Updated version from September 25, 2010

Maps of Ecological Patterns of the southern Baltic Sea

Compiled by

Joachim W Dippner, Tina Henrich, Karin Junker, Patrick Schibat, Janina Werner

Updated version from September 25, 2010

Content

- Part 1: Hovmöller Diagrams
- Part 2: Changes in seasonality
- Acknowledgment
- References

Updated version from September 25, 2010

Part 1: Hovmöller Diagrams

Content Part 1

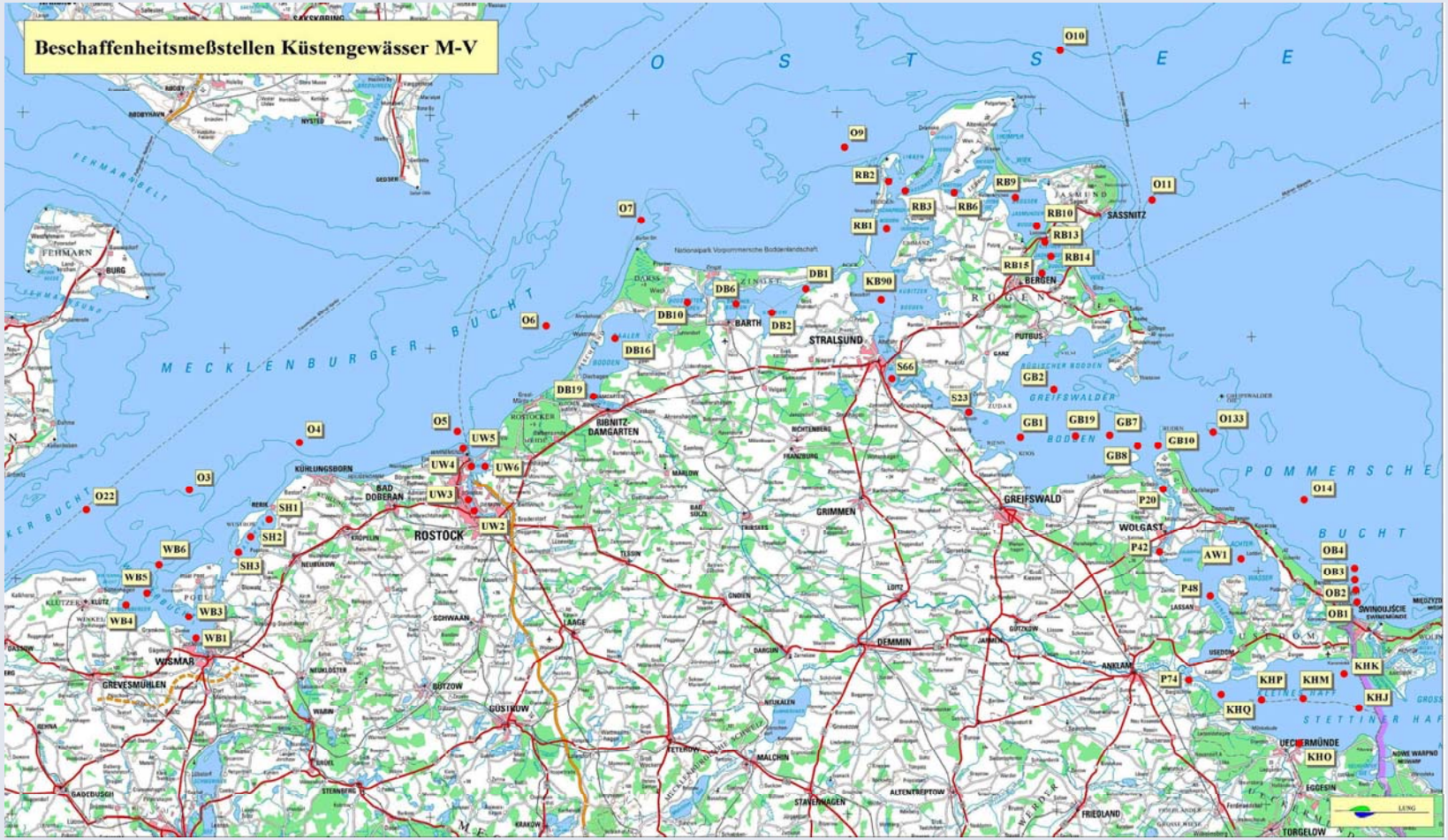
- Summary
- Map of monitoring stations
- Hovmöller diagrams
- Geographical Key
- Maps of ecological patterns
  - Phsyical data
  - Nutrient data
  - Phytoplankton (taxonomic divisions)

Summary

Physical and chemical properties and phytoplankton on a species level are routinely monitored in the southern Baltic Sea (LUNG 2004). The phytoplankton observations are merged into taxonomic divisions. We present all monitoring data in a comprehensive graphical form using Hovmöller diagrams which allow to view properties in a space-time domain.

Updated version from September 25, 2010

Map of Monitoring Stations

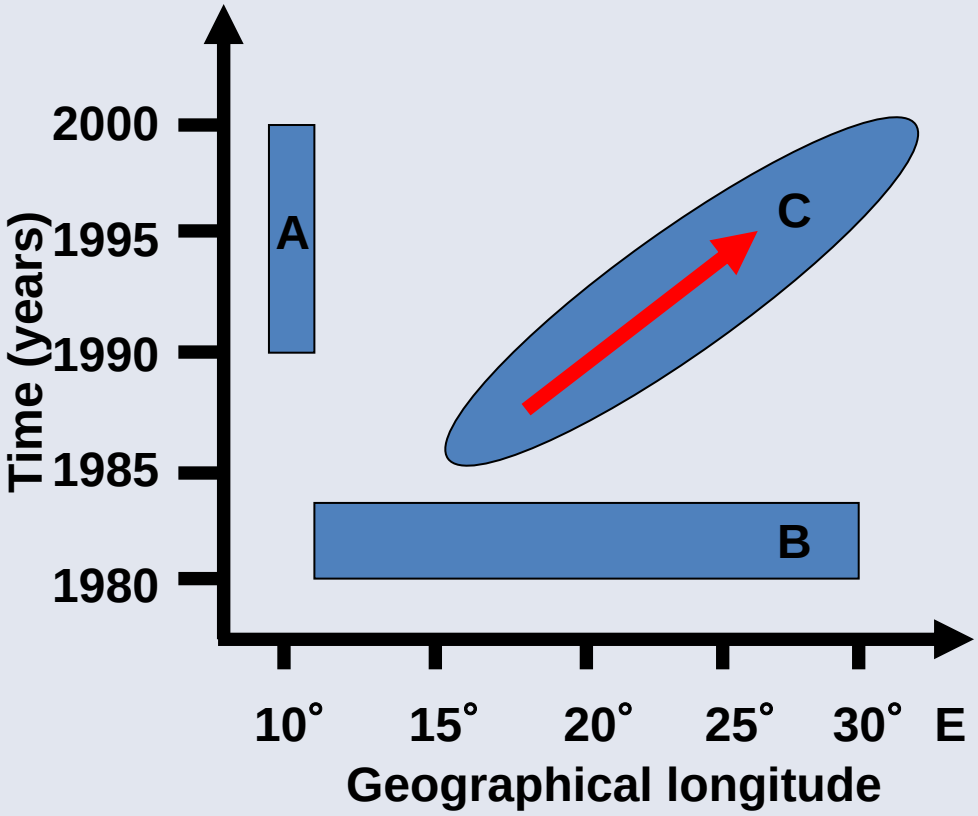


Hovmöller diagrams

Hovmöller diagrams are invented by the Danish meteorologist Ernest Aabo Hovmöller (1912-2008).

A Hovmöller diagram is a commonly used way of plotting meteorological data to highlight the role of waves or other propagating structures. The axes of a Hovmöller diagram are typically longitude or latitude (abscissa) and time (ordinate) with the value of some field represented through color or shading.

How to read a Hovmöller Diagram

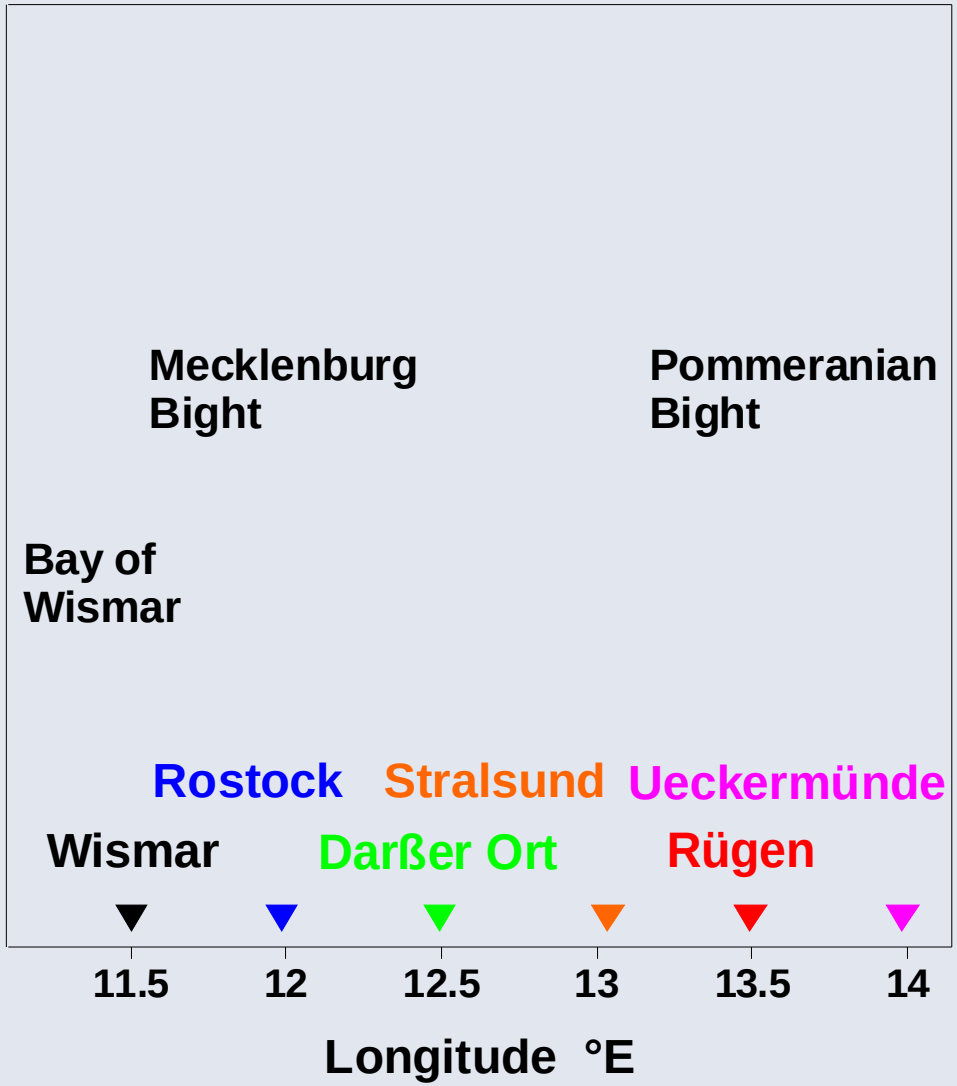


A = 10 years event at ~10° E

B = 1980-83 spatial homogeneity

C = propagating signal from 15° E in 1985 to 30° E in 2000

Geographical Key



Maps of Ecological Patterns

- In the following the ecological maps are presented.
- The data cover the near coastal monitoring from the Bay of Wismar up to the Polish boarder in the Pommeranian Bight and are plotted as function of geographical longitude.
- White spaces in the plot indicate either missing values or negative values due to variable spacing in the interpolation routine.

List of Presented Data

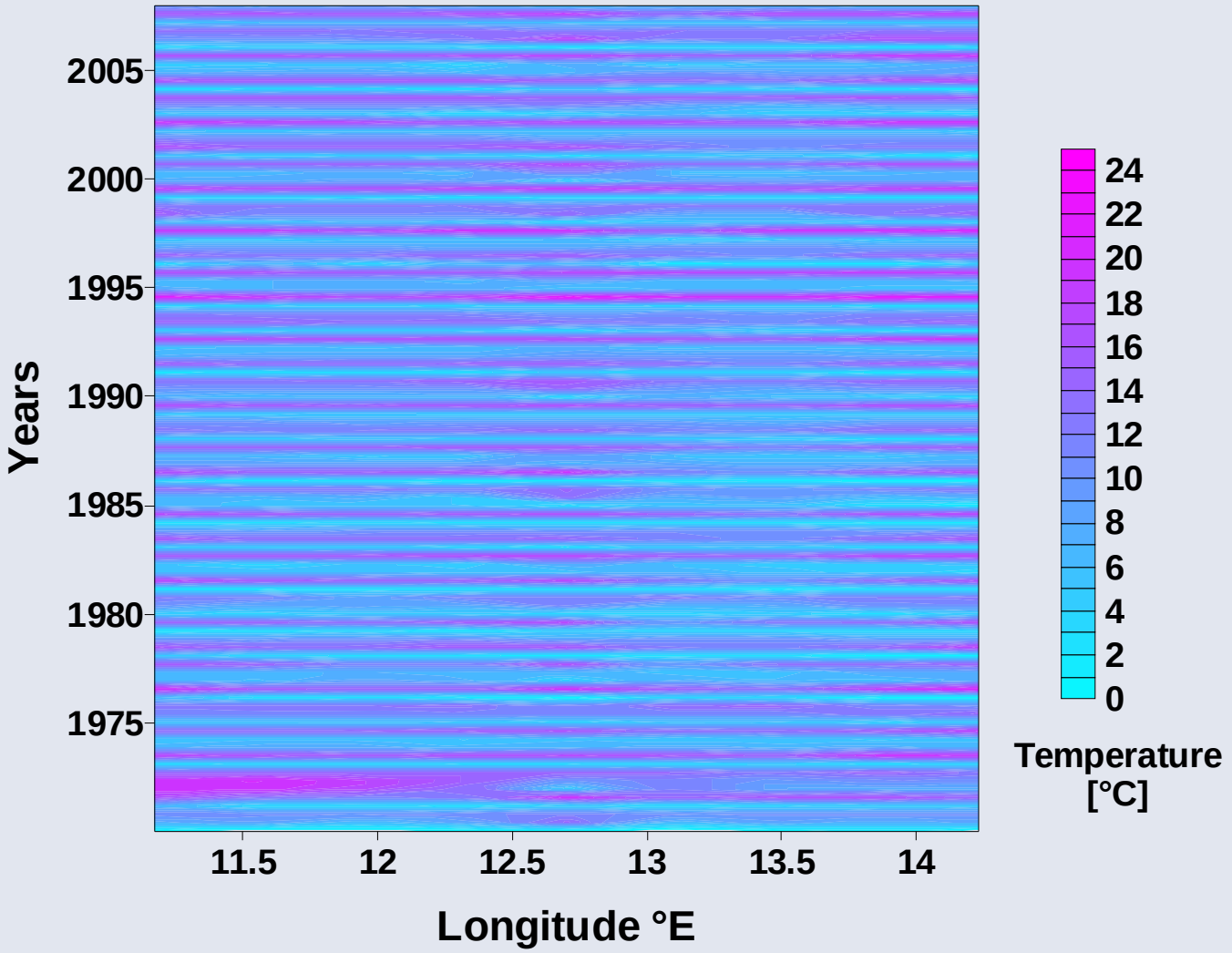
- Physical data
- Nutrient data
- Phytoplankton (taxonomic divisions)

Physical Data

- Temperature
- Salinity
- Oxygen
- Oxygen saturation
- pH value

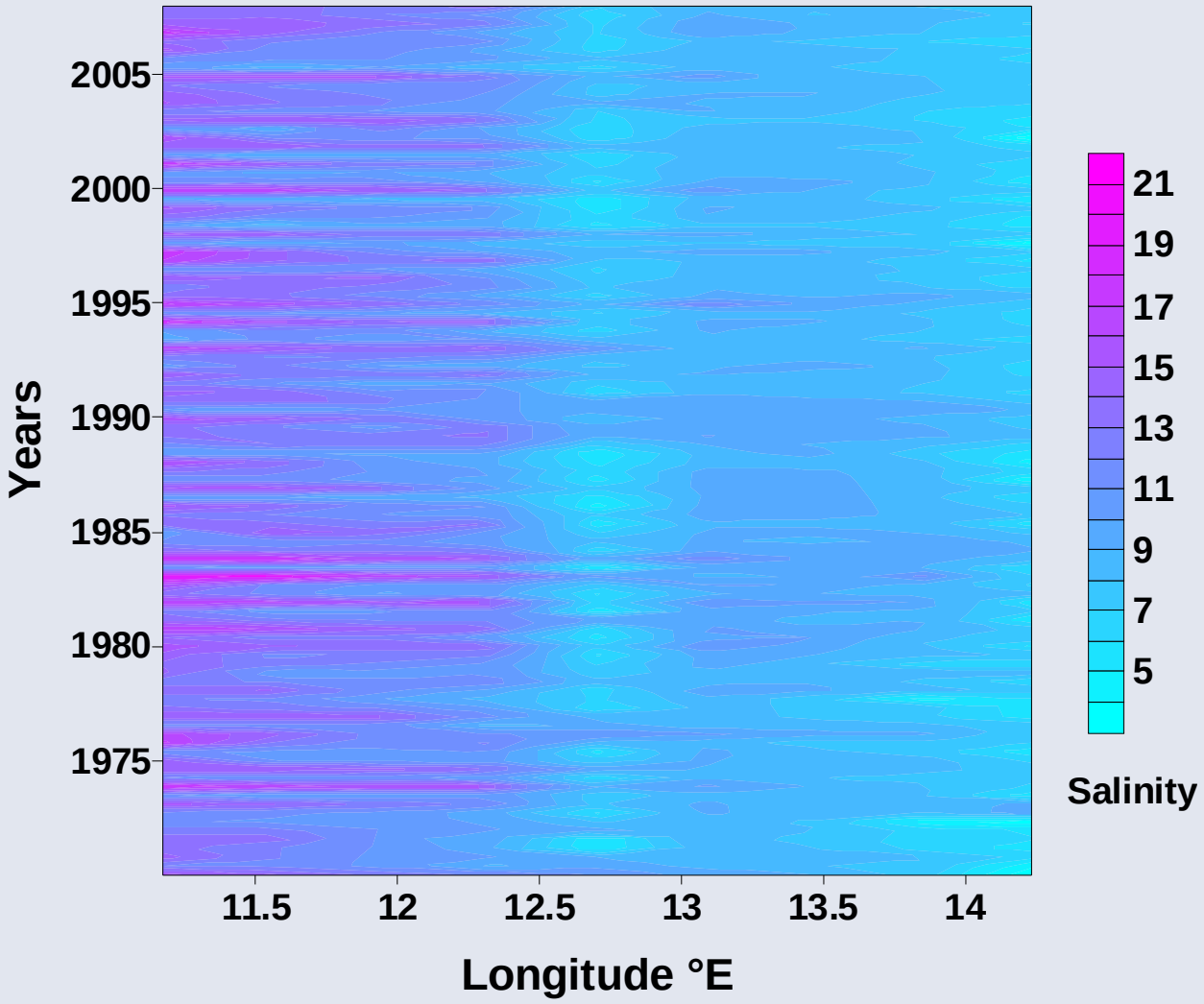
Updated version from September 25, 2010

Temperature



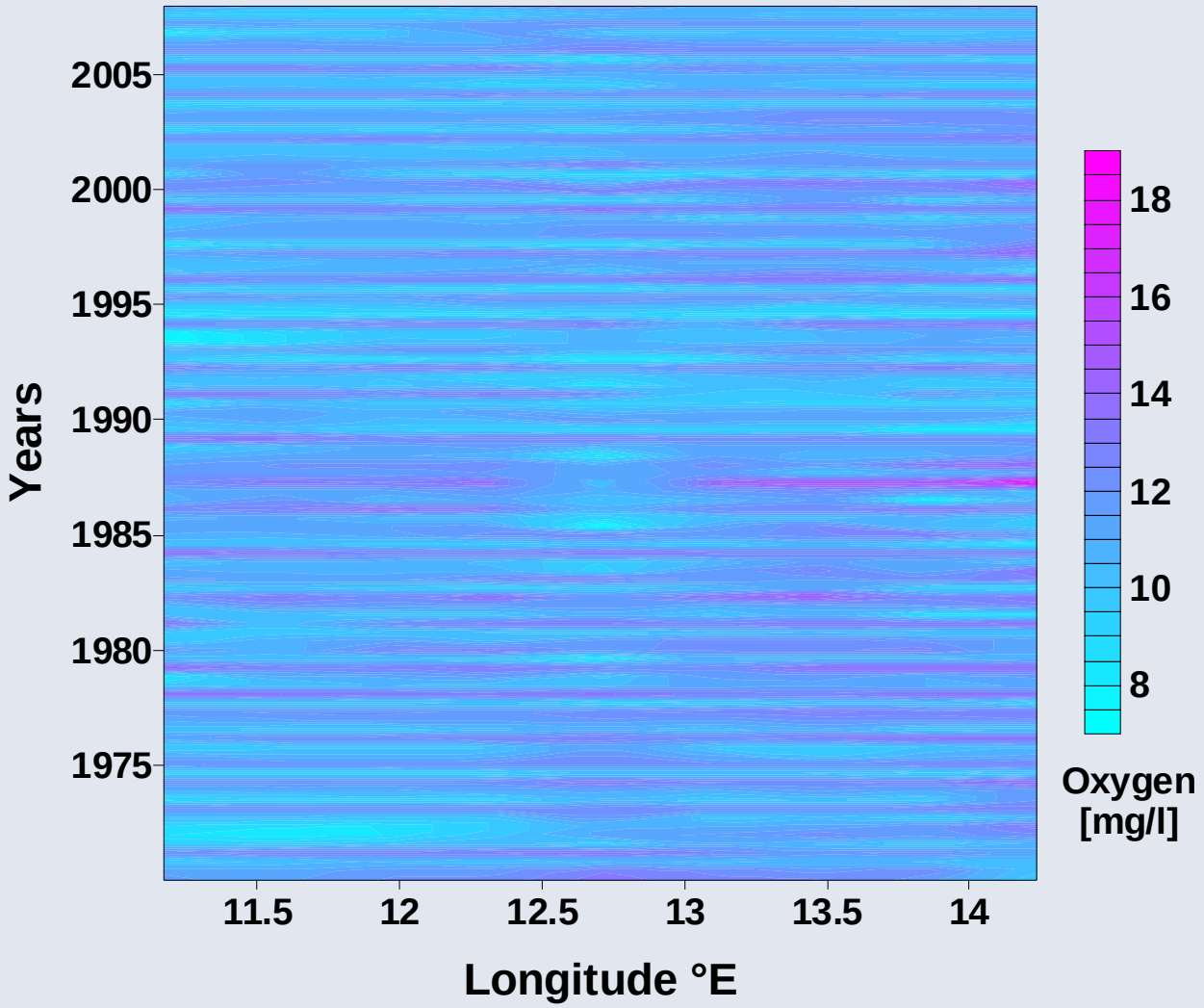
Updated version from September 25, 2010

Salinity



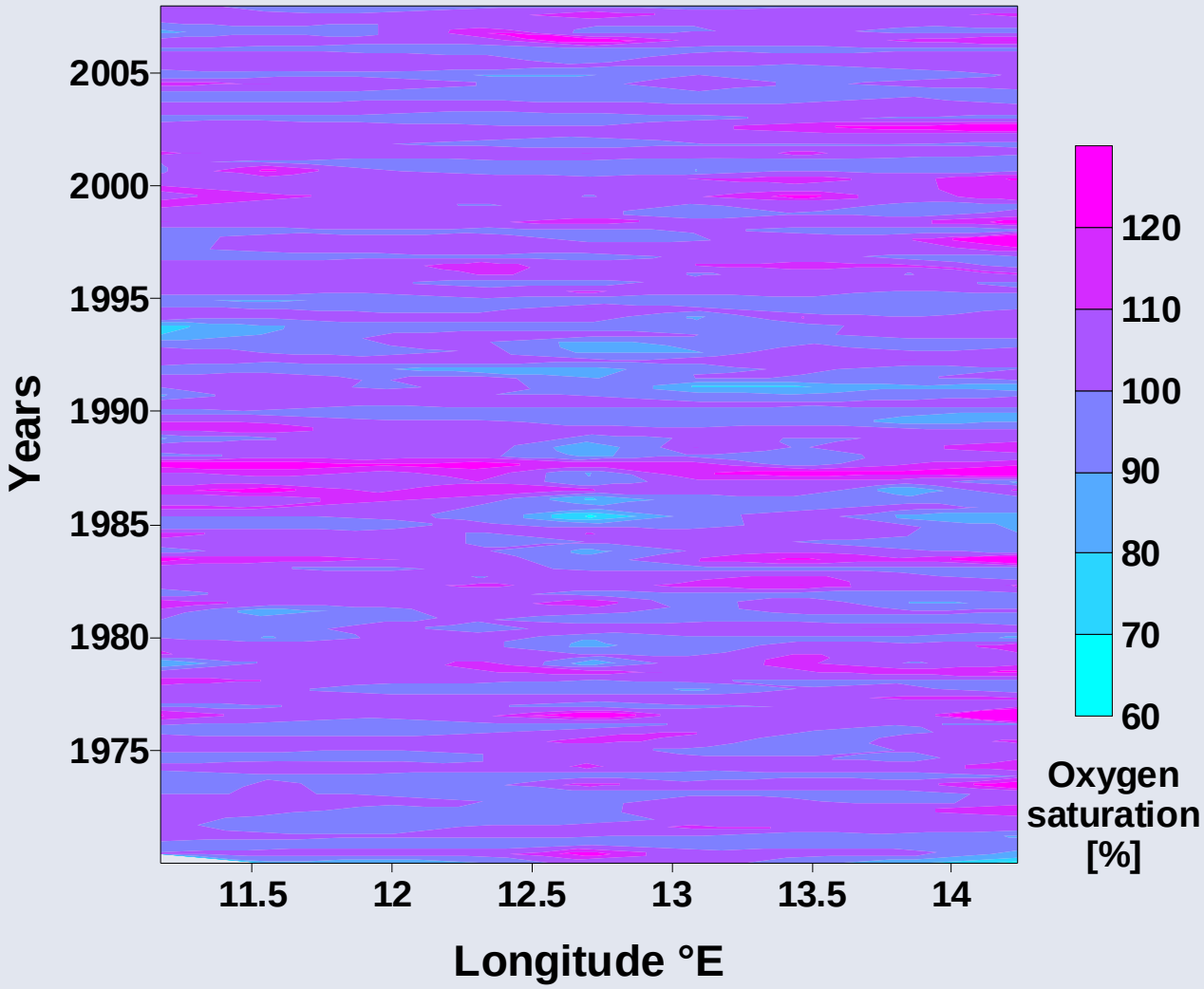
Updated version from September 25, 2010

Oxygen



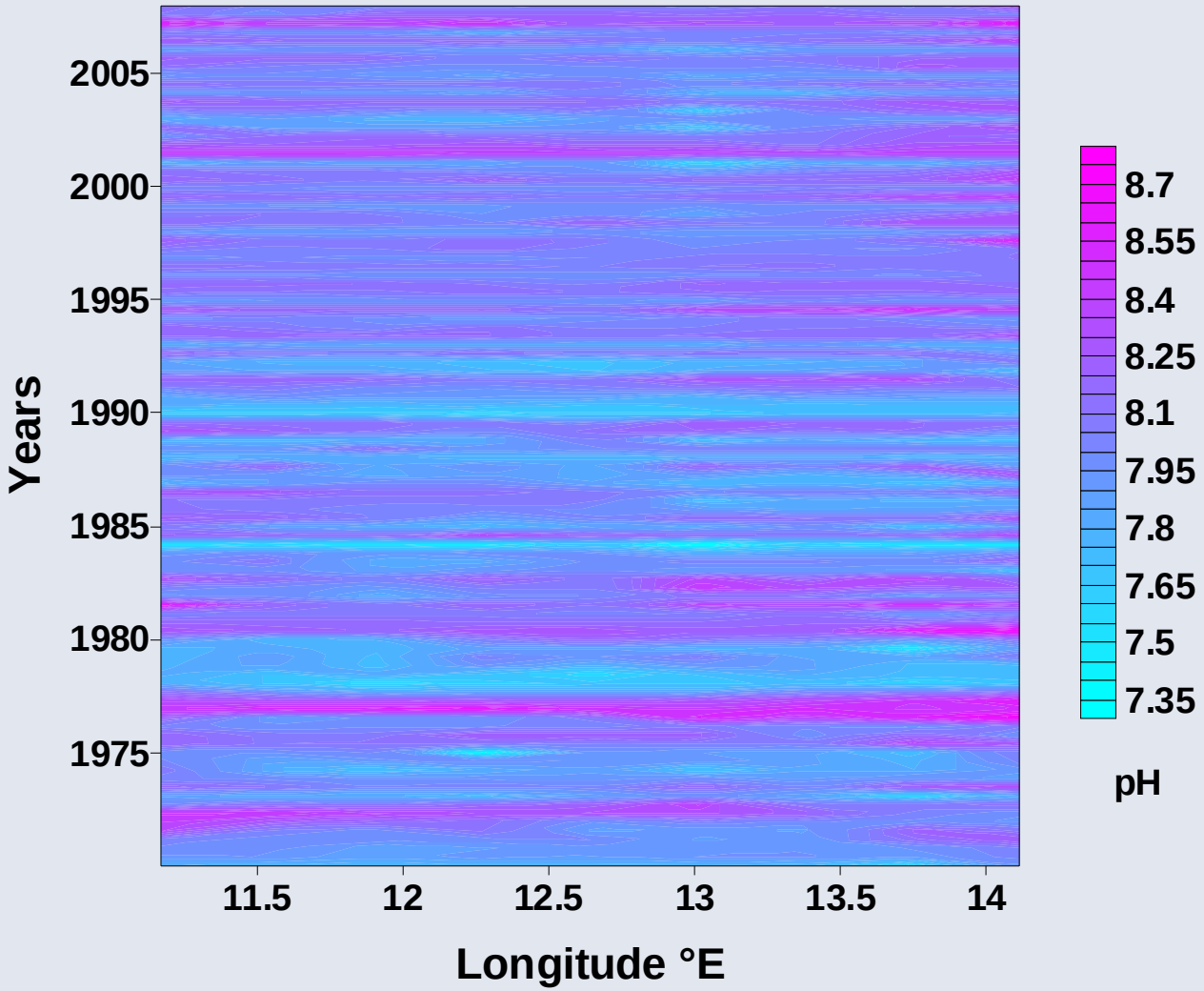
Updated version from September 25, 2010

Oxygen saturation



Updated version from September 25, 2010

pH value

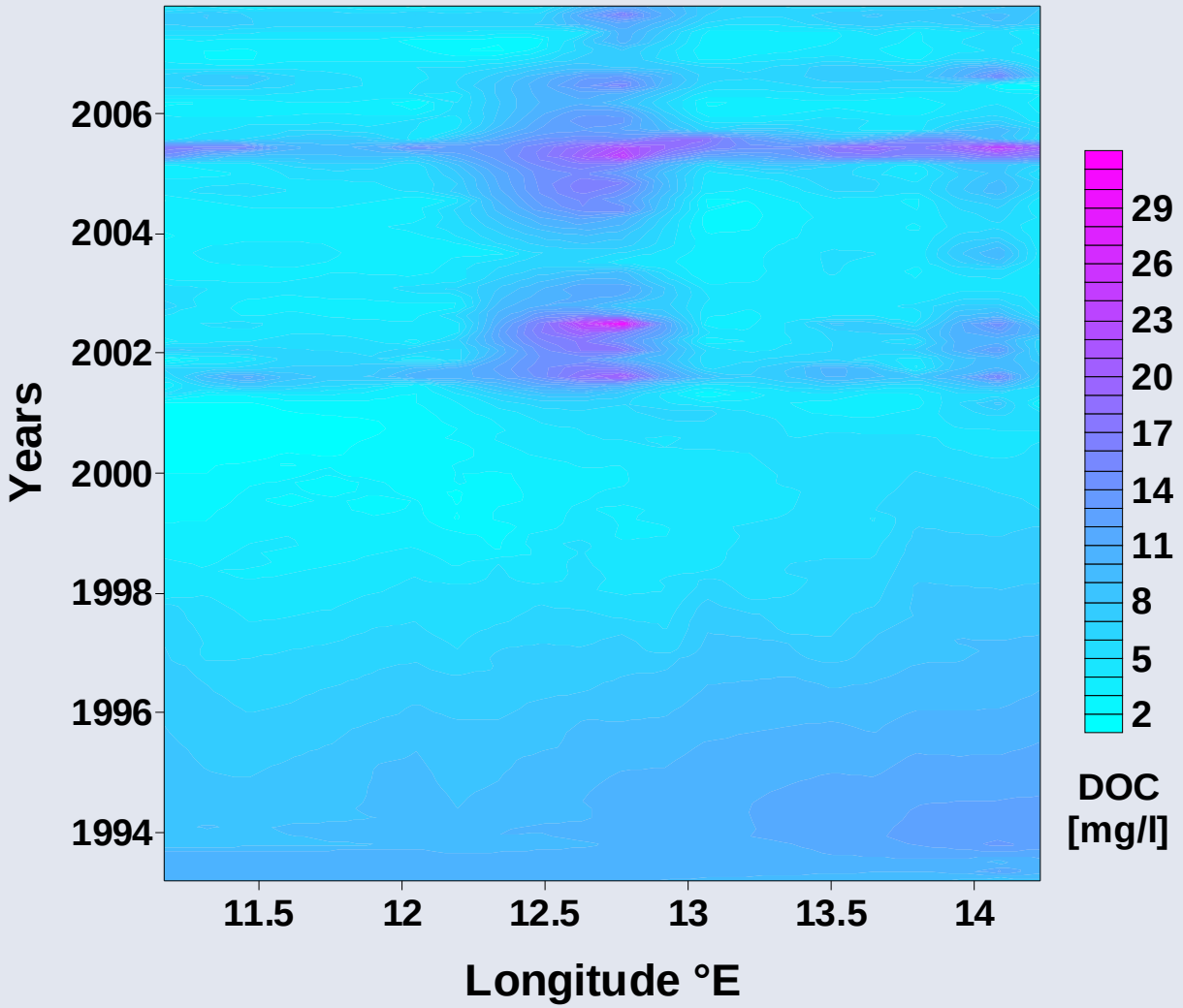


Nutrient Data

- Dissolved Organic Carbon (DOC)
- Total Organic Carbon (TOC)
- Nitrate
- Nitrite
- Ammonia
- Total N
- Phosphate
- Total phosphorus
- Silicate

