Fish Growth Rate Potential as a Quantitative Ecosystem Indicator of Habitat Quality

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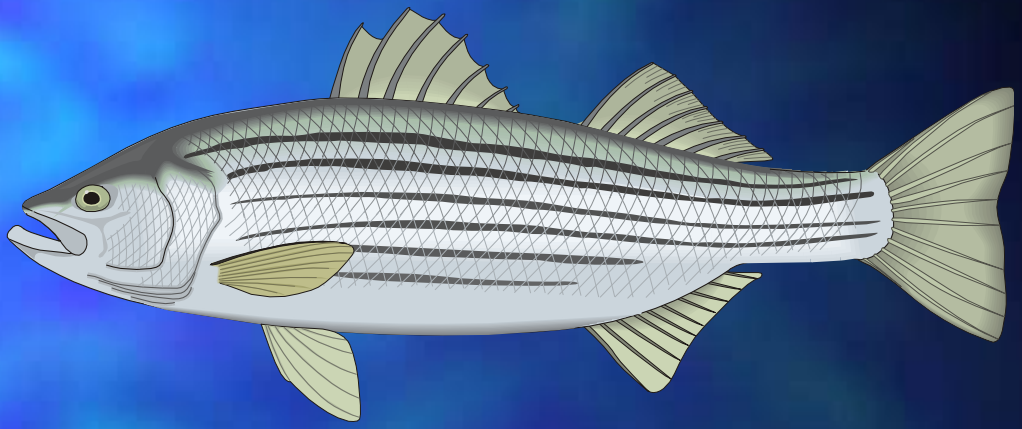
What is good habitat for a pelagic fish?

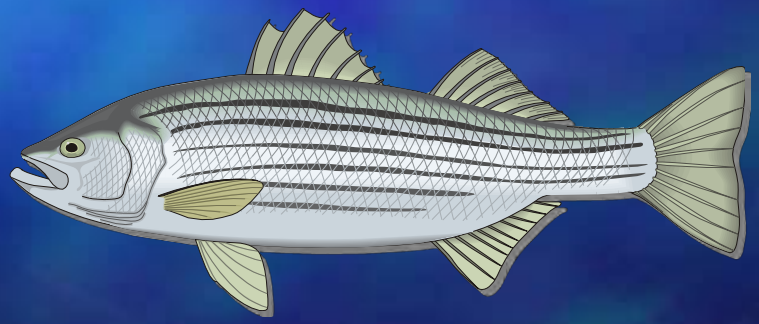


How can it be quantified and compared?

- Among species?
- Across physical and biological gradients?
- Across time and space?

Growth Rate Potential

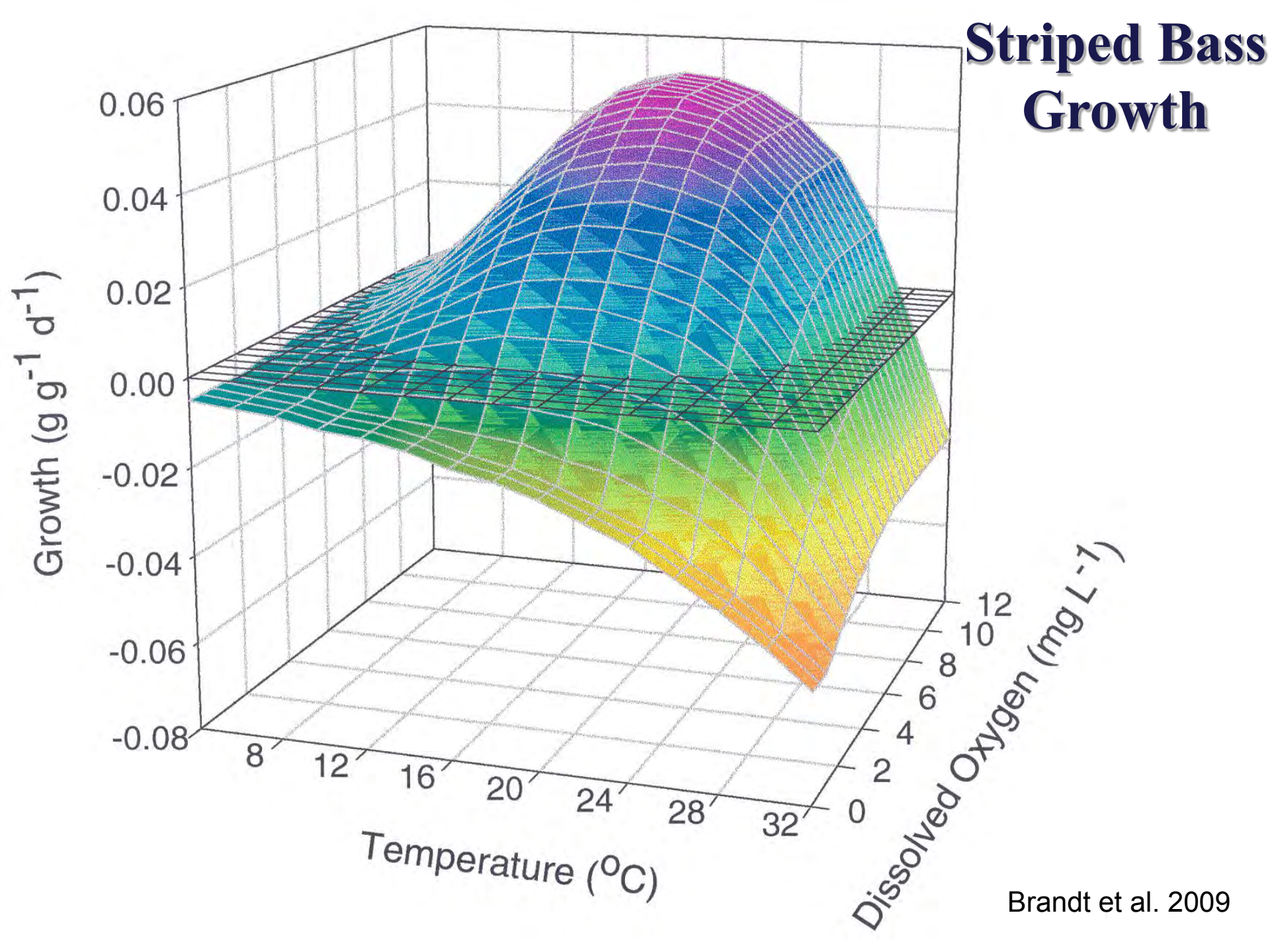
Expected daily growth rate of a fish if placed in a volume of water with known conditions such as prey type, prey size, prey density, temperature, oxygen and light



Fish Growth Rate Potential

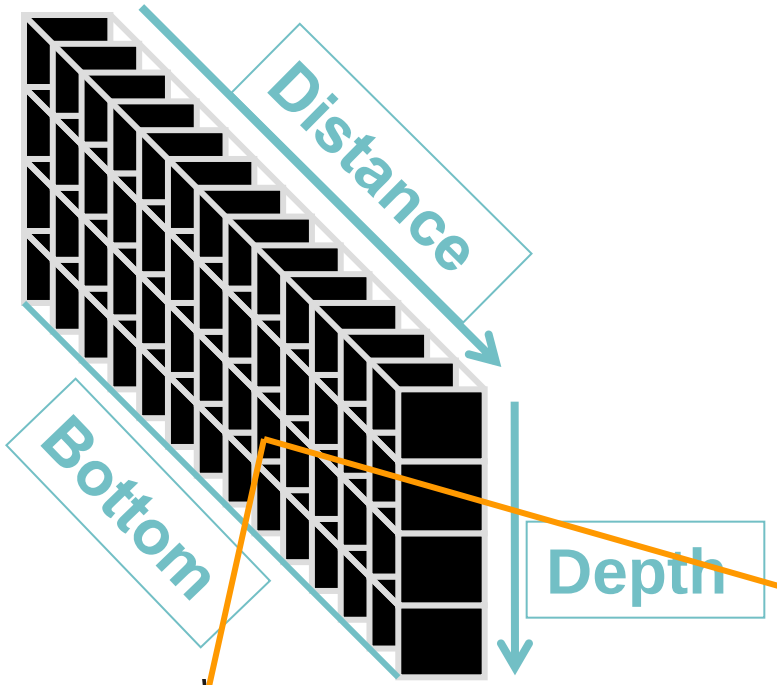
- Based on fish's requirements and prevailing environmental conditions
- Differs among species and life stages
- Includes physical and biological factors
- Varies in time and space
- Nonlinear response

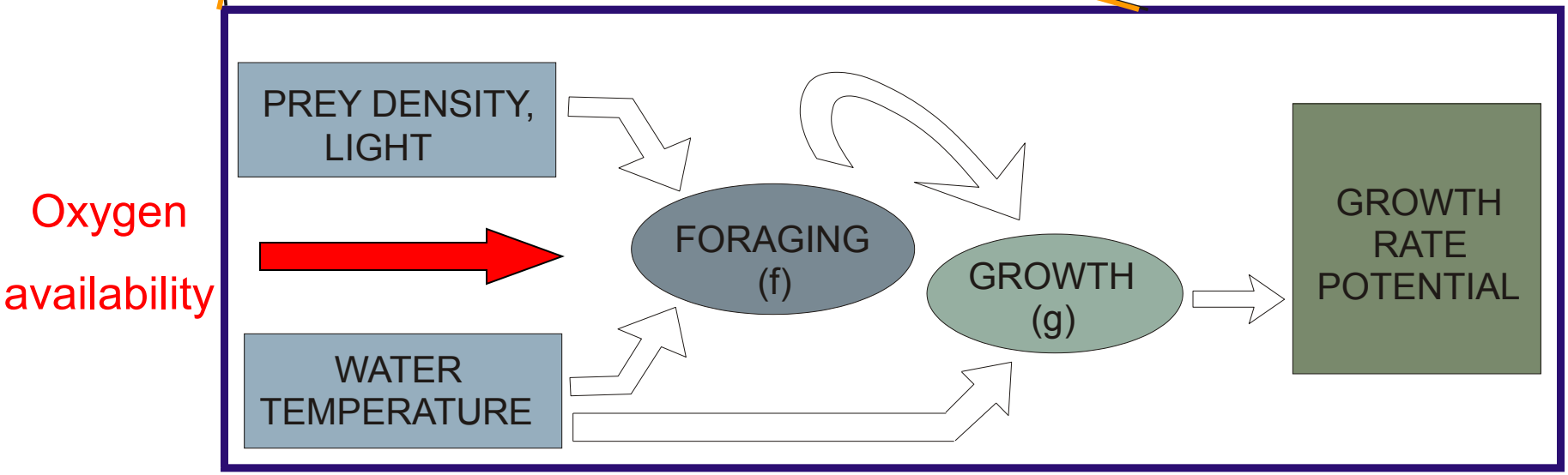
Striped Bass Growth



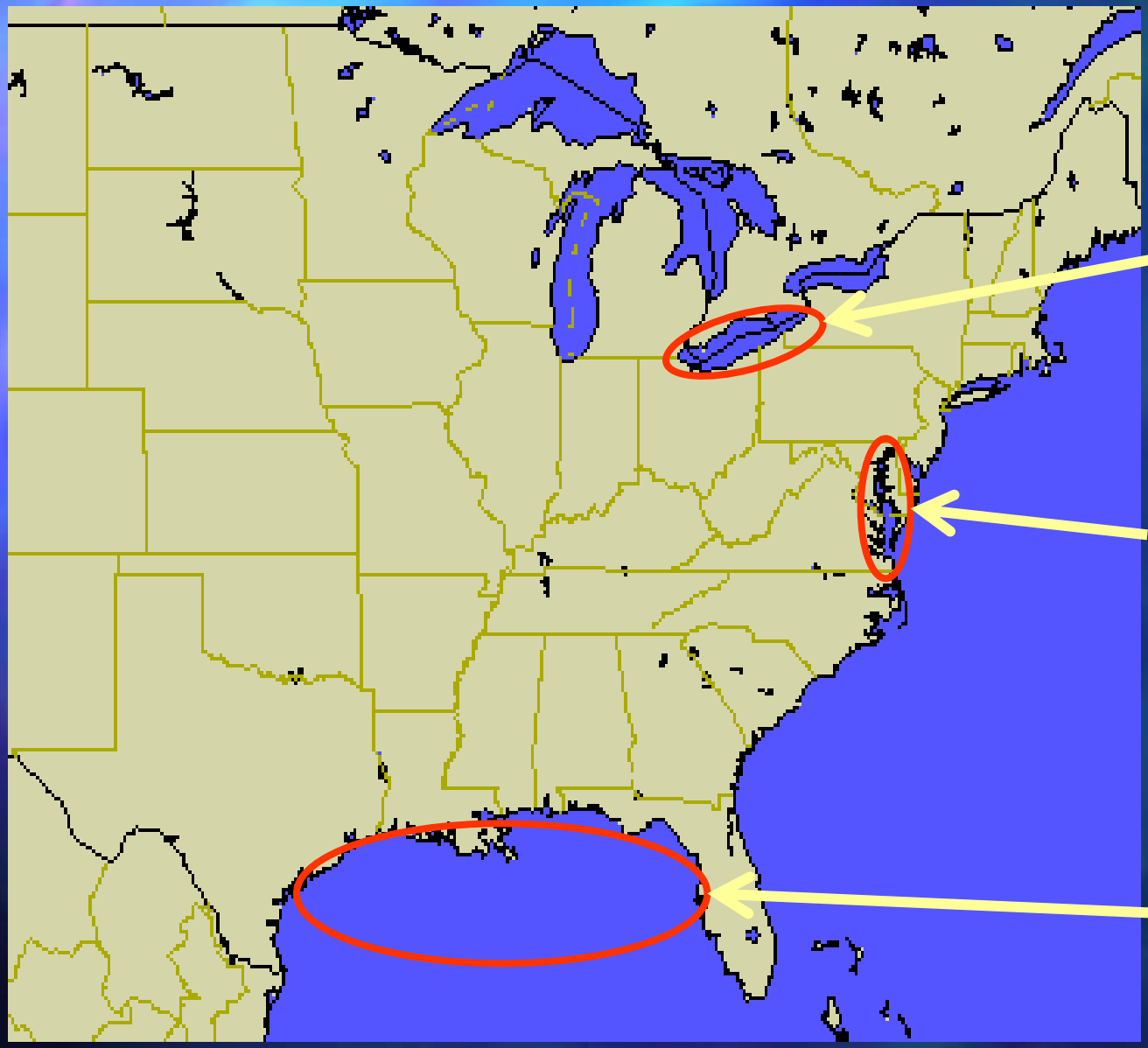
Brandt et al. 2009

Growth Rate Potential





Coastal "Dead Zones"

