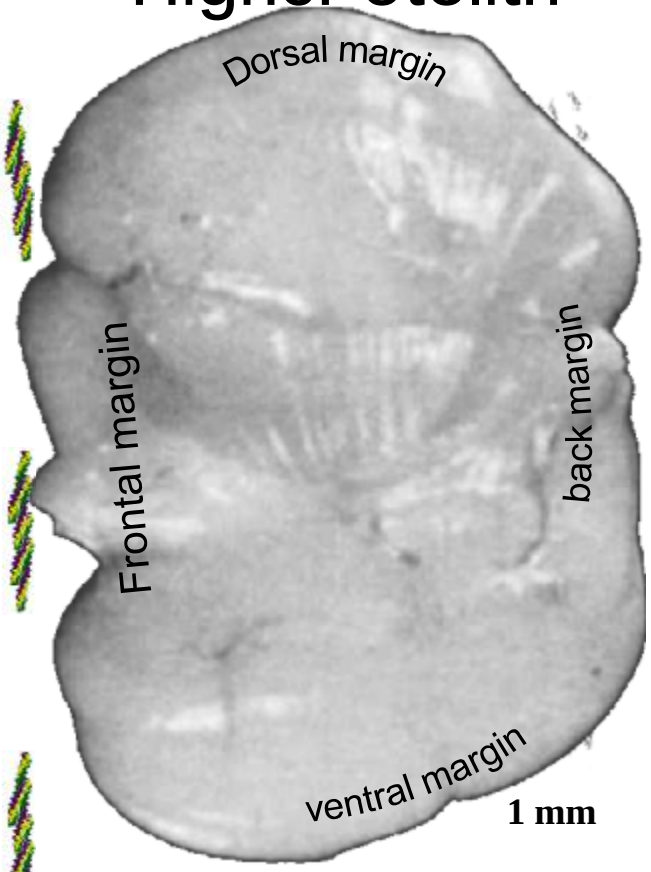
Sound ordering molecules give evolution passage to overcoming barriers: by otolith elongate that improve measure the deviations from direction of swimming