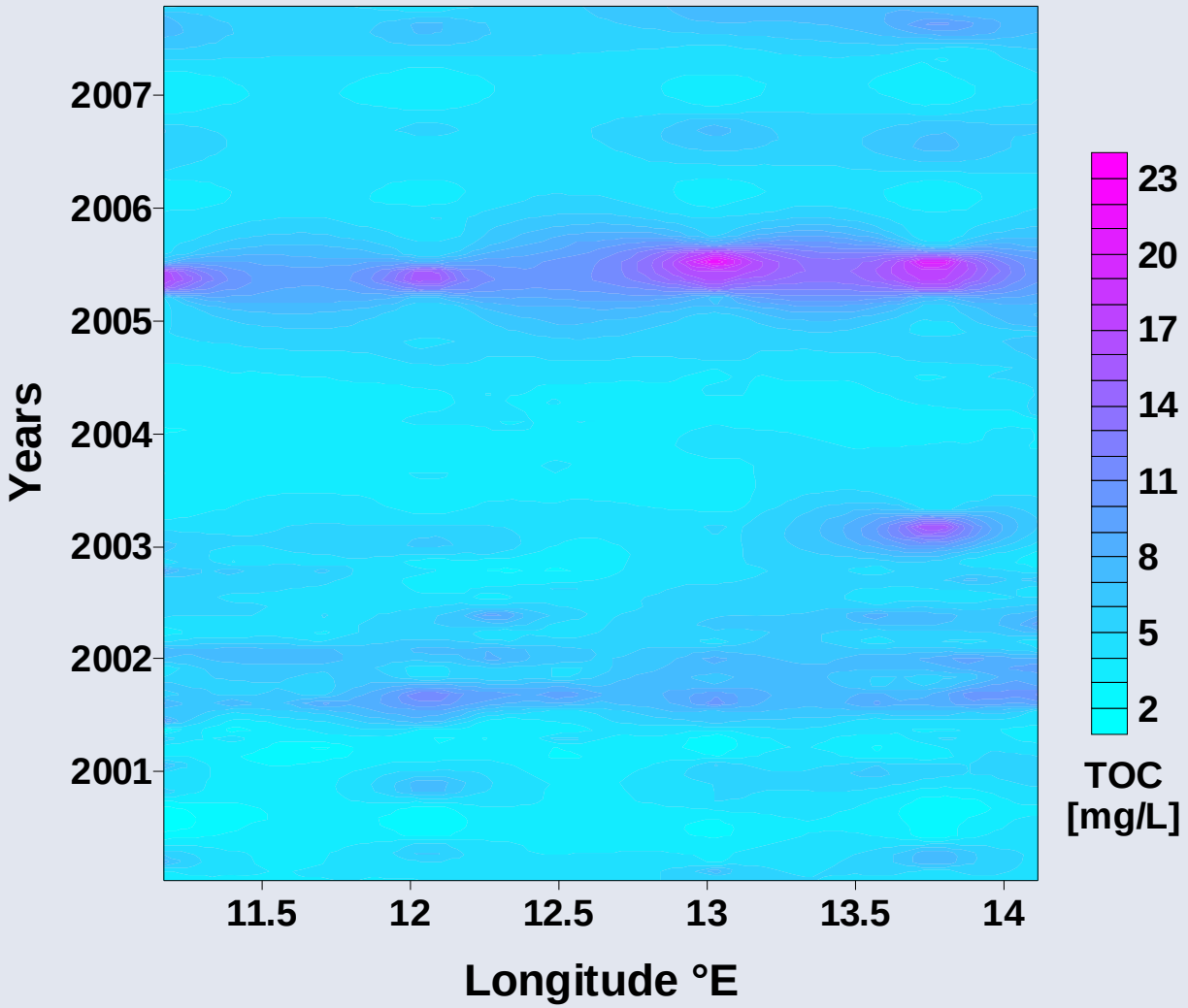
Updated version from September 25, 2010

Dissolved Organic Carbon



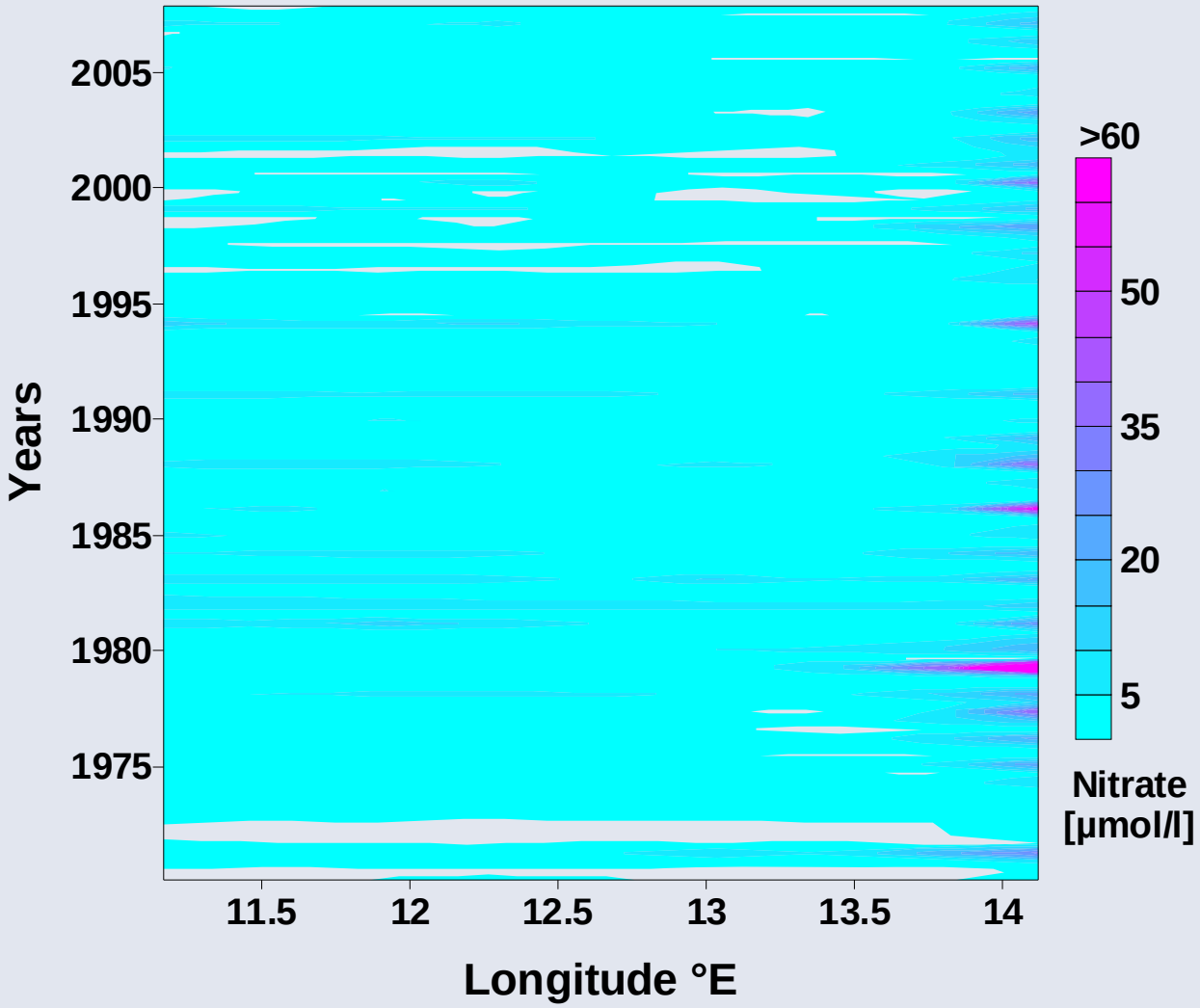
Updated version from September 25, 2010

Total Organic Carbon



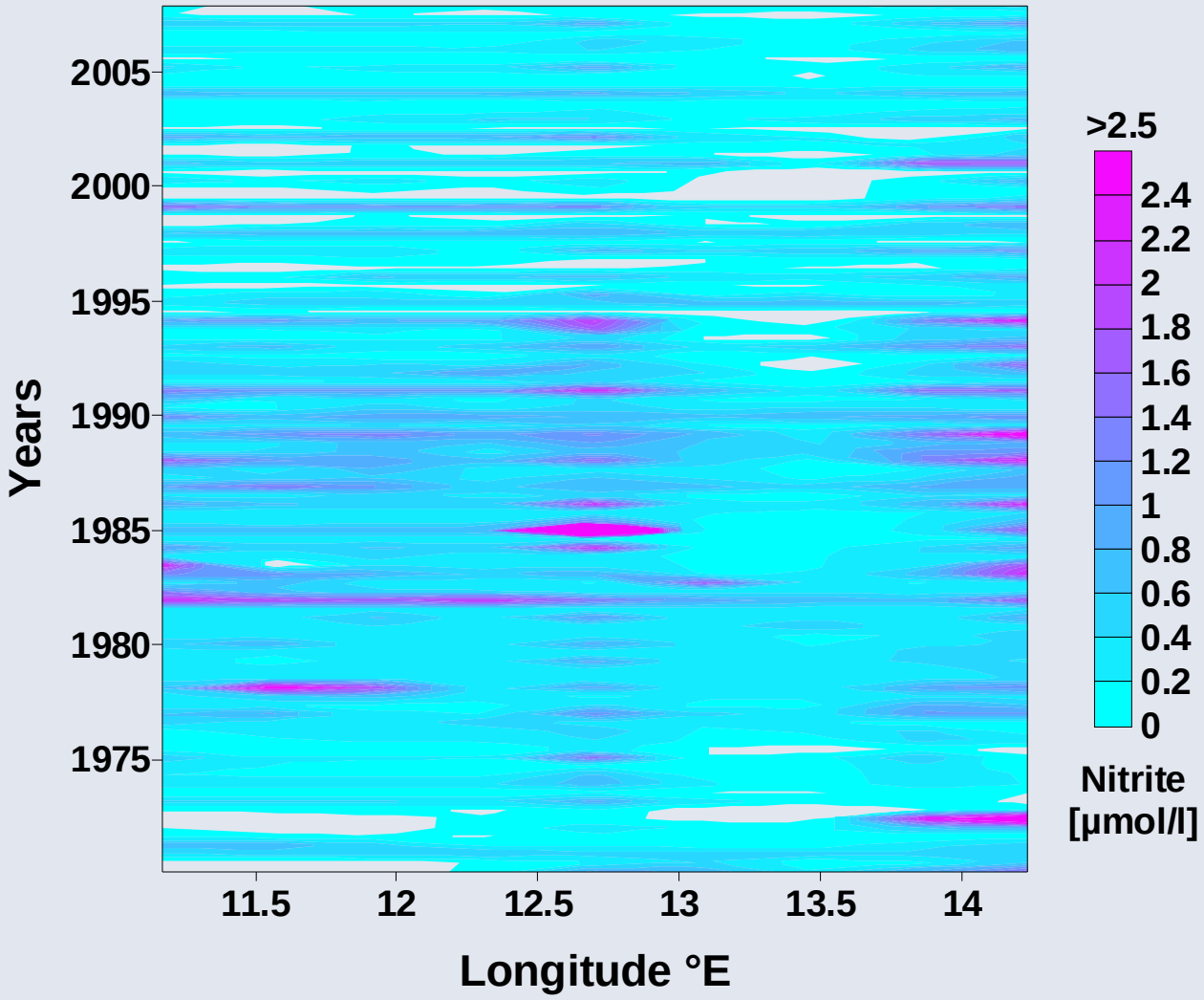
Updated version from September 25, 2010

Nitrate



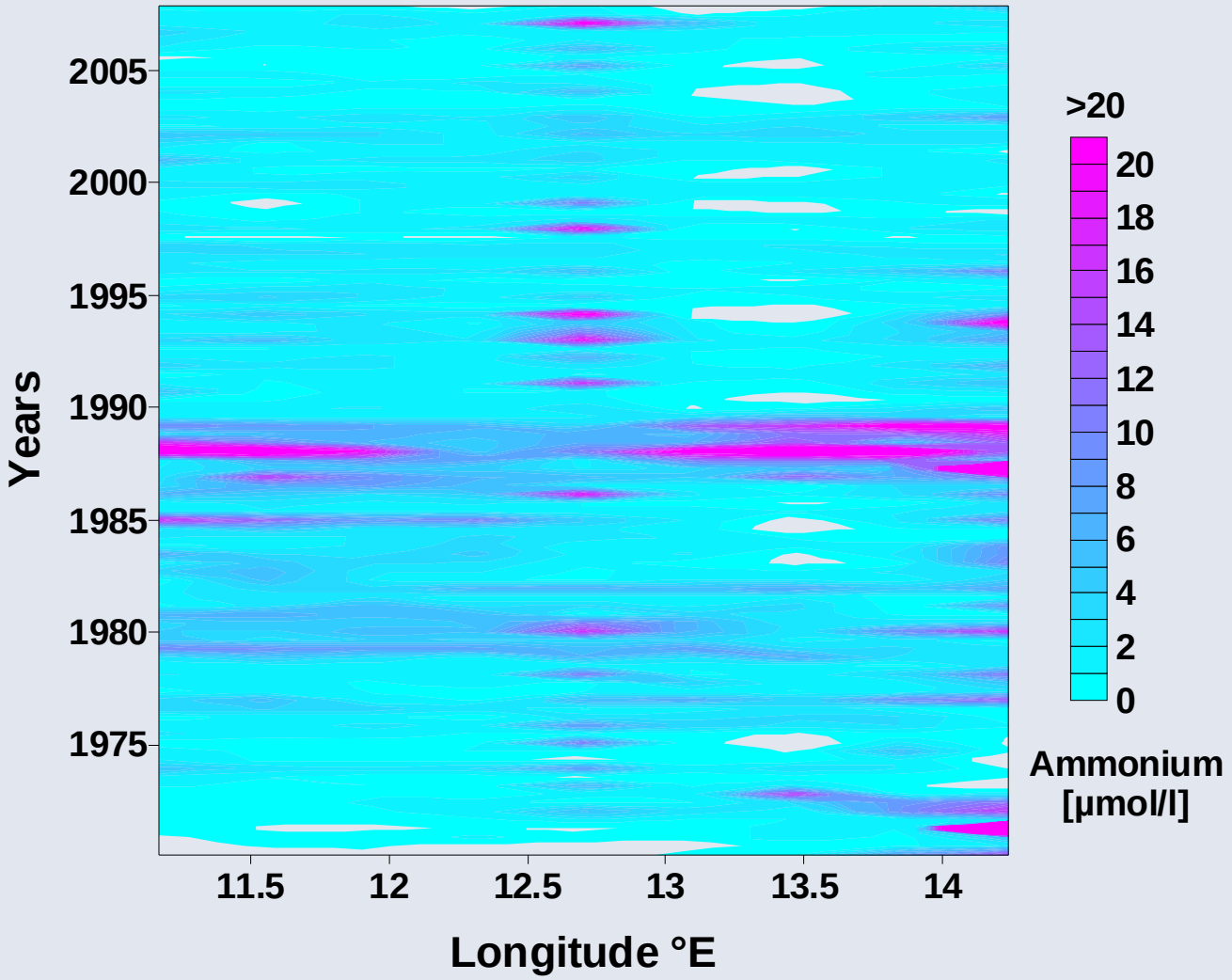
Updated version from September 25, 2010

Nitrite



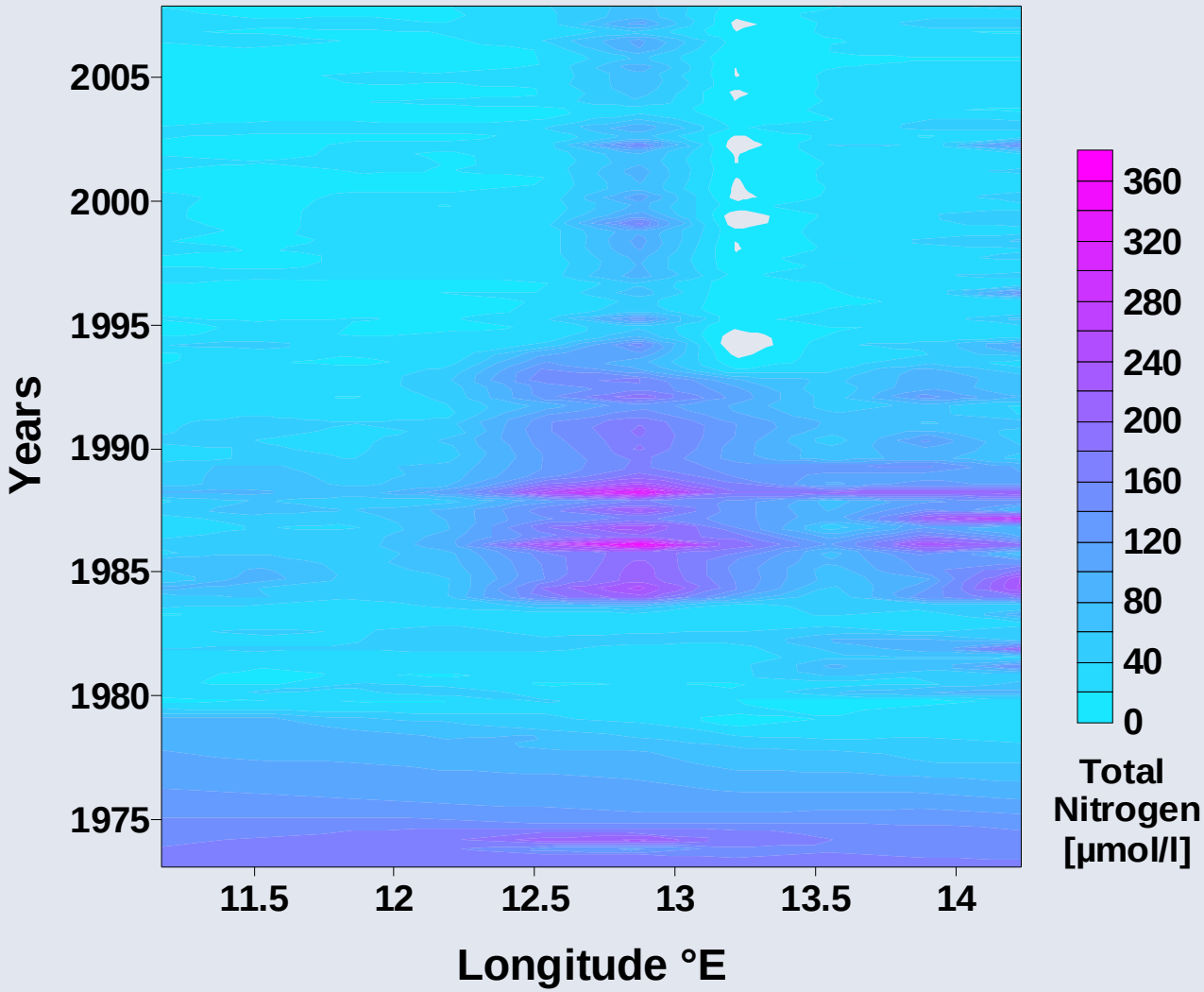
Updated version from September 25, 2010

Ammonium



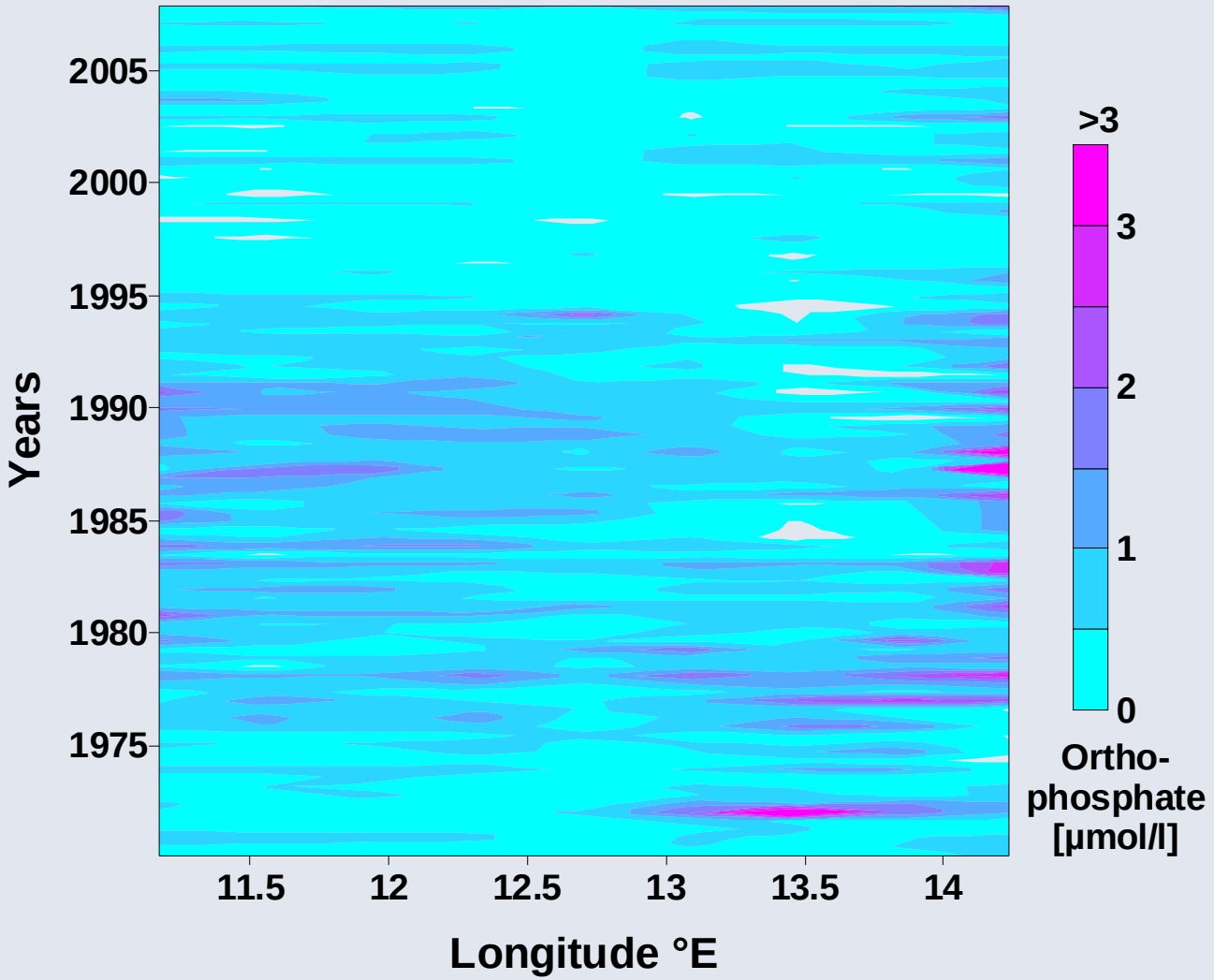
Updated version from September 25, 2010

Total Nitrogen



Updated version from September 25, 2010

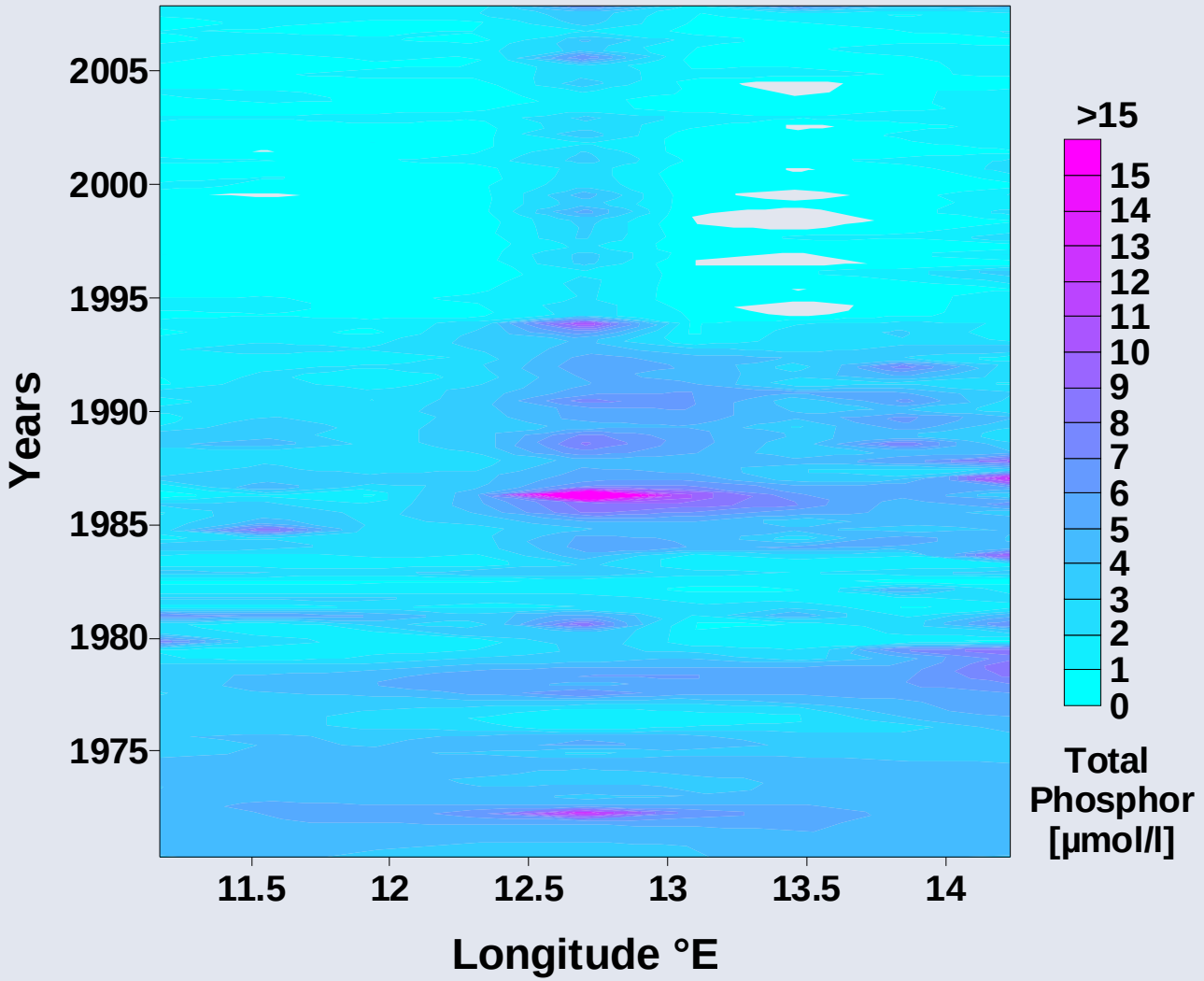
Phosphate



Federal Ministry
of Education
and Research

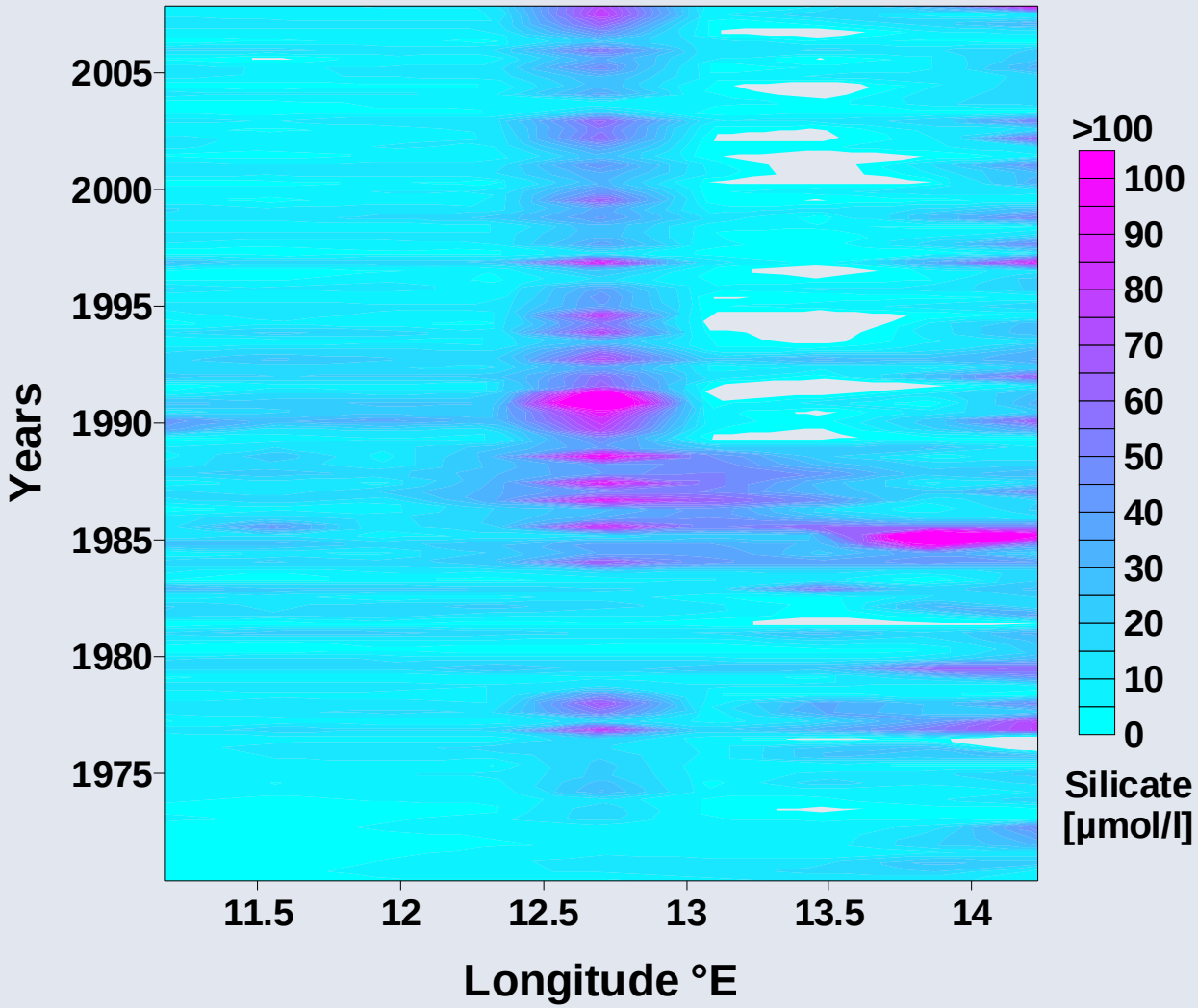
Updated version from September 25, 2010

Total phosphorus



Updated version from September 25, 2010

Silicate



List of taxonomic divisions

- Chlorophyta
- Heterokontophyta
  - class Chrysophyceae
  - class Bacillariophyceae
- Cryptophyta
- Dinophyta
- Euglenophyta
- Cyanophyta
- Ciliophora

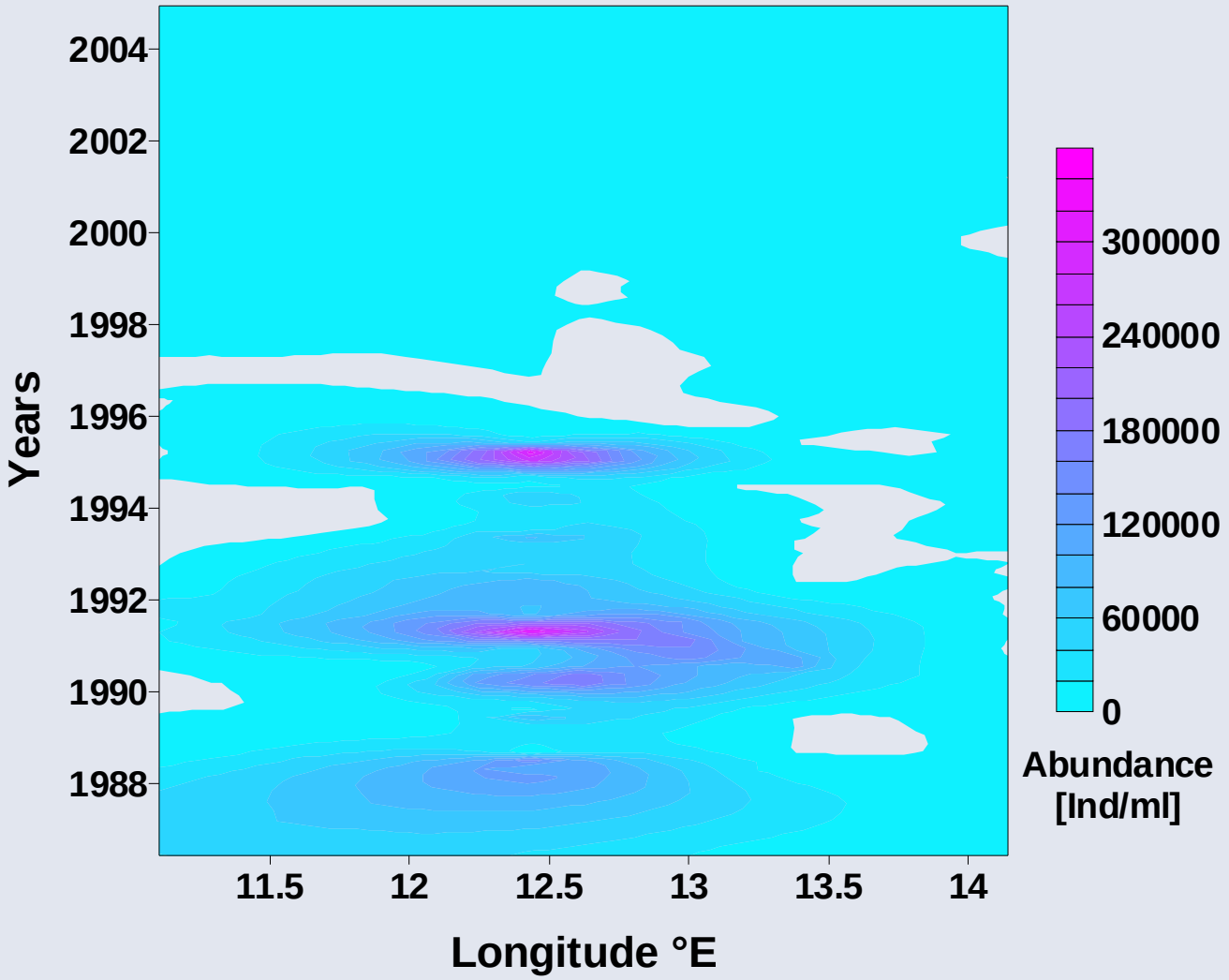
Chlorophyta

class Chlorophyceae

- The members of this class exhibits a great variety of level of organisation. Some are free-living flagellates, either unicellular of colonial; others are coccoid or palmelloid and hence non-motile; others are multicellular; others are siphonous.
- About 355 genera encompassing 2650 species are included. The great majority occur in freshwater, but there are also a fair number of terrestrial forms and just a few species that live in brackish or marine habitat.