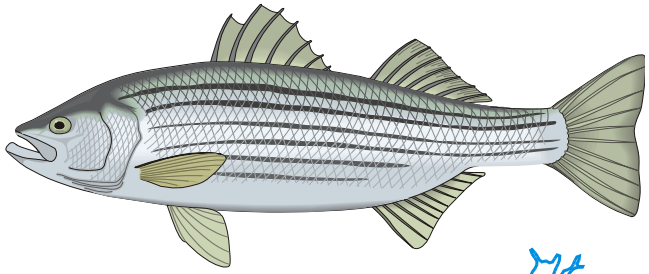


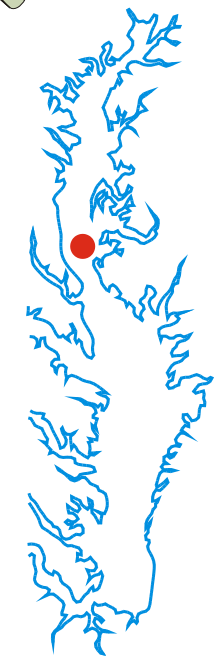
Lake Erie
up to 12,000 km^2

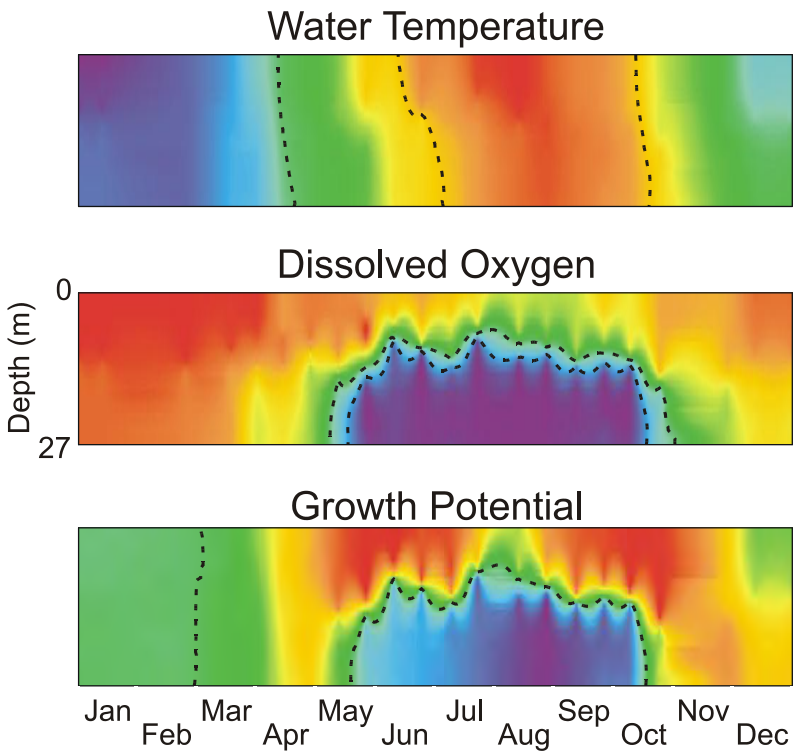
Chesapeake Bay
up to 10,000 km^2

Gulf of Mexico
6,000 to 20,000 km^2

Striped Bass Growth Potential
Mid-Chesapeake Bay

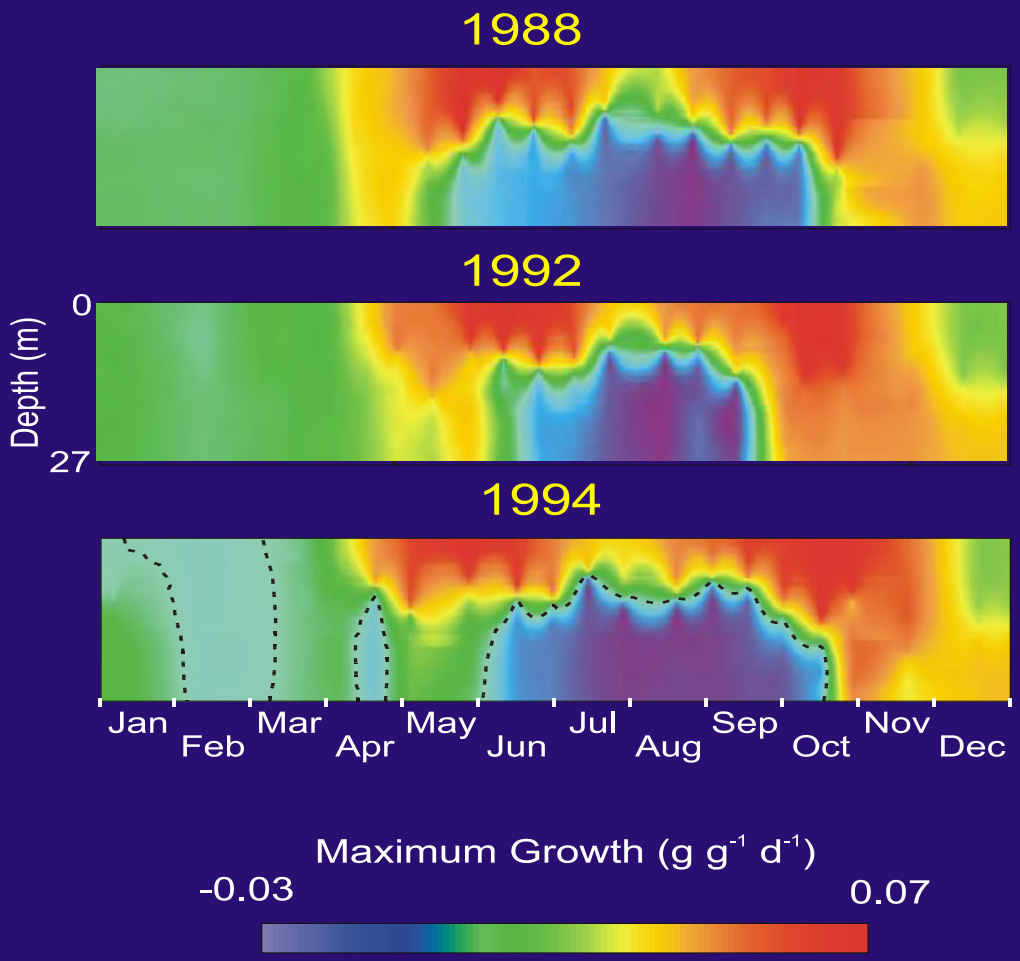




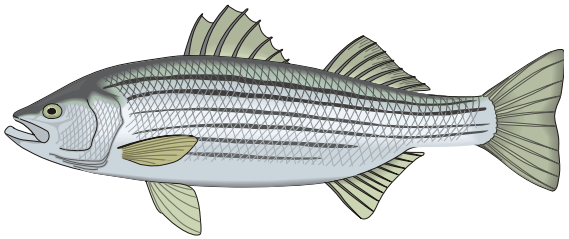


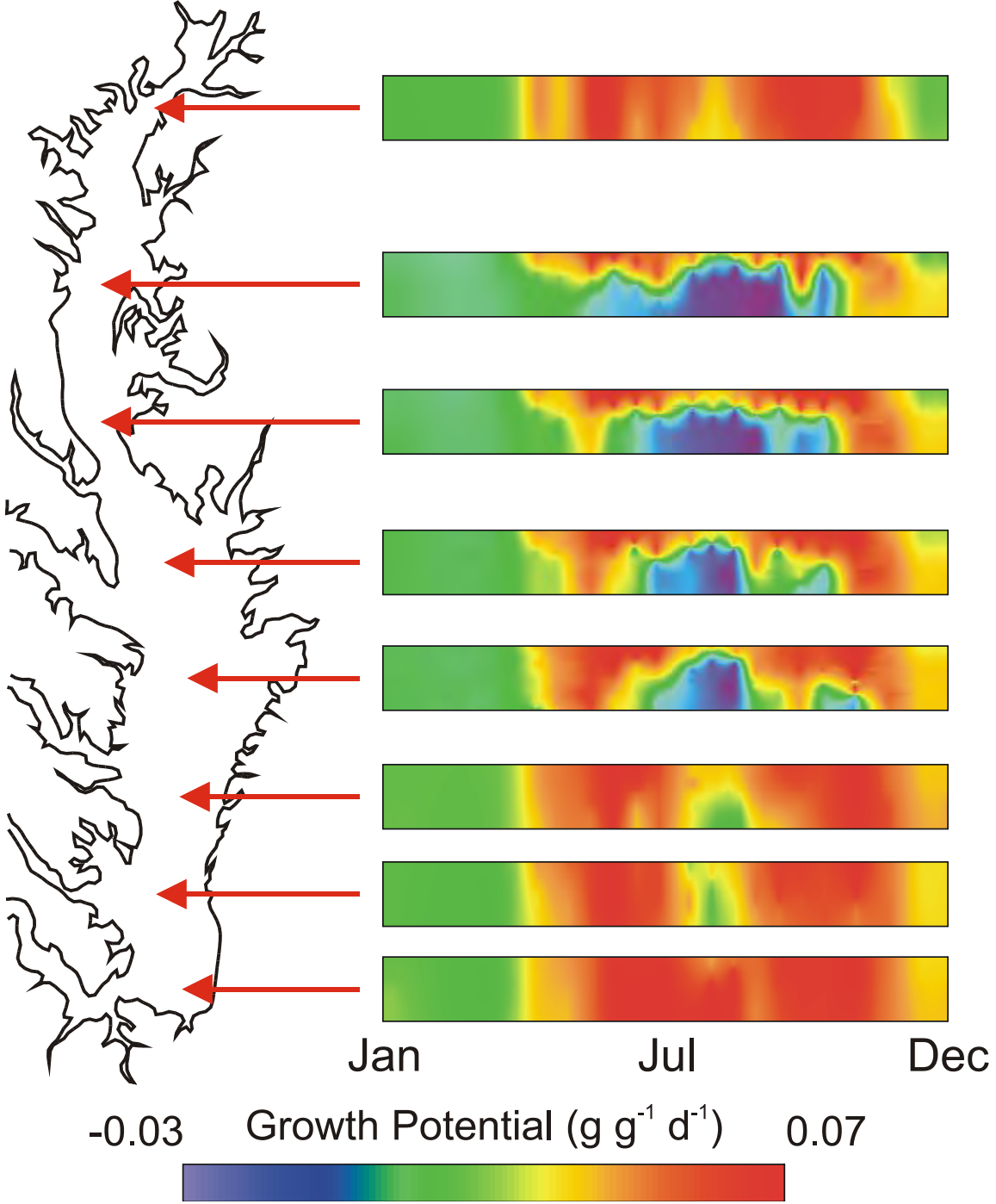
2	Temperature (°C)	26
0	Dissolved Oxygen (mg L^{-1})	12
-0.03	Maximum Growth (g g^{-1} d^{-1})	0.07