elongate otolith



***S. japonicus*, ~21 km/h**

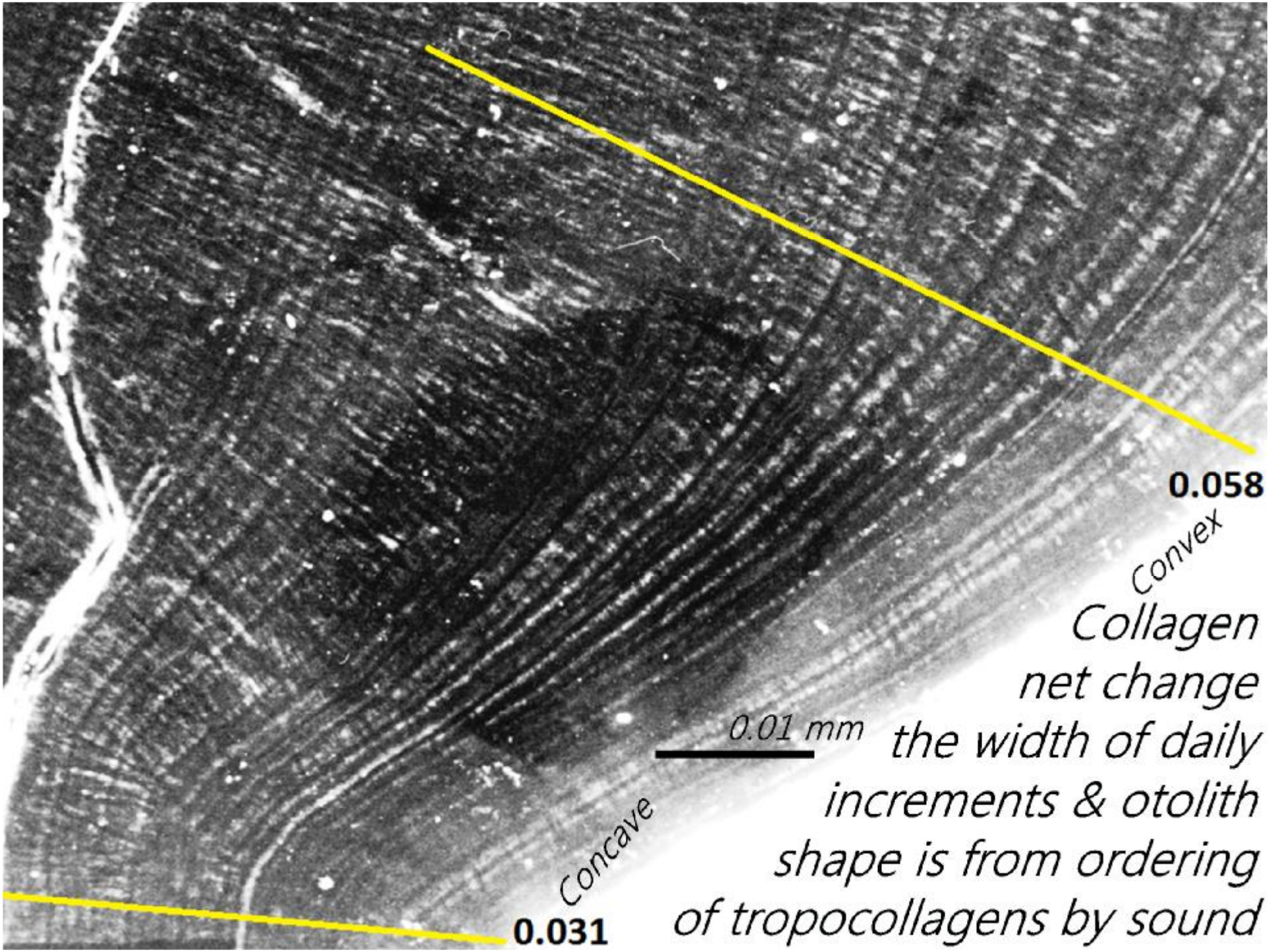
Higher otolith



***Ps. georgianus*, ~1.6 km/h**

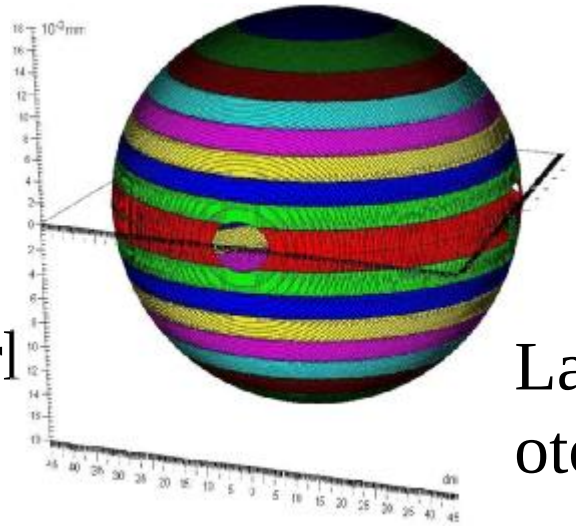
Horizontally give faster swimming, that also stimulates body shape & swimming strategy.

Vertically give faster migration


0.058
Convex
Collagen
net change
0.01 mm
the width of daily
increments & otolith
shape is from ordering
Concave
of tropocollagens by sound
0.031