Van den Hoek et al. 1993

Chlorophyceae (Abundance)



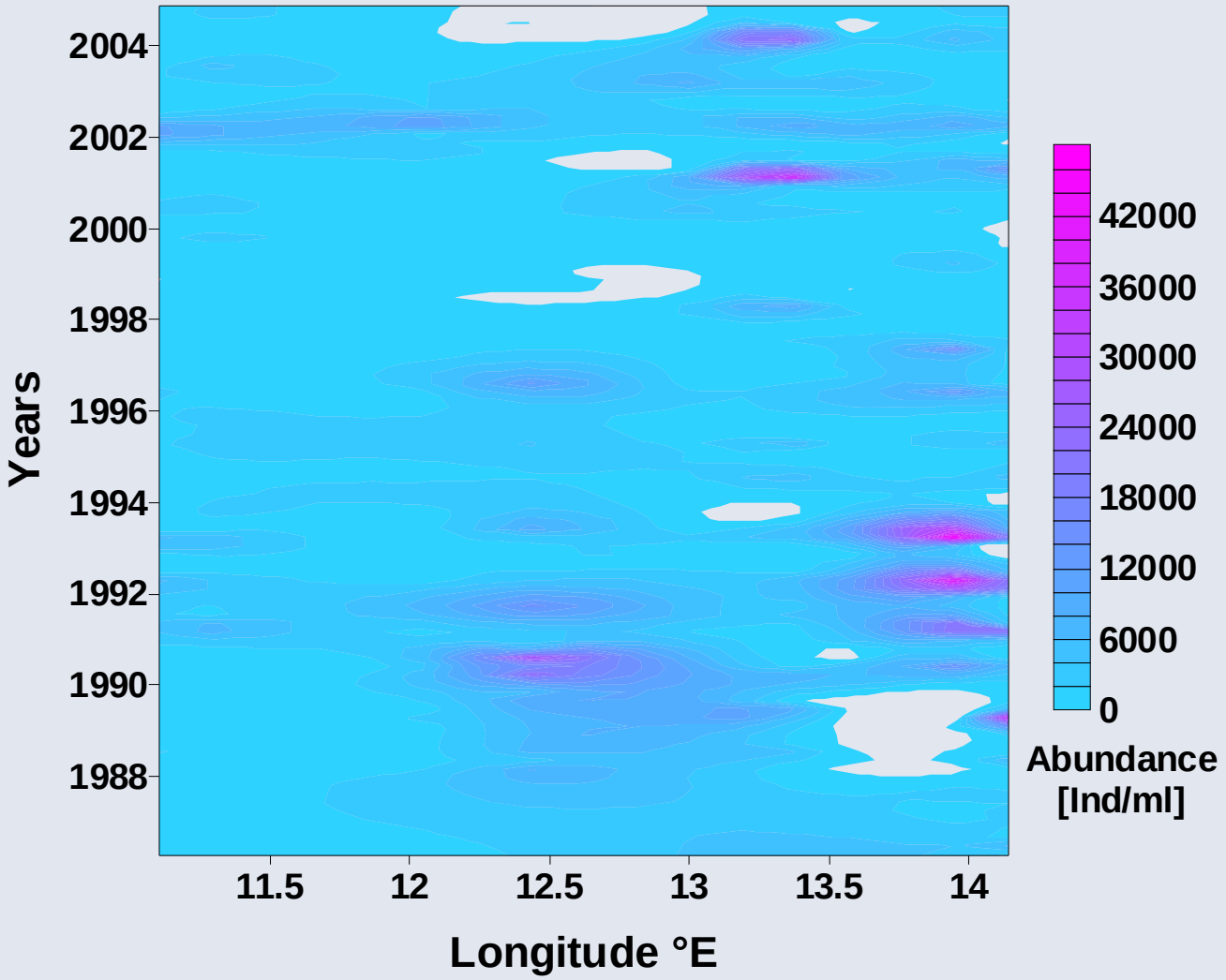
Heterokontophyta

class Chrysophyceae

- Most of the species are unicellular or colonial organisms which may or may not be flagellate. A relative small number of species, however, have a simple multicellular organisation.
- It is estimated that Chrysophyceae contains about 200 genera and roughly 1000 species. The class reaches the maximum diversity in freshwater, although a few species are to be found in brackish or salt water.

Van den Hoek et al. 1993

Chrysophyceae (Abundance)



Heterokontophyta

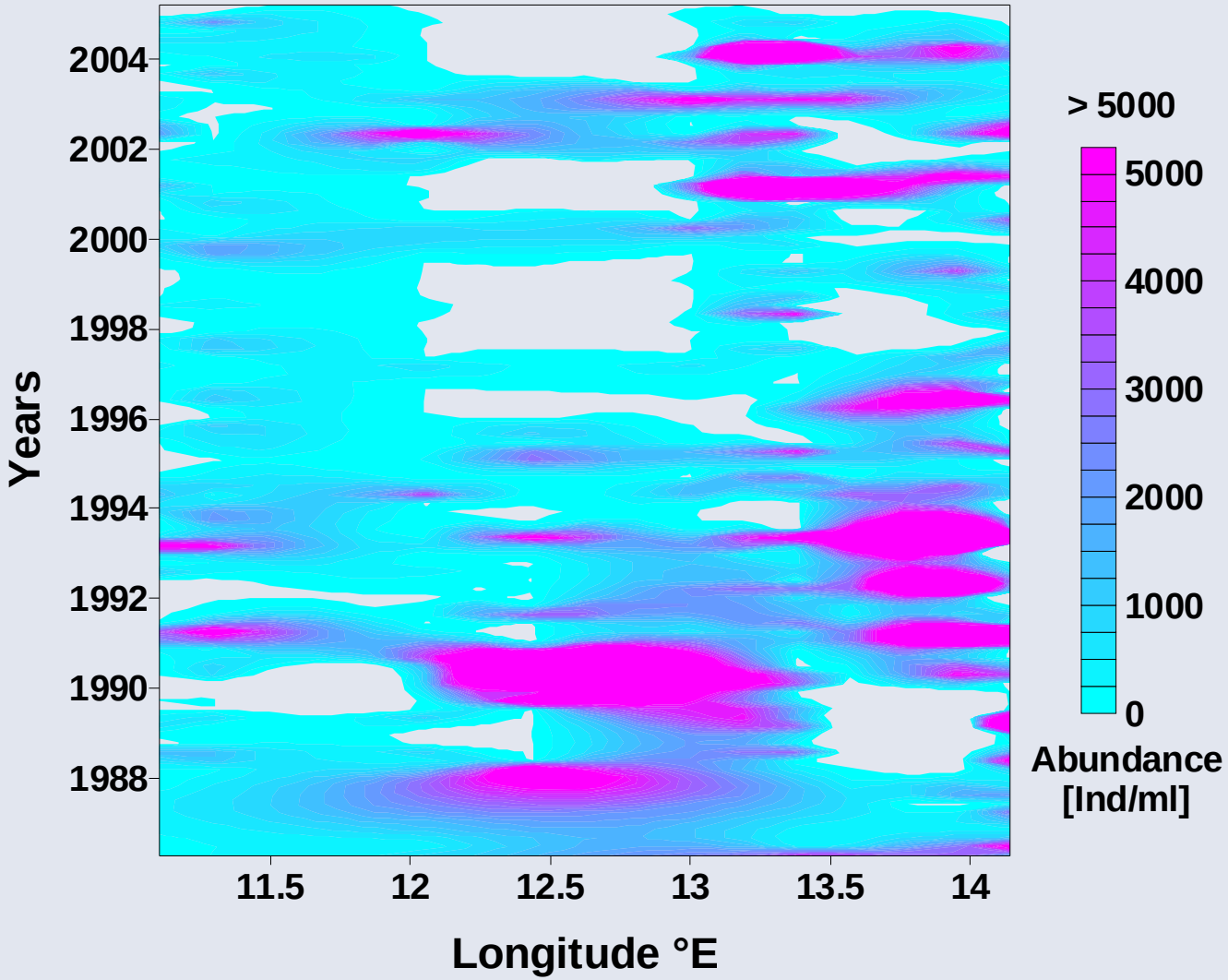
class Bacillariophyceae

- Bacillariophyceae (Diatoms) are a major group of algae. Most diatoms are unicellular, although they can exist as various colony forms. The species specific cell walls consist on silica (hydrated silicon dioxide).
- It is estimated that Diatoms contains about 250 genera and roughly 100 000 species. They are a widespread group and can be found in marine and freshwater habitats in pelagic or benthic forms.

Van den Hoek et al. 1993

Updated version from September 25, 2010

Bacillariophyceae (Abundance)

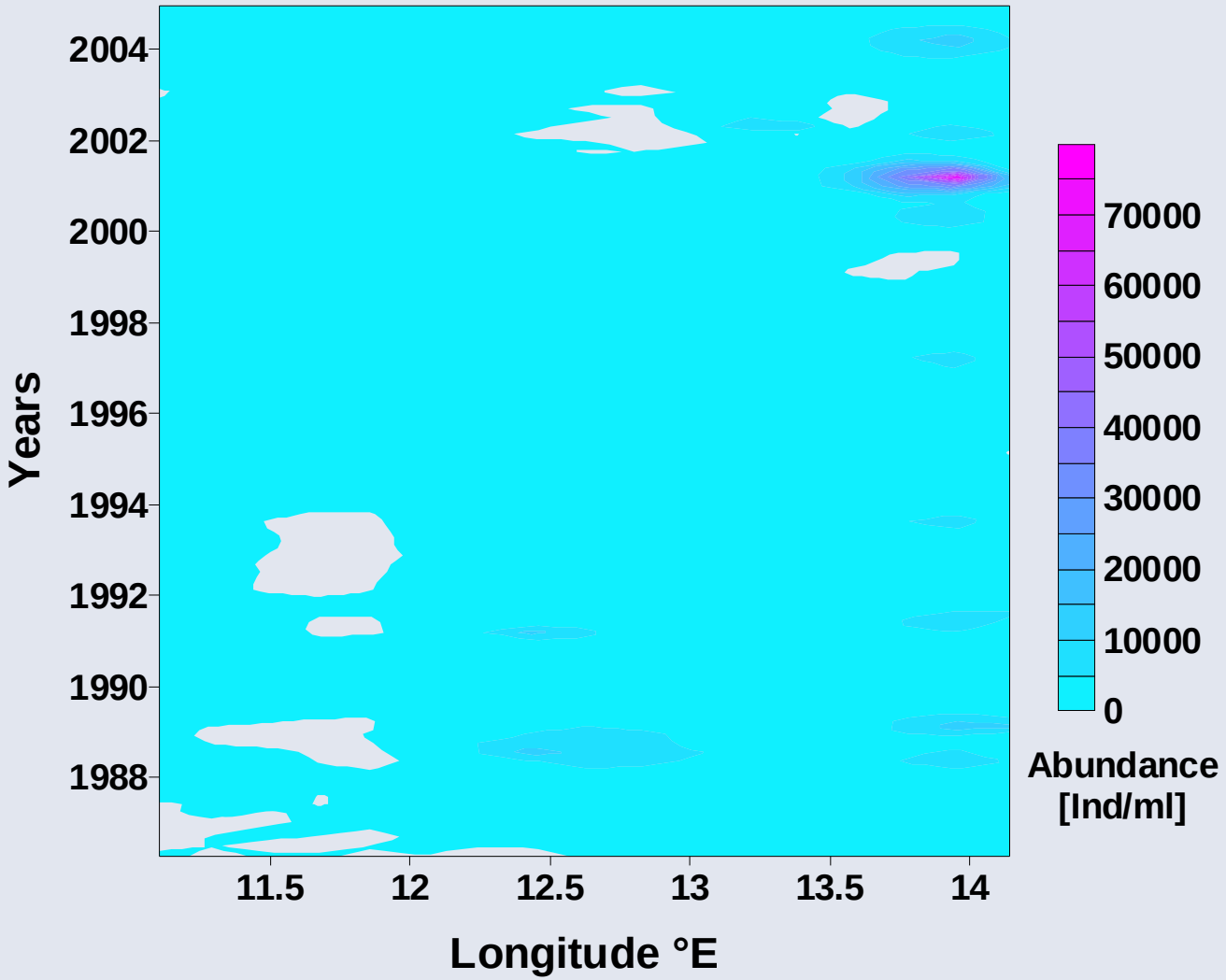


Cryptophyta

- Almost all of the Cryptophyta (one class: Cryptophyceae) are unicellular flagellates, although some of them can form sessile encapsulated stages.
- The class consists of around 12 genera, containing almost 100 freshwater species and 100 marine species.

Van den Hoek et al. 1993

Cryptophyta (Abundance)

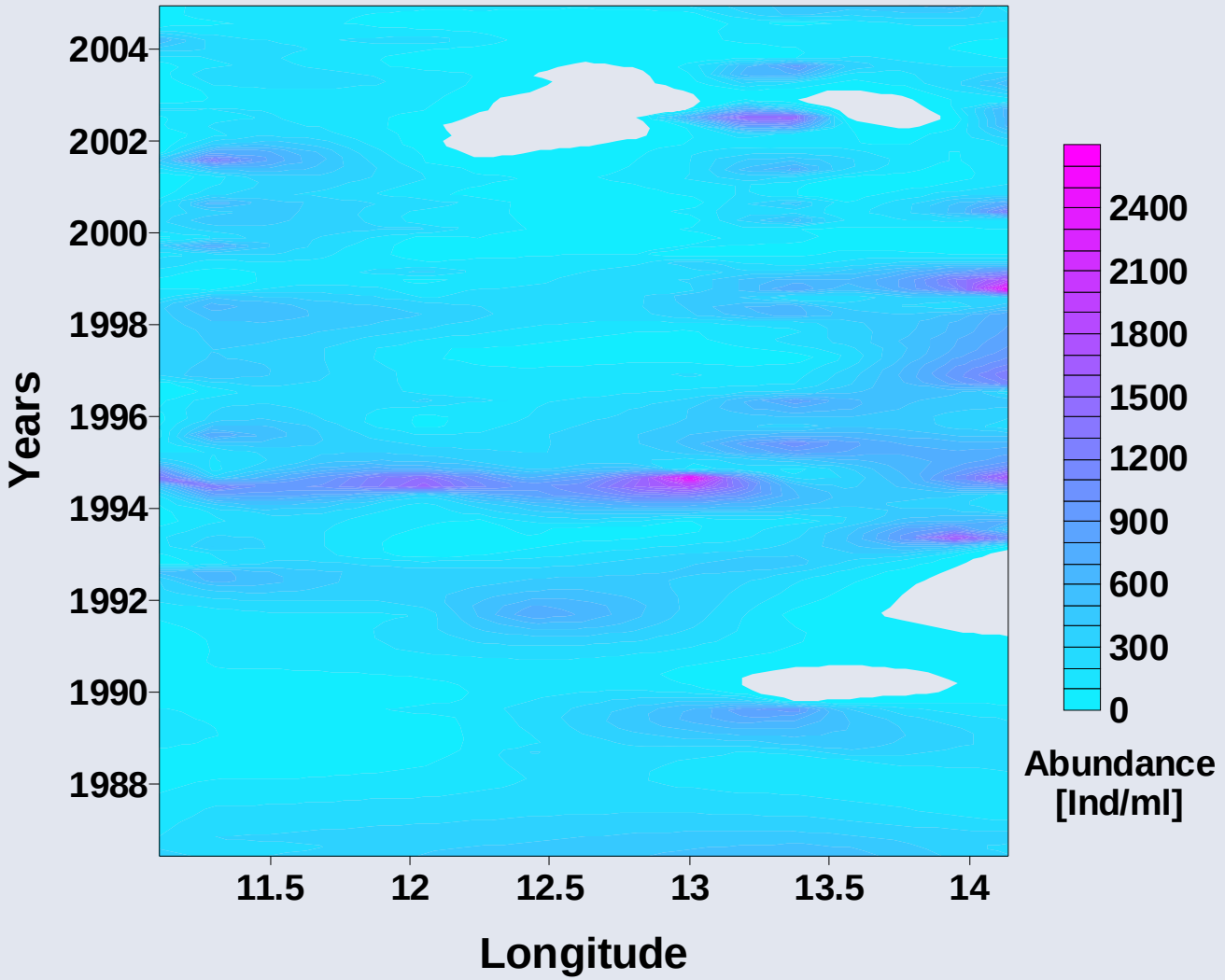


Dinophyta

- The vast majority of Dinophyta (one class: Dinophyceae) are unicellular flagellates and only few are coccoid or filamentous.
- More than 2000 living and 2000 fossil species are known belonging to 130 genera. They live in the surface waters of seas or fresh or brackish waters. Roughly 90% of species are marine.

Van den Hoek et al. 1993

Dinophyta (Abundance)

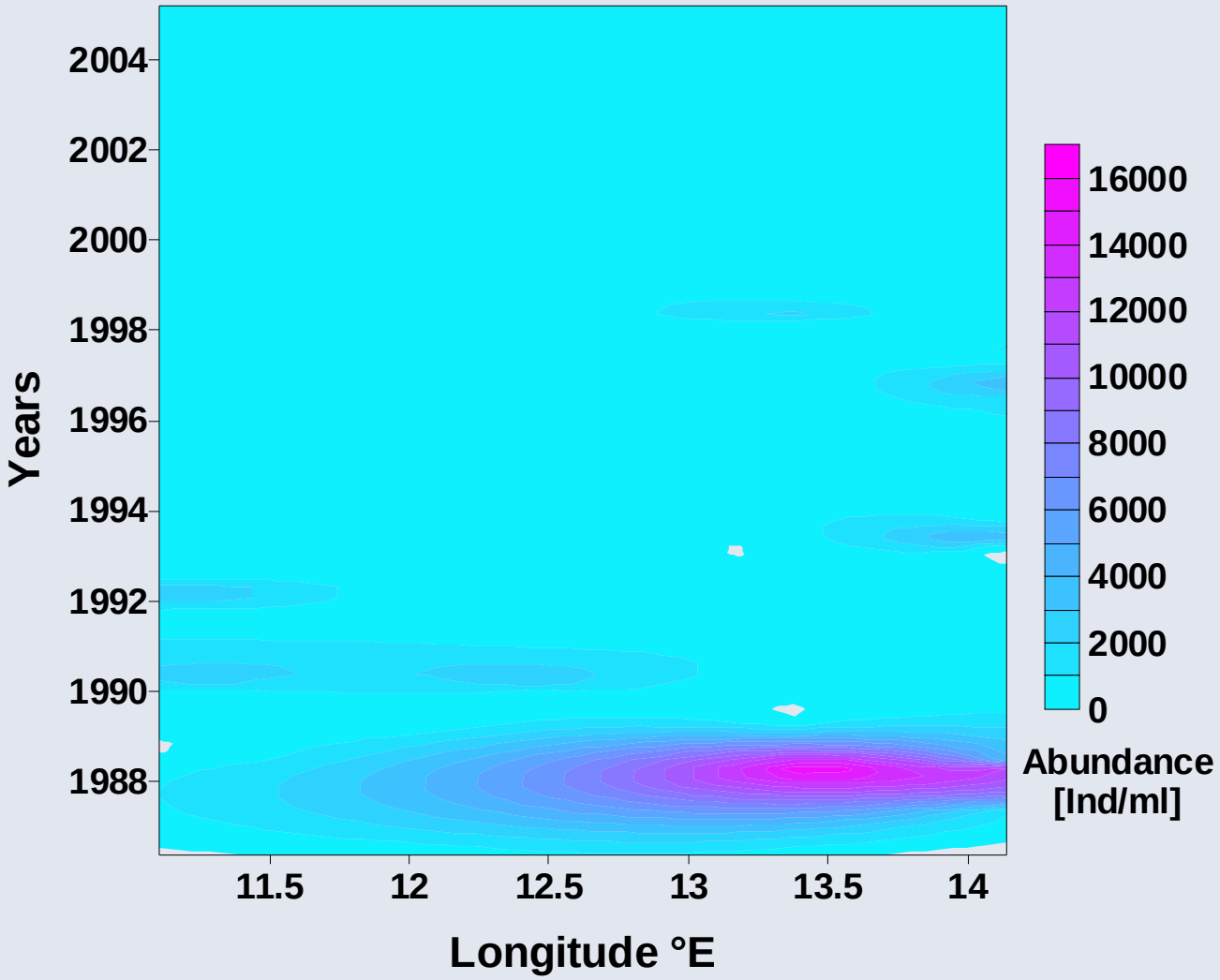


Euglenophyta

- The great majority of Euglenophyta (one class: Euglenophyceae) are unicellular flagellates. They are monads. A few, however, have stages during which the cells are enclosed within a mucilage capsule.
- The number of genera is around 40, with more than 800 species.

Van den Hoek et al. 1993

Euglenophyta (Abundance)

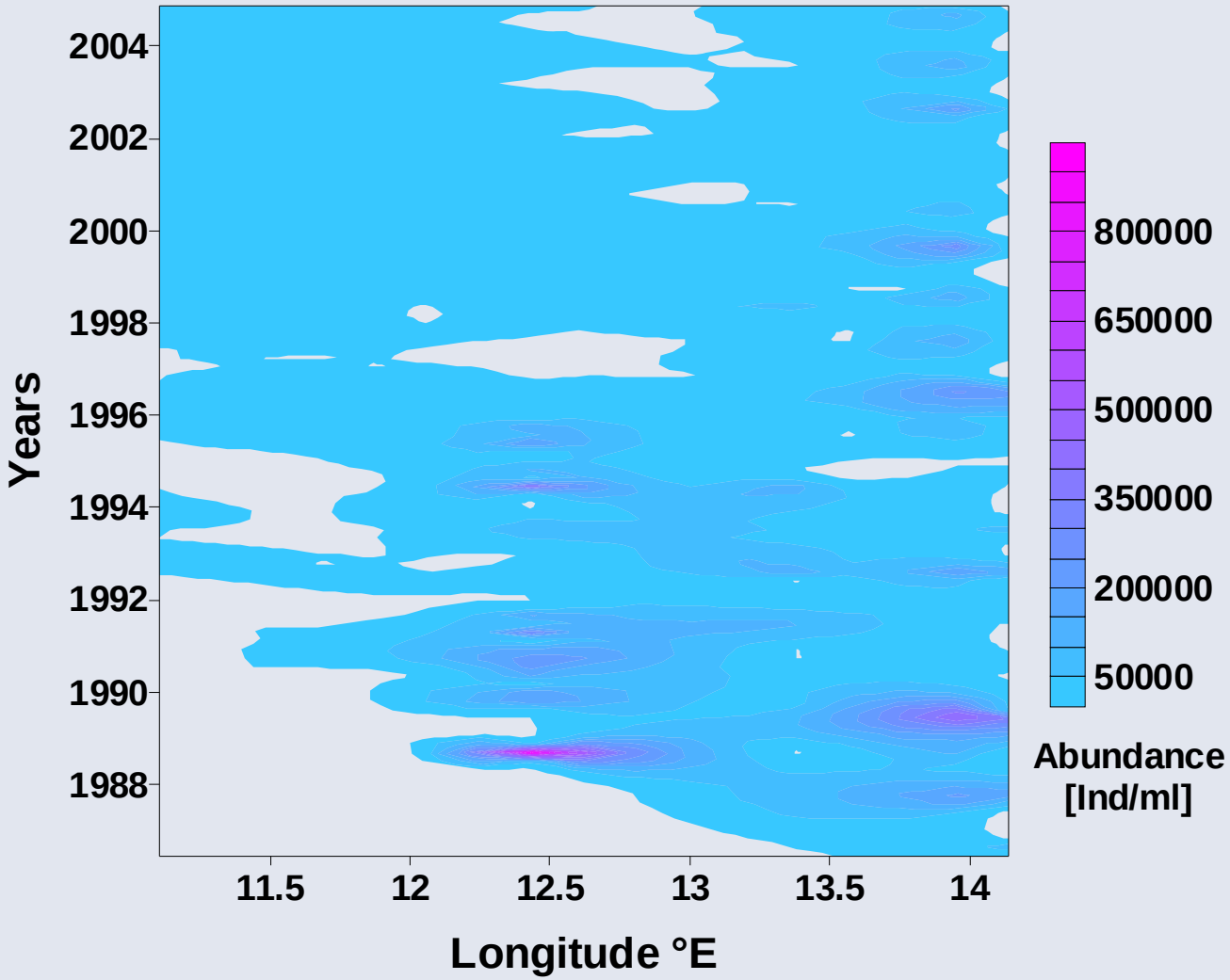


Cyanophyta

- Among the blue-green algae (Cyanophyta, one class: Cyanophyceae) there are unicellular, colonial, and filamentous forms, and there are even some with simple parenchymatous organization. Flagellate cells never occur at any stage in the life cycle.
- The division contains about 150 genera and 2000 species. They are found in the most diverse habitats: in freshwater and in the sea, on damp soil, and even in such extreme and inhospitable places as glaciers, deserts and hot springs.

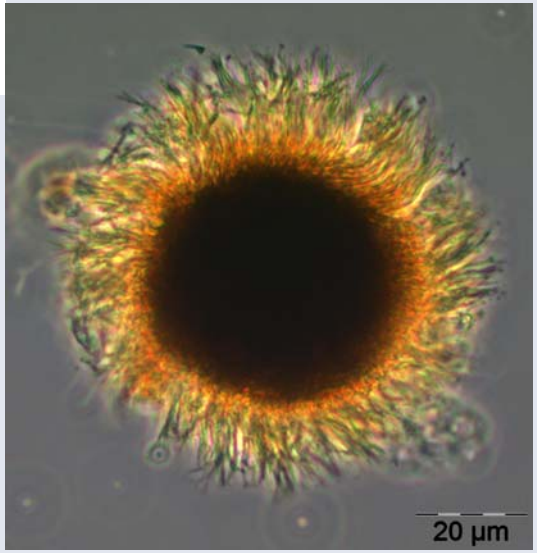
Van den Hoek et al. 1993

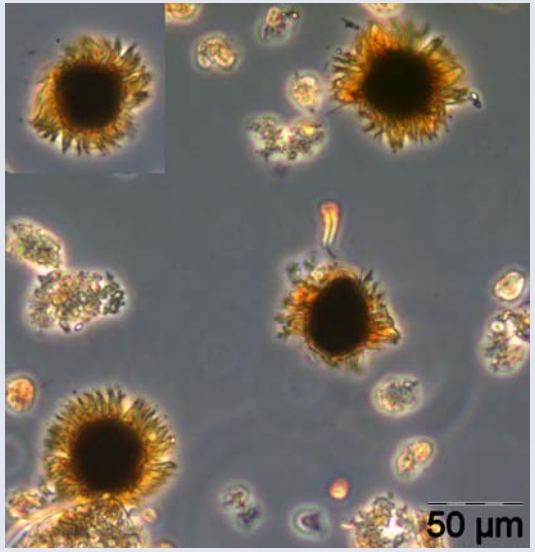
Cyanophyta (Abundance)



Ciliophora

- Ciliophora are mainly heterotroph, but, only one autotroph species exists in the Baltic Sea. Therefore, we consider only this species namely „Mesodinium rubrum“.

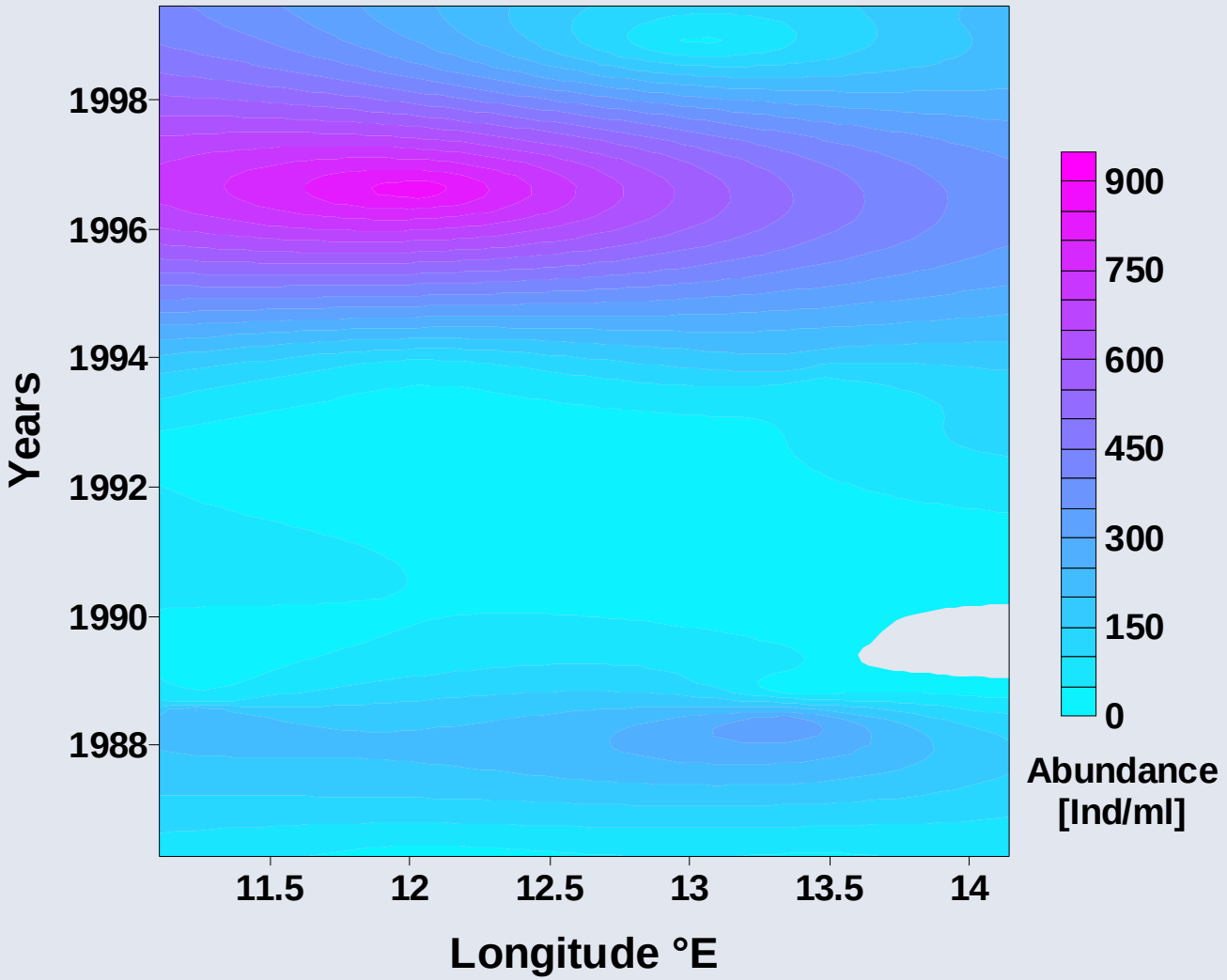




Van den Hoek et al. 1993

Photos: Susanne Busch

Mesodinium rubrum (Abundance)



Federal Ministry of Education and Research

Part 2: Changes in Seasonality

Content Part 2

- Summary
- Maps of ecological patterns (O5)
  - Physical data
  - Nutrient data
  - Phytoplankton data
- Maps of ecological patterns (O11)
  - Physical data
  - Nutrient data
  - Phytoplankton data
- Maps of ecological patterns (OB4)
  - Physical data
  - Nutrient data
  - Phytoplankton data

Summary

Physical and chemical properties and phytoplankton on a species level are routinely monitored in the southern Baltic Sea (LUNG 2004). The phytoplankton observations are merged into taxonomic divisions. We present the monitoring data for three selected stations in graphical form using phase diagrams which allow to identify changes in seasonality, inter-annual variability or regime shift. The stations (see station map) are O5 in the Mecklenburg Bight, O11 in the Arkona Sea, and OB4 in the Pommeranian Bight.
Compared to the Hovmöller diagram, not all divisions can be presented due to insufficient data density.