Striped Bass Growth Potential
Mid-Chesapeake Bay

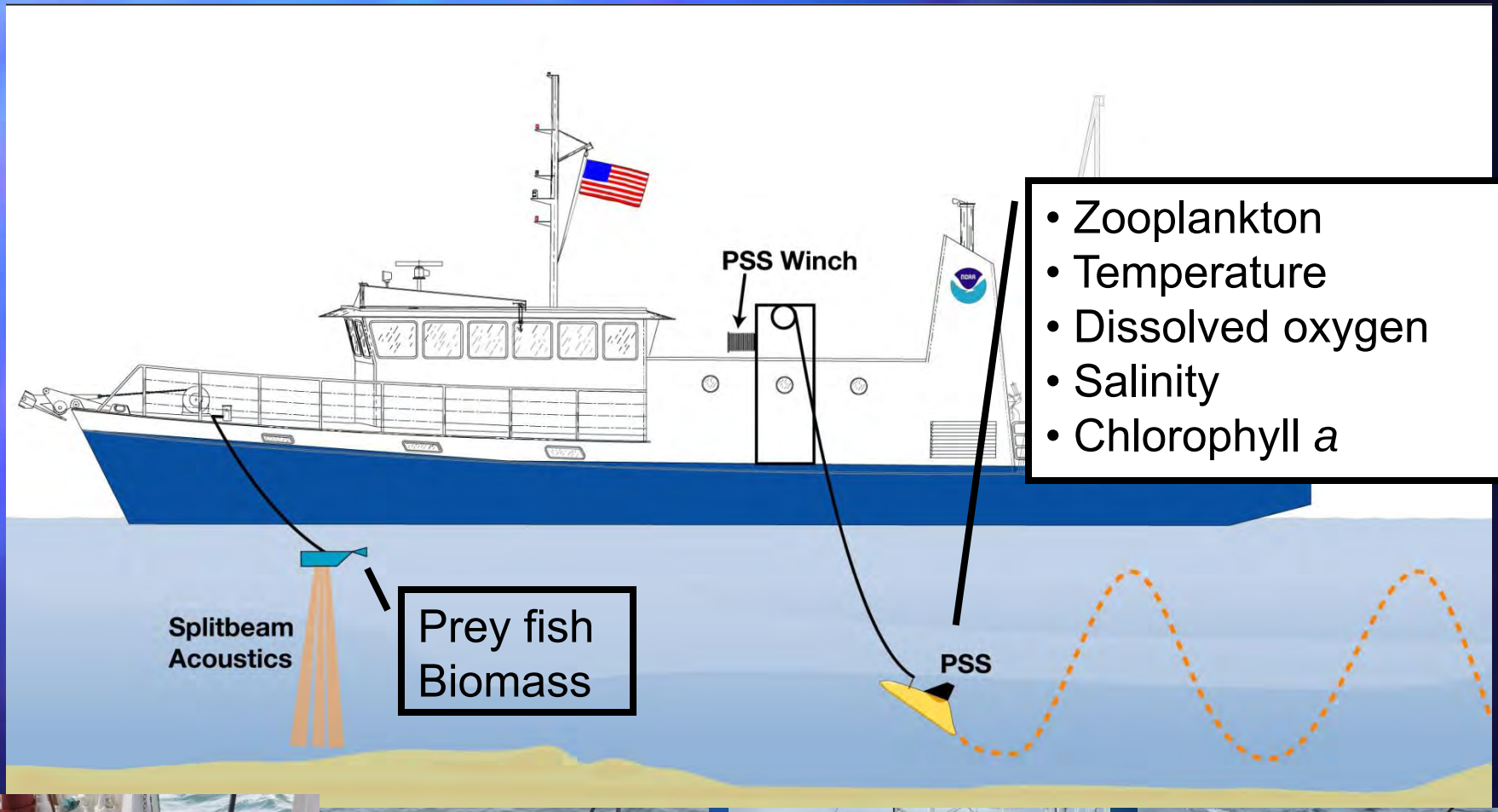


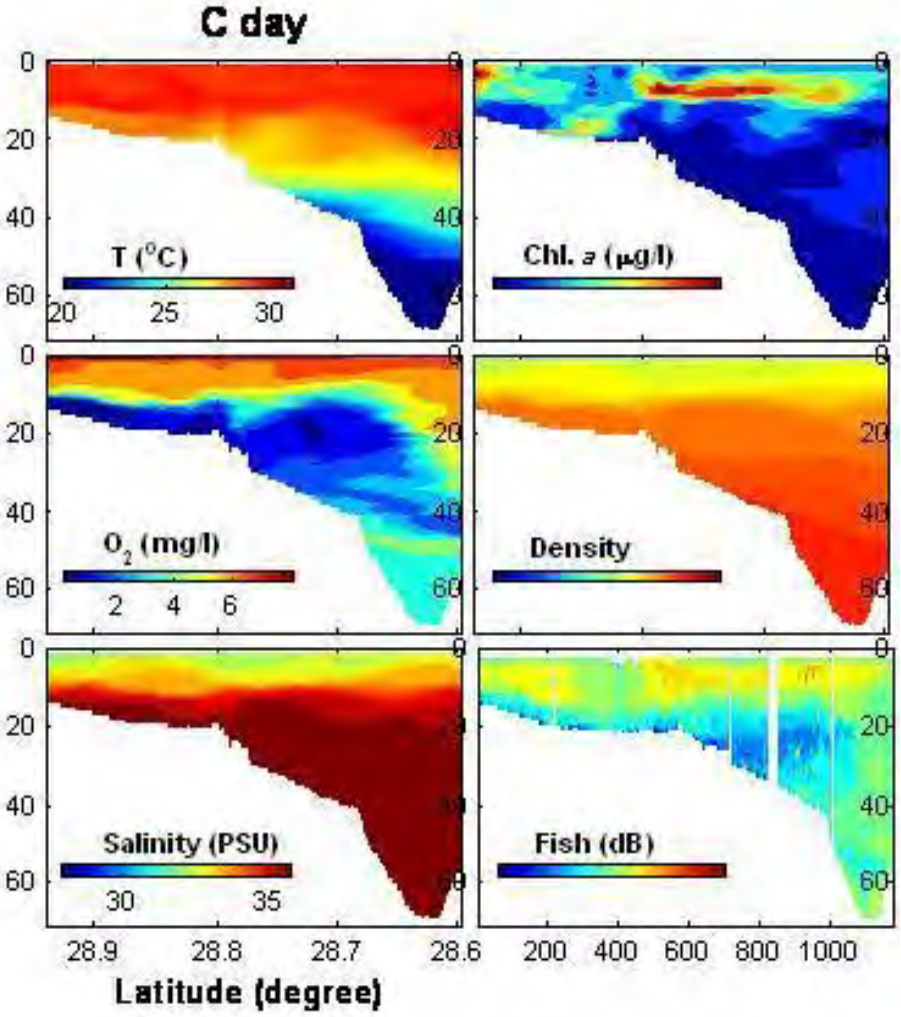
Striped Bass Annual Growth Pattern



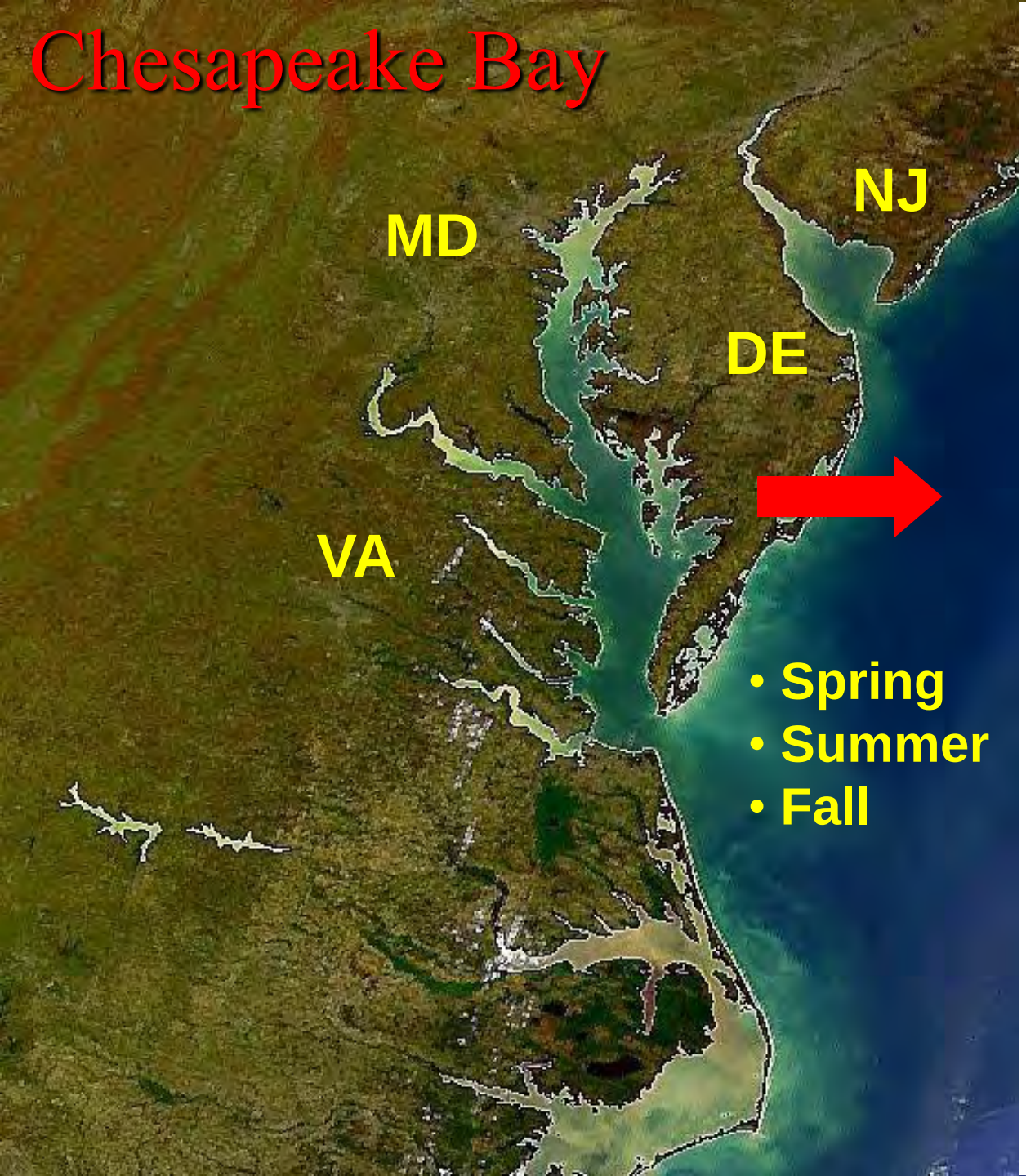


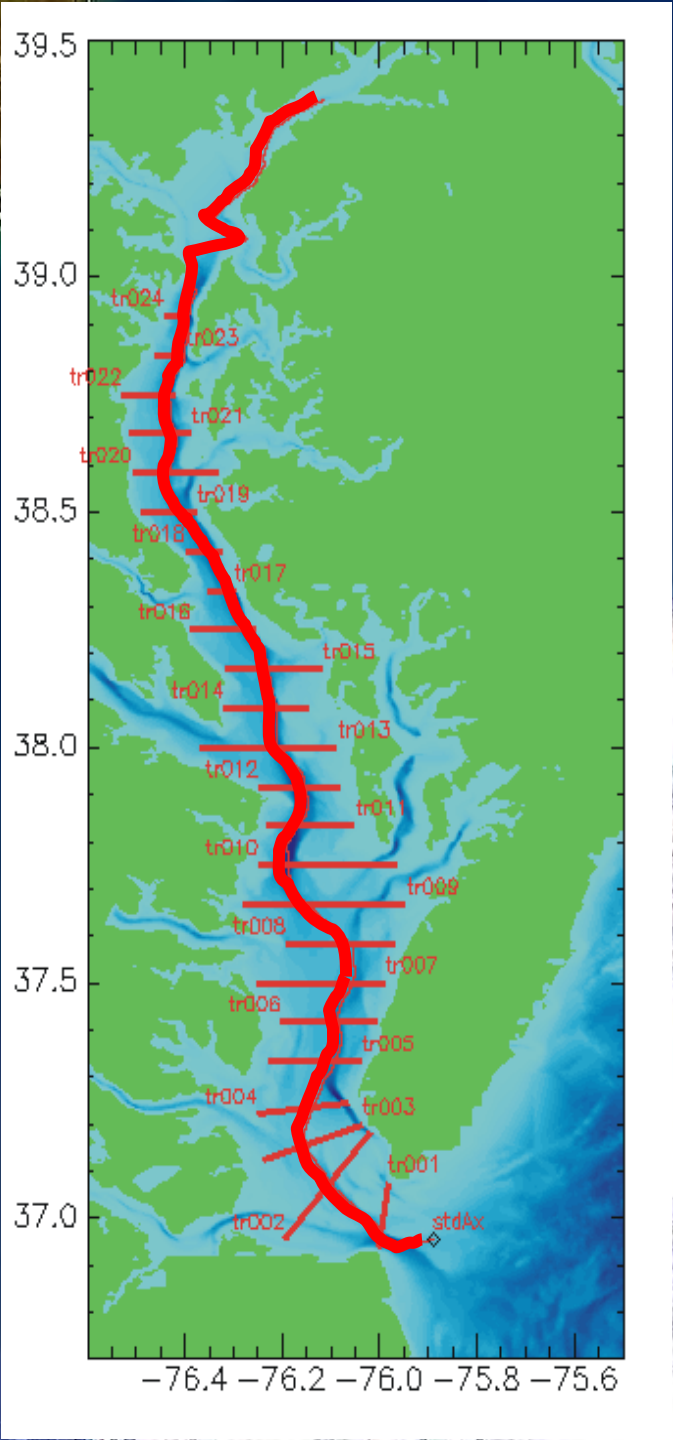
Baseline Field Sampling



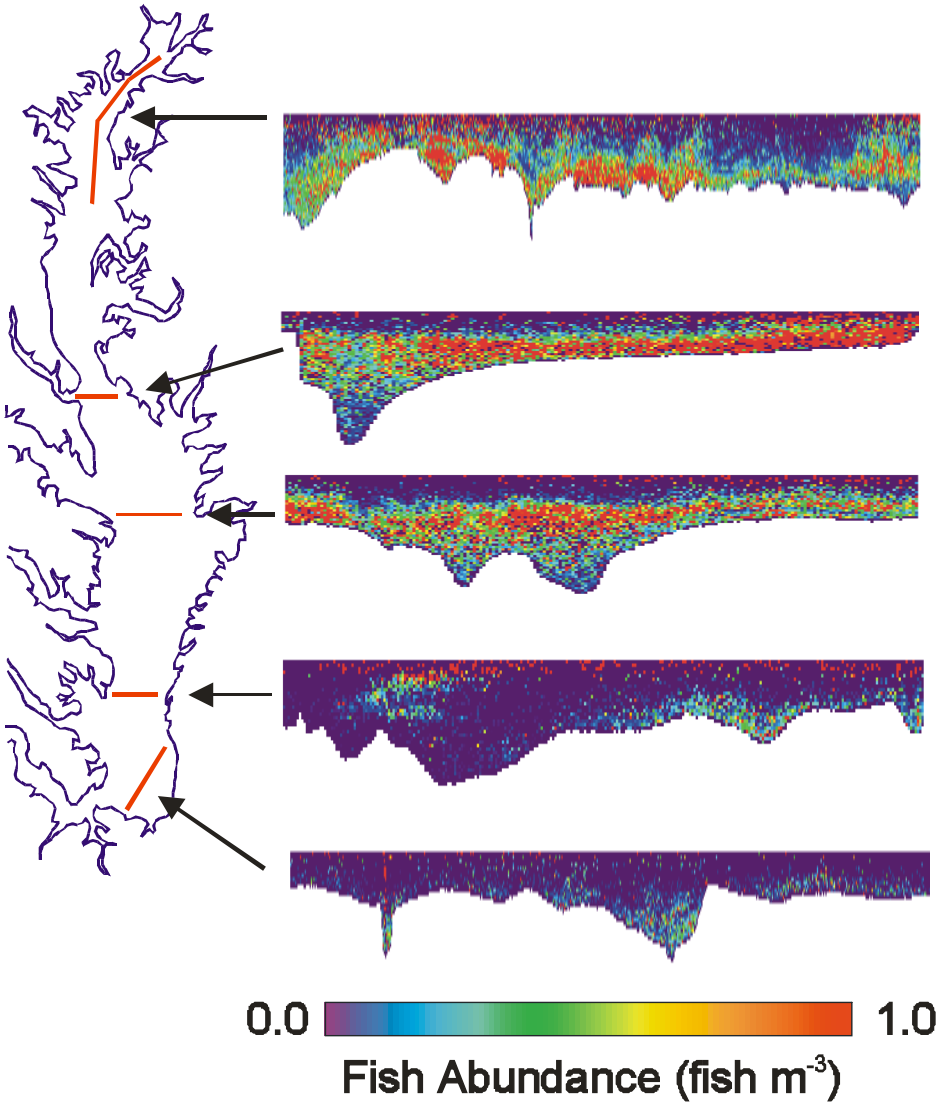

C day
T (°C)
20
25
30
Chl. a (µg/l)
O2 (mg/l)
2
4
6
Density
Salinity (PSU)
30
35
Fish (dB)
0
20
40
60
28.9
28.8
28.7
28.6
200
400
600
800
1000
Latitude (degree)