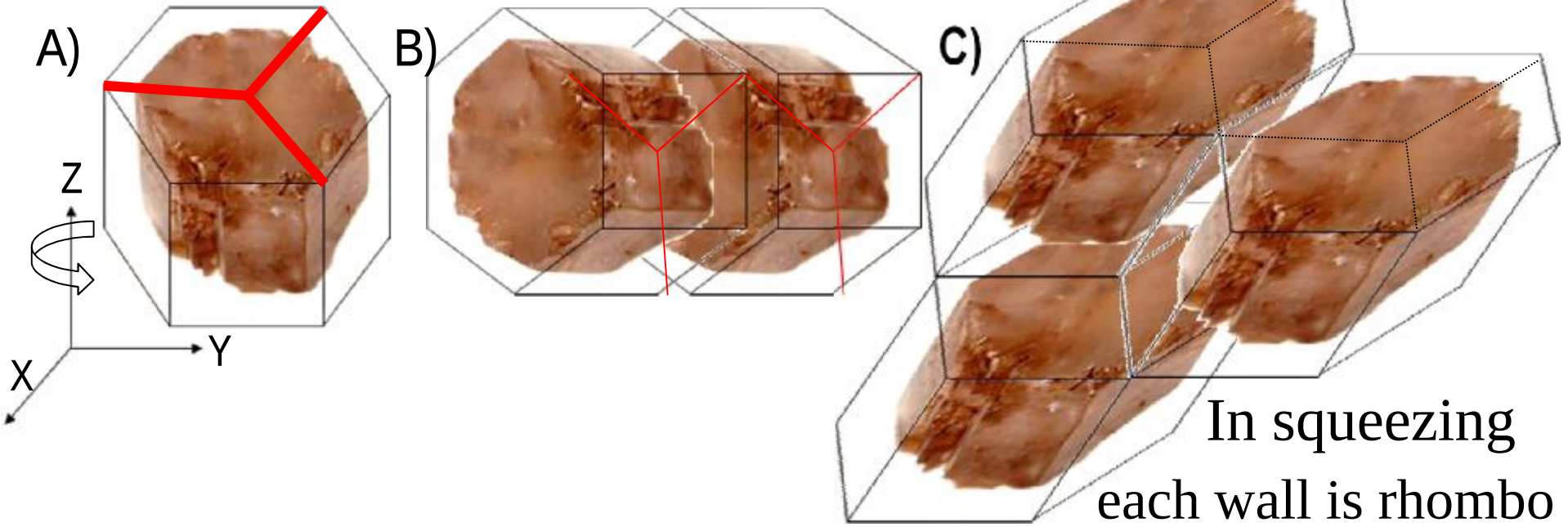
Aragonite crystallize precursors radially in the state of immobility

Pearl



Larval otolith

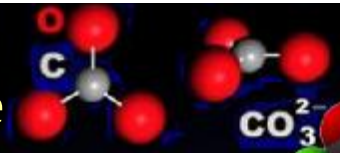
It crystallize in twinned Rhombohedrons filling with squeezing the pattern of space of collagen net.



In squeezing each wall is rhombo

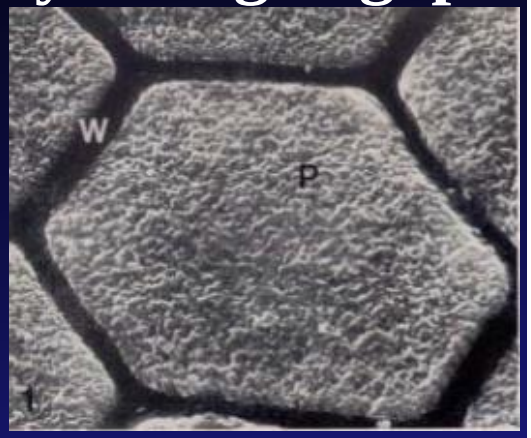
Aragonite precipitates with the form, size & orientation determined by collagen gaps.