Updated version from September 25, 2010

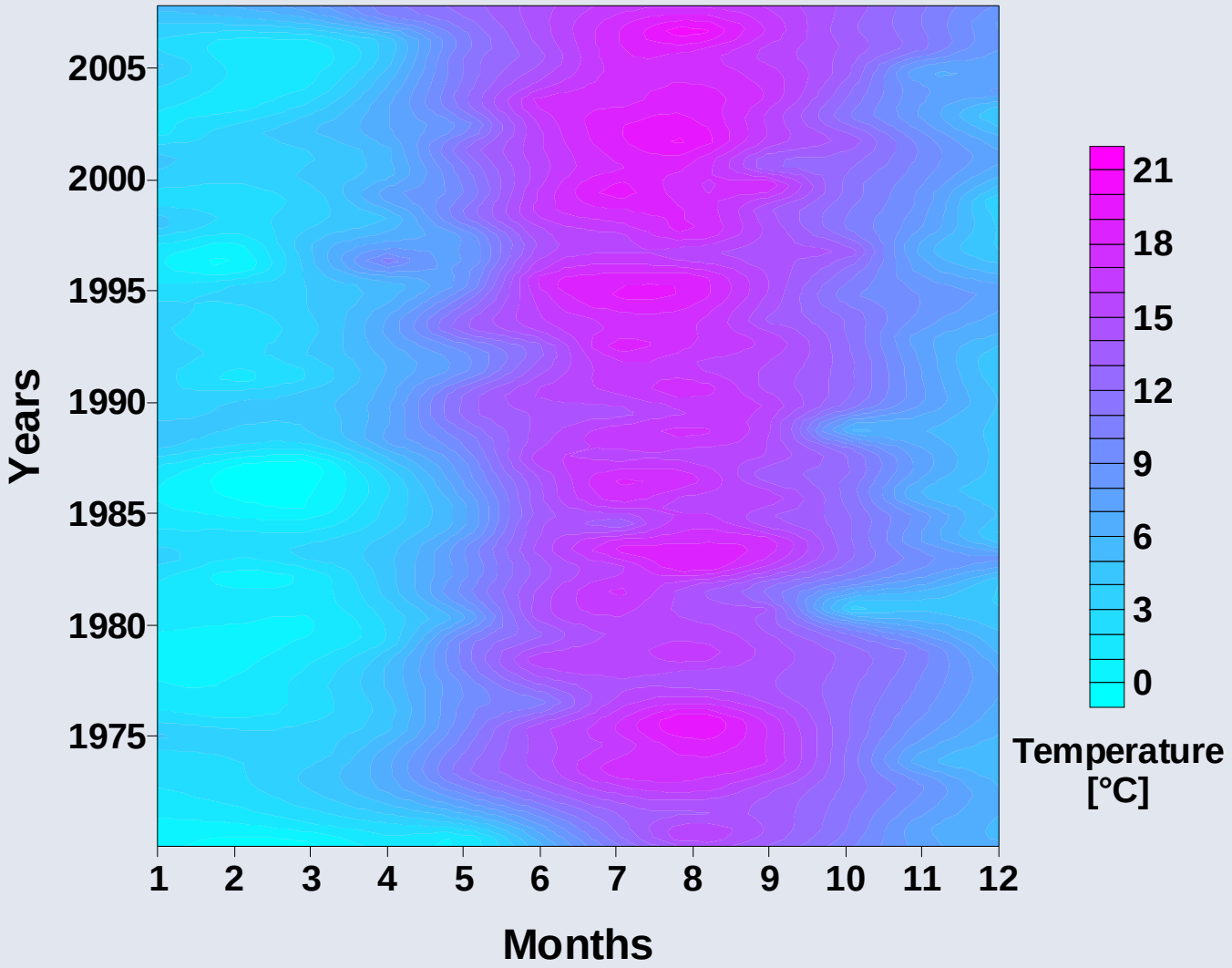
Maps of ecological patterns
Station O5

Physical Data at O5

- Temperature
- Salinity
- Oxygen
- Oxygen saturation
- pH value

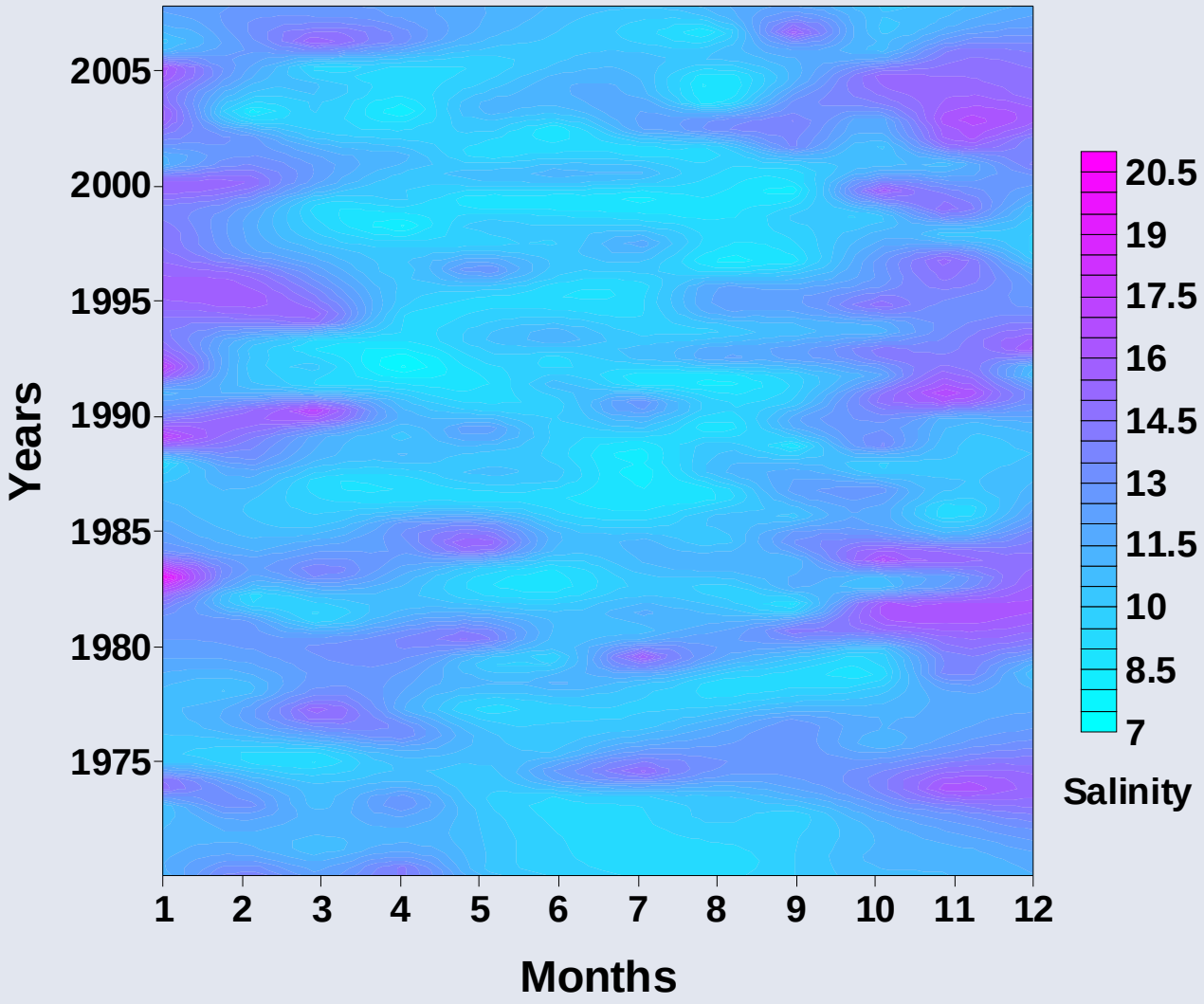
Updated version from September 25, 2010

Temperature O5



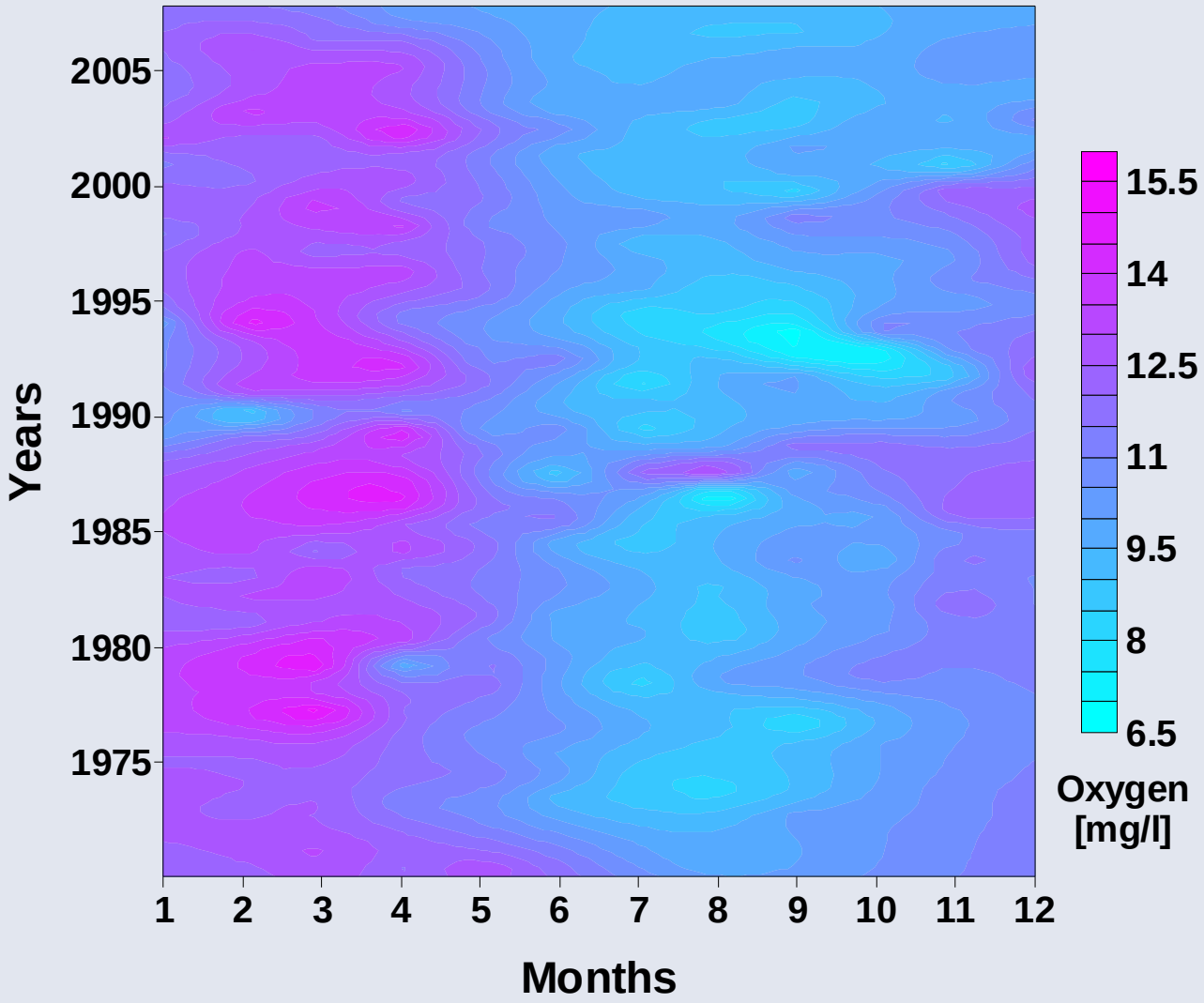
Updated version from September 25, 2010

Salinity O5



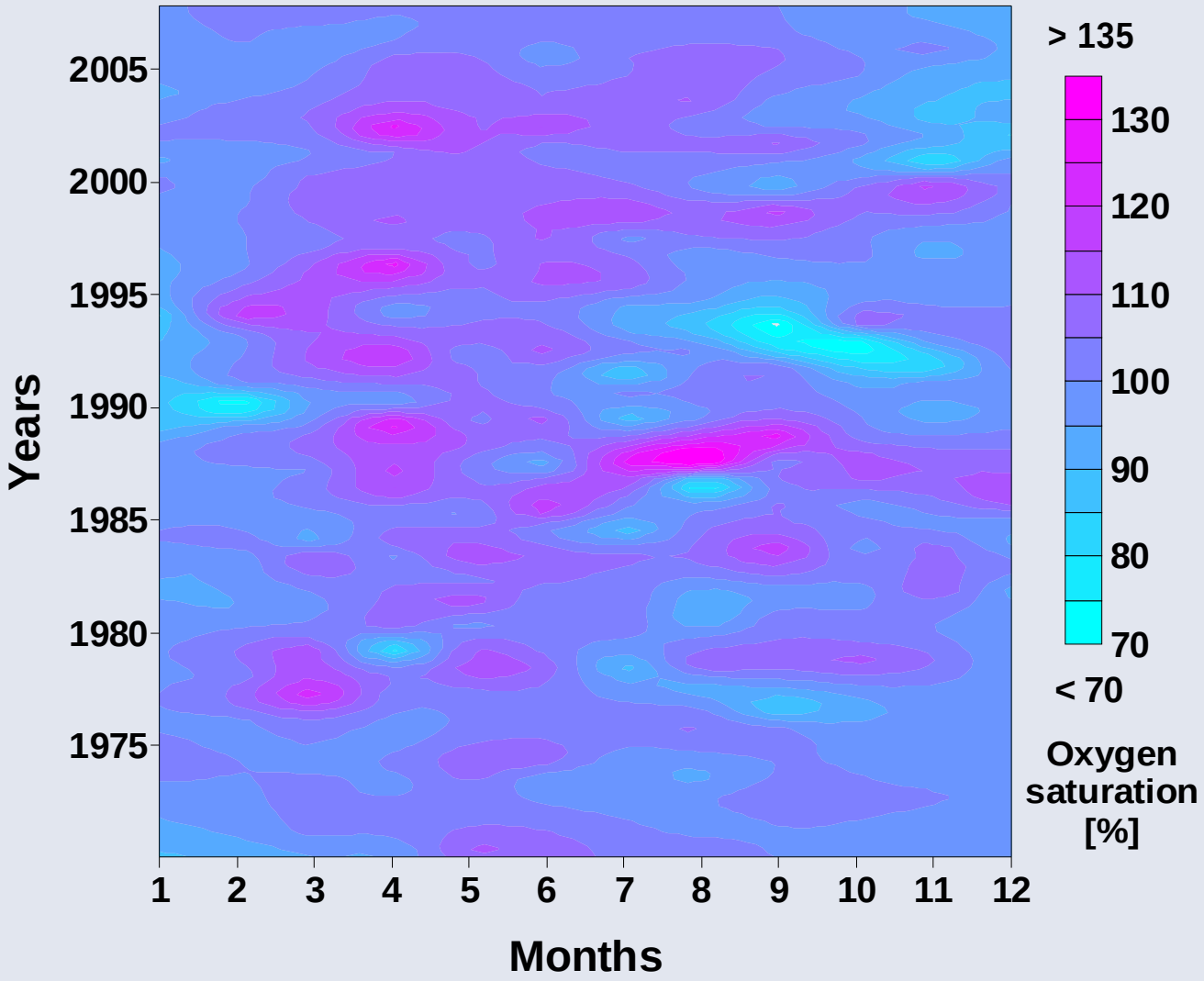
Updated version from September 25, 2010

Oxygen O5



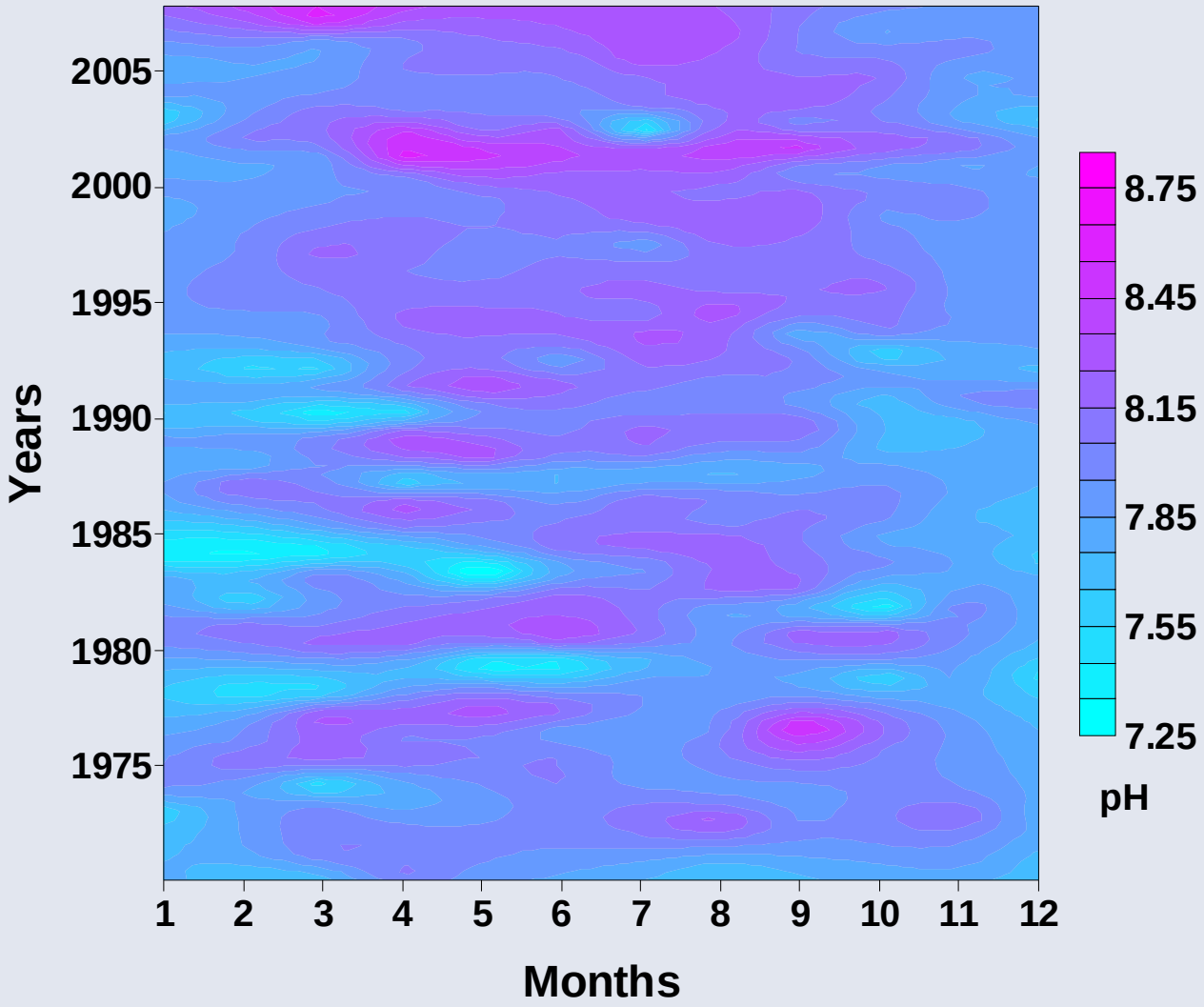
Updated version from September 25, 2010

Oxygen saturation O5



Updated version from September 25, 2010

pH value O5

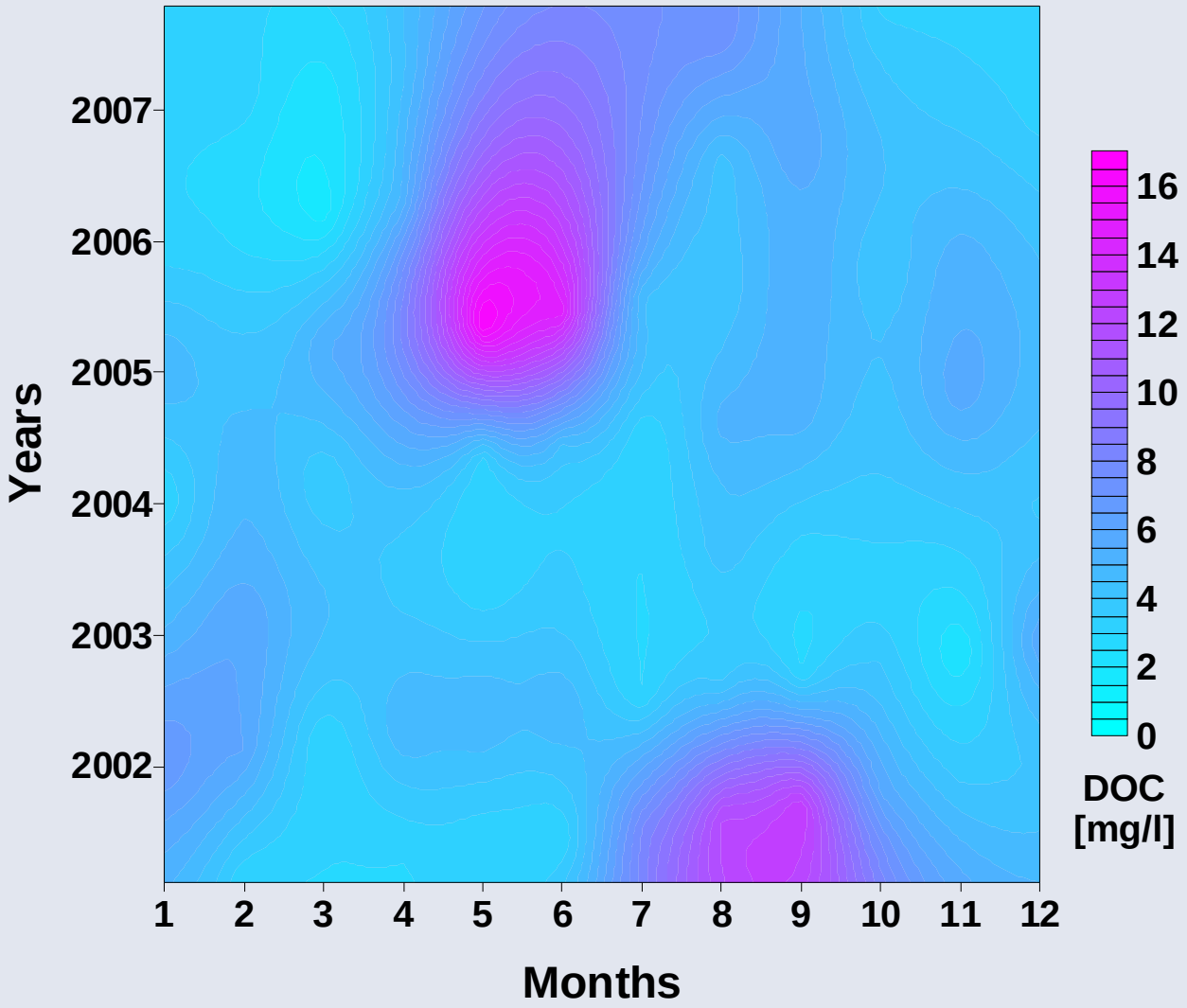


Nutrient Data at O5

- Dissolved Organic Carbon (DOC)
- Total Organic Carbon (TOC)
- Nitrate
- Nitrite
- Ammonia
- Total N
- Phosphate
- Total phosphorus
- Silicate