Chesapeake Bay

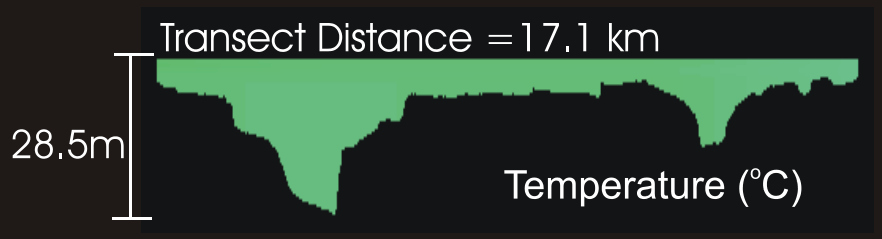


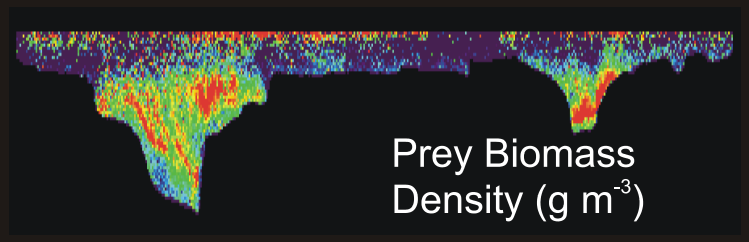


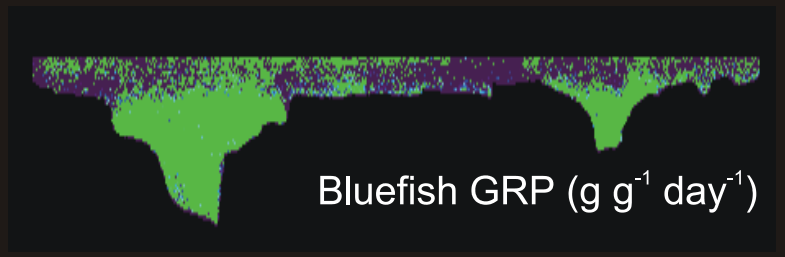
Acoustic Estimates of Fish Abundance from Selected Transects: October

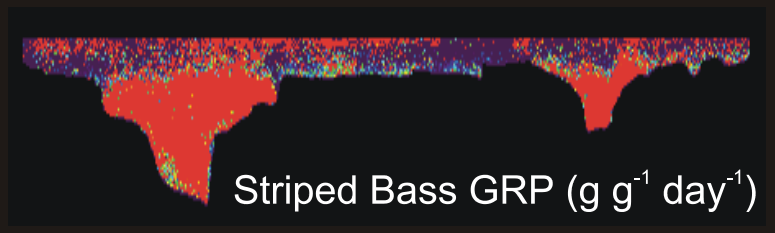


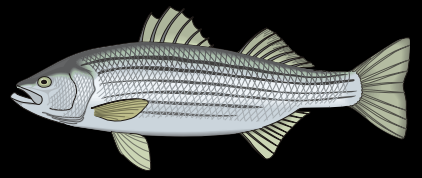
October [redacted] - Transect 010

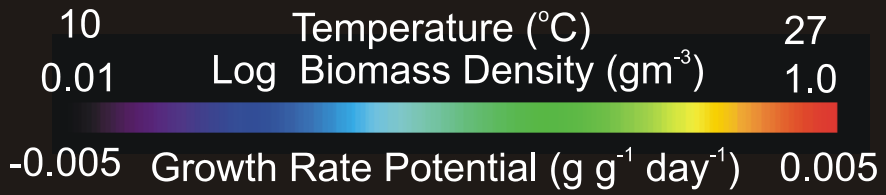






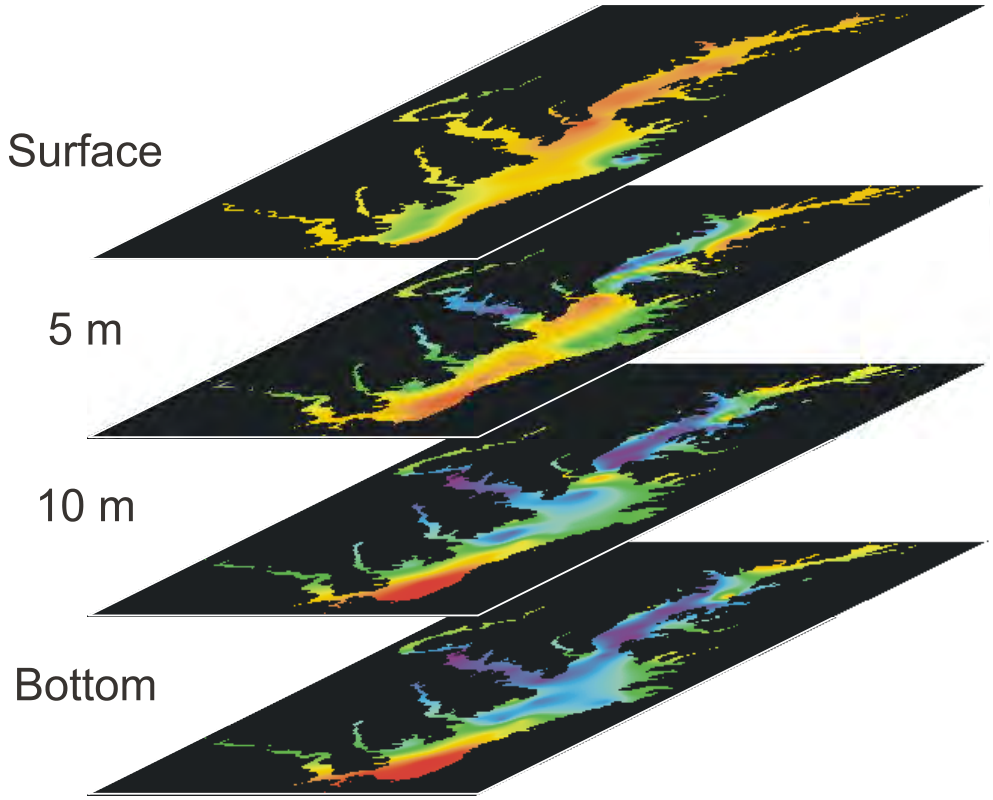




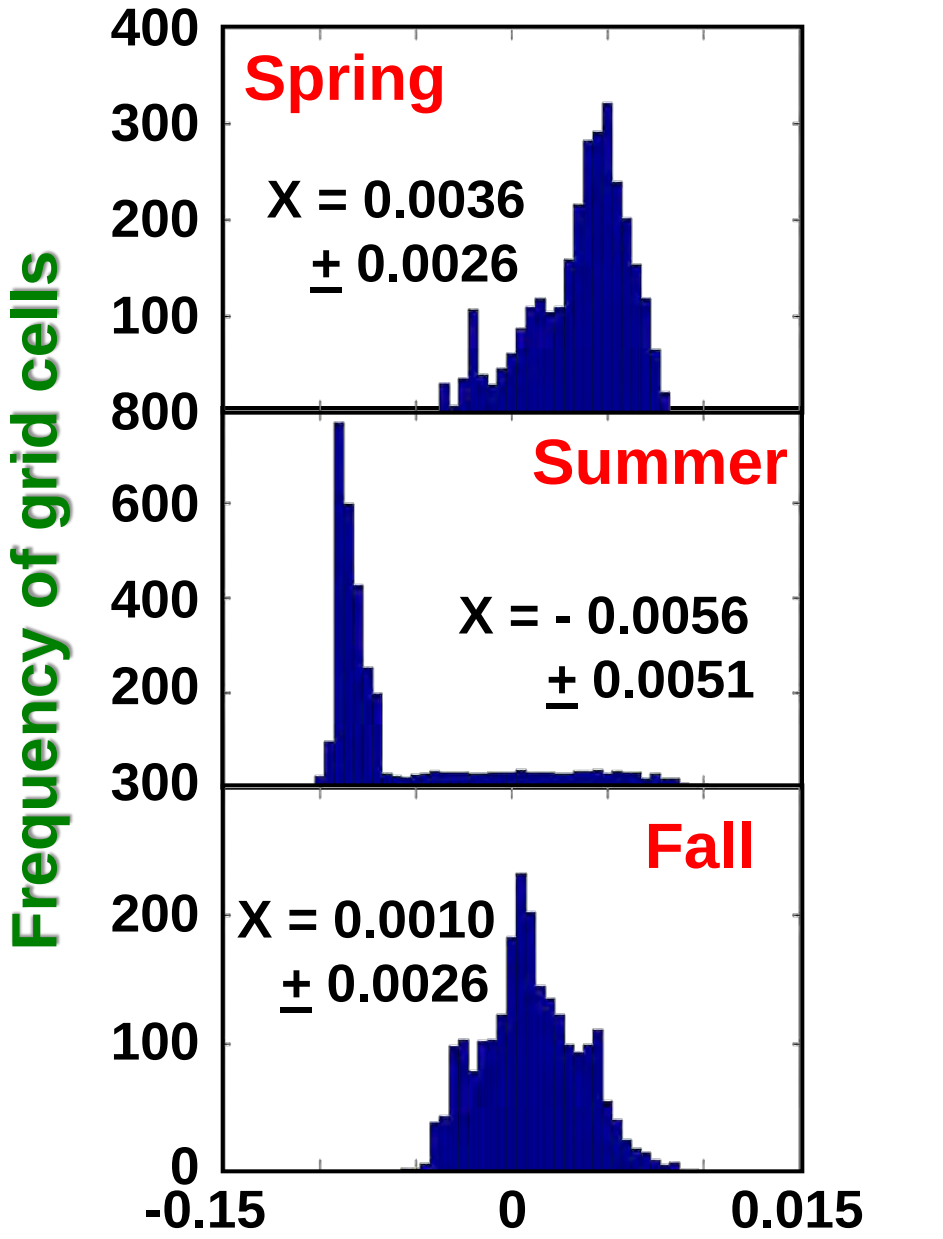


Striped Bass Potential Growth

Chesapeake Bay

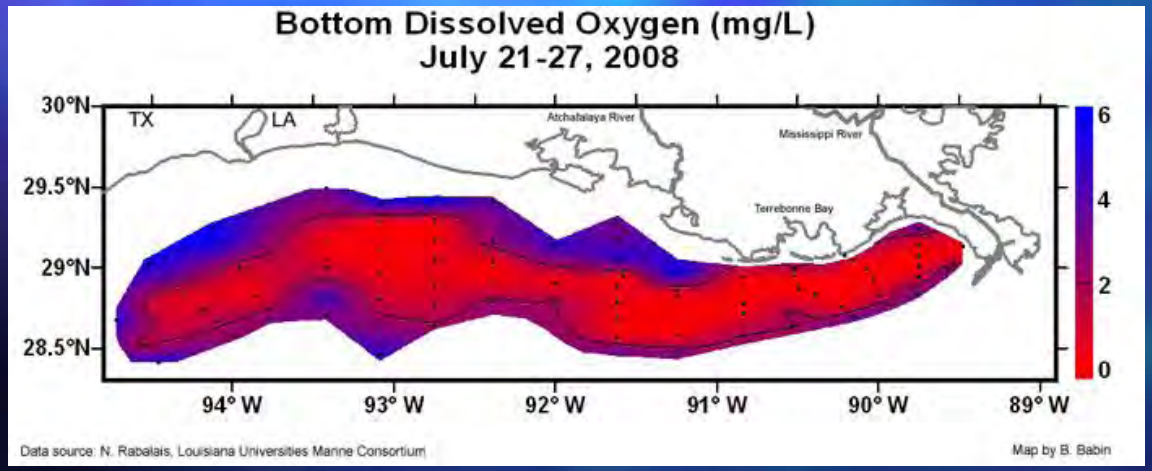


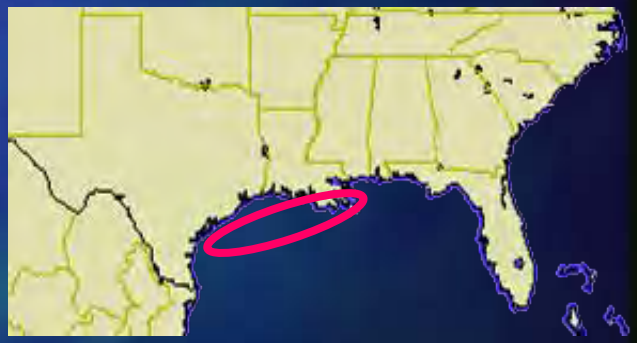
Results (mean GRP, g/g/d)