CO_3^{-2} chelate anion



Ca^{+2} form tetrahedrons with CO_3^{-2} as base
2 layers CO_3^{-2} on 1 Ca^{+2}

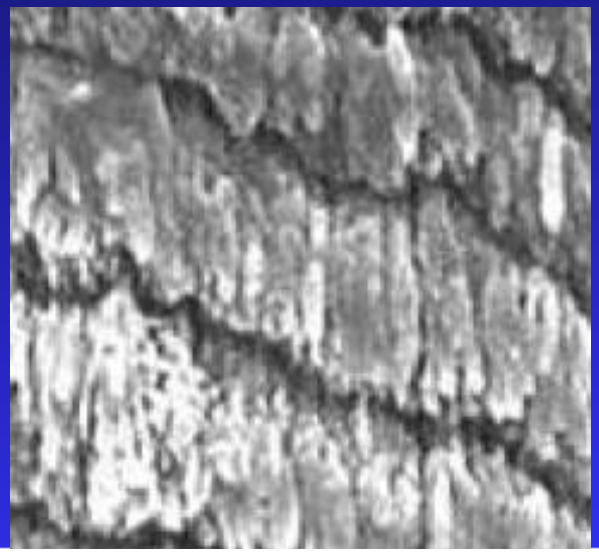
Plates

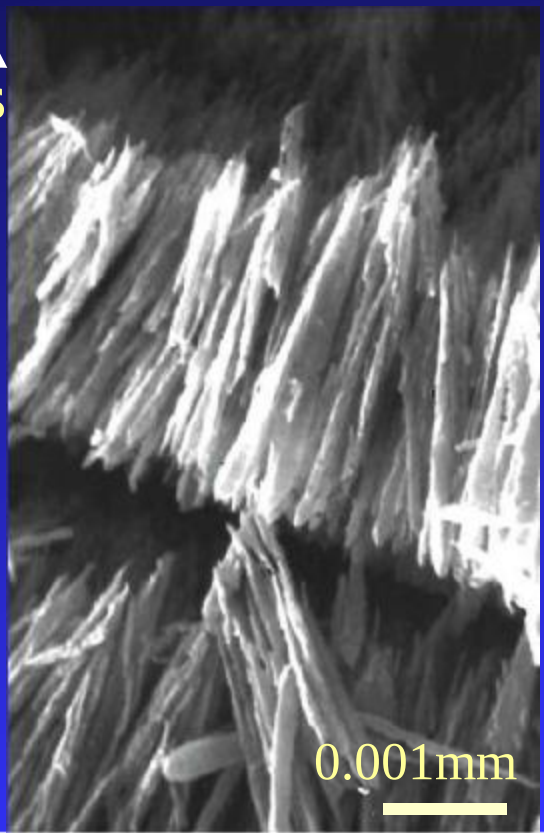


Needles

Hairs

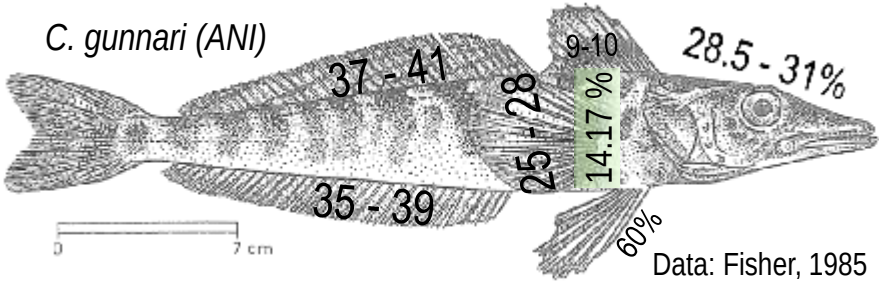
Tablets





Thanks to plascity of aragonite crystals the collagen arrangament obtained by acoustic oscillation contein their information. That informations are transferred via otolith aragonite to hair cells & brain. Became passages for overcame obstacles

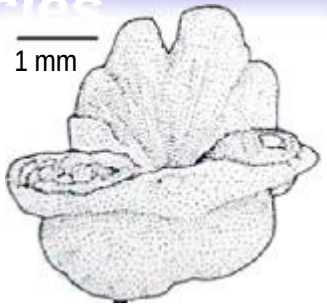
C. gunnari (ANI)



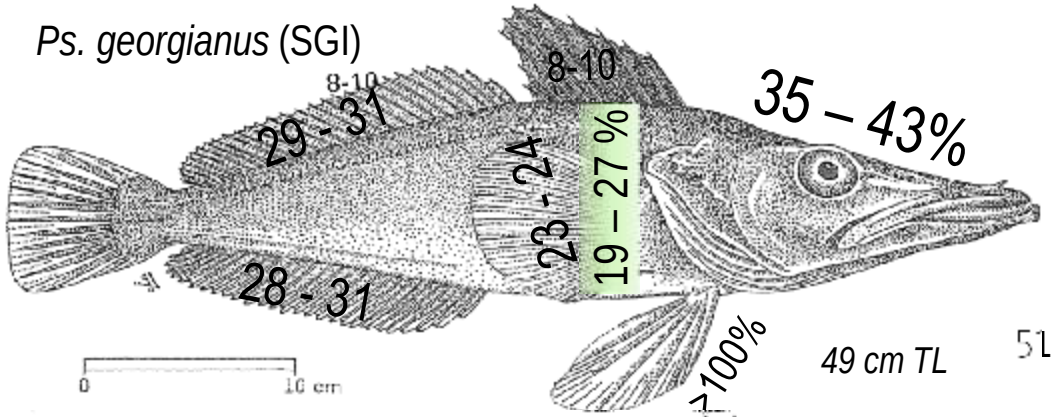
Data: Fisher, 1985

The smaller are pelagic

34 cm TL



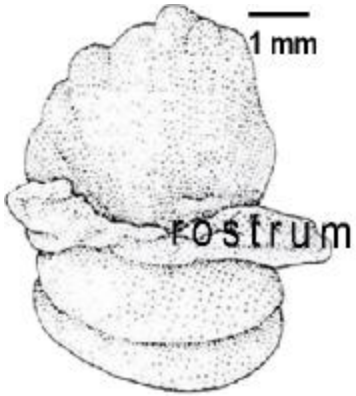
Ps. georgianus (SGI)