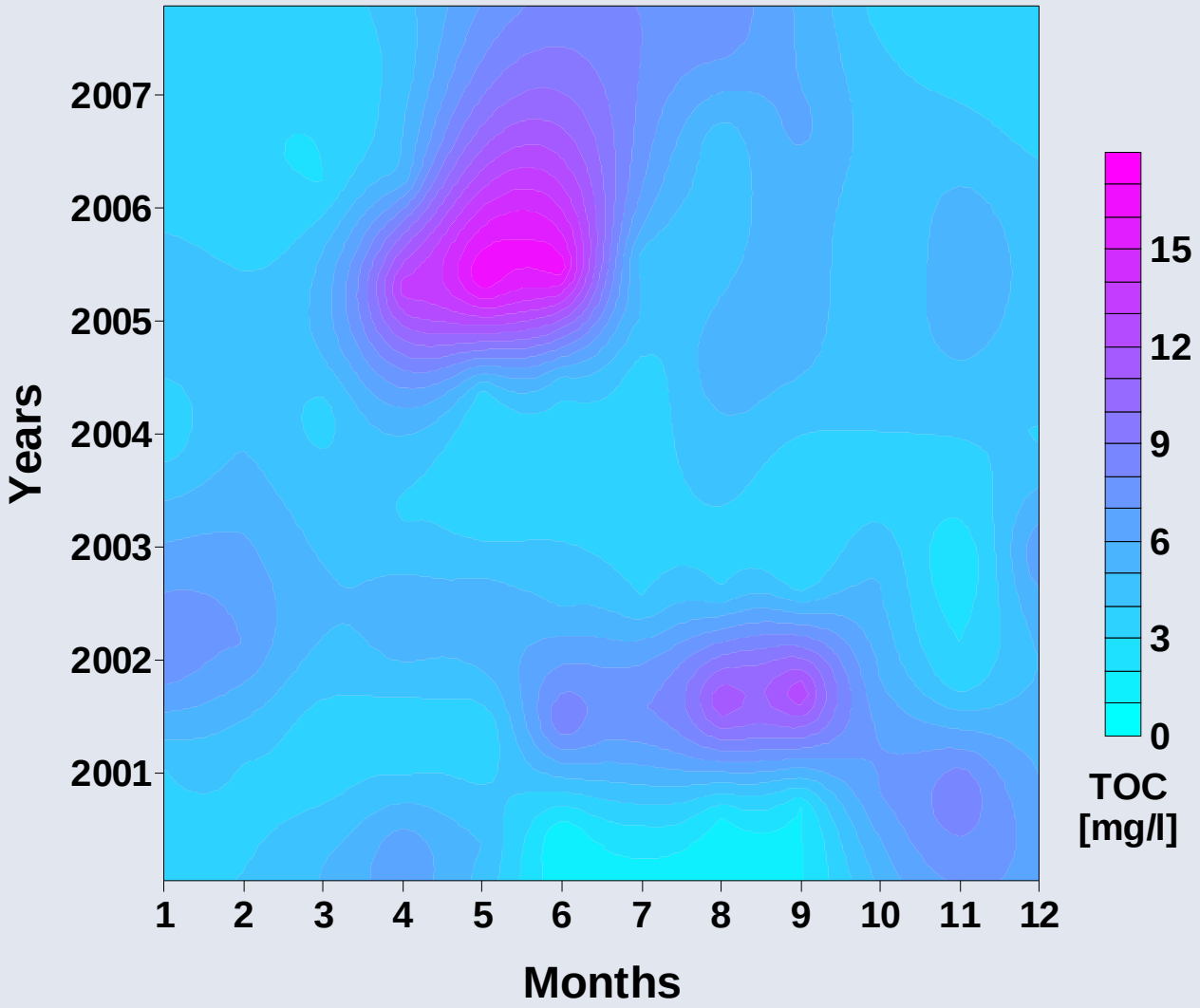
Updated version from September 25, 2010

Dissolved Organic Carbon O5



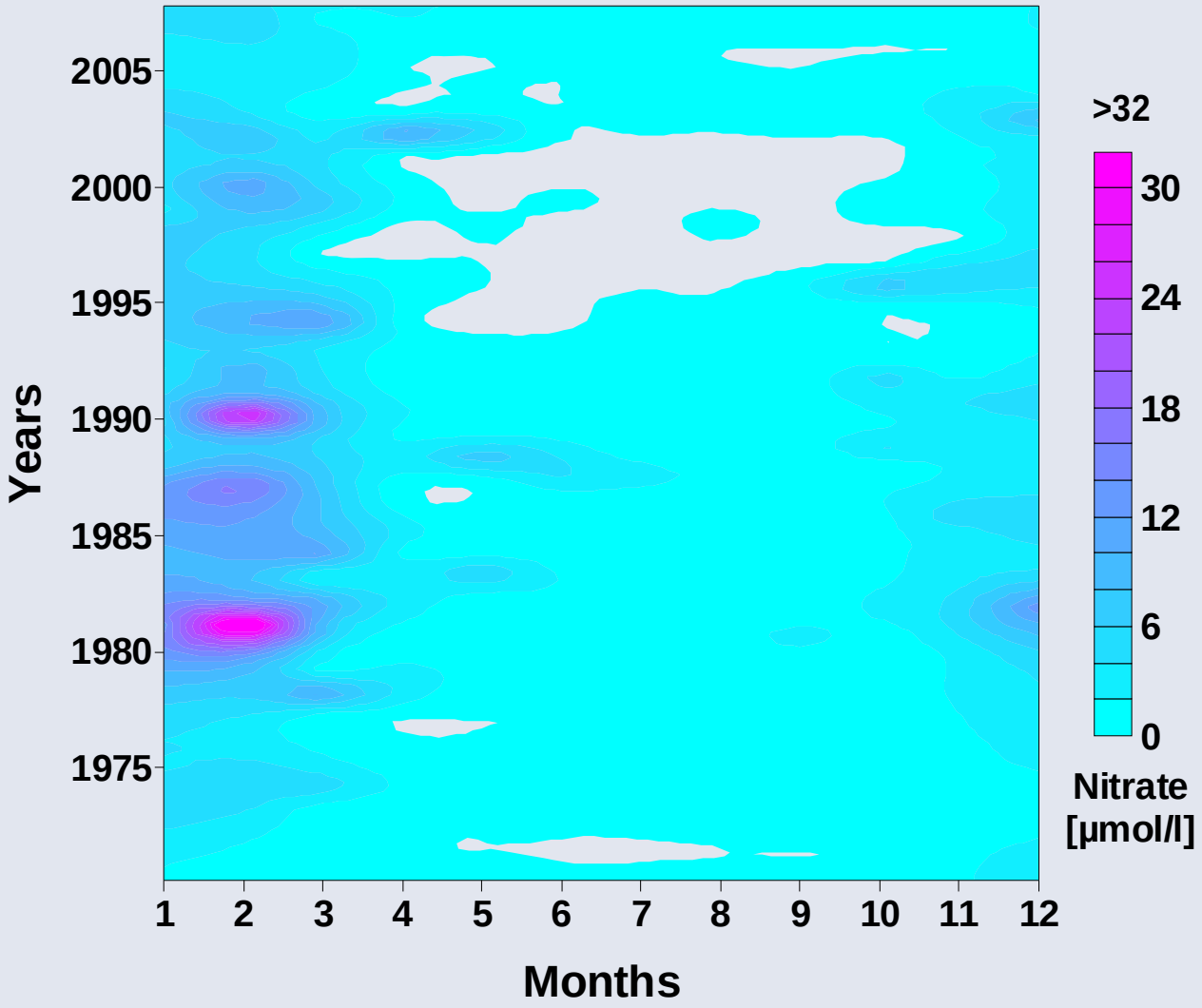
Updated version from September 25, 2010

Total Organic Carbon O5



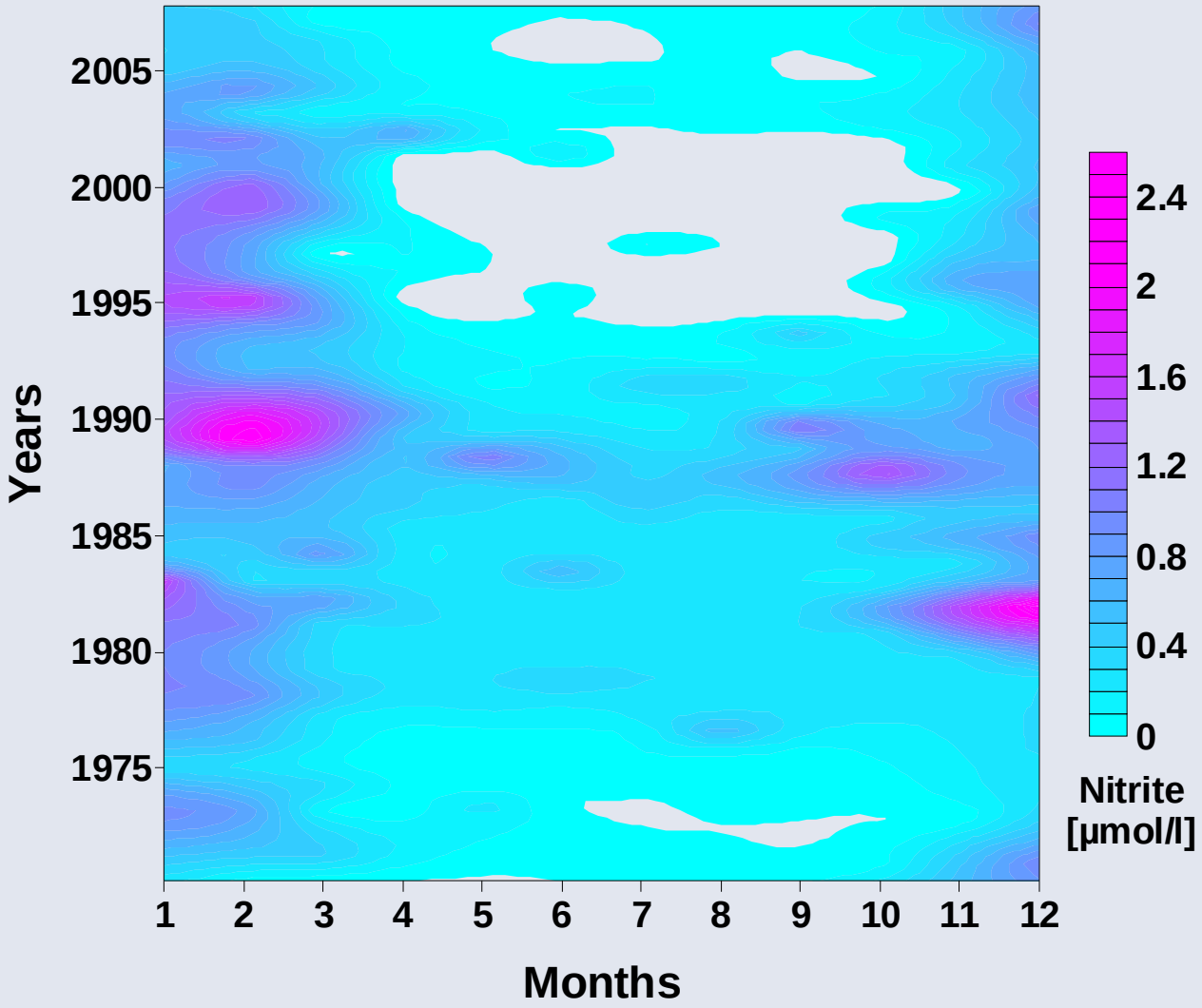
Updated version from September 25, 2010

Nitrate O5



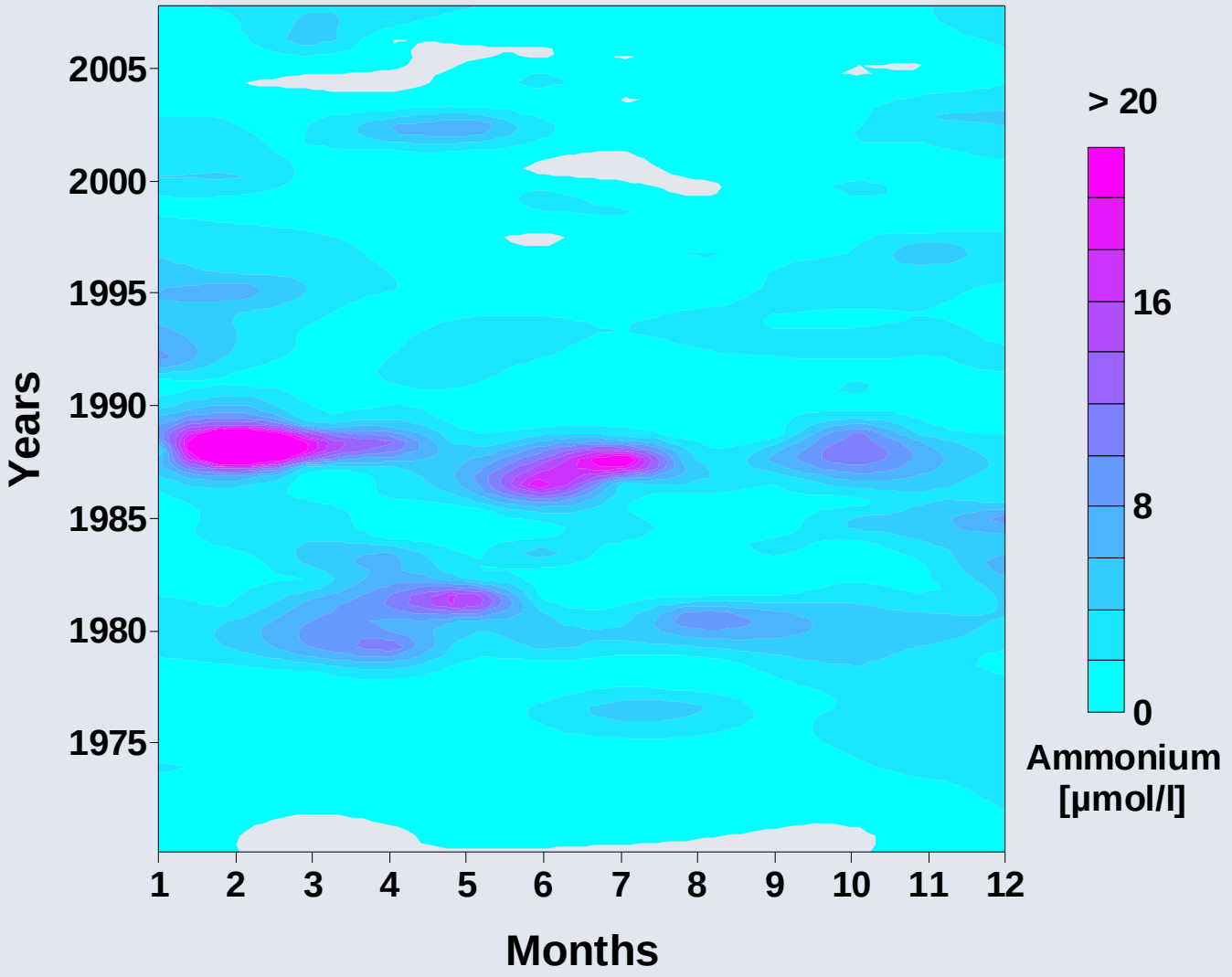
Updated version from September 25, 2010

Nitrite O5

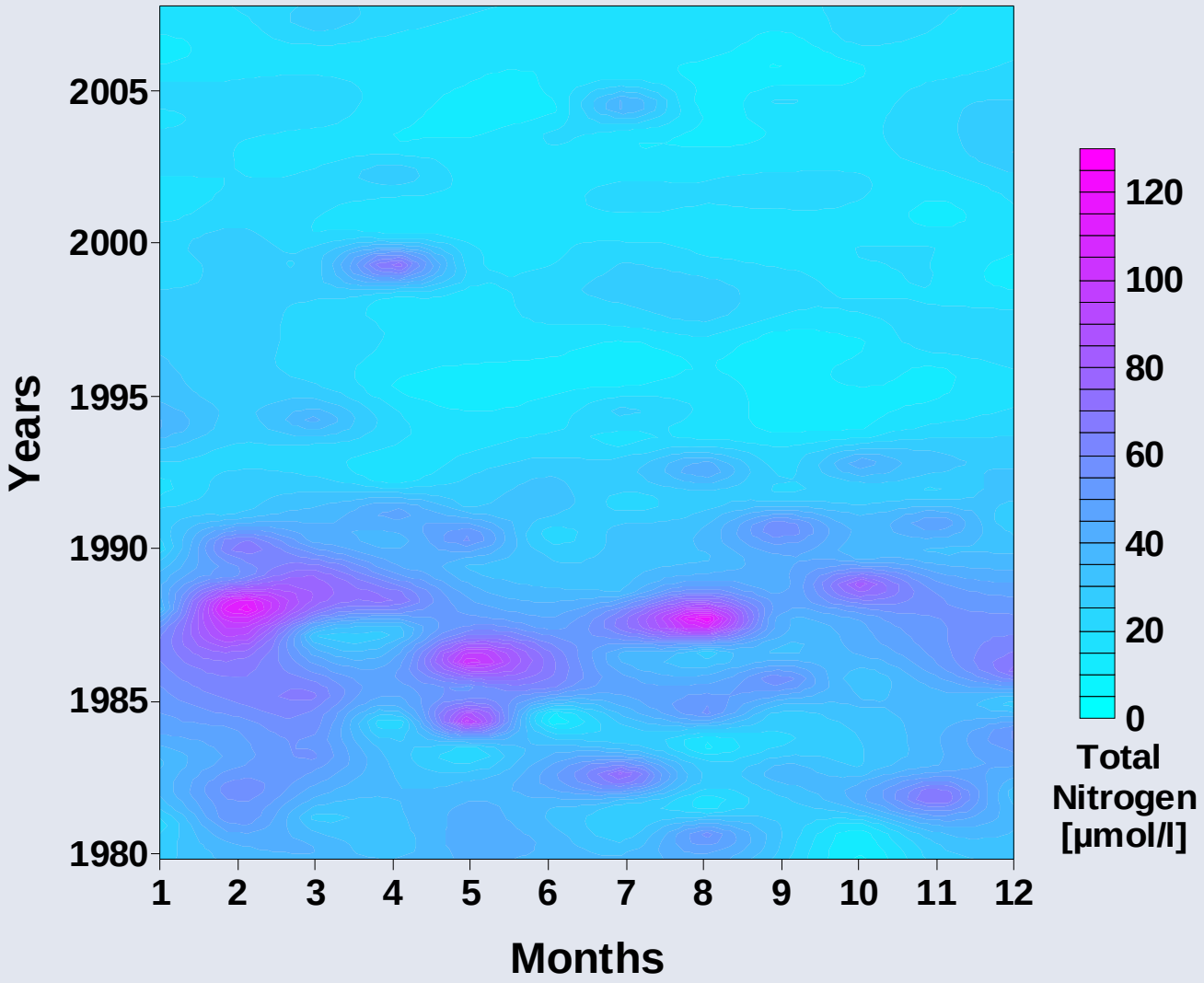


Updated version from September 25, 2010

Ammonium O5

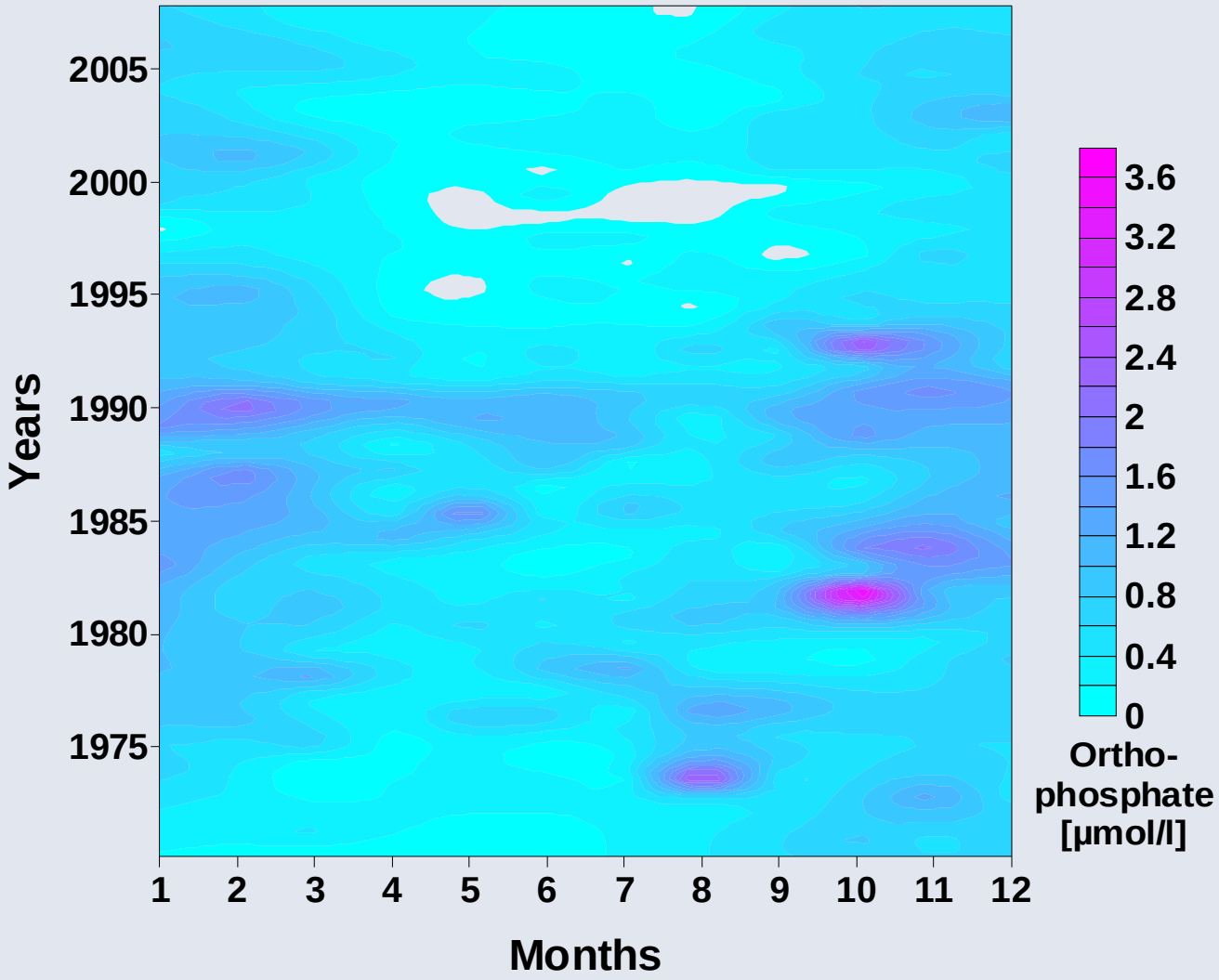


Total Nitrogen O5



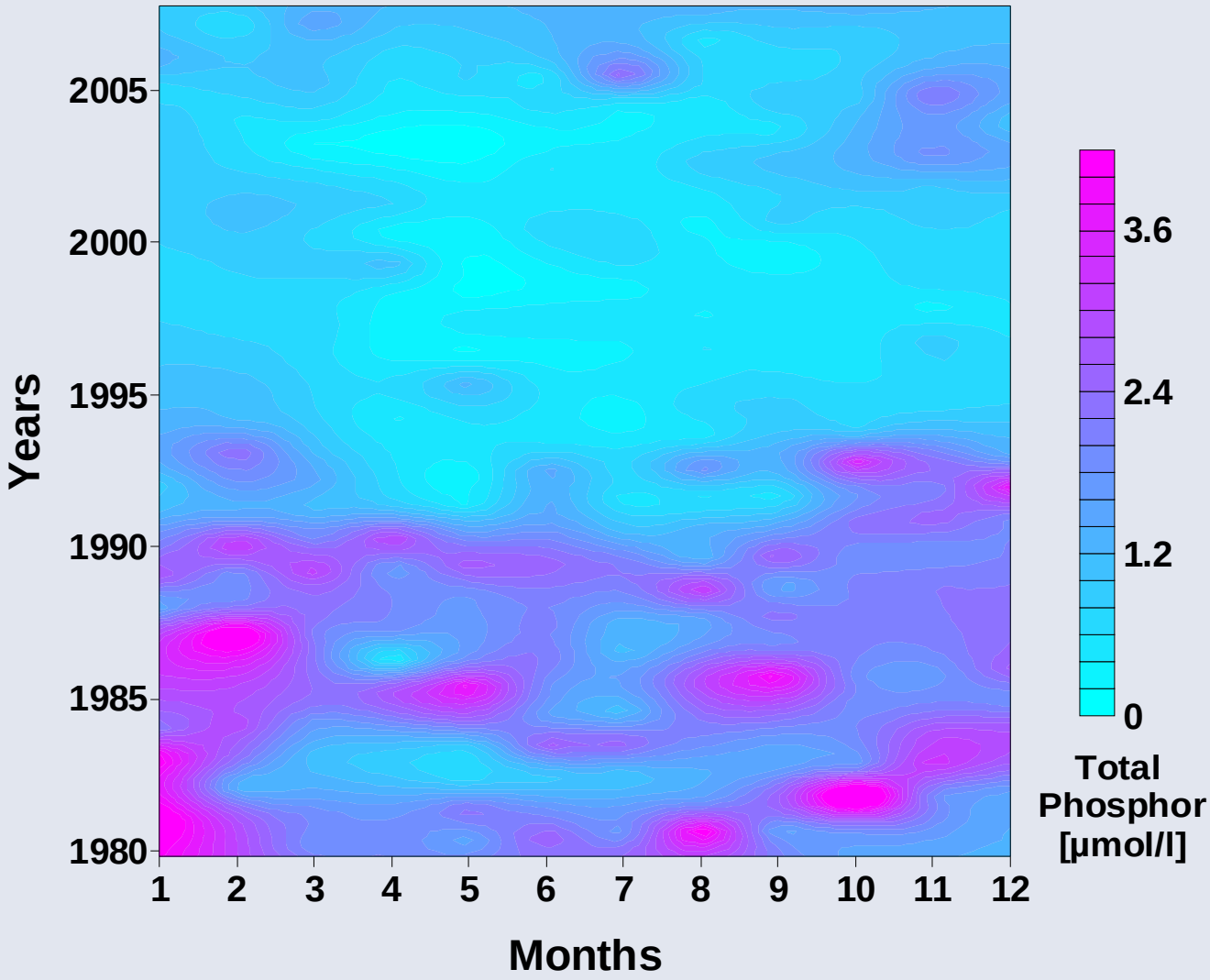
Updated version from September 25, 2010

Phosphate O5



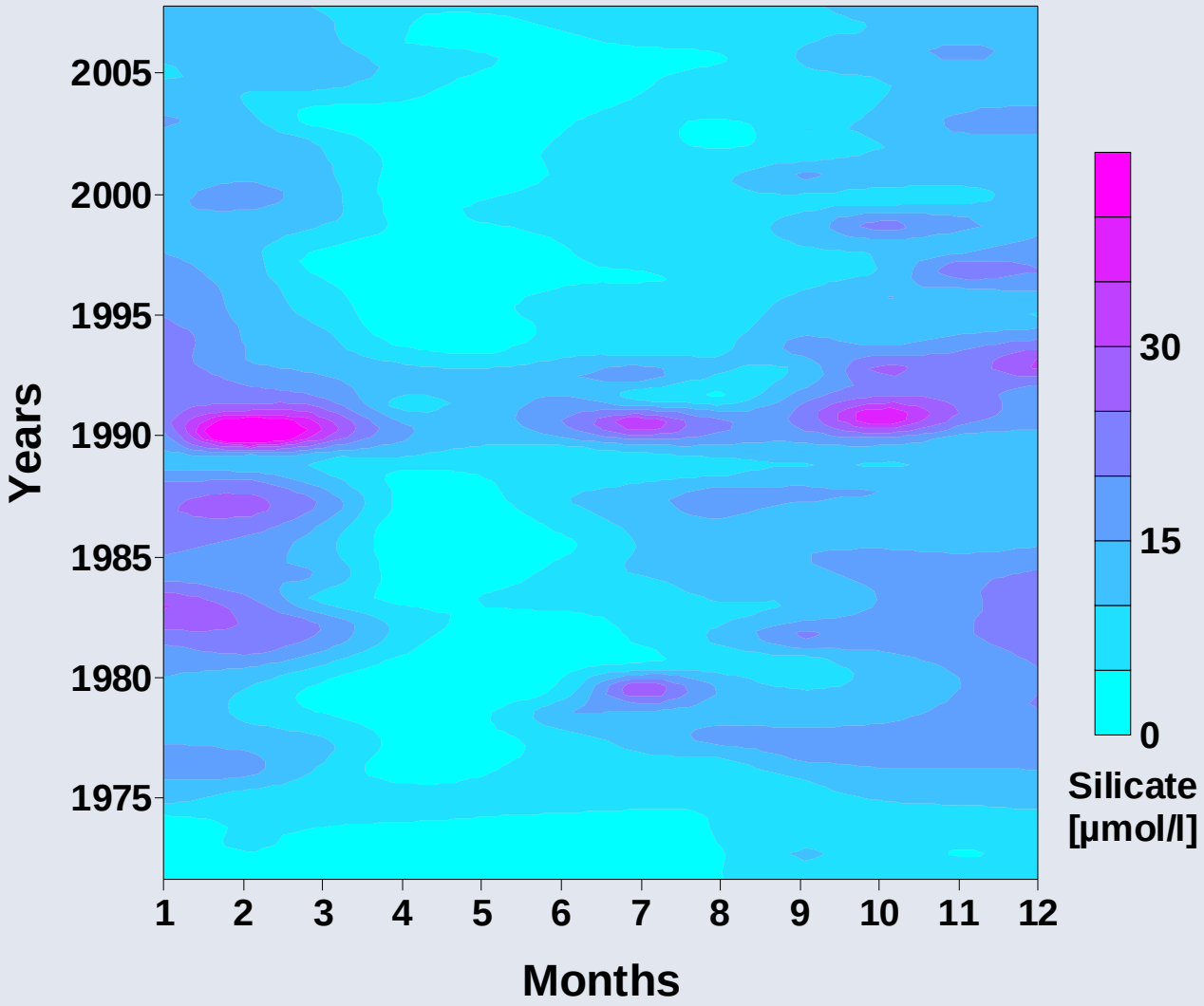
Updated version from September 25, 2010

Total phosphorus O5



Updated version from September 25, 2010

Silicate O5

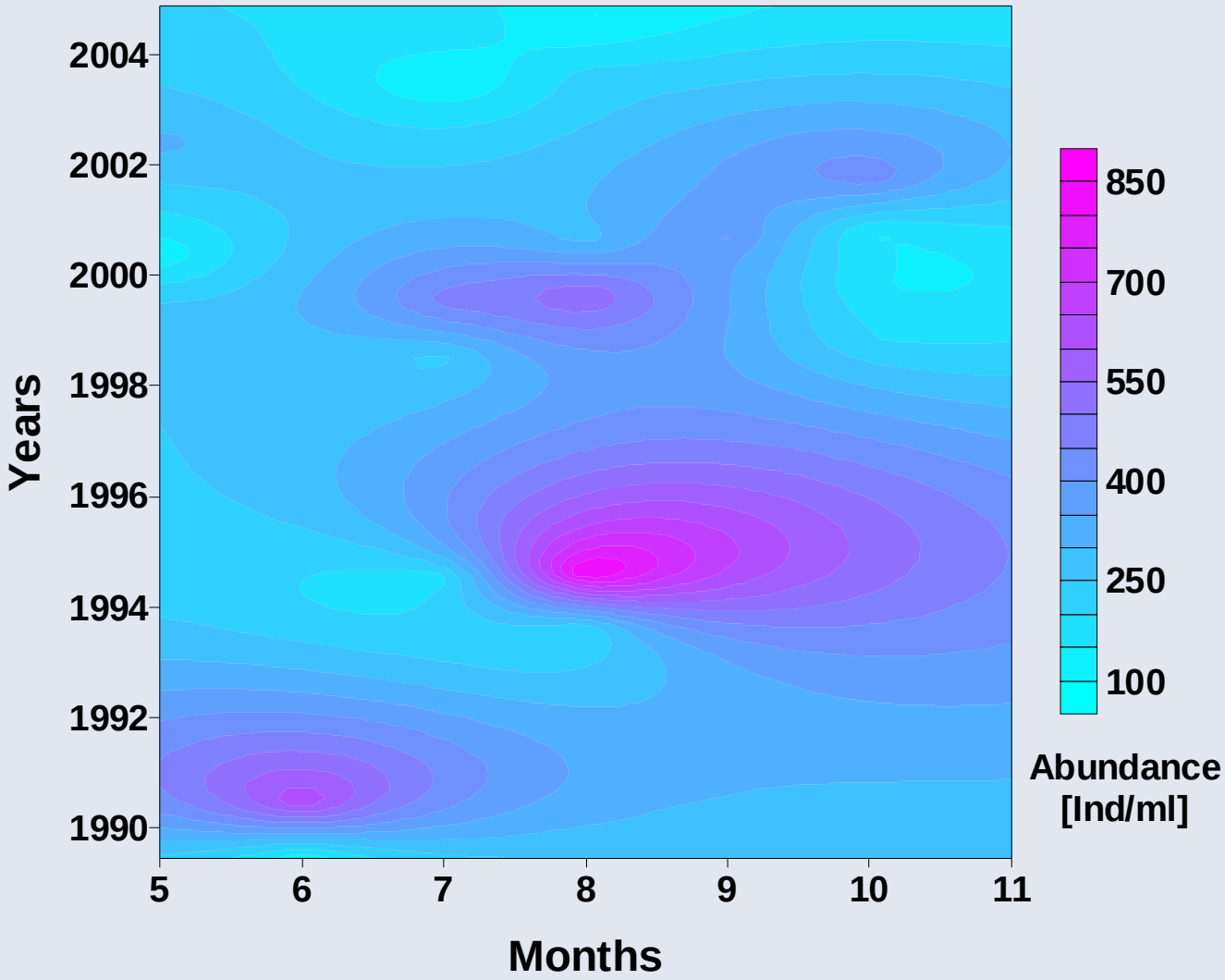


List of taxonomic divisions O5

- Chlorophyta
- Heterokontophyta
  - class Chrysophyceae
  - class Bacillariophyceae
- Cryptophyta
- Dinophyta
- Euglenophyta
- Cyanophyta