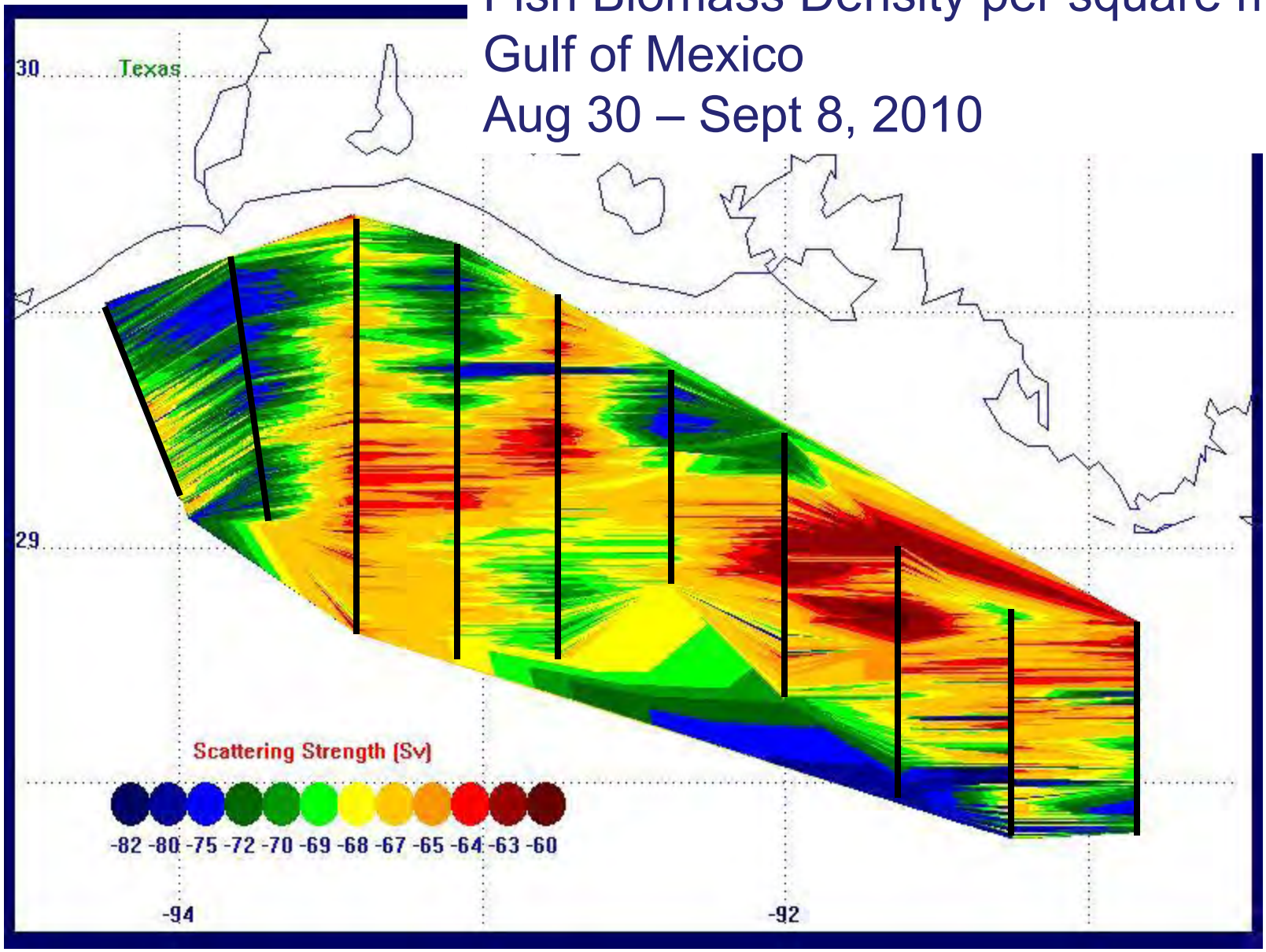
Northern Gulf of Mexico Hypoxia

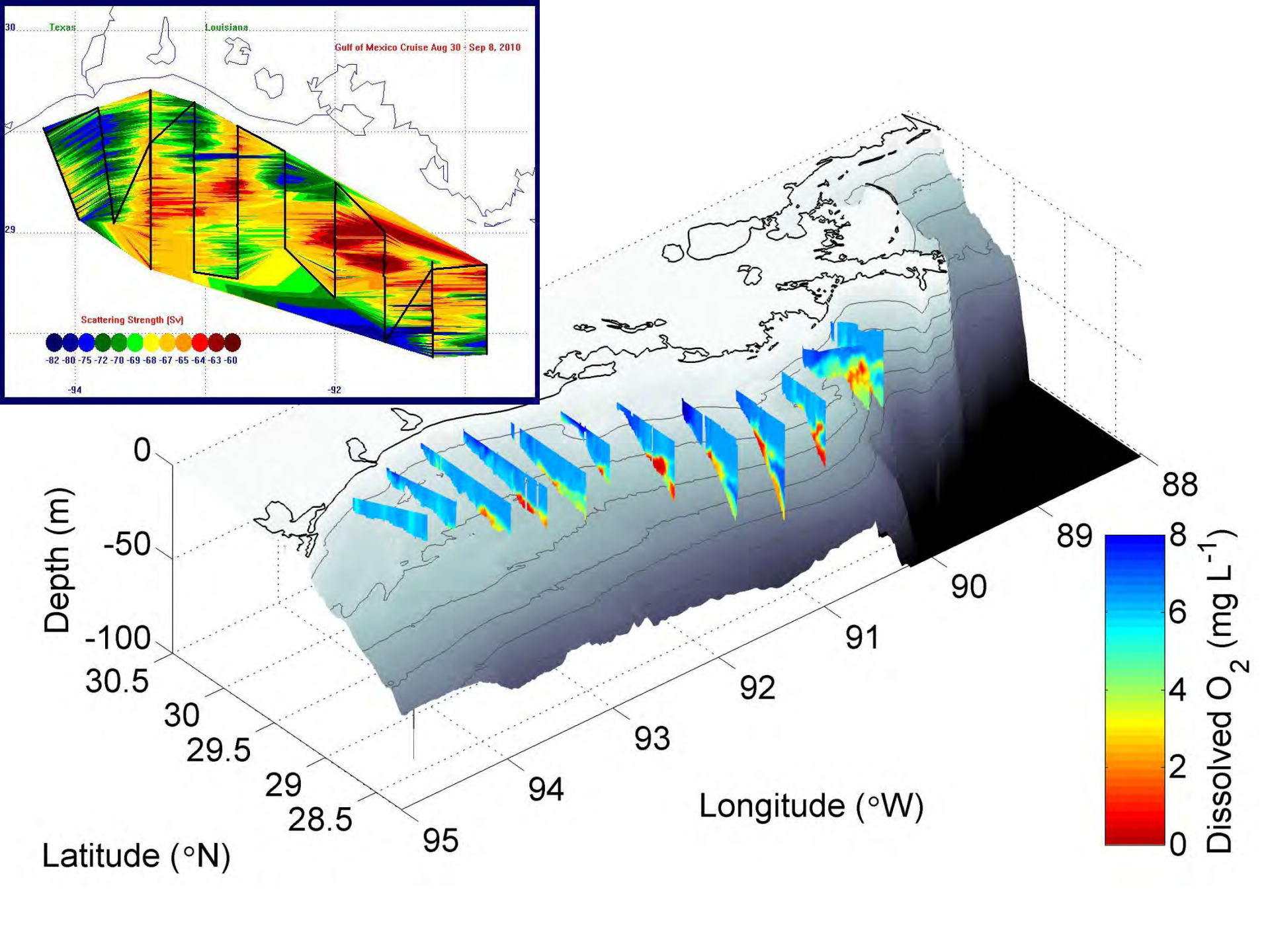
- Hypoxia occurs annually in the bottom waters of the Northern Gulf of Mexico
- Spatial extent averages ~ 16,000 – 20,000 km^2
- Typically occurs June - September