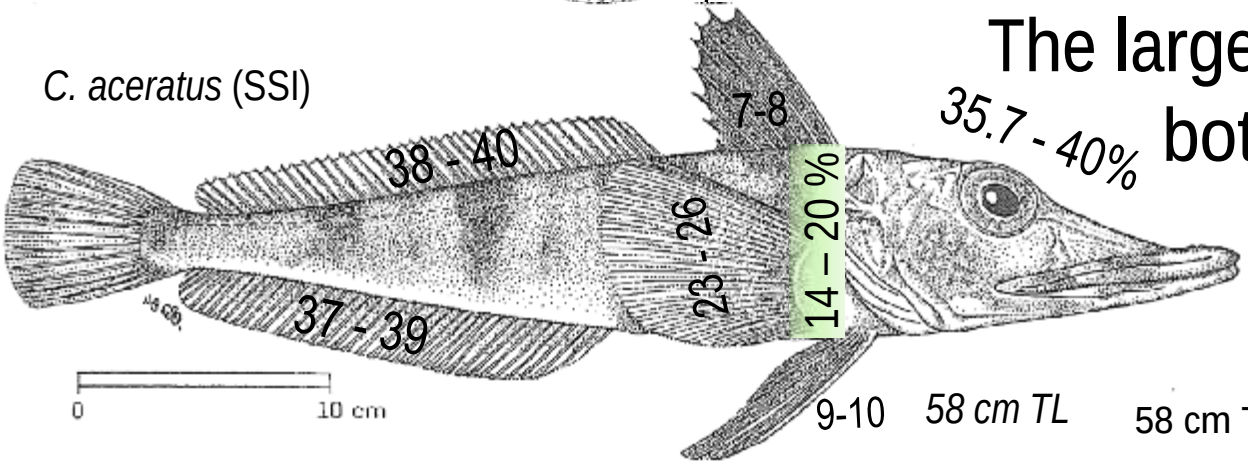
The higher are semipelagic

49 cm TL

51 cm TL, age group +IV



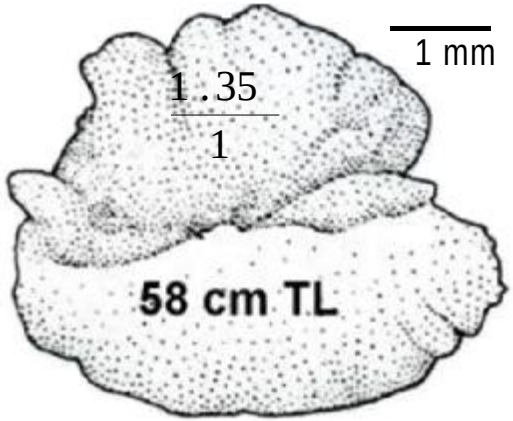
C. aceratus (SSI)



The larger are bottom

9-10 *58 cm TL*

58 cm TL, age group +VI



Conclusions

1. Extracellural growth of otolits is the base in the evolution for space acquisition with adaptation to environment changes.

2. Endolymph oscillations bearing environment & physiology information write them in otolith microstructure by ordering tropo-collagens & transfer to hearing.

3. At depth of about 200 m of sound canal all icefish species concentrate but they do not share the same places. In mesopelagic darkness they recognize themselves and their development stages inhabit seperated opposite sides and periods.

3. *Ps. georgianus* living in a dark in a currents recognize their 3-dim biotic & physics sound map and during evolution adapt to them its life cycle migrations.

4. Adults recognize in the dark krill adults concentrated by vertical whirls on North-East S. Georgia I, while young krill nauplius & calyoptis in deep currents bringing them from slope (2000 m) to shelf at depth to 500 m at South West.