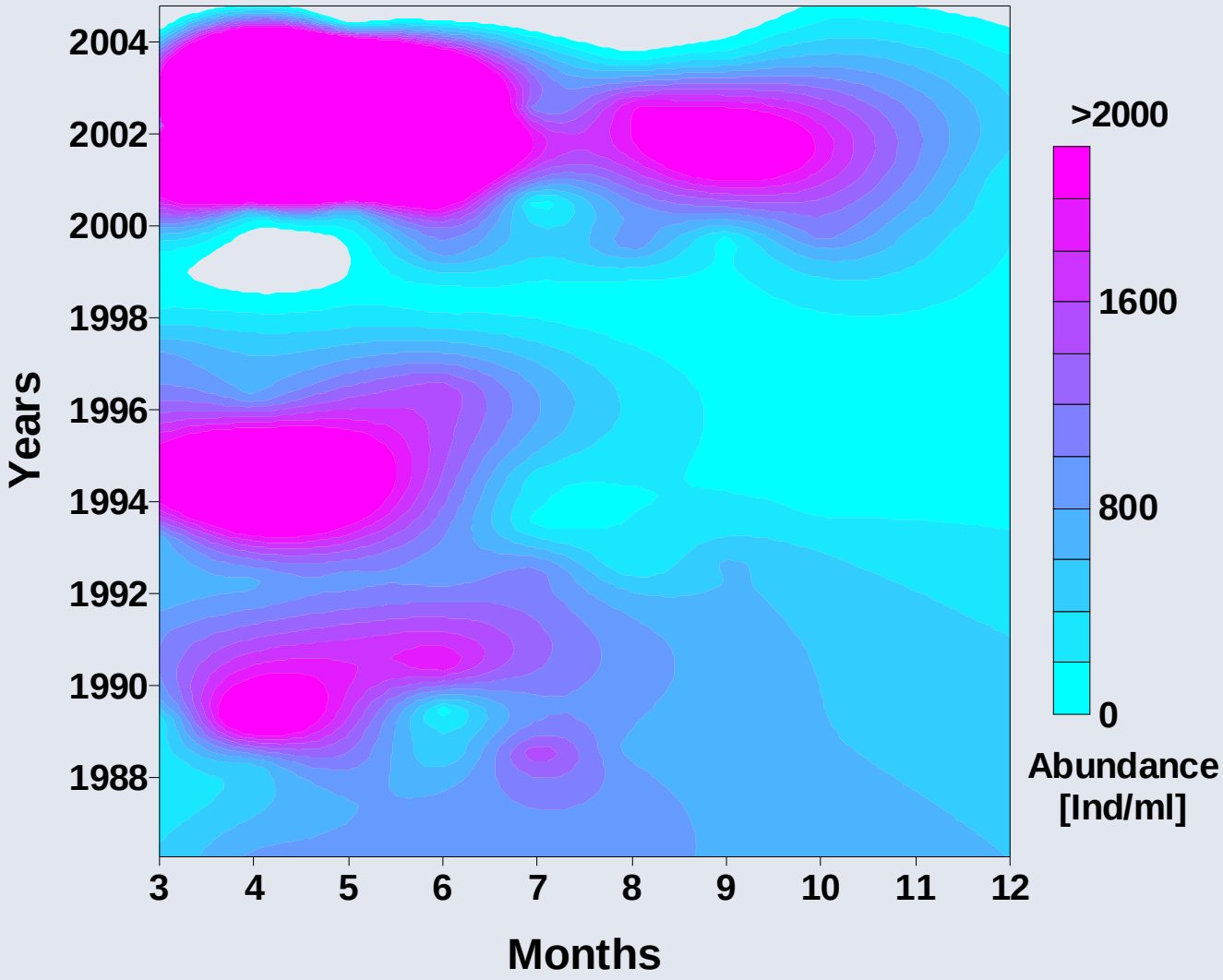
Updated version from September 25, 2010

Chlorophyceae (Abundance) O5



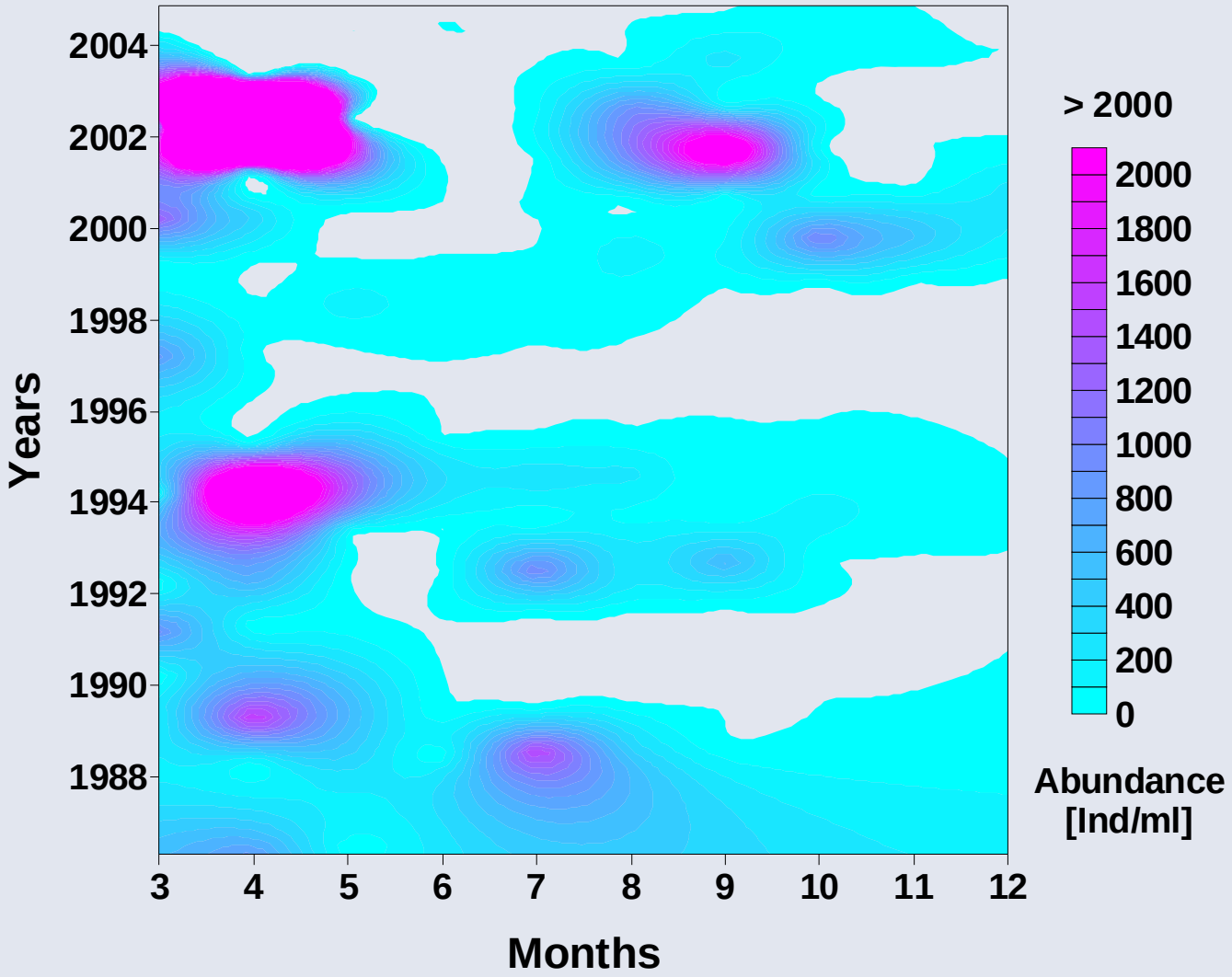
Updated version from September 25, 2010

Chrysophyceae (Abundance) O5



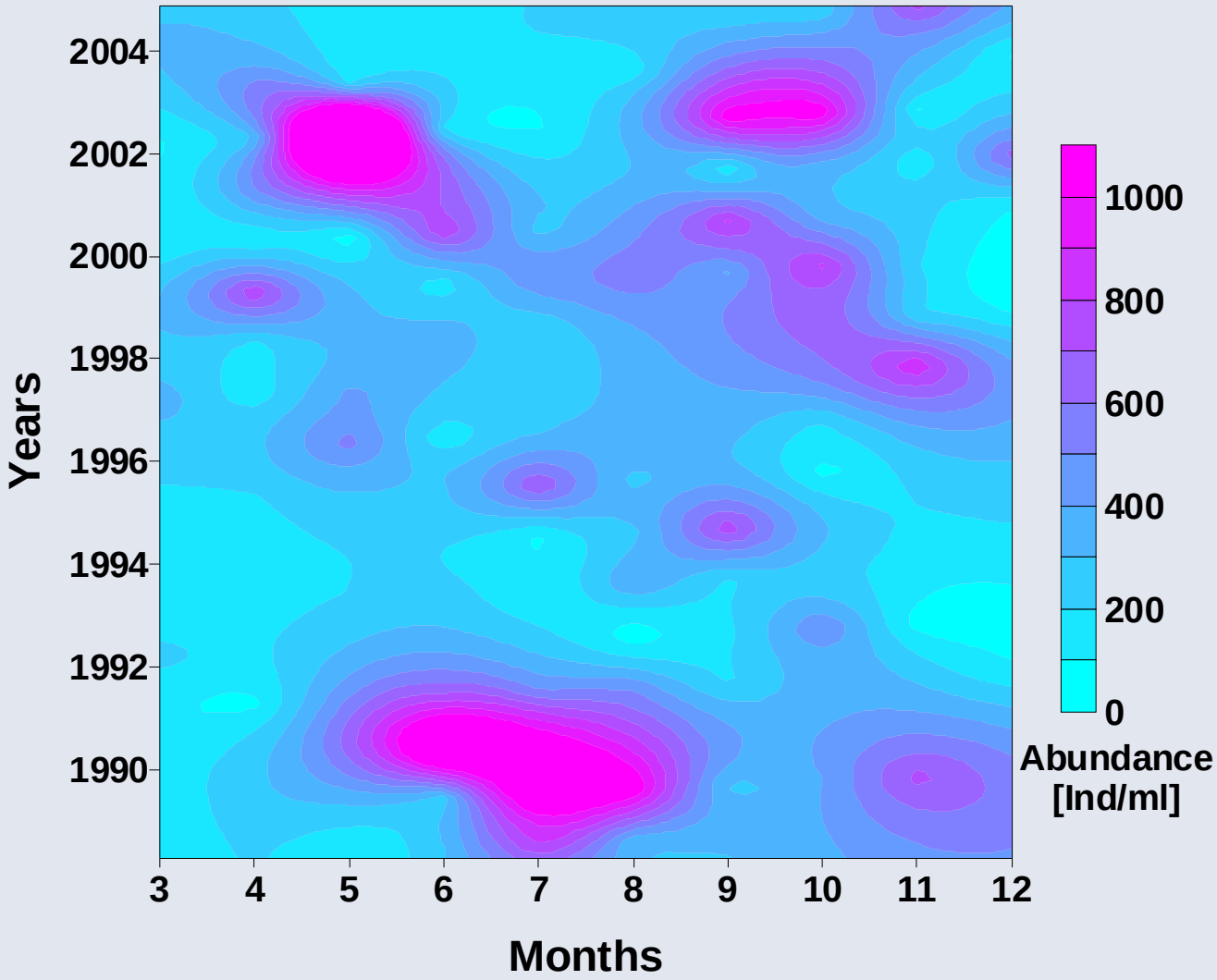
Updated version from September 25, 2010

Bacillariophyceae (Abundance) O5

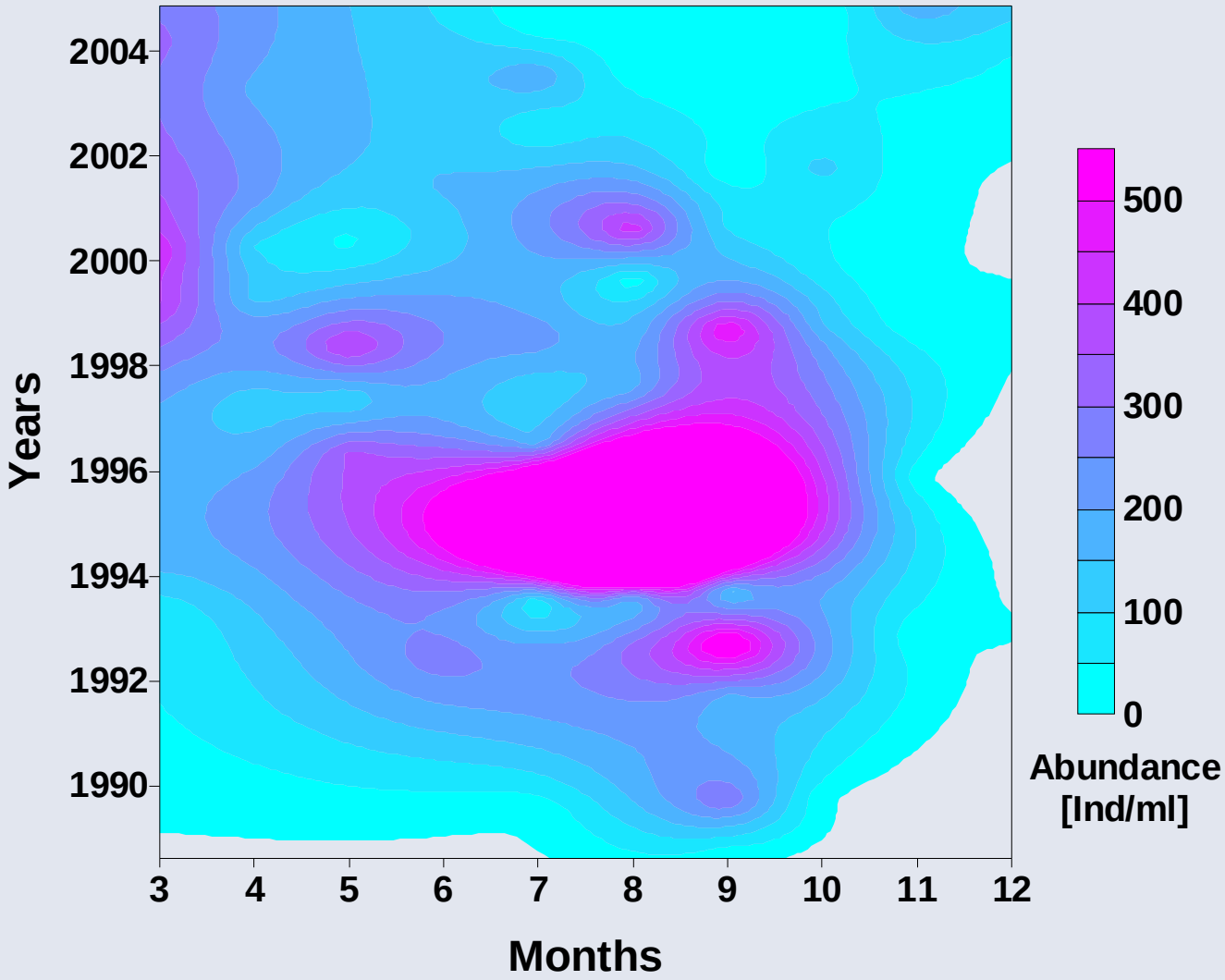


Updated version from September 25, 2010

Cryptophyta (Abundance) O5

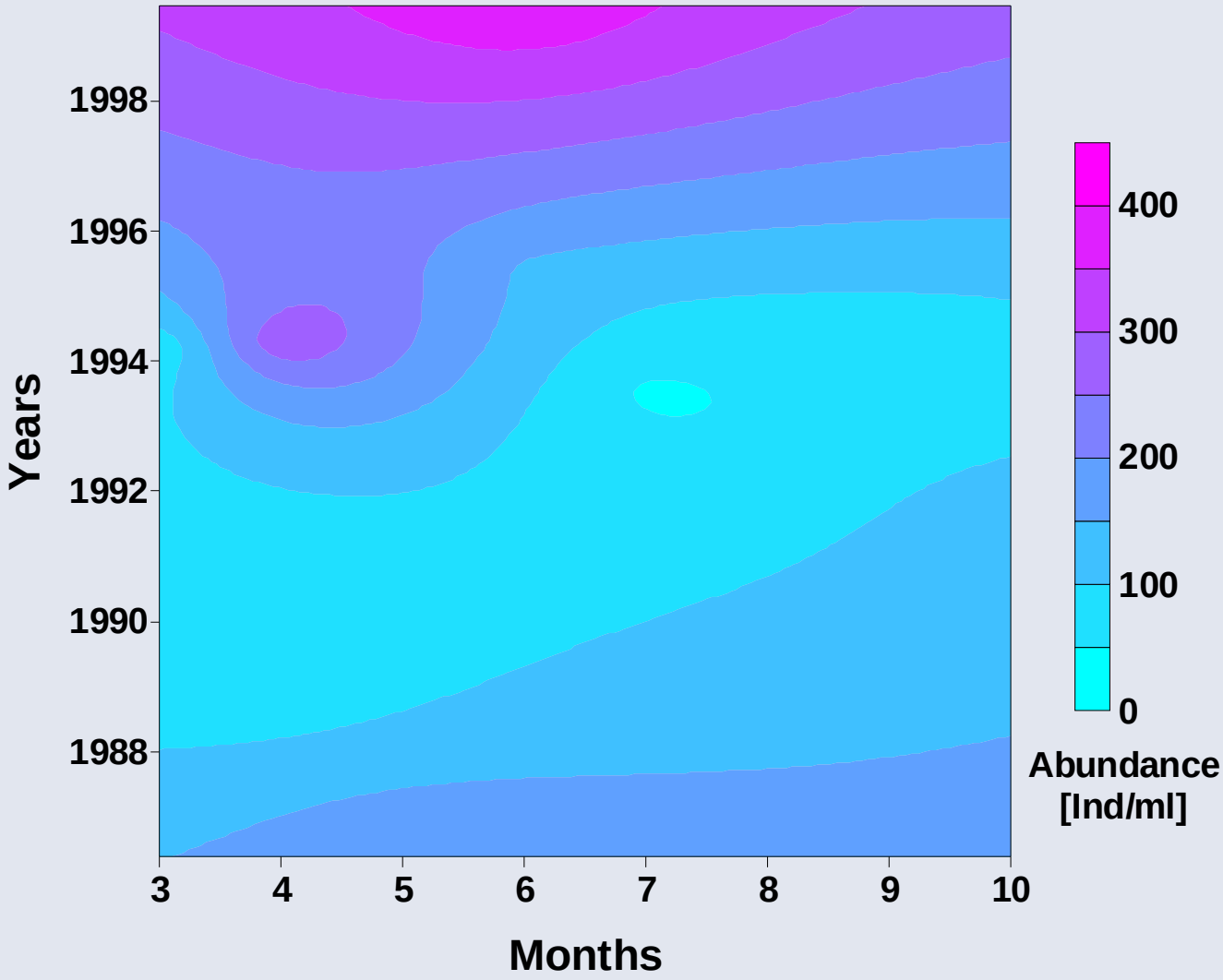


Dinophyta (Abundance) O5



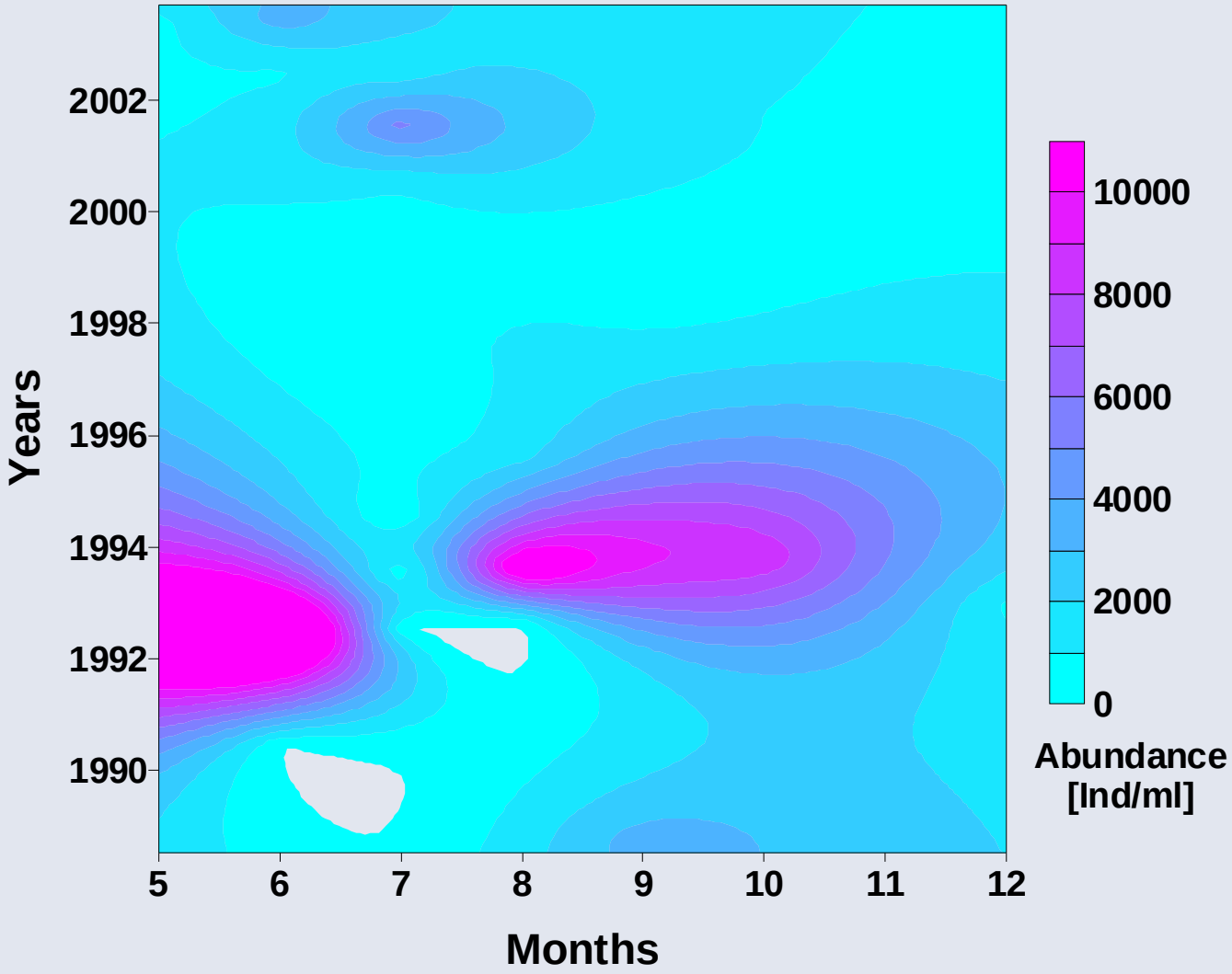
Updated version from September 25, 2010

Euglenophyta (Abundance) O5



Updated version from September 25, 2010

Cyanophyta (Abundance) O5



Updated version from September 25, 2010

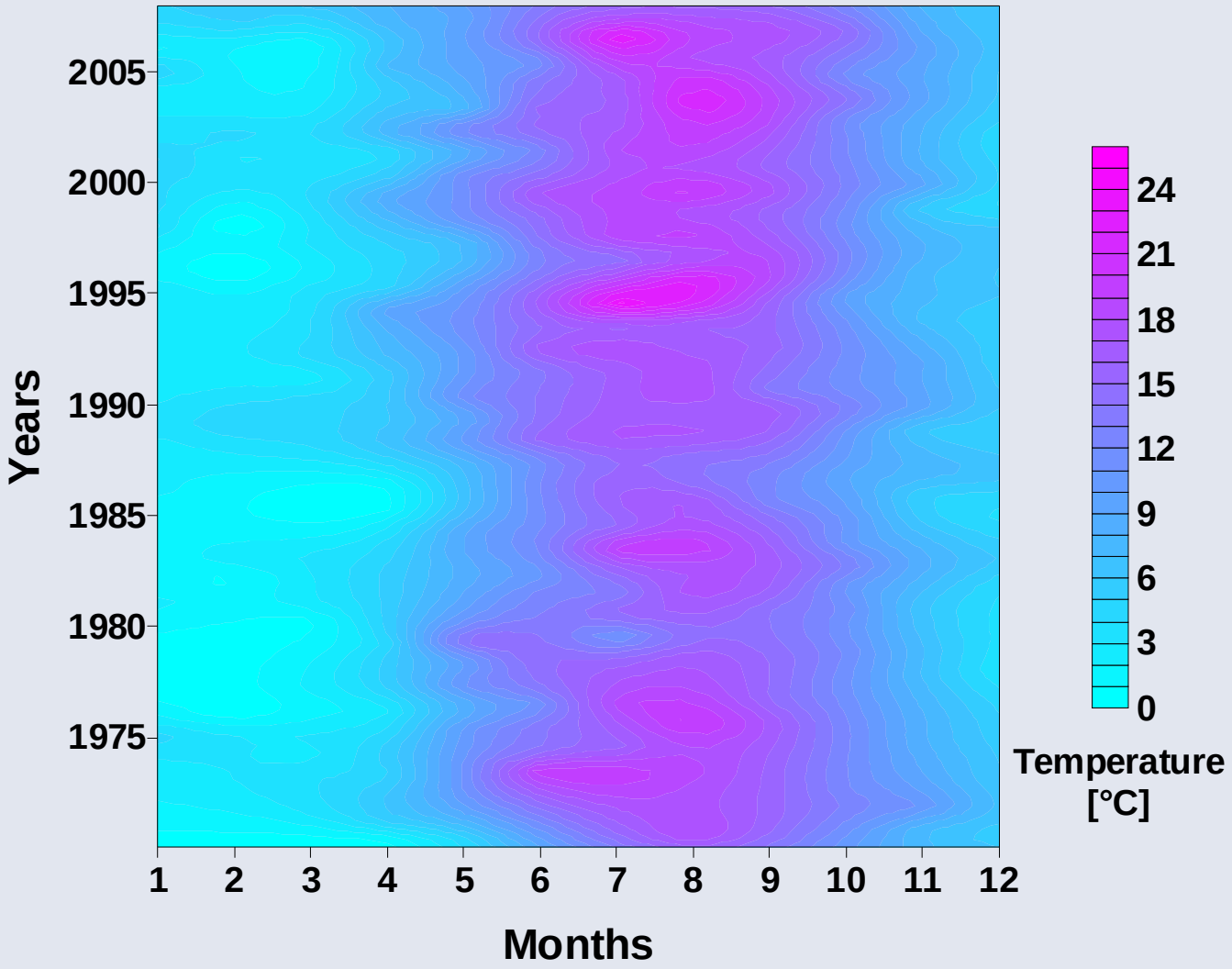
Maps of ecological patterns
Station O11

Physical Data at O11

- Temperature
- Salinity
- Oxygen
- Oxygen saturation
- pH value

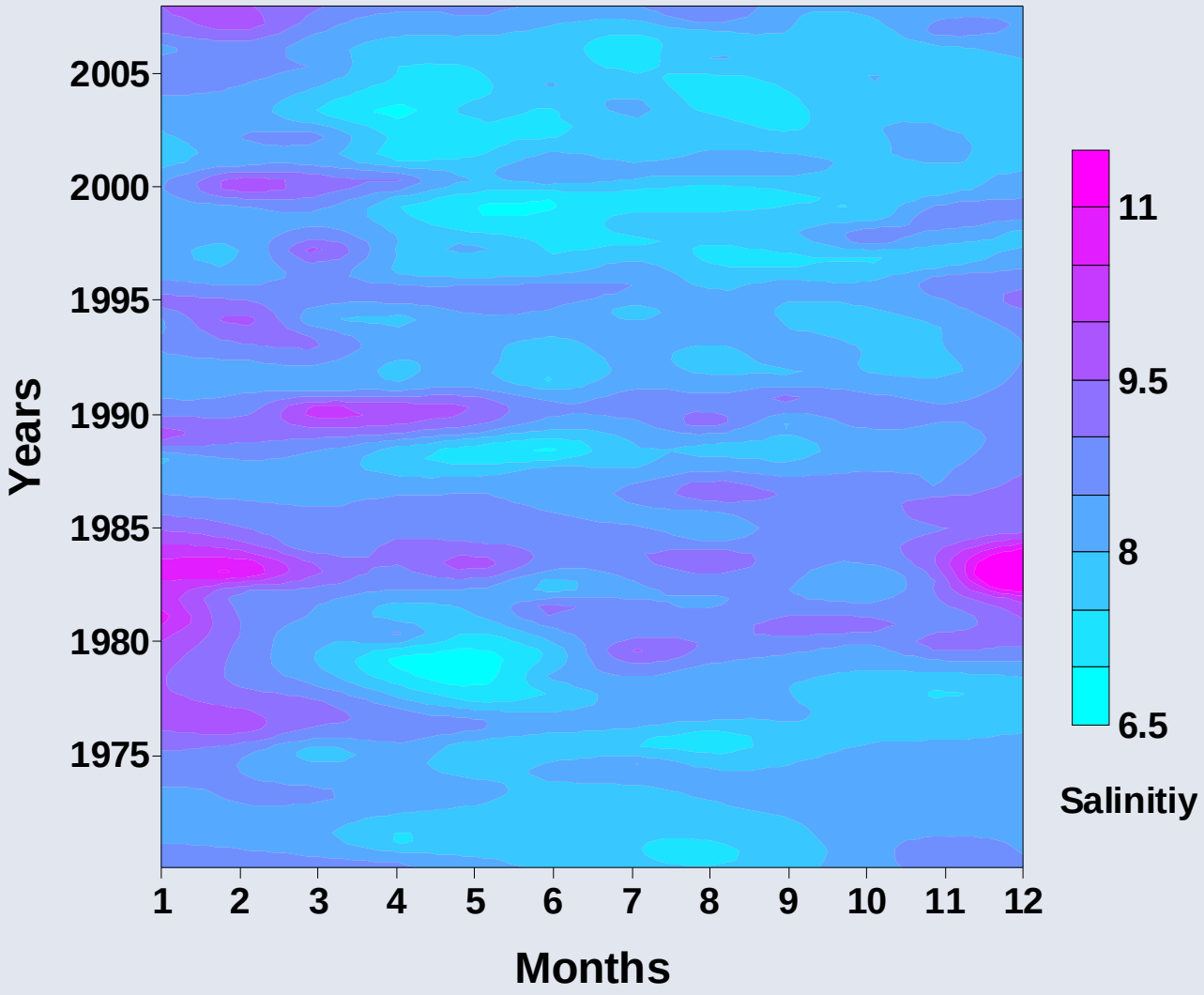
Updated version from September 25, 2010

Temperature O11



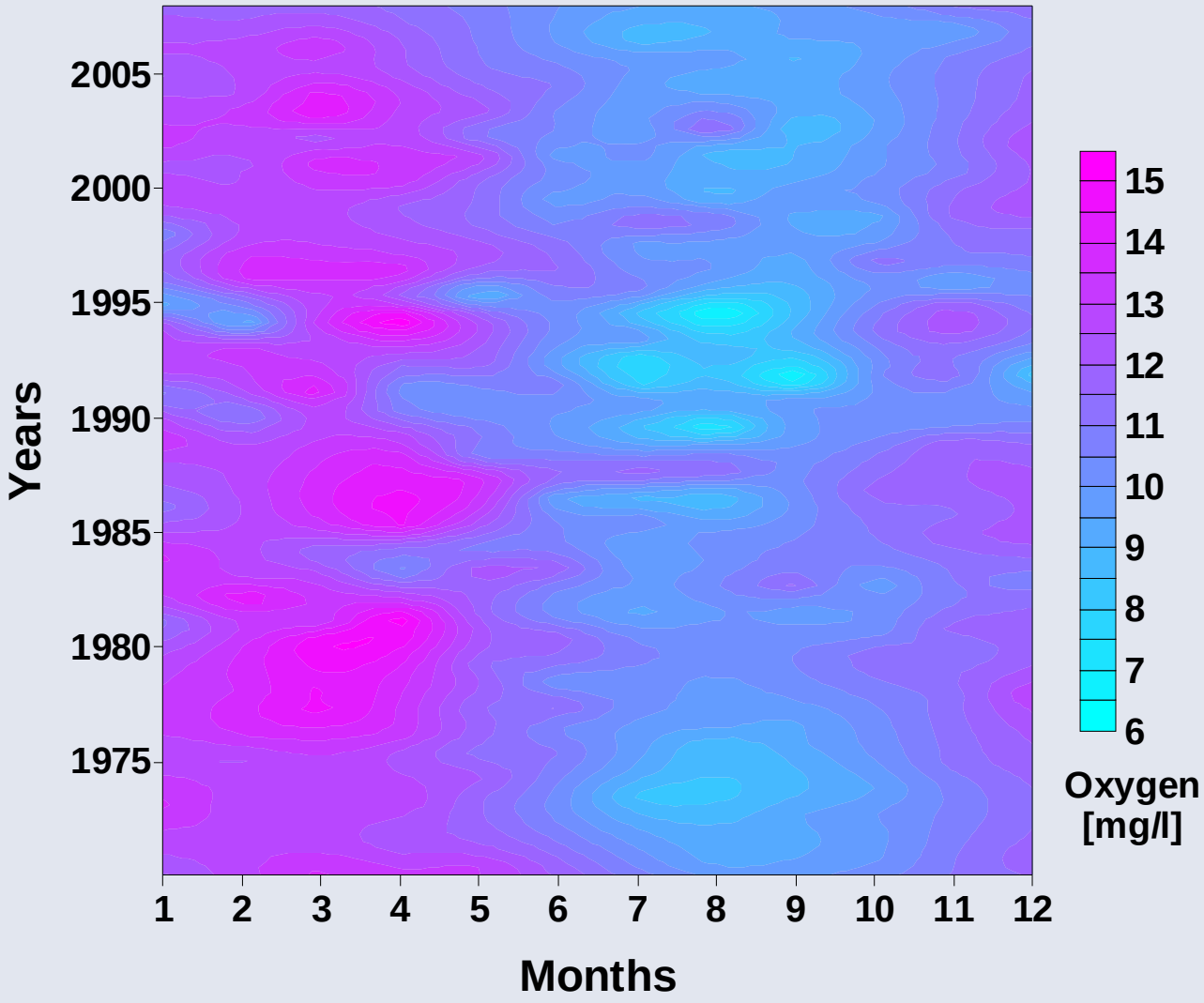
Updated version from September 25, 2010

Salinity O11

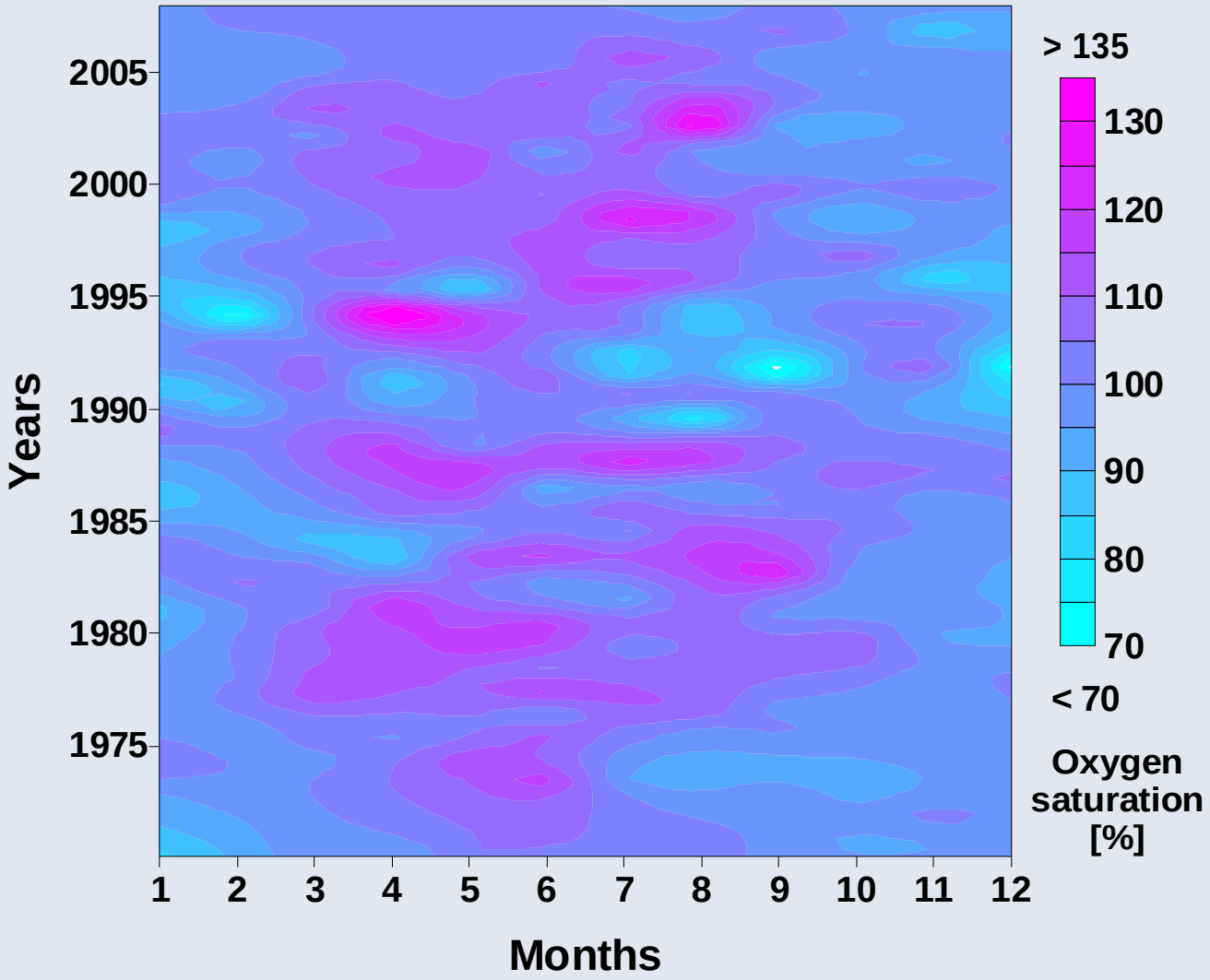


Updated version from September 25, 2010

Oxygen O11

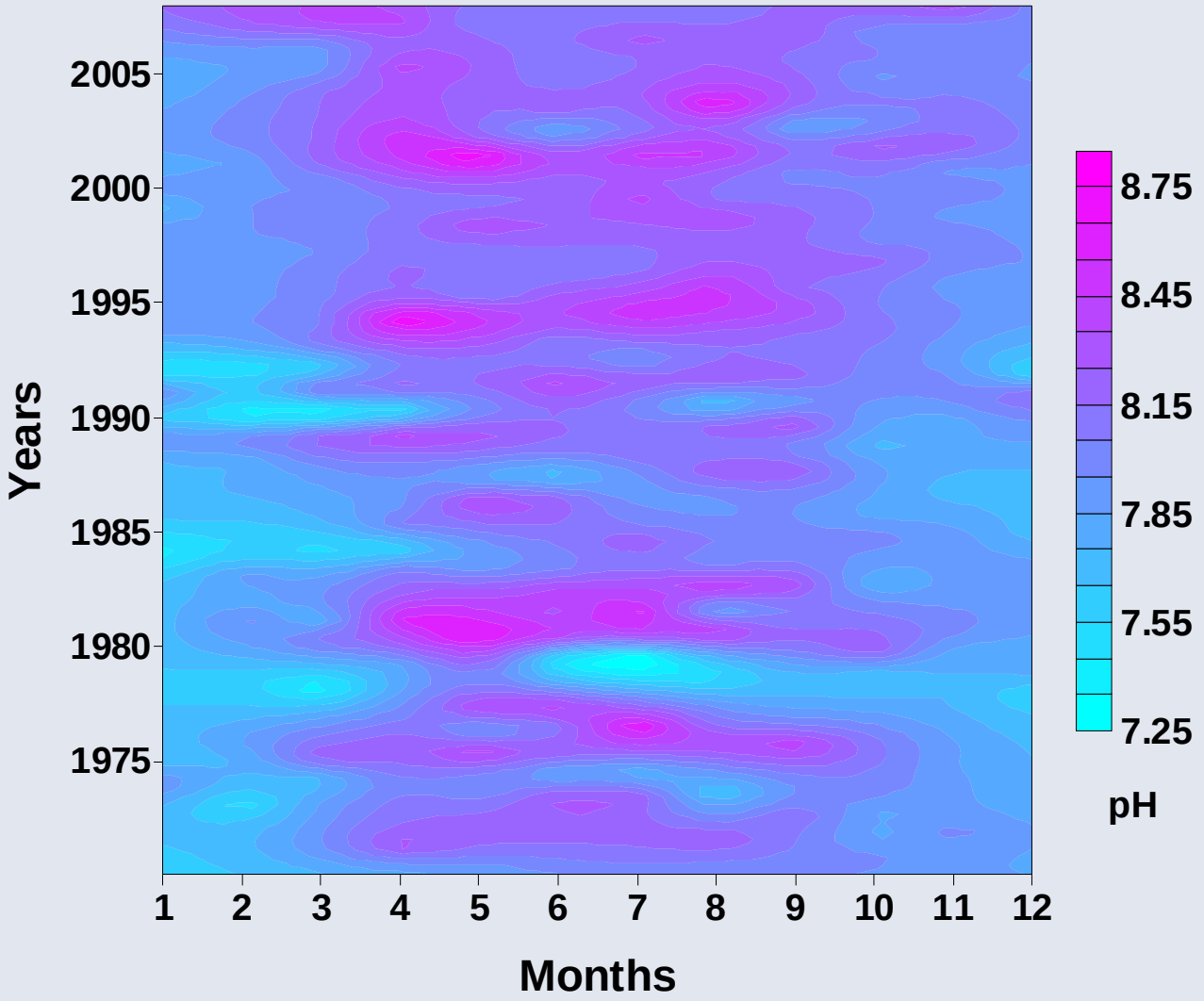


Oxygen saturation O11



Updated version from September 25, 2010

pH value O11

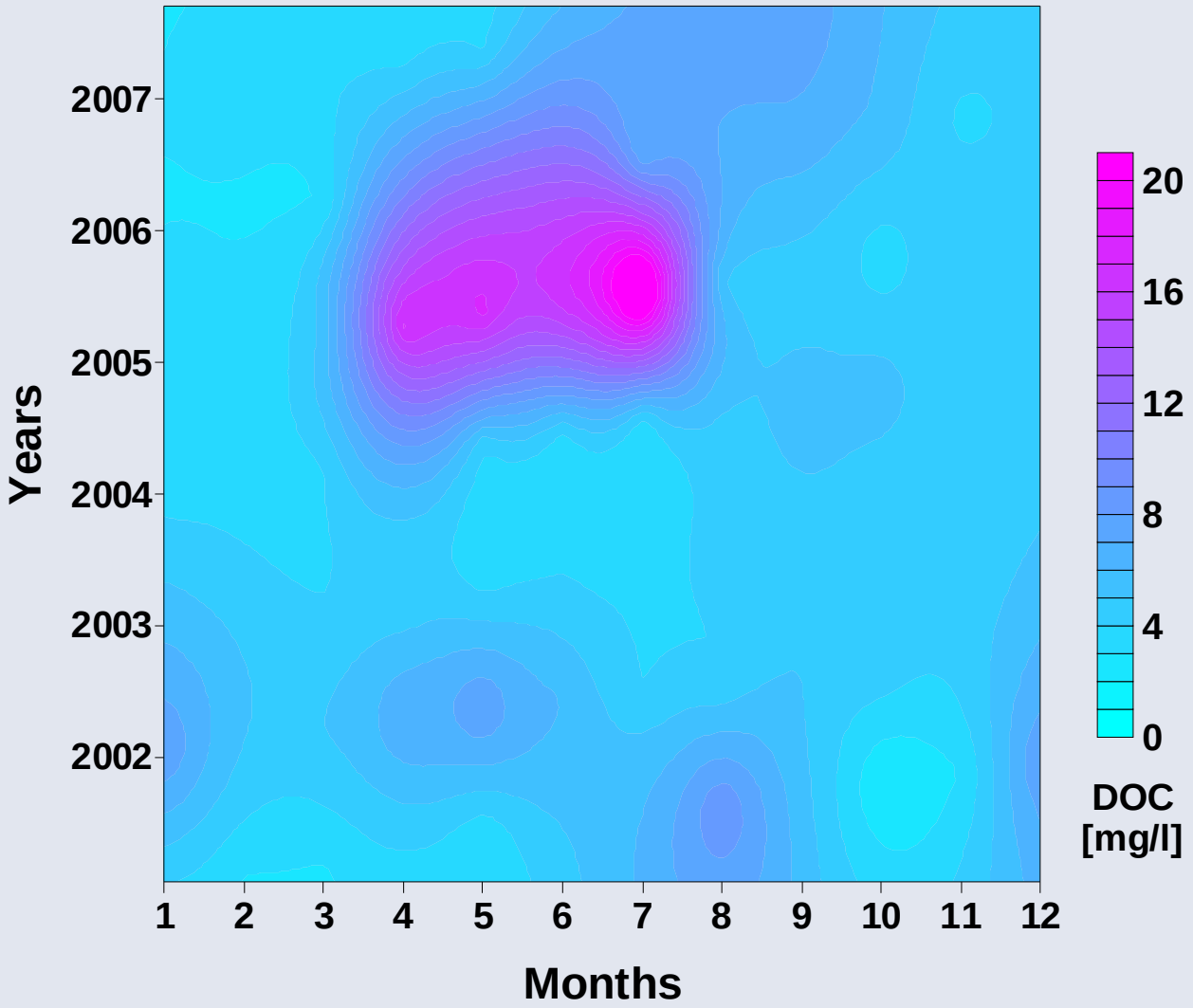


Nutrient Data at O11

- Dissolved Organic Carbon (DOC)
- Total Organic Carbon (TOC)
- Nitrate
- Nitrite
- Ammonia
- Total N
- Phosphate
- Total phosphorus
- Silicate