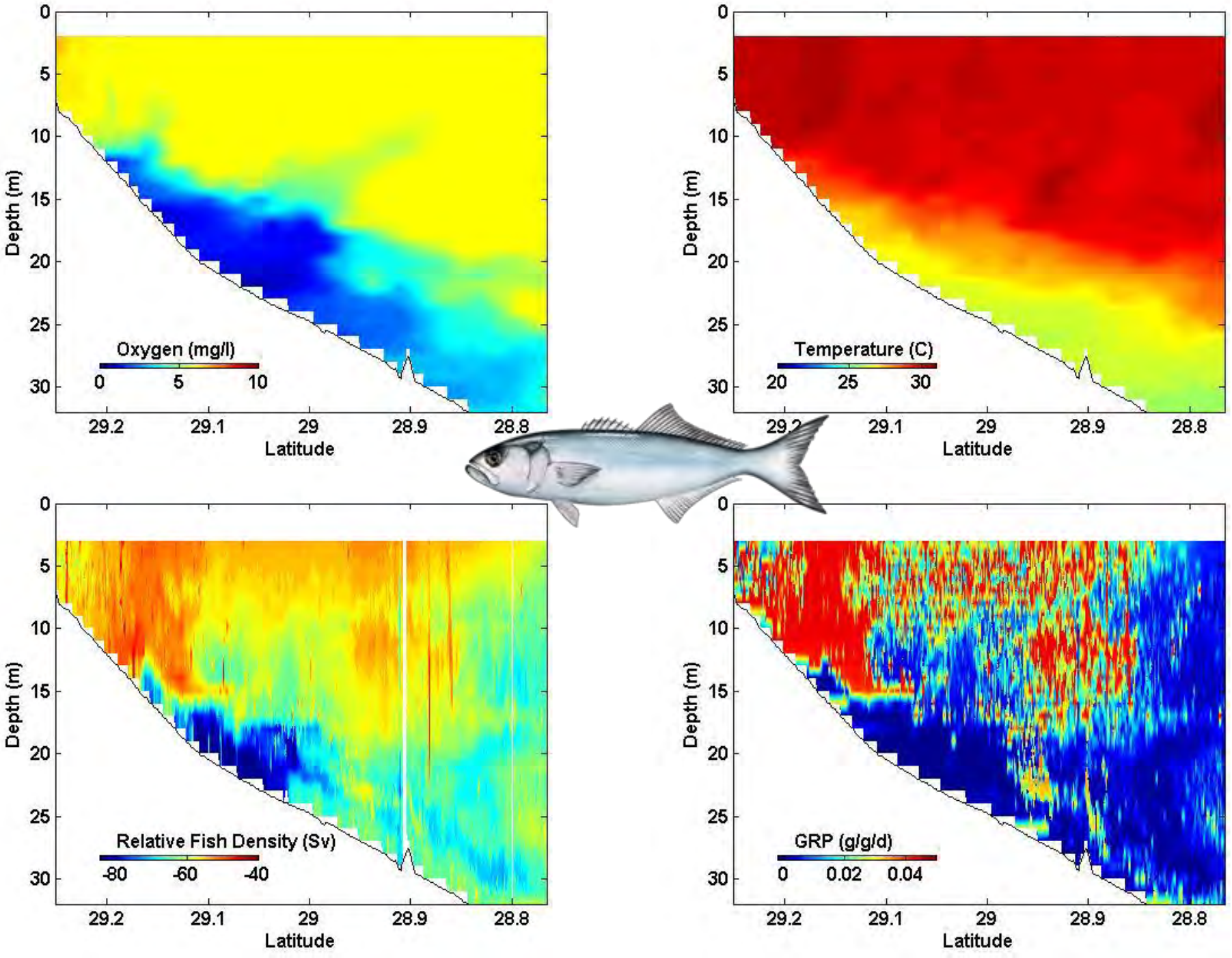


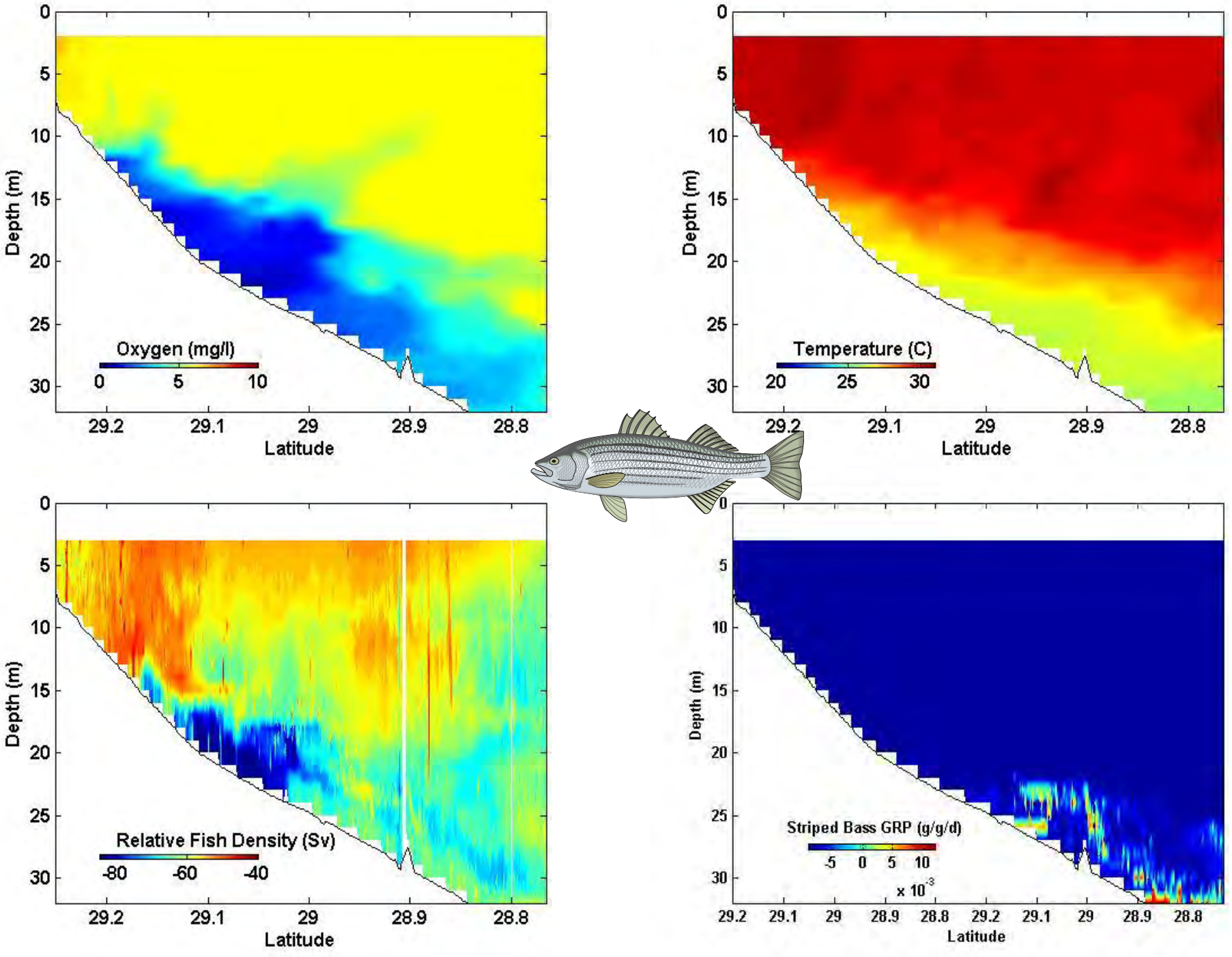


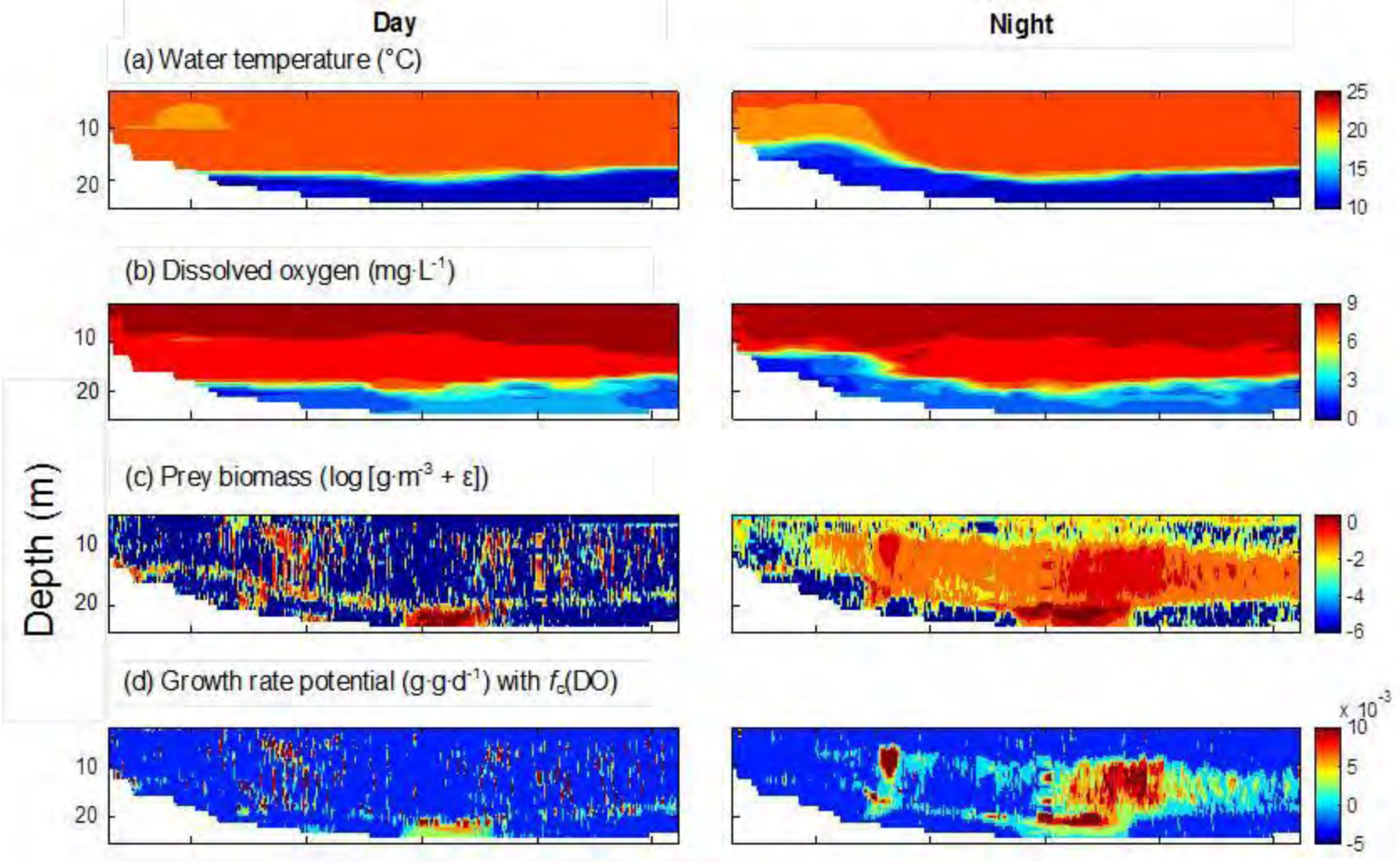
Fish Biomass Density per square meter
Gulf of Mexico
Aug 30 – Sept 8, 2010




Texas
Louisiana
Gulf of Mexico Cruise Aug 30 - Sep 8, 2010
30
29
-94
-92
Scattering Strength (Sv)
-82 -80 -75 -72 -70 -69 -68 -67 -65 -64 -63 -60
Depth (m)
0
-50
-100
30.5
30
29.5
29
28.5
Latitude (°N)
95
94
93
92
91
90
89
88
Longitude (°W)
Dissolved O_2 (mg L^{-1})
8
6
4
2
0


Depth (m)
Latitude
Oxygen (mg/l)
0
5
10
Temperature (C)
20
25
30
Relative Fish Density (Sv)
-80
-60
-40
GRP (g/g/d)
0
0.02
0.04
29.2
29.1
29
28.9
28.8


Depth (m)
Latitude
Oxygen (mg/l)
0 5 10
Temperature (C)
20 25 30
Relative Fish Density (Sv)
-80 -60 -40
Striped Bass GRP (g/g/d)
-5 0 5 10
x 10^-3
29.2 29.1 29 28.9 28.8



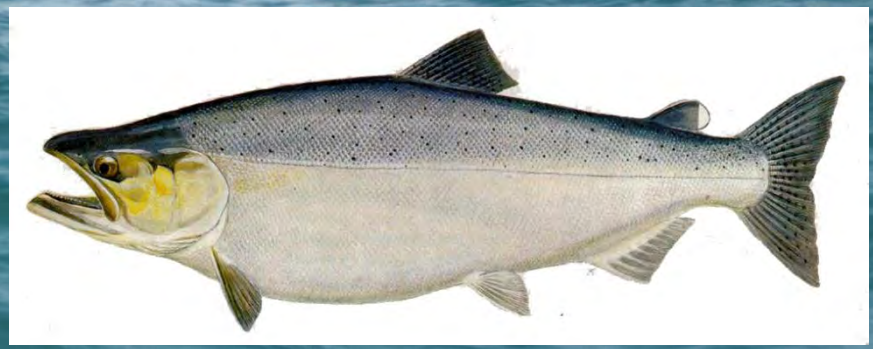
Walleye
Lake Erie

Brandt et al. 2011

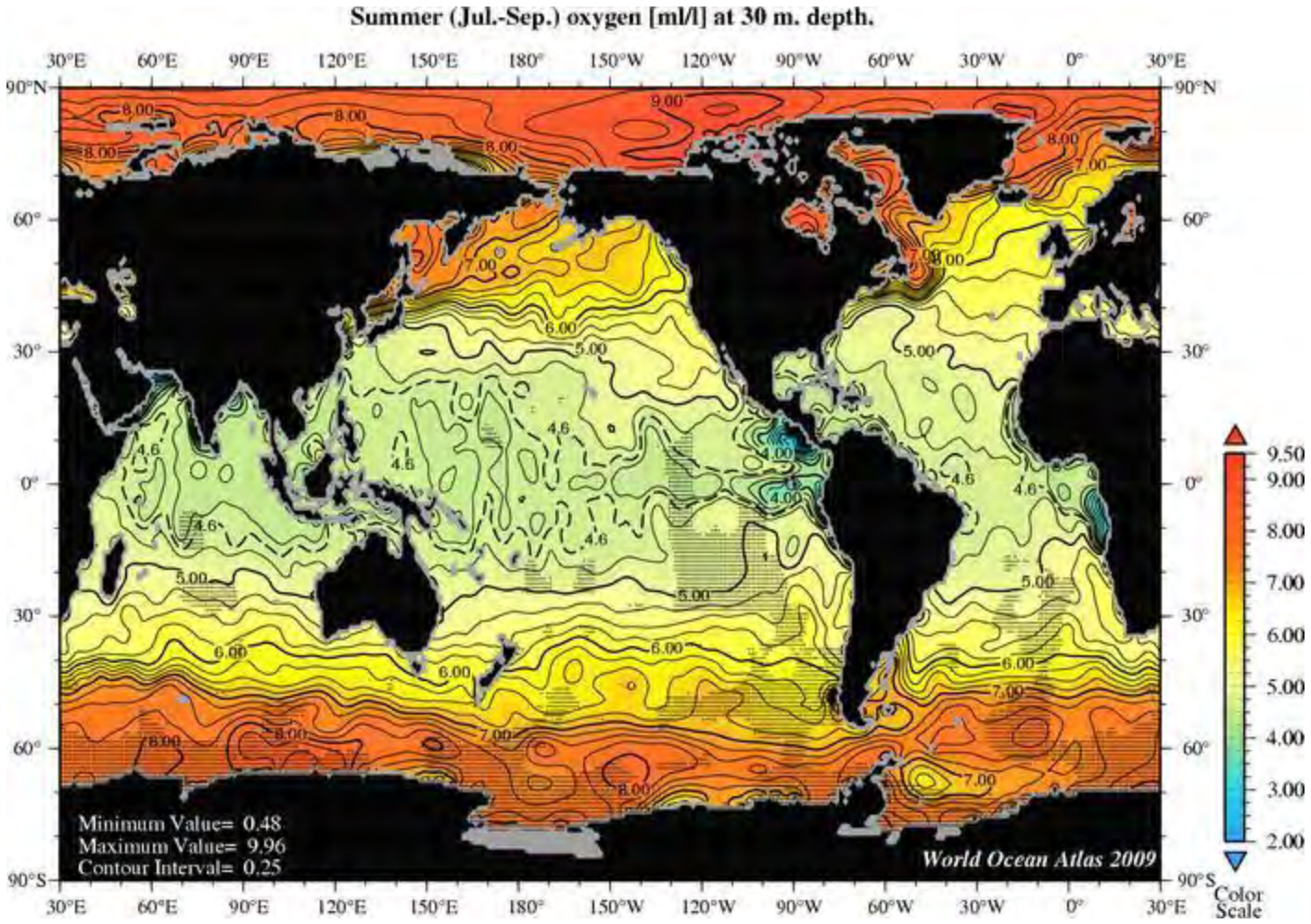
North Pacific Applications?