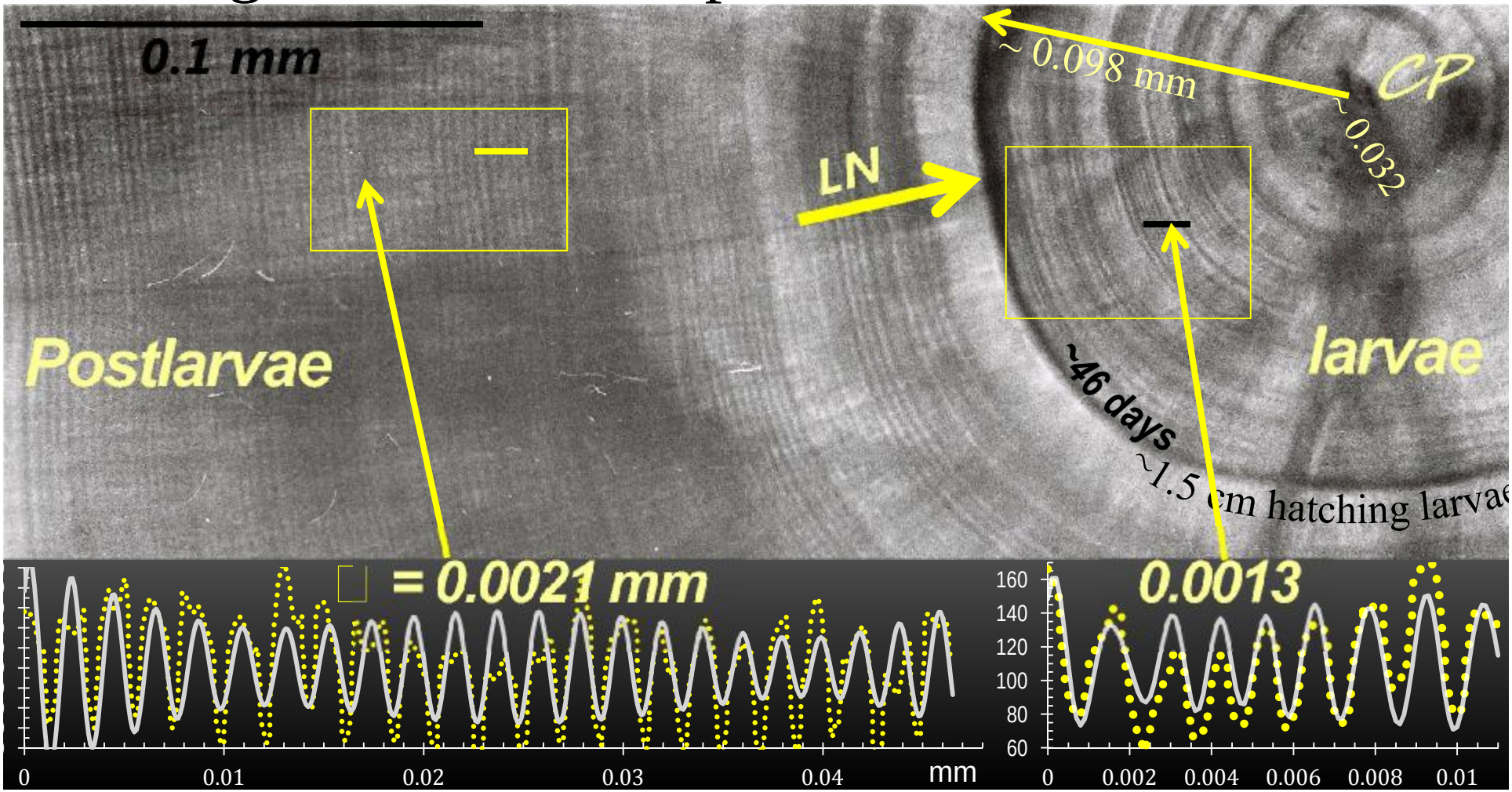
5. Young SGI developmental stages migrate in darkness from East to South to cold deep currents below 250 m for appropriate food size & faster body growth.

6. Unlike the other icefish, not postlarvae but adults of *Ps. georgianus* with sound passage migrate in the mezopelagic darkness to neighbor islands.