Updated version from September 25, 2010

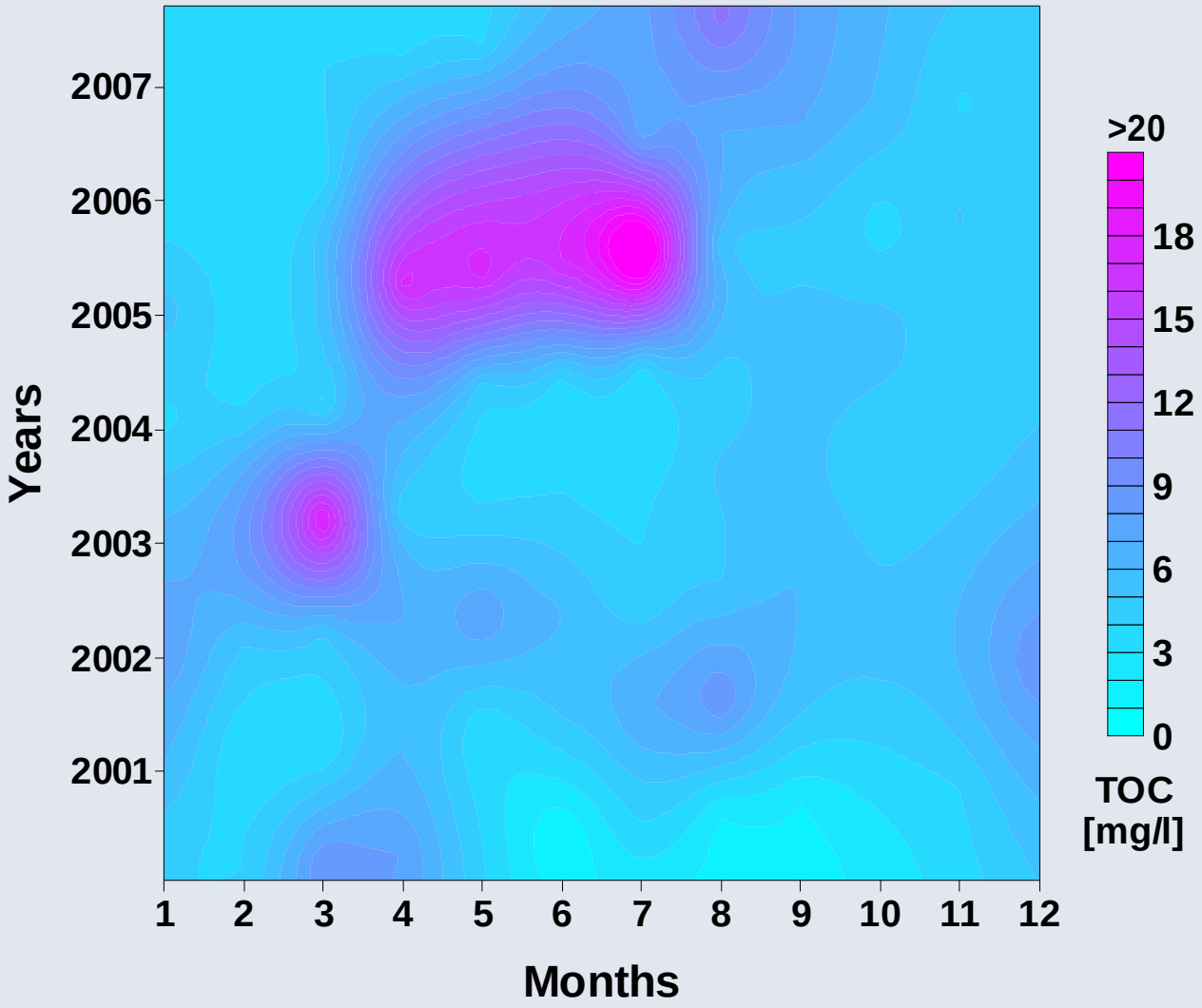
Dissolved Organic Carbon O11



AMBER
BONUS
BALTEX
Federal Ministry of Education and Research

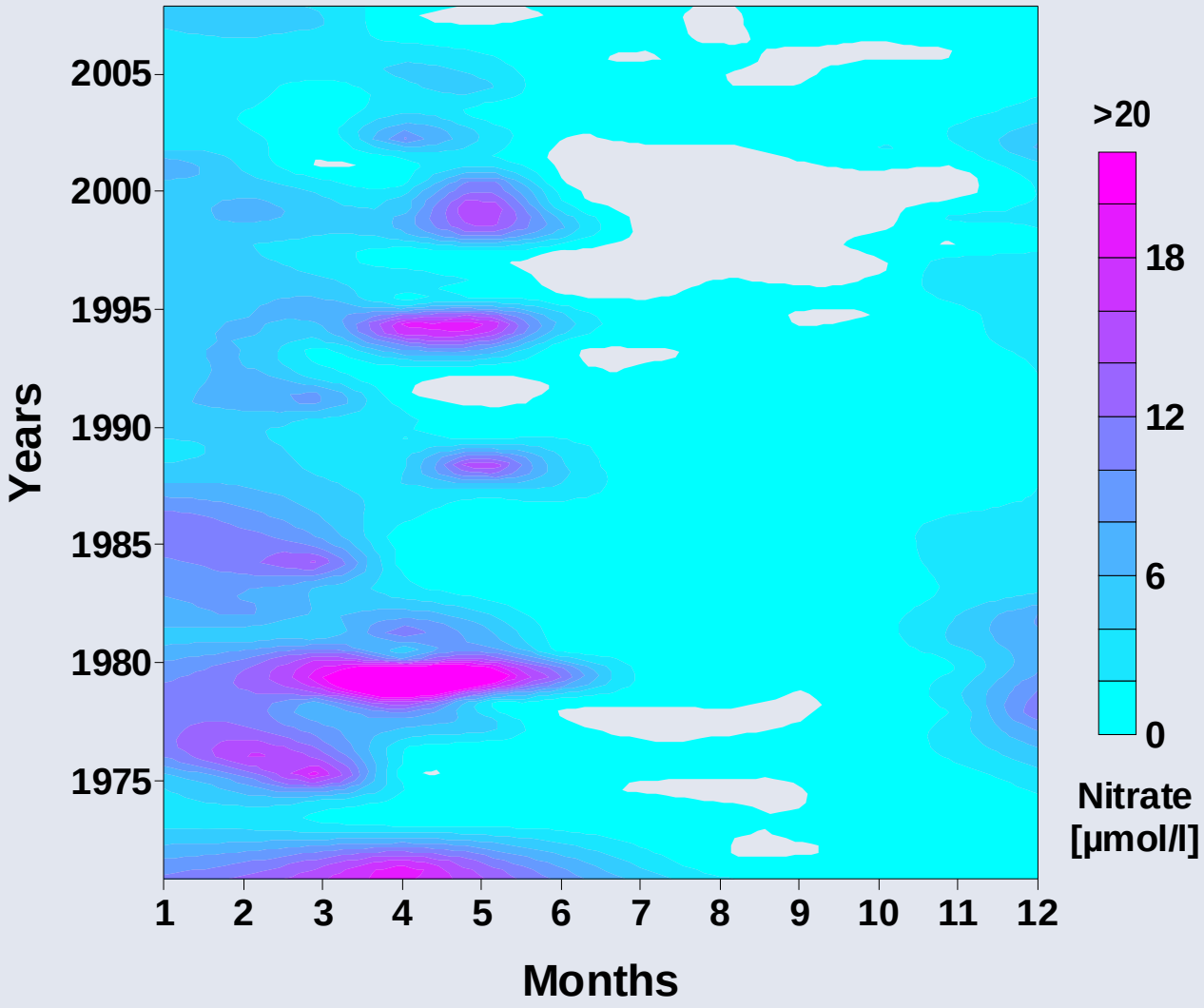
Updated version from September 25, 2010

Total Organic Carbon O11



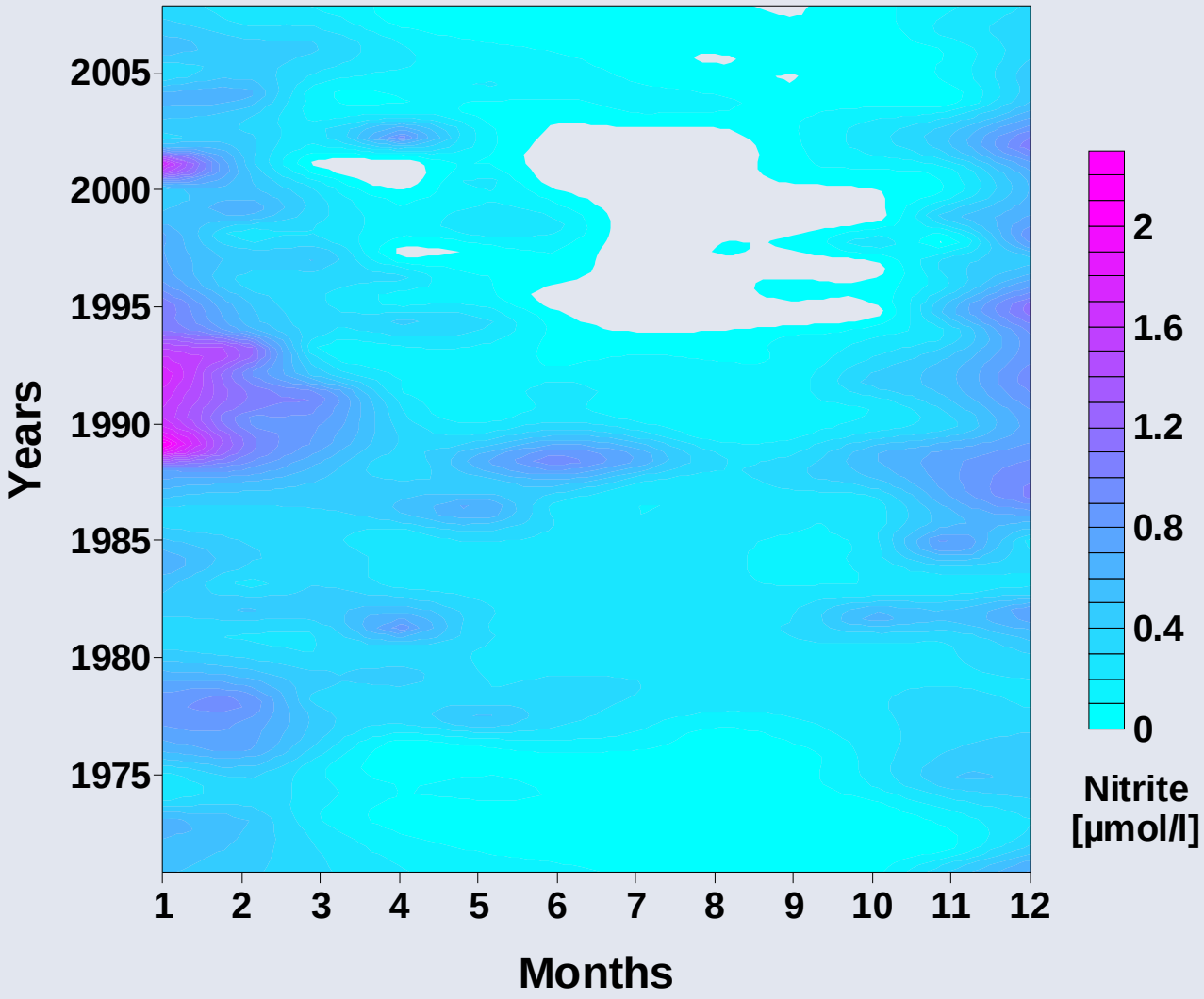
Updated version from September 25, 2010

Nitrate O11



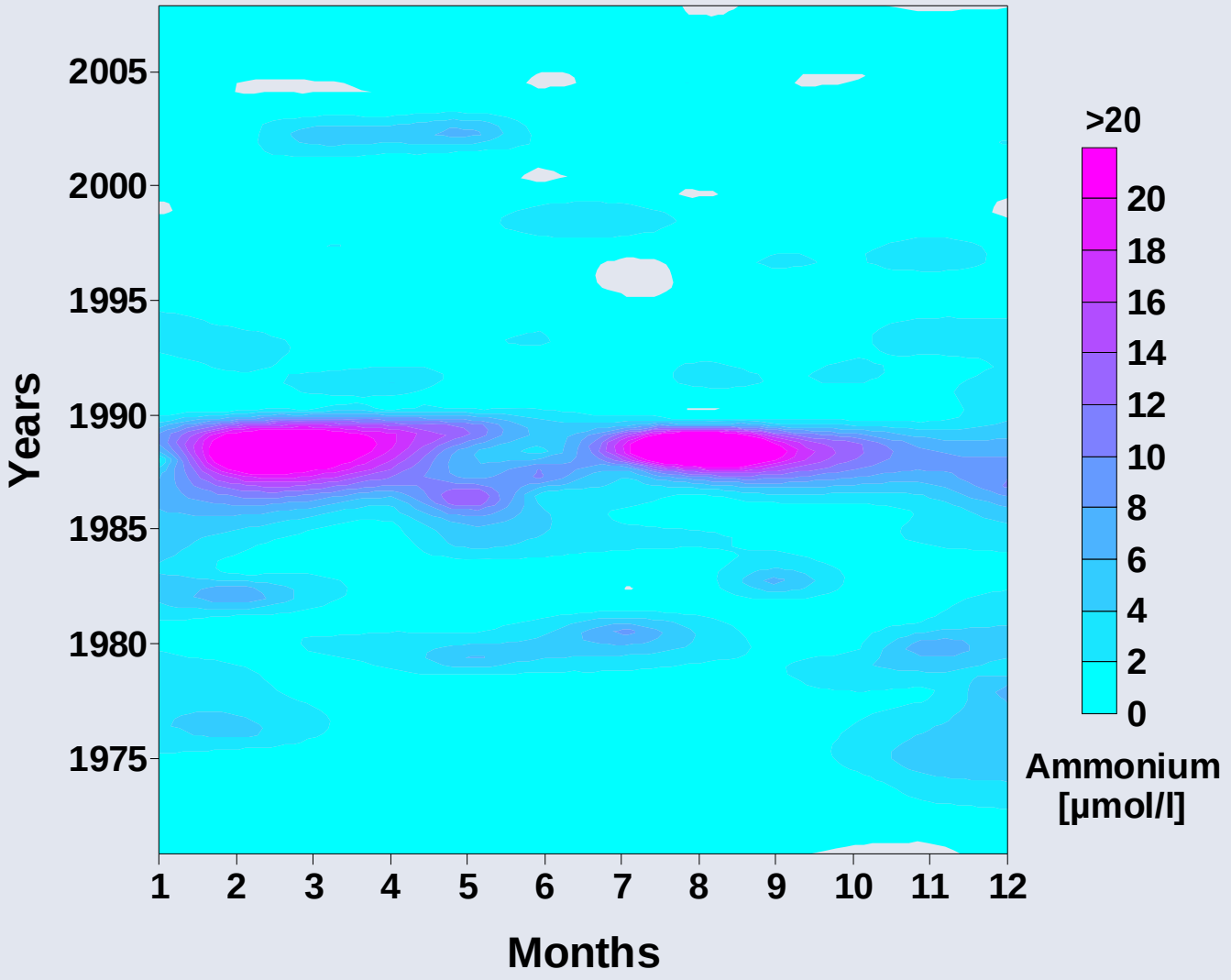
Updated version from September 25, 2010

Nitrite O11



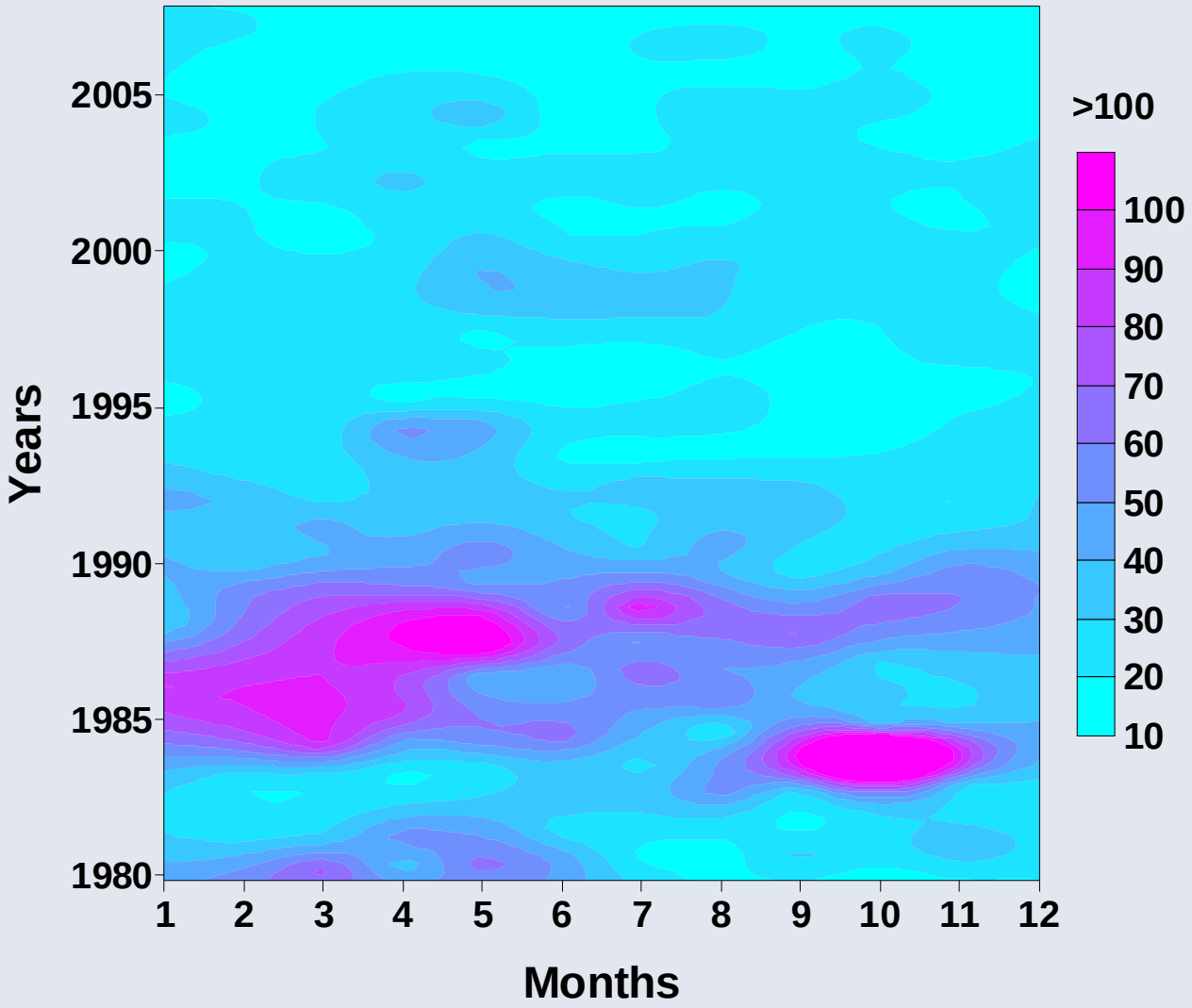
Updated version from September 25, 2010

Ammonium O11



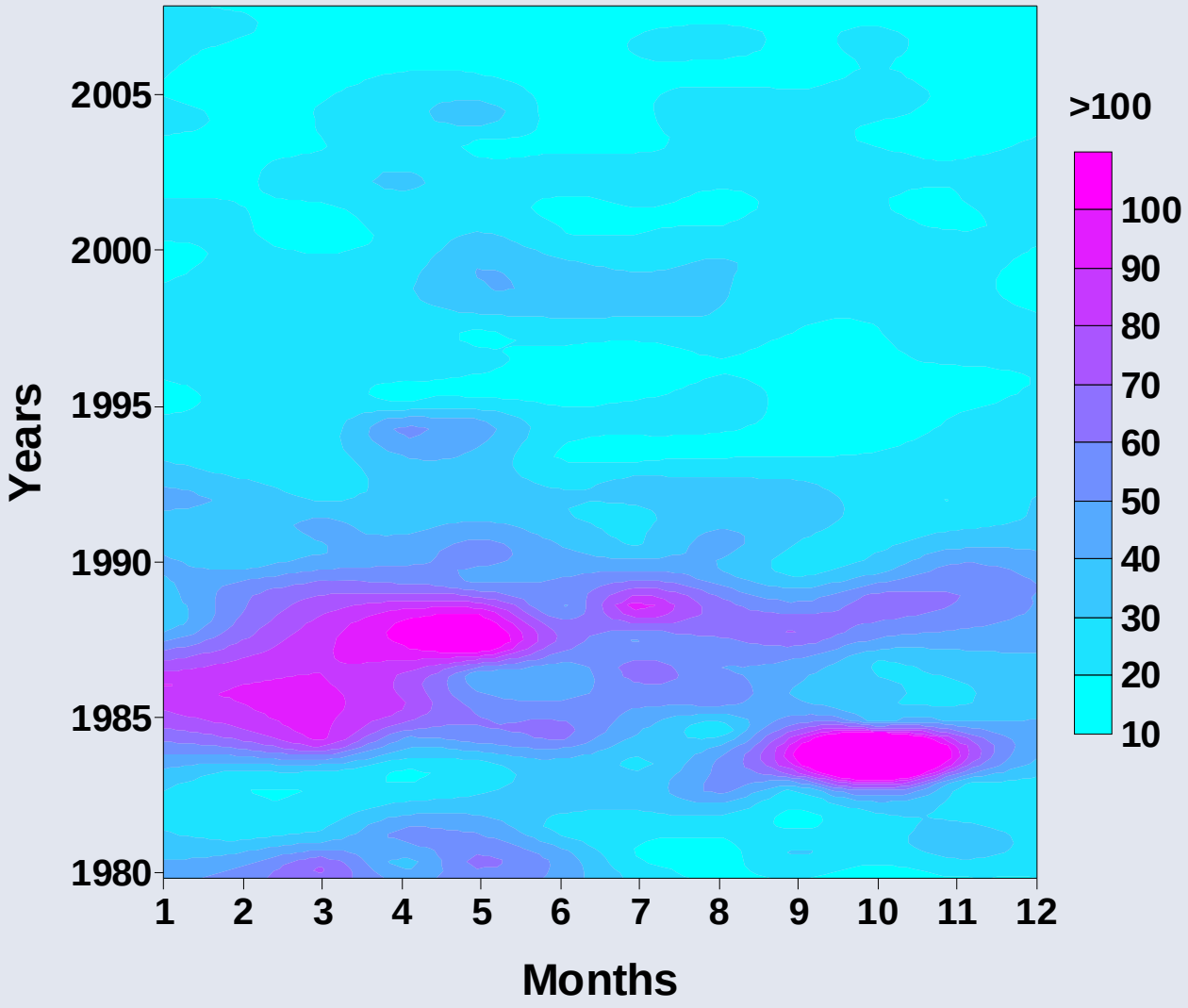
Updated version from September 25, 2010

Total Nitrogen O11



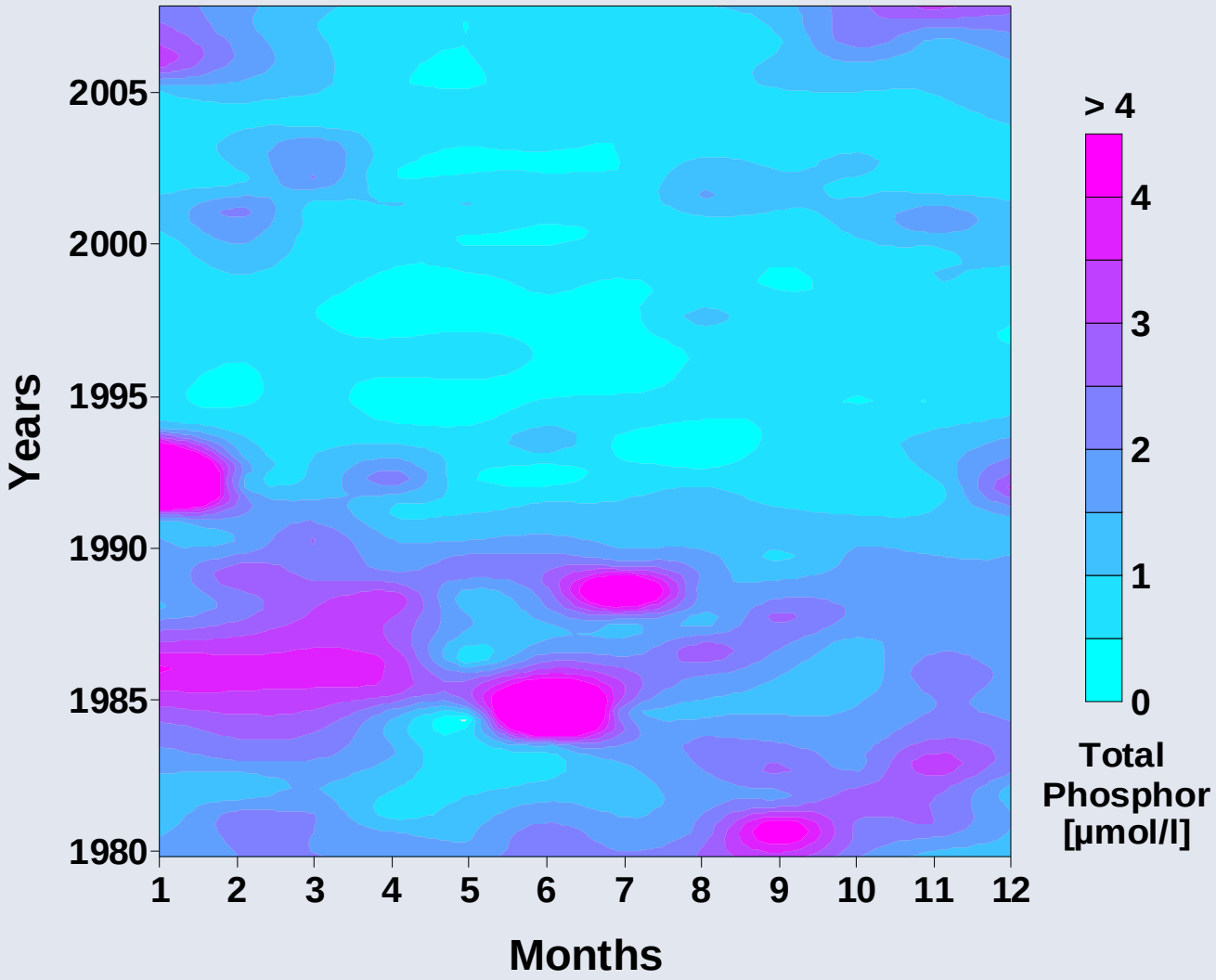
Updated version from September 25, 2010

Phosphate O11



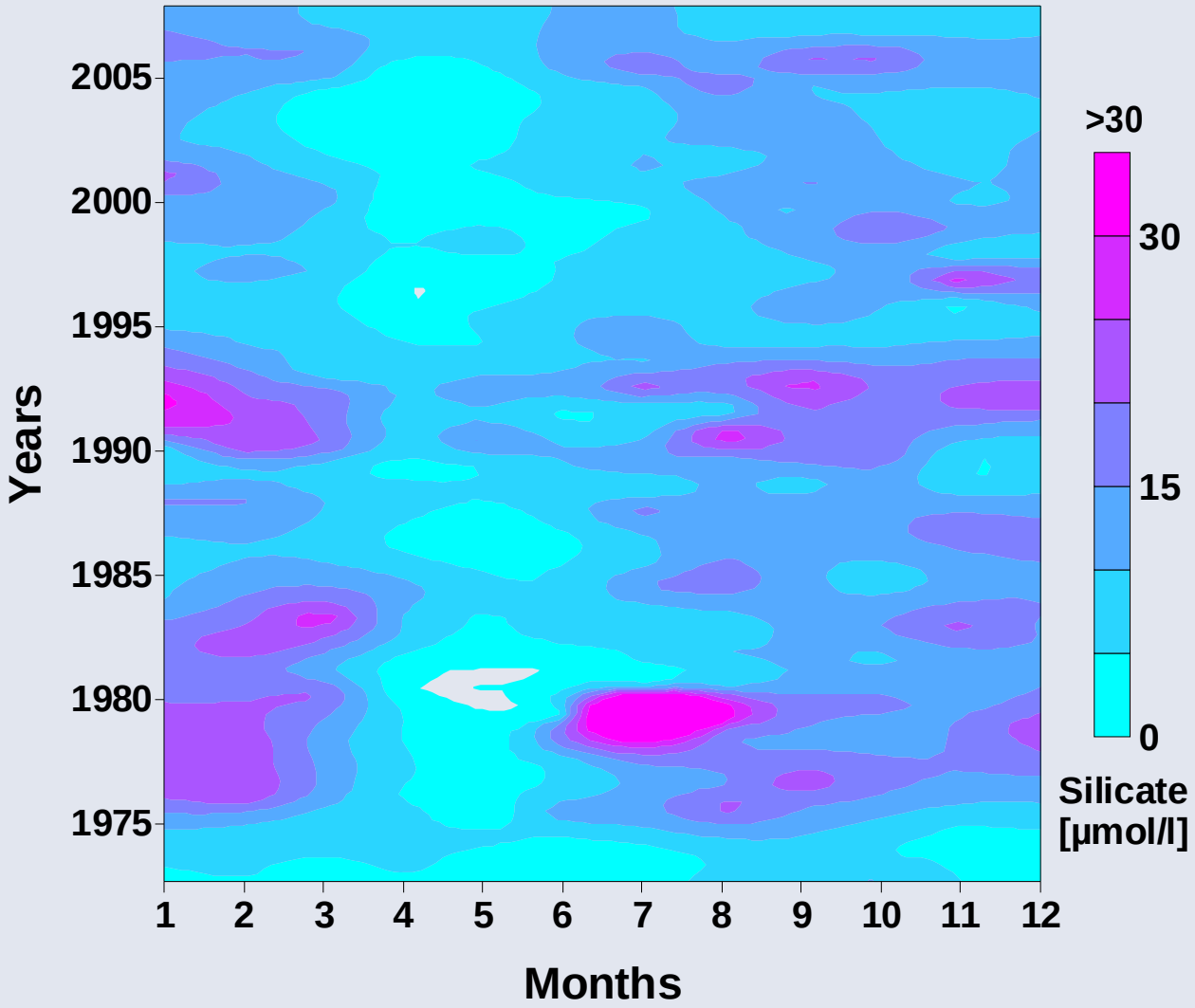
Updated version from September 25, 2010

Total phosphorus O11



Updated version from September 25, 2010

Silicate O11

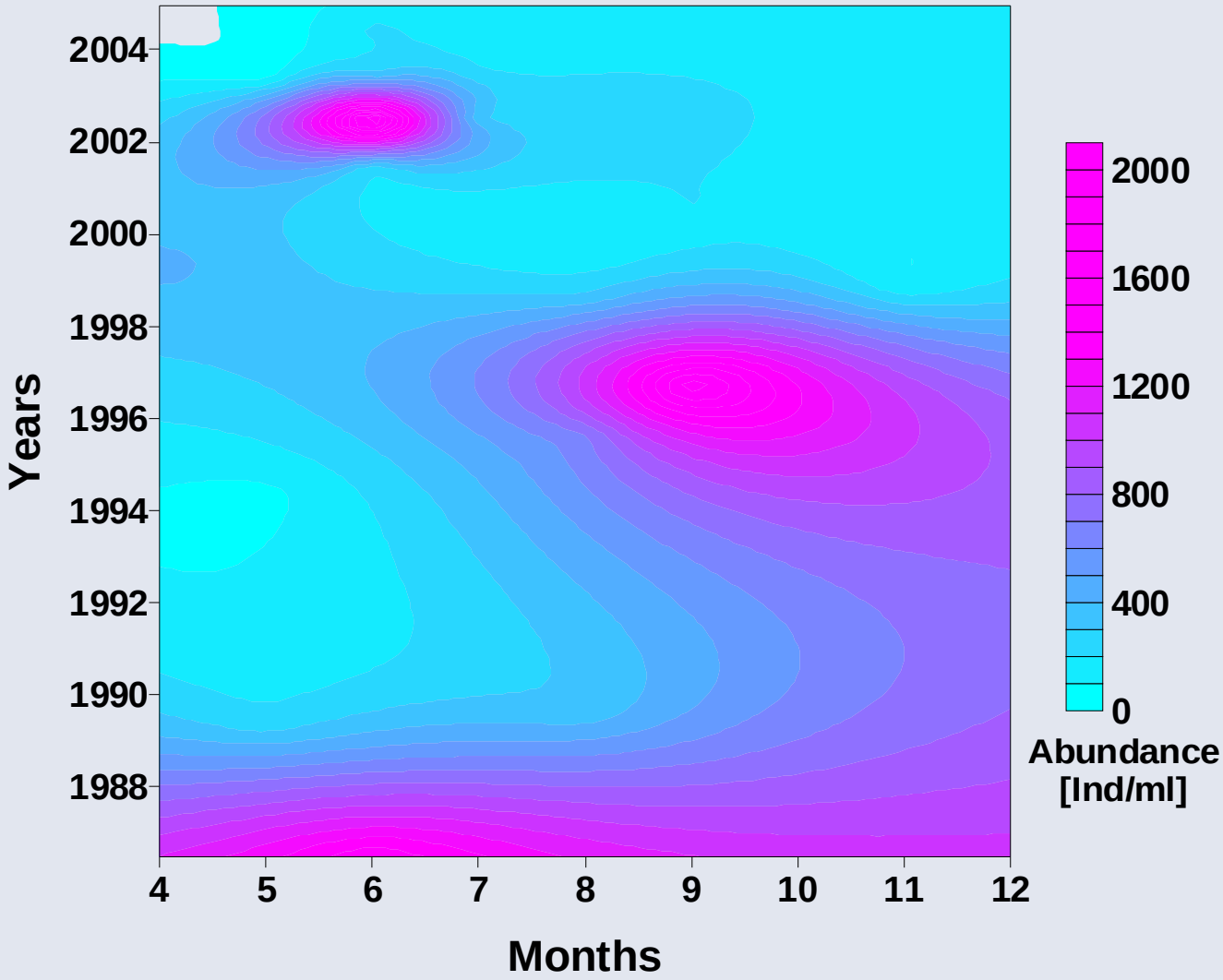


List of taxonomic divisions O11

- Chlorophyta
- Heterokontophyta
  - class Chrysophyceae
  - class Bacillariophyceae
- Cryptophyta
- Dinophyta
- Euglenophyta
- Cyanophyta