➢Use spatially-explicit, foraging, and bioenergetics models to predict **habitat quality** of key fish species

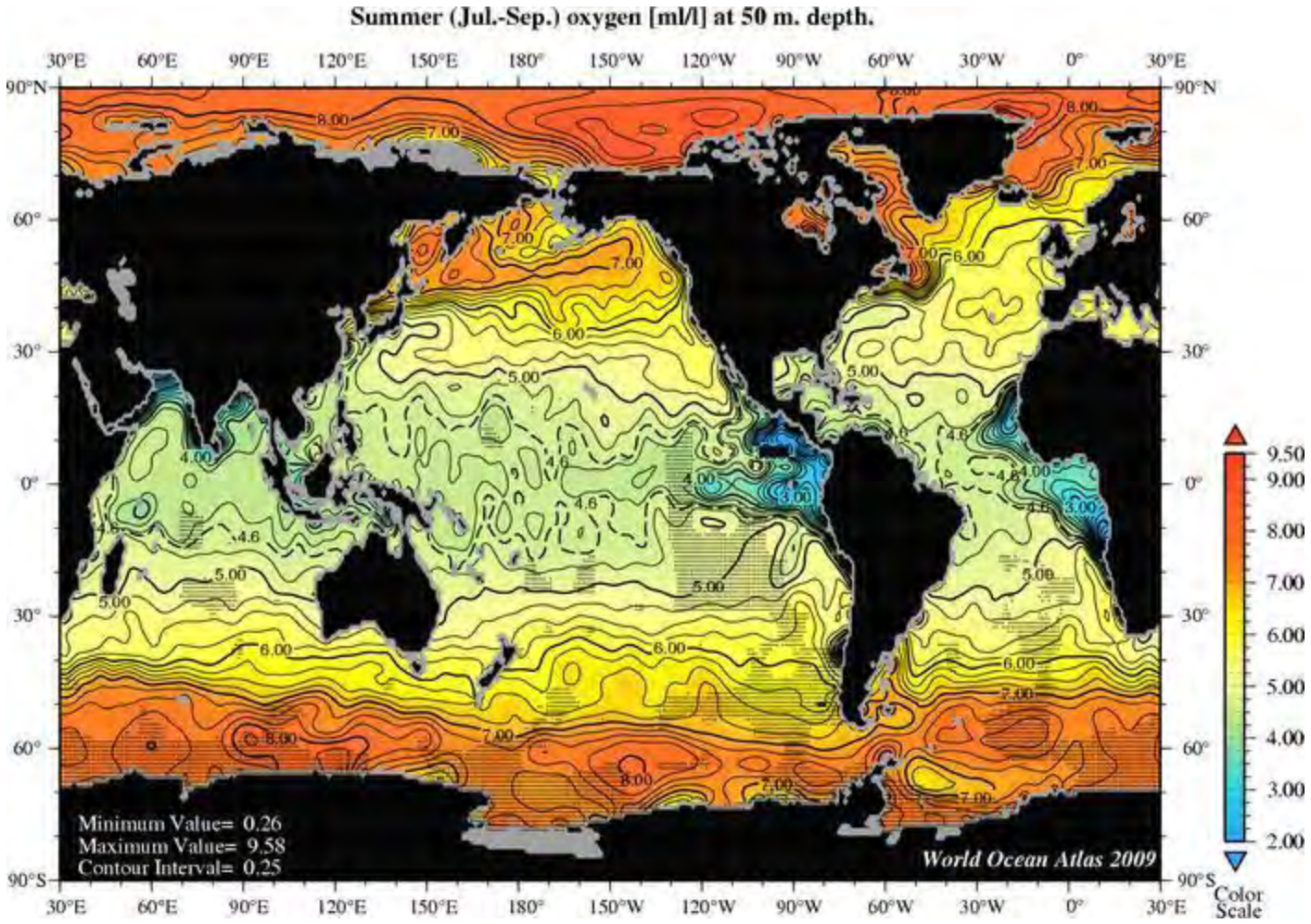
Temperature
Oxygen
Currents
Prey Density