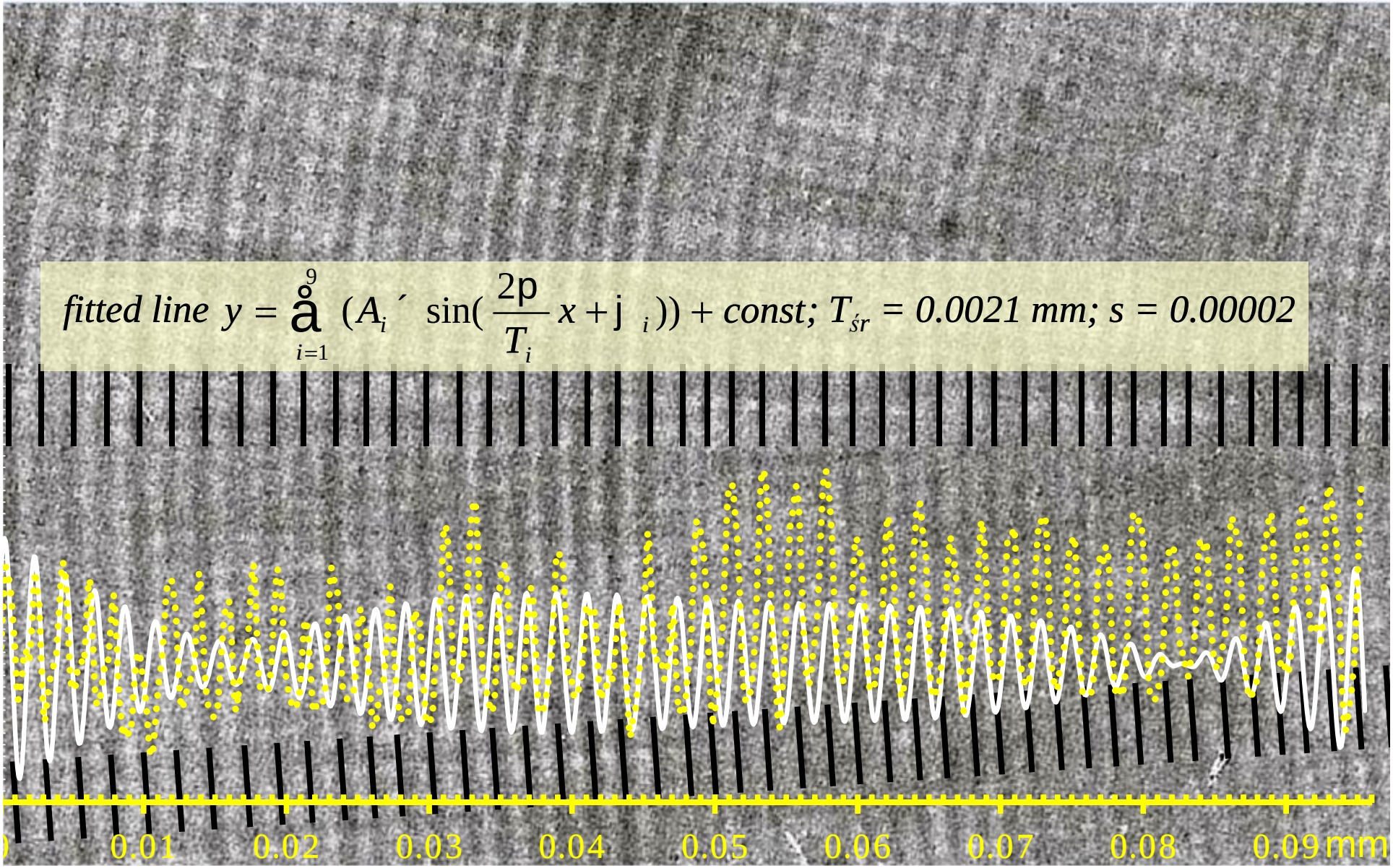
7. In warm years SSI exchange SGI at the bottom on North East, while ANI increase schooling in mezopelagic appropriate to recognized organization level on krill swarms.

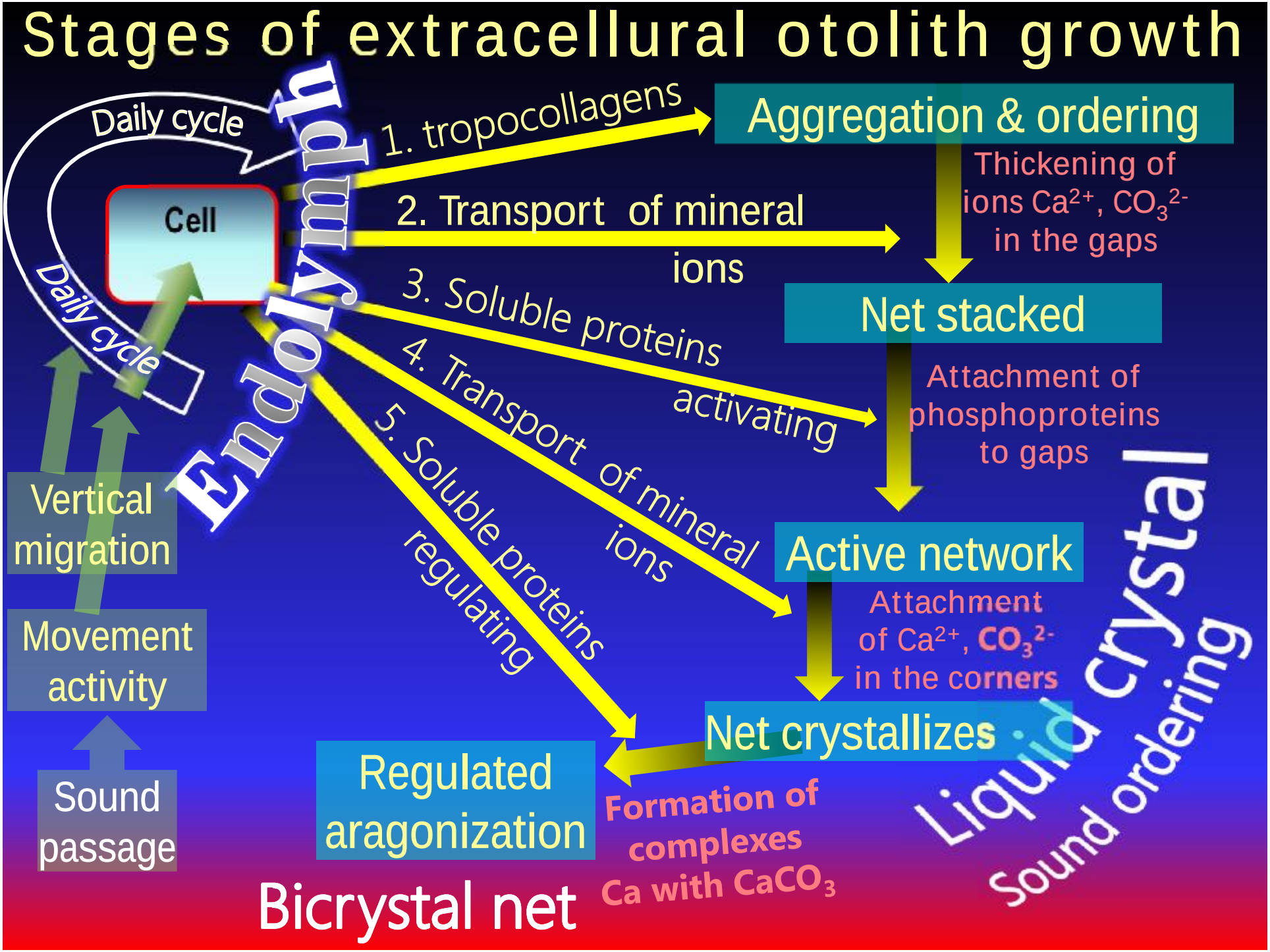
Question: ryszardtraczyk@gmail.com

Discover and measurements:
The size of microvilli that percept low Hz
is the same as size of tropocollagens - components of collagen like otoliths protein



Collagen net measured by harmonic functions




Stages of extracellural otolith growth
Daily cycle
Cell
Daily cycle
Endolymph
1. tropocollagens
Aggregation & ordering
Thickening of ions Ca^{2+}, CO_3^{2-} in the gaps
2. Transport of mineral ions
Net stacked
3. Soluble proteins activating
Attachment of phosphoproteins to gaps
4. Transport of mineral ions
5. Soluble proteins regulating
Active network
Attachment of Ca^{2+}, CO_3^{2-} in the corners
Net crystallizes
Vertical migration
Movement activity
Sound passage
Regulated aragonization
Formation of complexes Ca with $CaCO_3$
Bicrystal net
Liquid crystal
Sound ordering