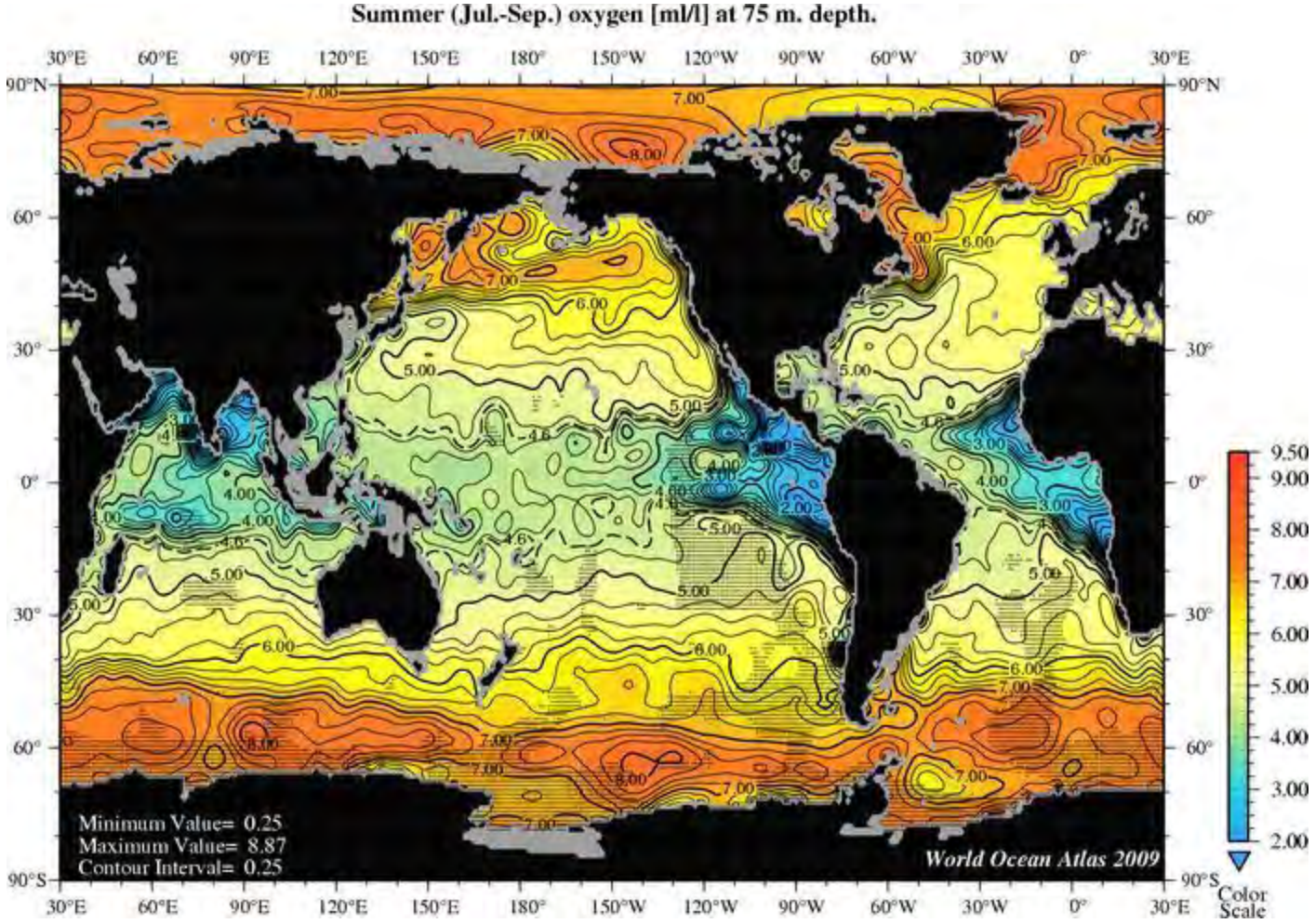


Oxygen 30m

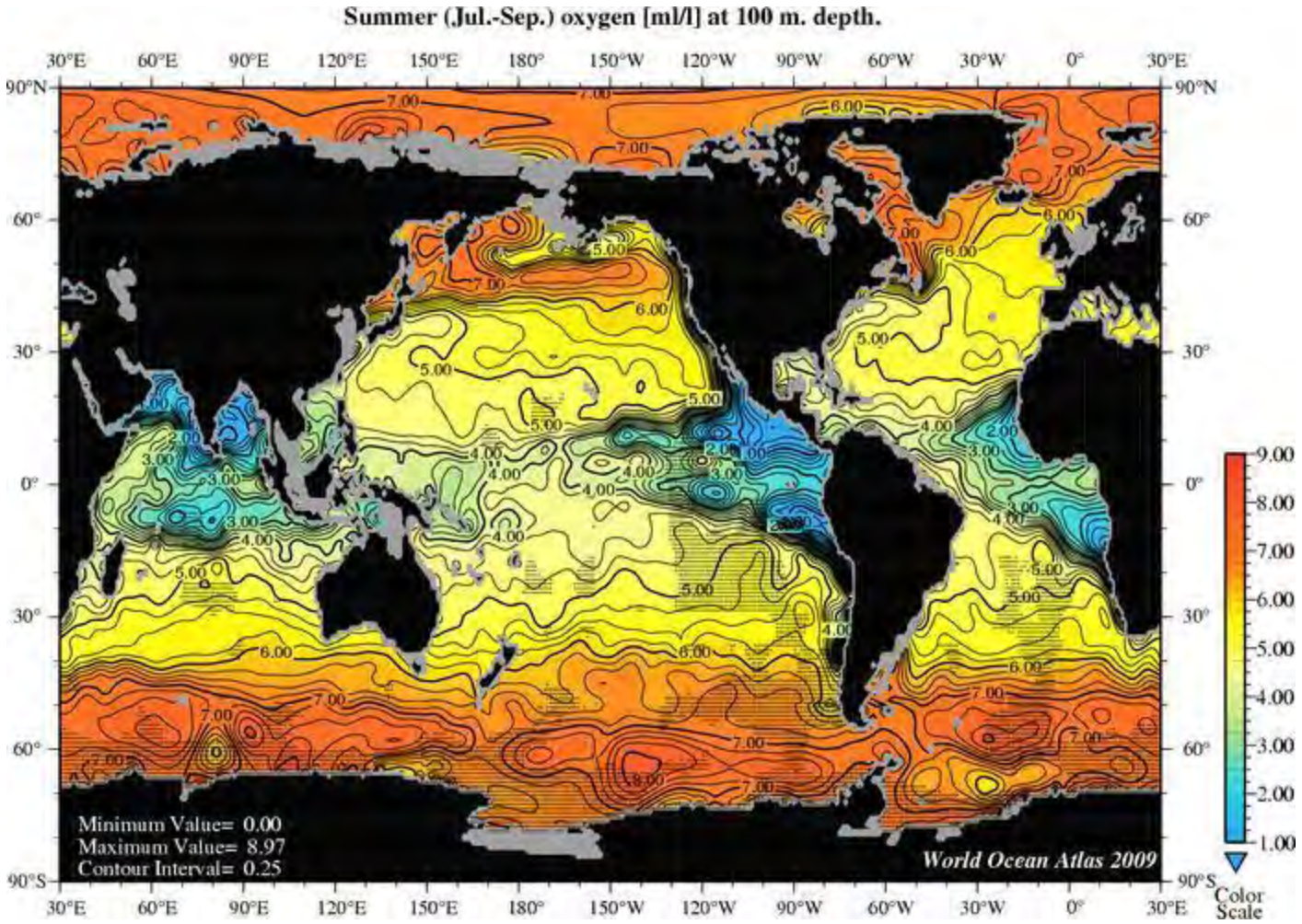


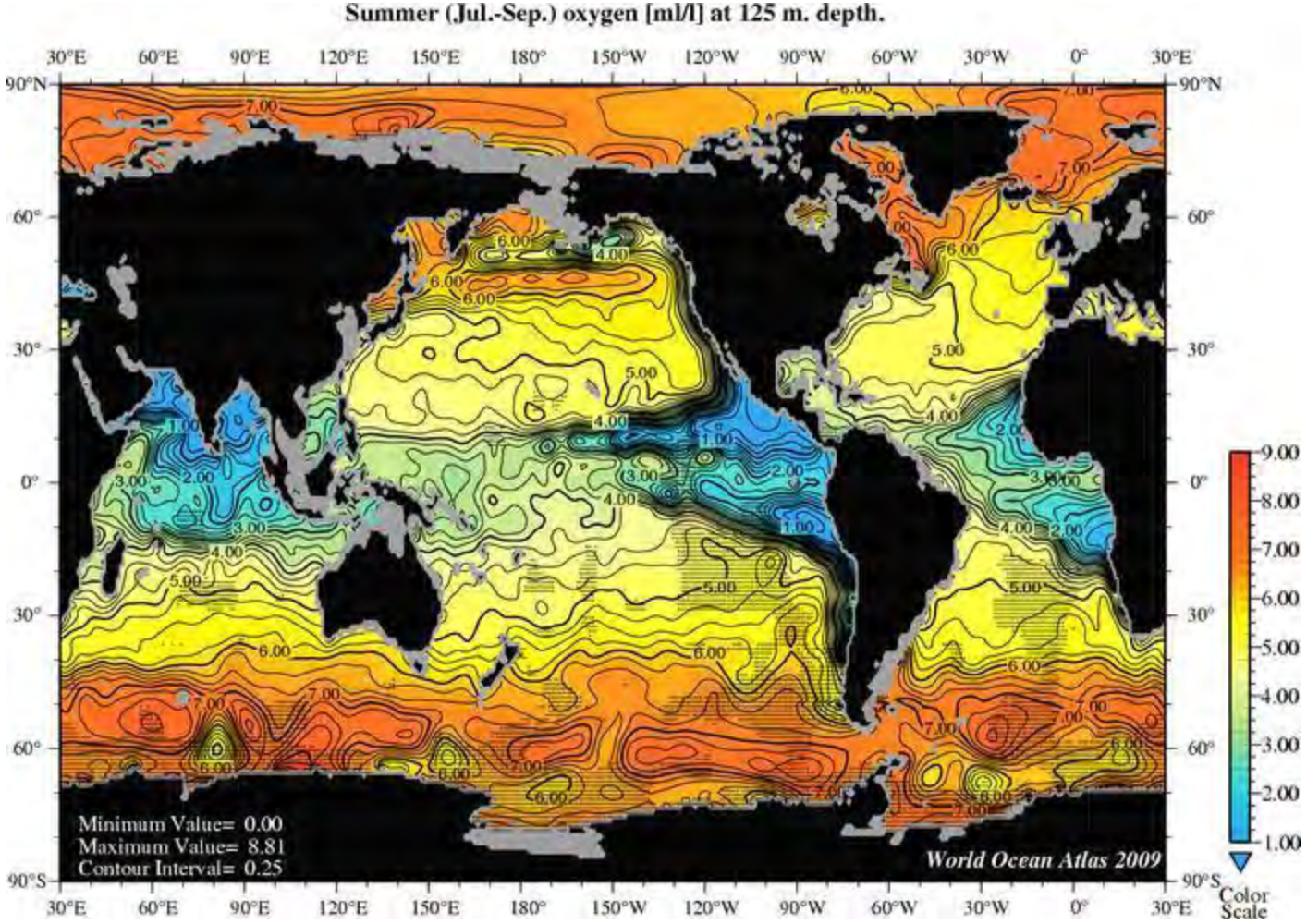
NOAA NODC

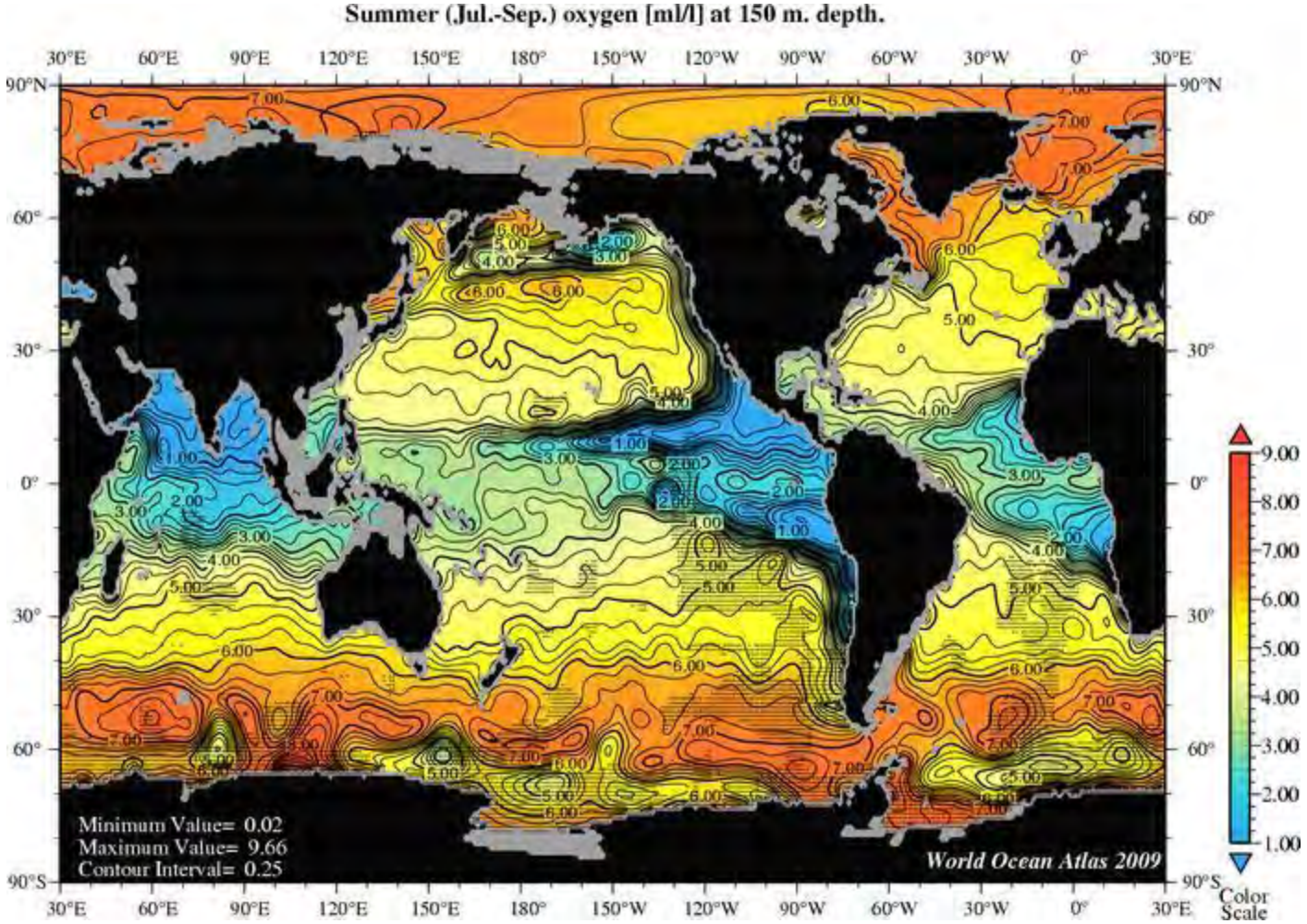

Summer (Jul.-Sep.) oxygen [ml/l] at 50 m. depth.
30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W 90°W 60°W 30°W 0° 30°E
90°N
60°
30°
0°
30°
60°
90°S
Minimum Value= 0.26
Maximum Value= 9.58
Contour Interval= 0.25
World Ocean Atlas 2009
9.50
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
Color Scale


Summer (Jul.-Sep.) oxygen [ml/l] at 75 m. depth.
30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W 90°W 60°W 30°W 0° 30°E
90°N
60°
30°
0°
30°
60°
90°S
Minimum Value= 0.25
Maximum Value= 8.87
Contour Interval= 0.25
World Ocean Atlas 2009
9.50
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
Color Scale

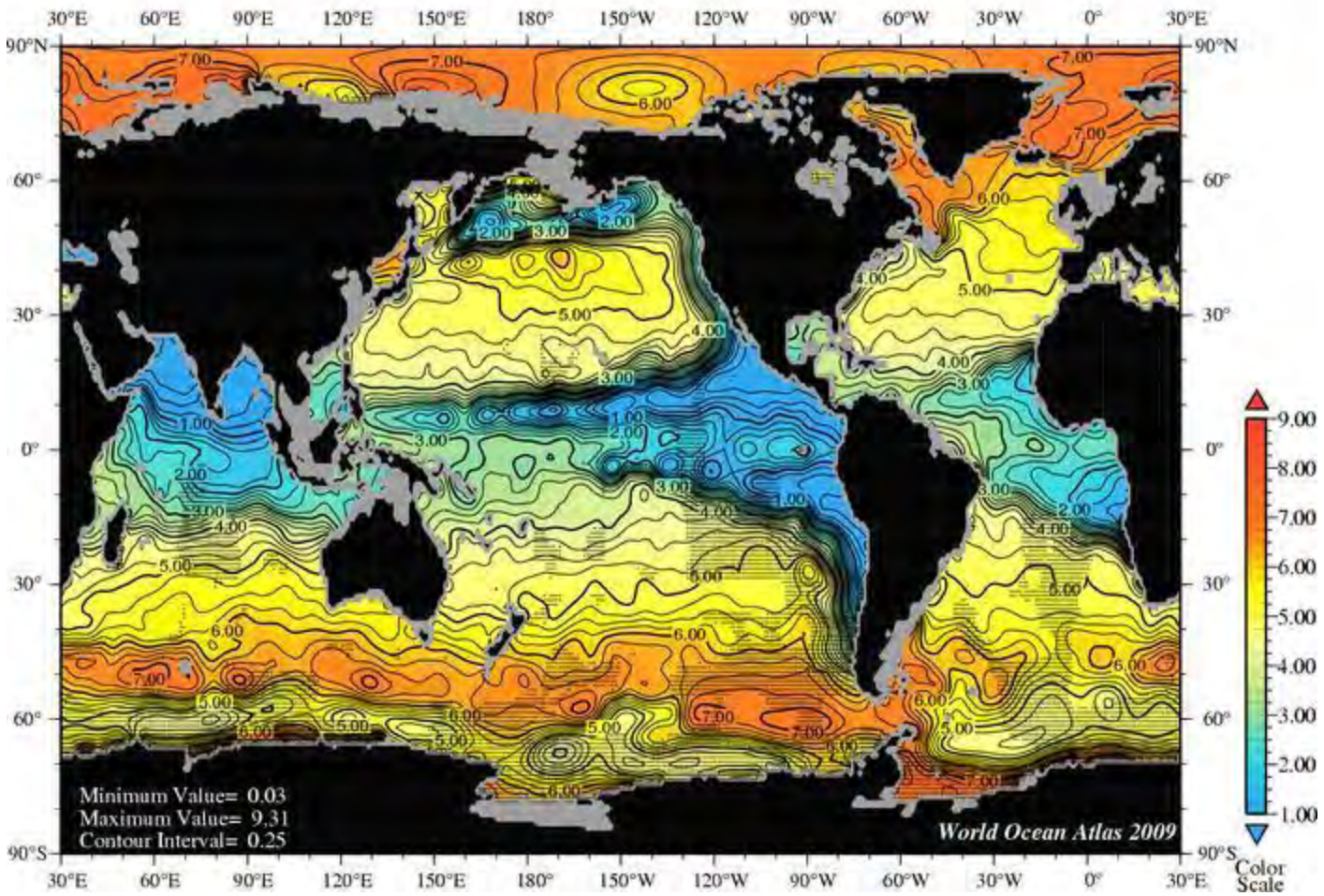
Oxygen 100m


Summer (Jul.-Sep.) oxygen [ml/l] at 100 m. depth.
30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W 90°W 60°W 30°W 0° 30°E
90°N
60°
30°
0°
30°
60°
90°S
Minimum Value= 0.00
Maximum Value= 8.97
Contour Interval= 0.25
World Ocean Atlas 2009
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
Color Scale

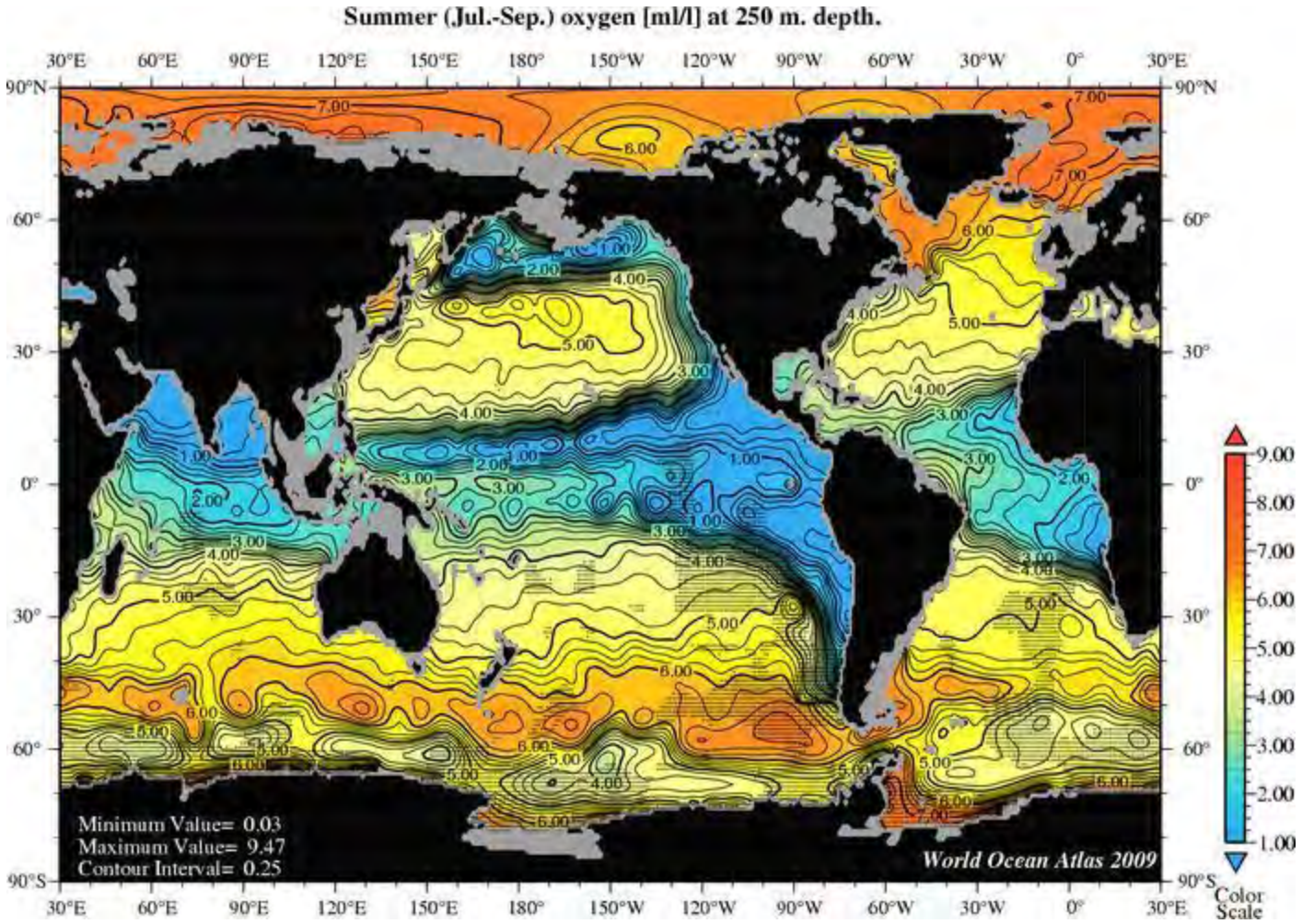

Summer (Jul.-Sep.) oxygen [ml/l] at 125 m. depth.
30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W 90°W 60°W 30°W 0° 30°E
90°N
60°
30°
0°
30°
60°
90°S
Minimum Value= 0.00
Maximum Value= 8.81
Contour Interval= 0.25
World Ocean Atlas 2009
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
Color Scale


Summer (Jul.-Sep.) oxygen [ml/l] at 150 m. depth.
30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W 90°W 60°W 30°W 0° 30°E
90°N
60°
30°
0°
30°
60°
90°S
Minimum Value= 0.02
Maximum Value= 9.66
Contour Interval= 0.25
World Ocean Atlas 2009
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
Color Scale

Summer (Jul.-Sep.) oxygen [ml/l] at 200 m. depth.



Oxygen 250m


Summer (Jul.-Sep.) oxygen [ml/l] at 250 m. depth.
30°E 60°E 90°E 120°E 150°E 180° 150°W 120°W 90°W 60°W 30°W 0° 30°E
90°N
60°
30°
0°
30°
60°
90°S
Minimum Value= 0.03
Maximum Value= 9.47
Contour Interval= 0.25
World Ocean Atlas 2009
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
Color Scale

Key Questions:

1. How does Growth Rate Potential of key species change
   - Seasonally
   - From year-to-year
   - With events
   - Long-term (Climate change)
   - Environmental stressors

2. How well do patterns in Growth Rate Potential map migrations or production?

3. What are the relevant Space and Time scales?

Questions?

Support from NOAA-CSCOR
NGOMEX and NSF RAPID RESPONSE