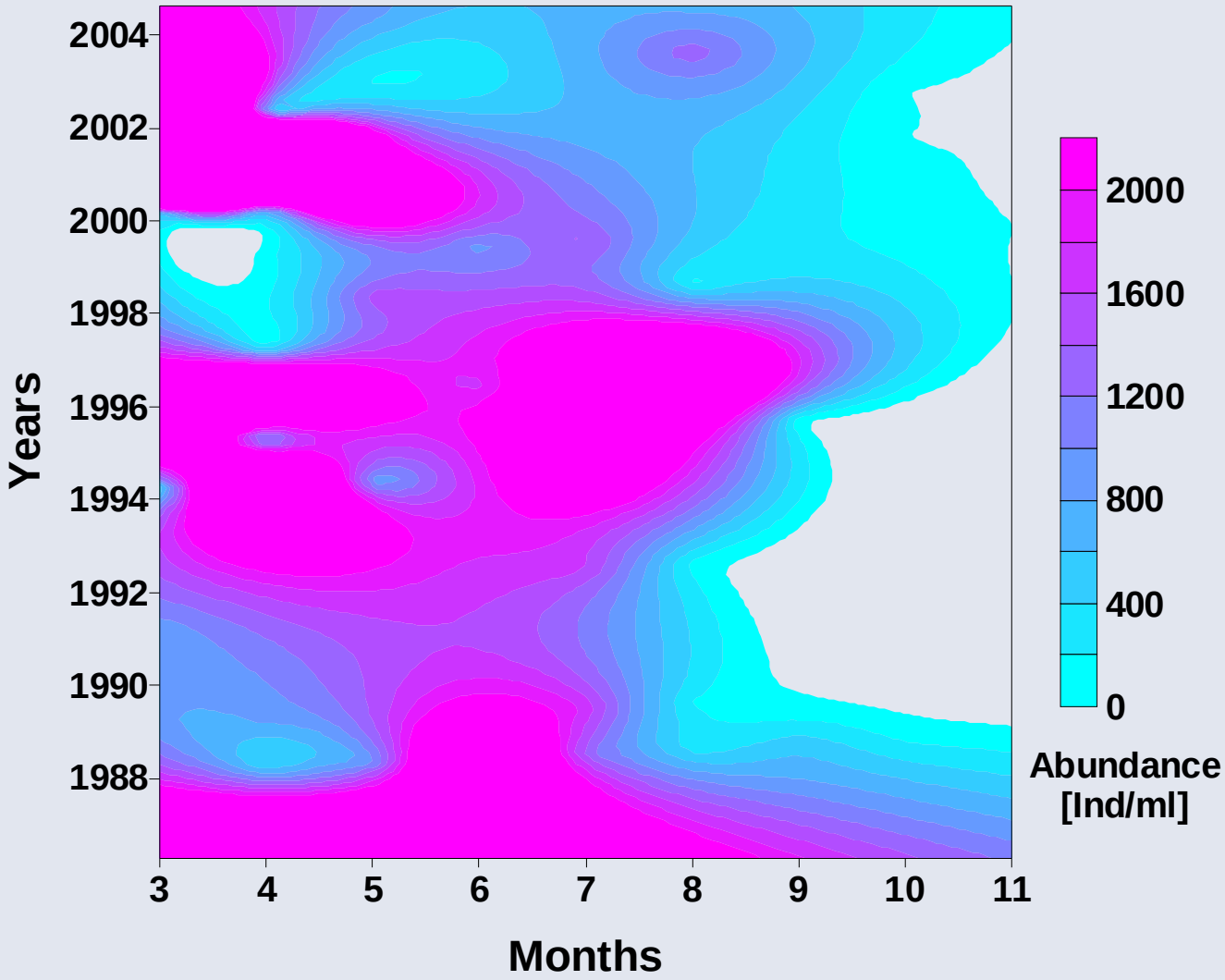
Updated version from September 25, 2010

Chlorophyceae (Abundance) O11



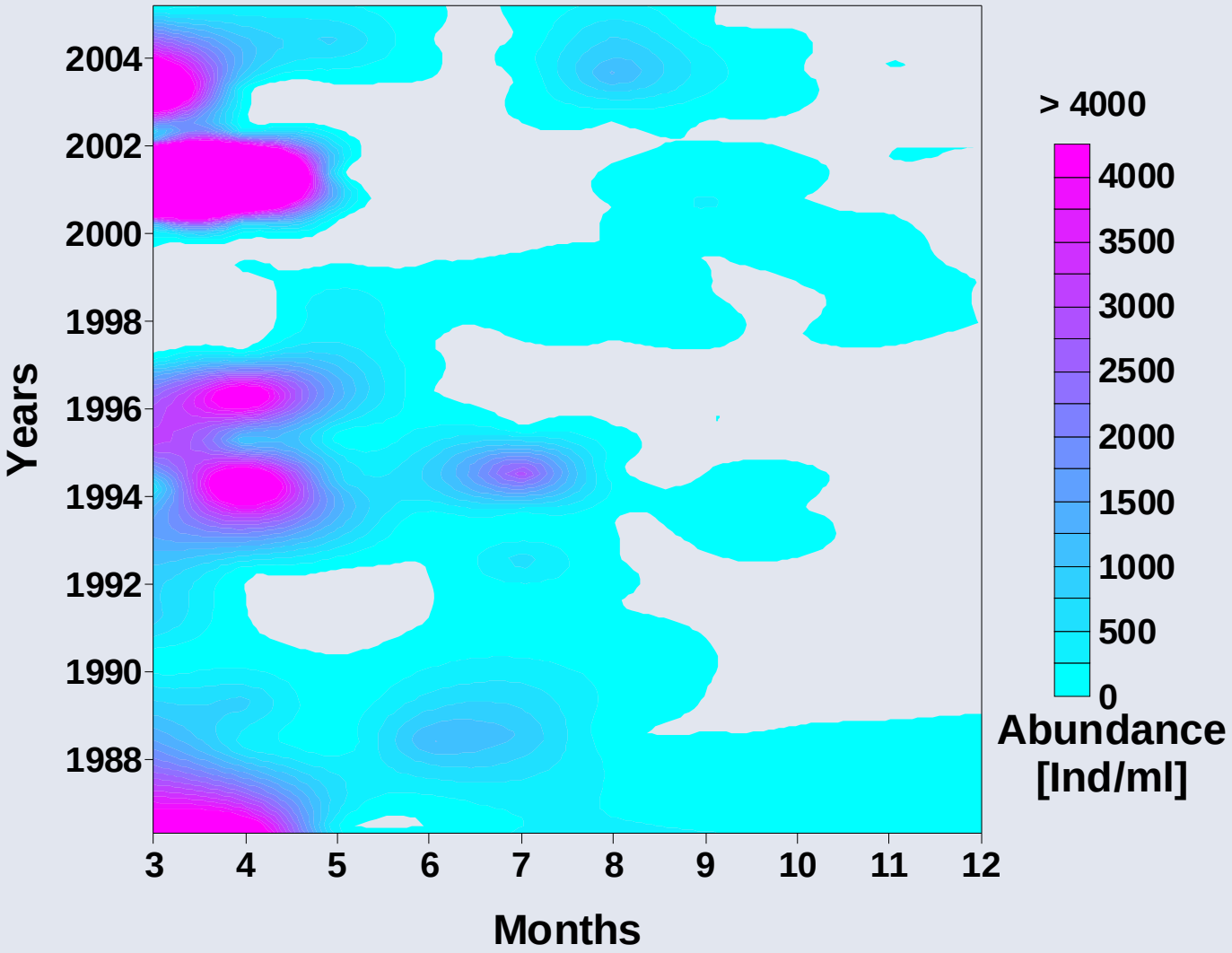
Updated version from September 25, 2010

Chrysophyceae (Abundance) O11



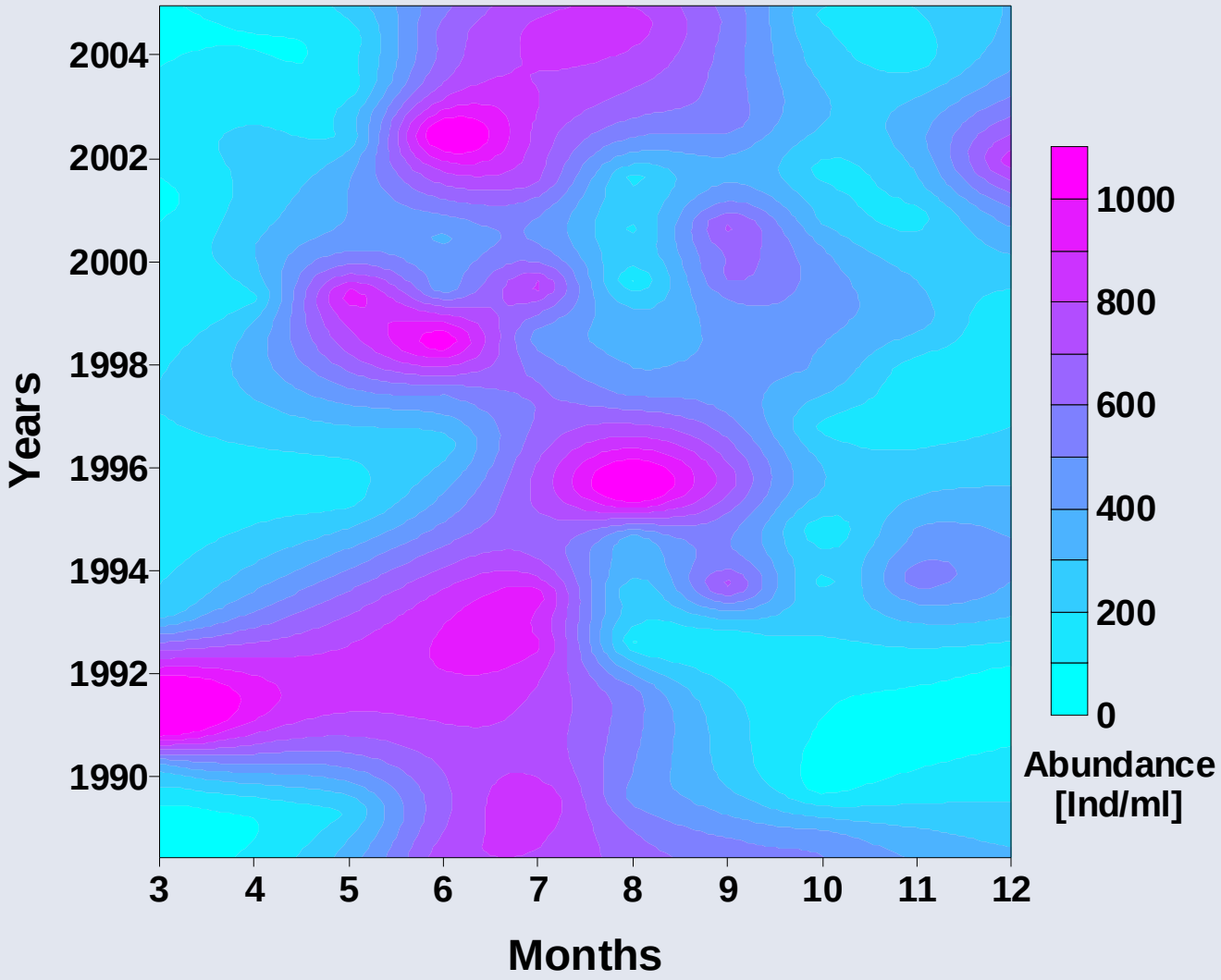
Updated version from September 25, 2010

Bacillariophyceae (Abundance) O11



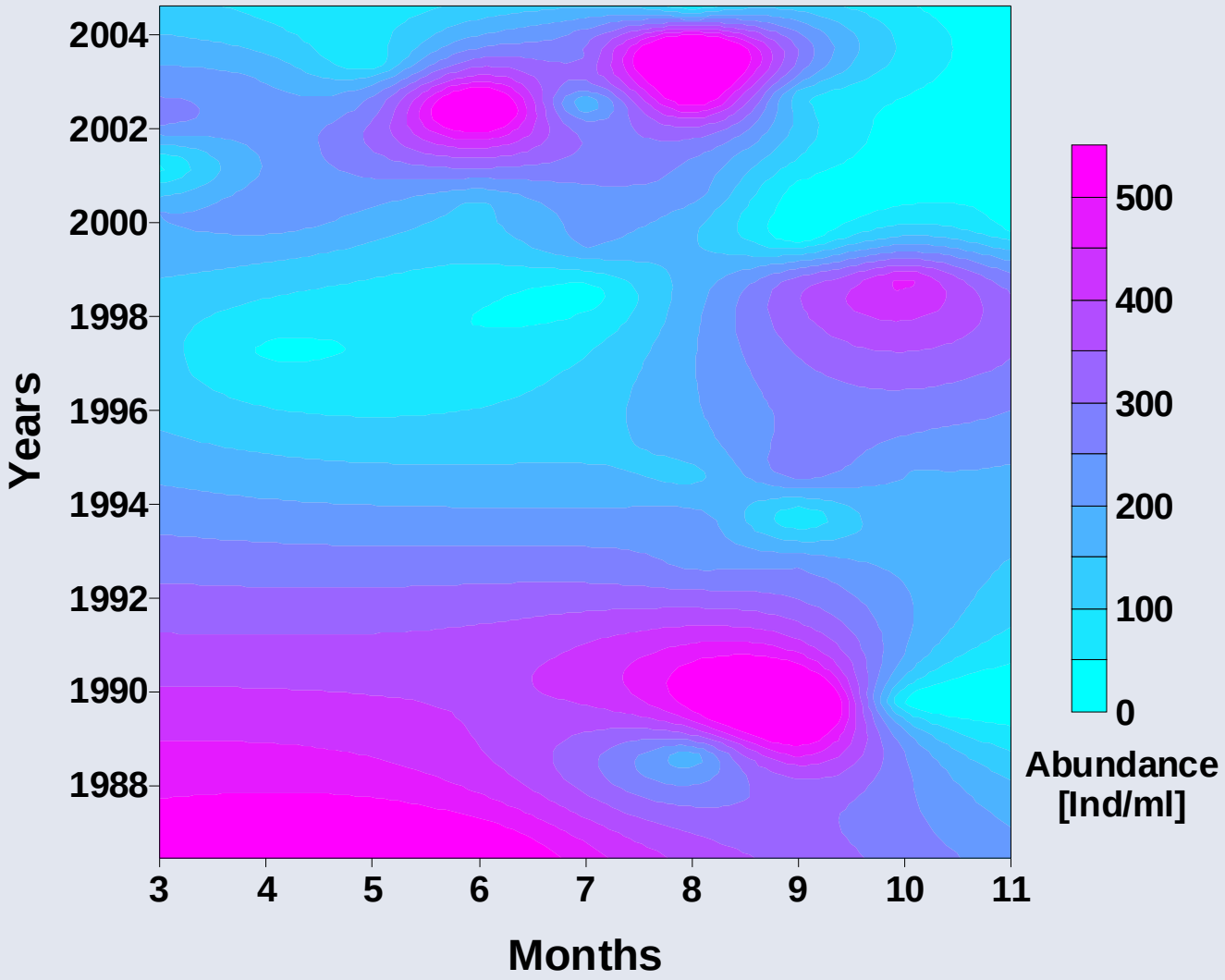
Updated version from September 25, 2010

Cryptophyta (Abundance) O11



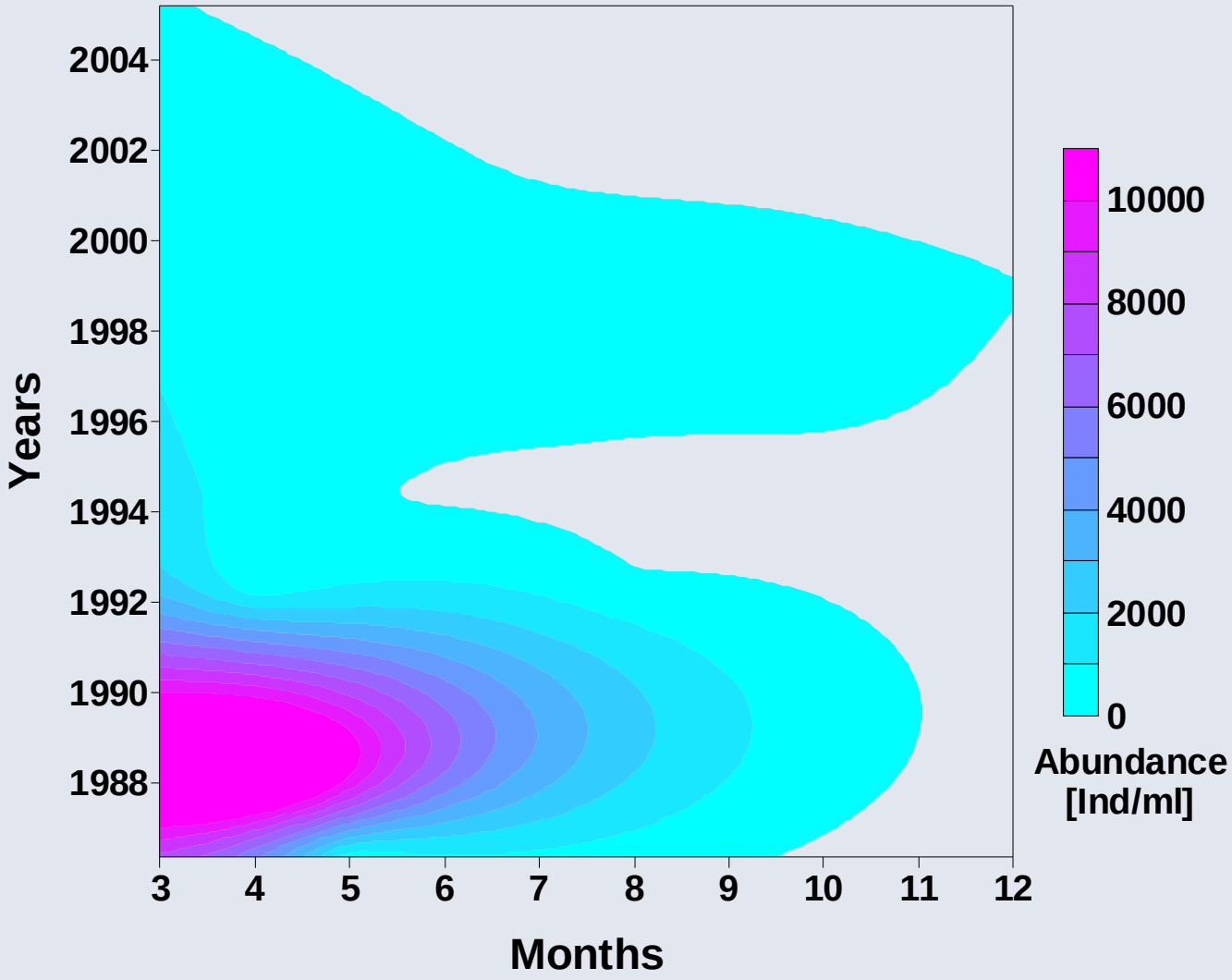
Updated version from September 25, 2010

Dinophyta (Abundance) O11



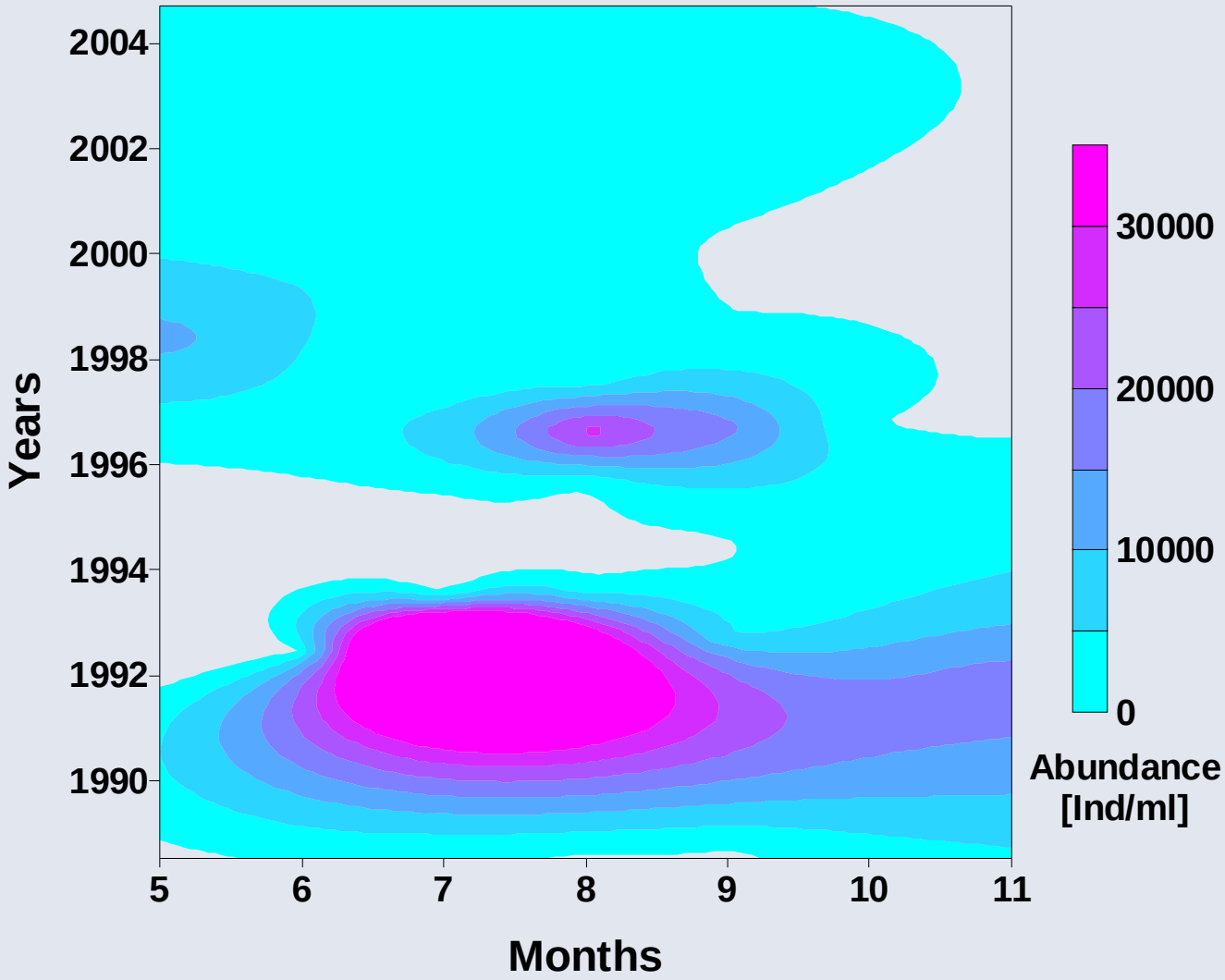
Updated version from September 25, 2010

Euglenophyta (Abundance) O11



Updated version from September 25, 2010

Cyanophyta (Abundance) O11



Updated version from September 25, 2010

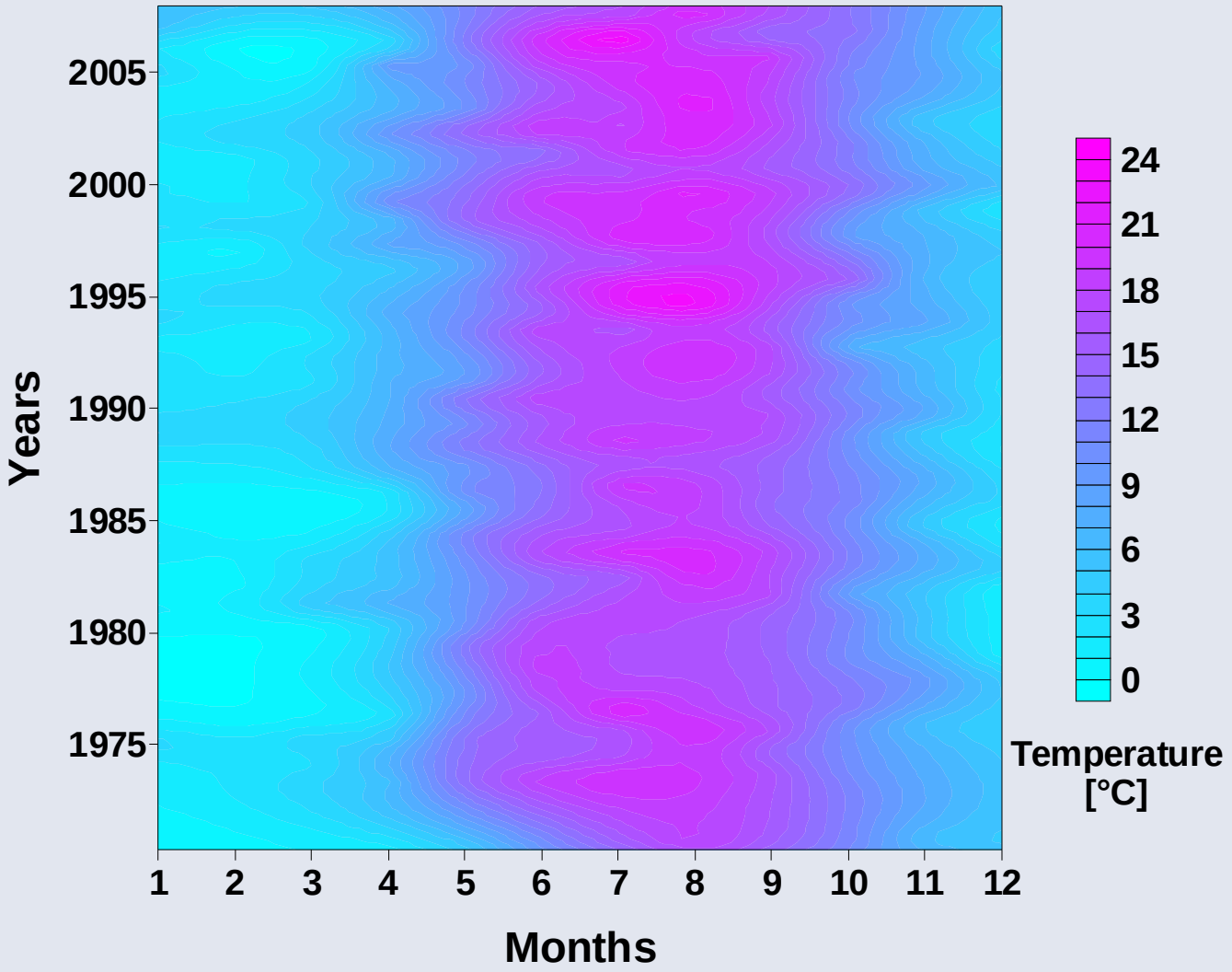
Maps of ecological patterns
Station OB4

Physical Data at OB4

- Temperature
- Salinity
- Oxygen
- Oxygen saturation
- pH value

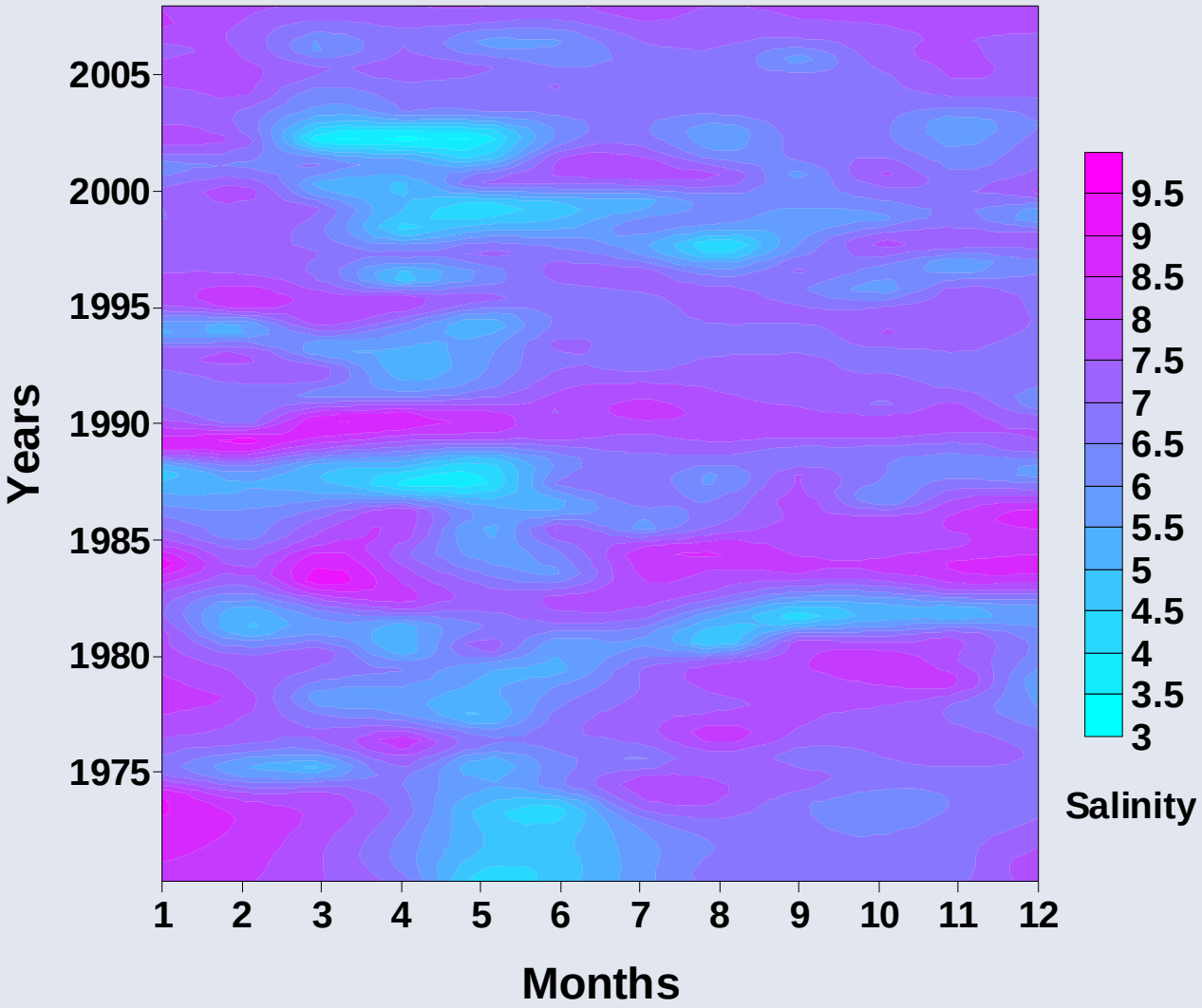
Updated version from September 25, 2010

Temperature OB4



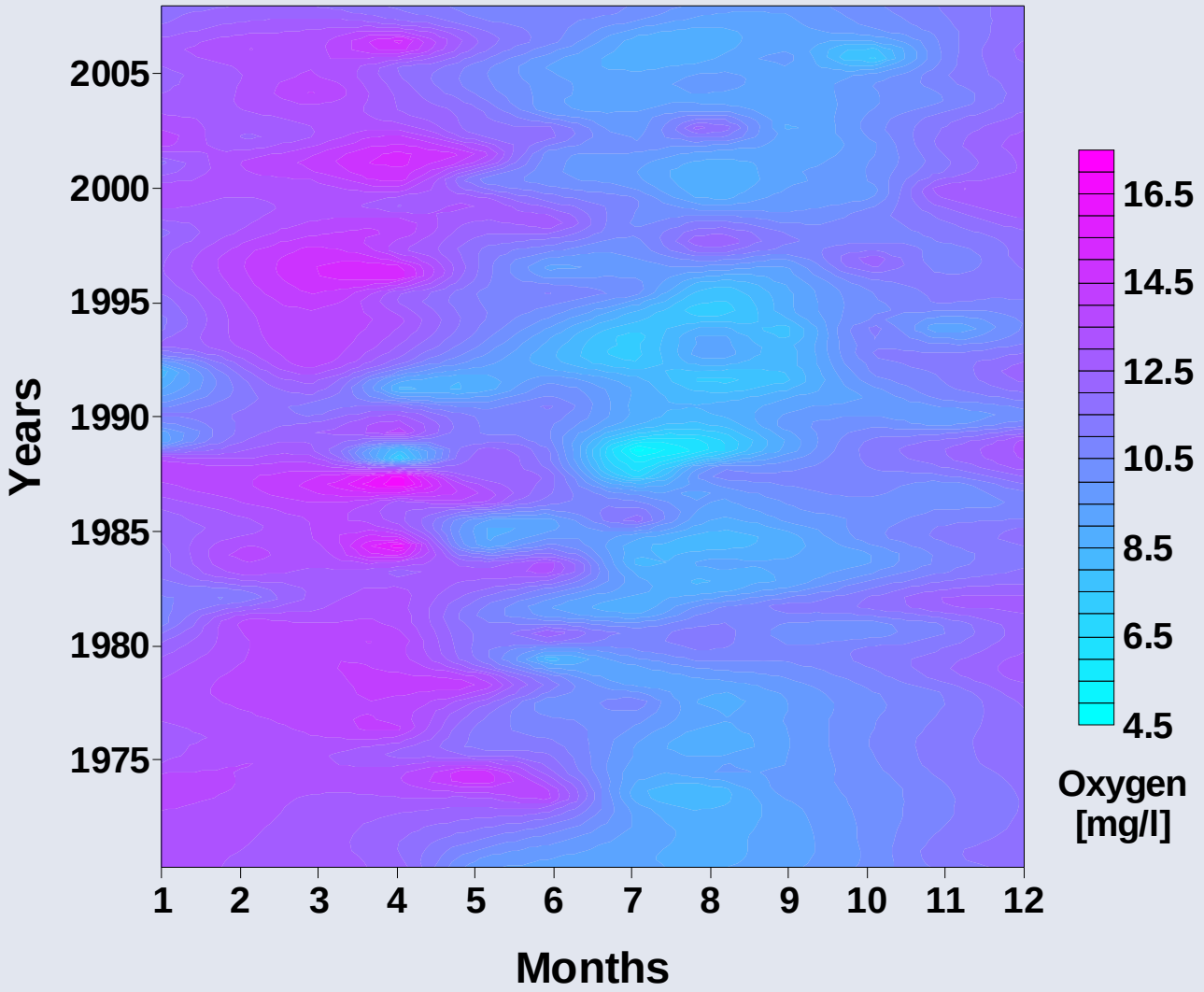
Updated version from September 25, 2010

Salinity OB4



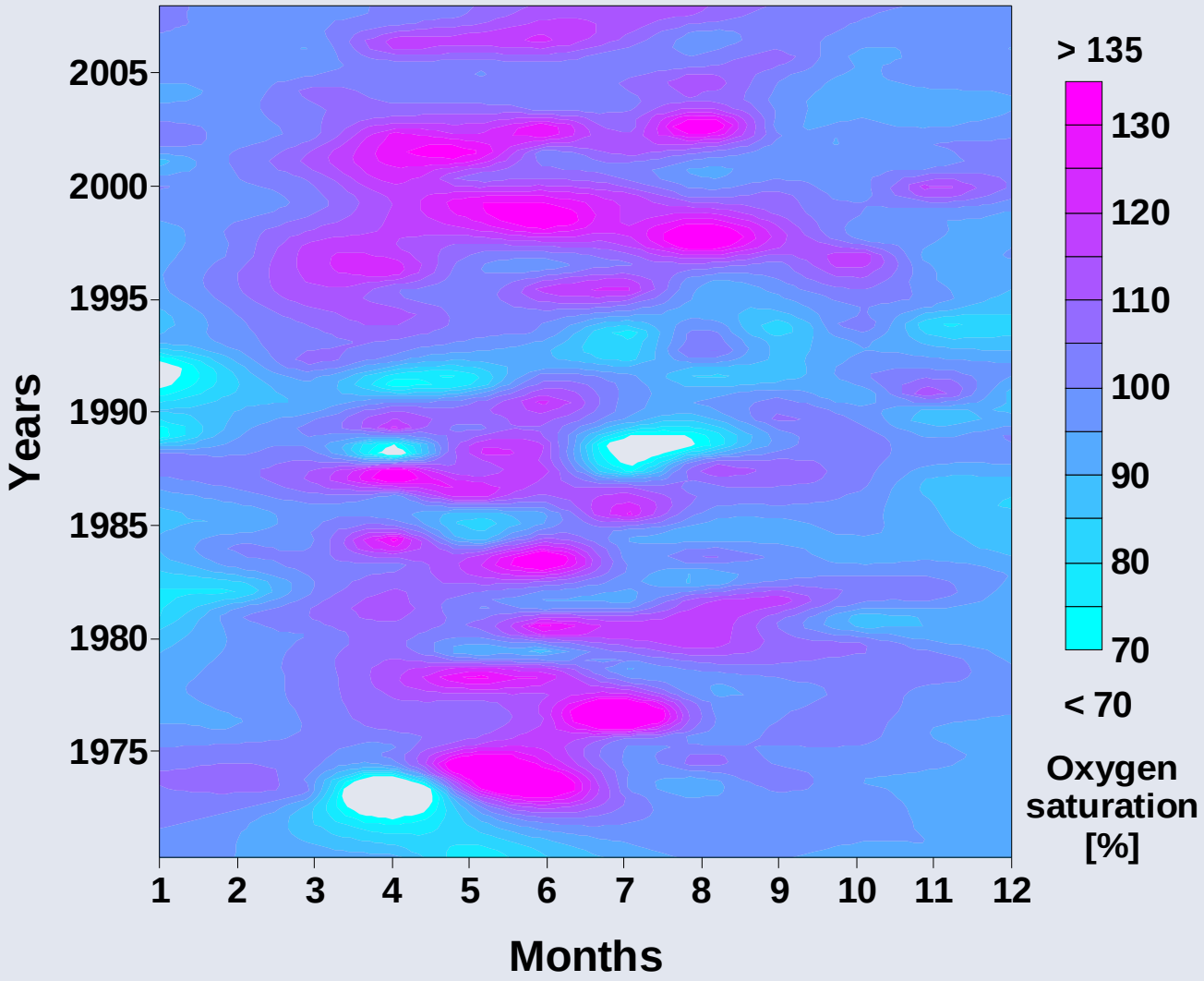
Updated version from September 25, 2010

Oxygen OB4



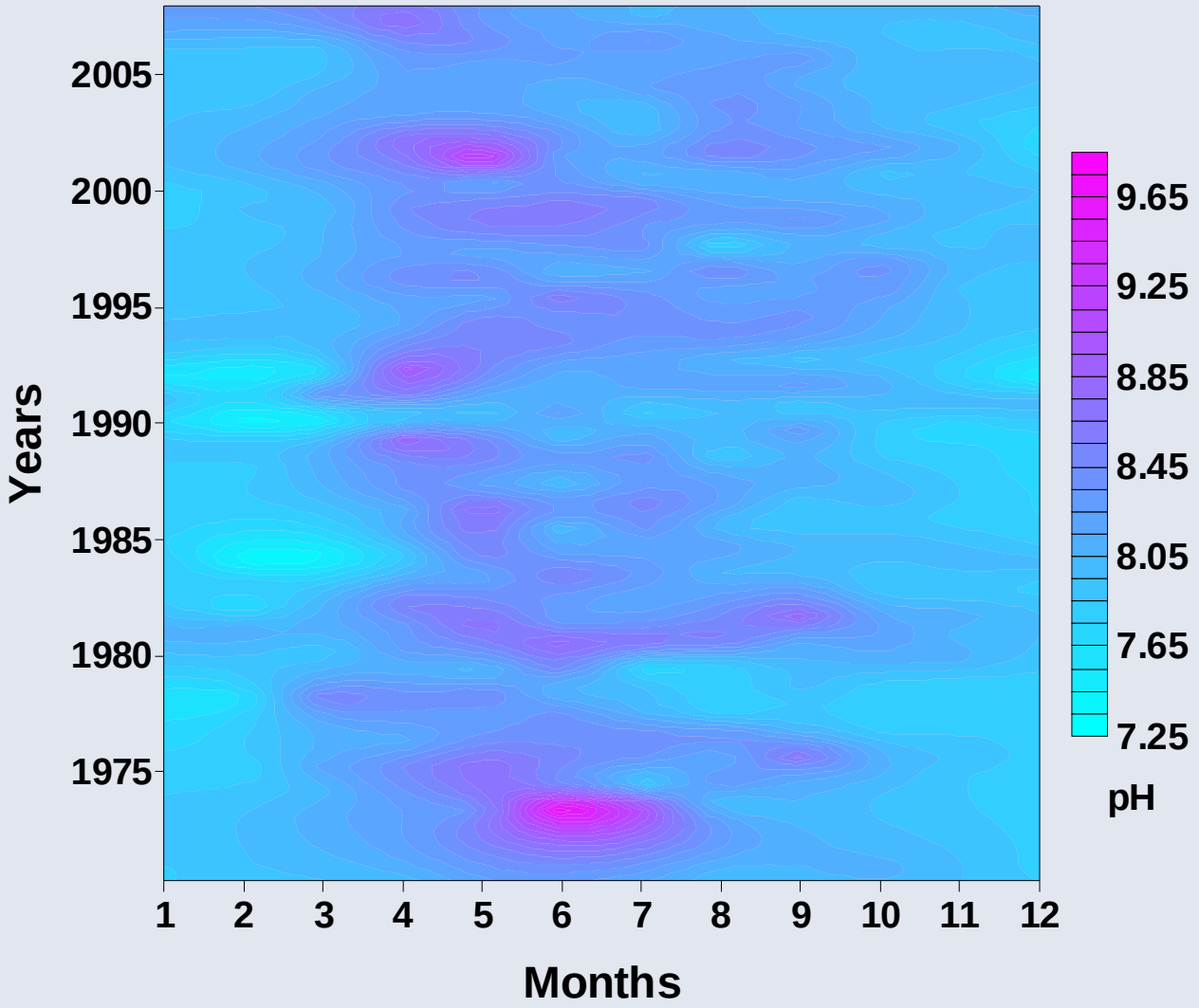
Updated version from September 25, 2010

Oxygen saturation OB4



Updated version from September 25, 2010

pH value OB4

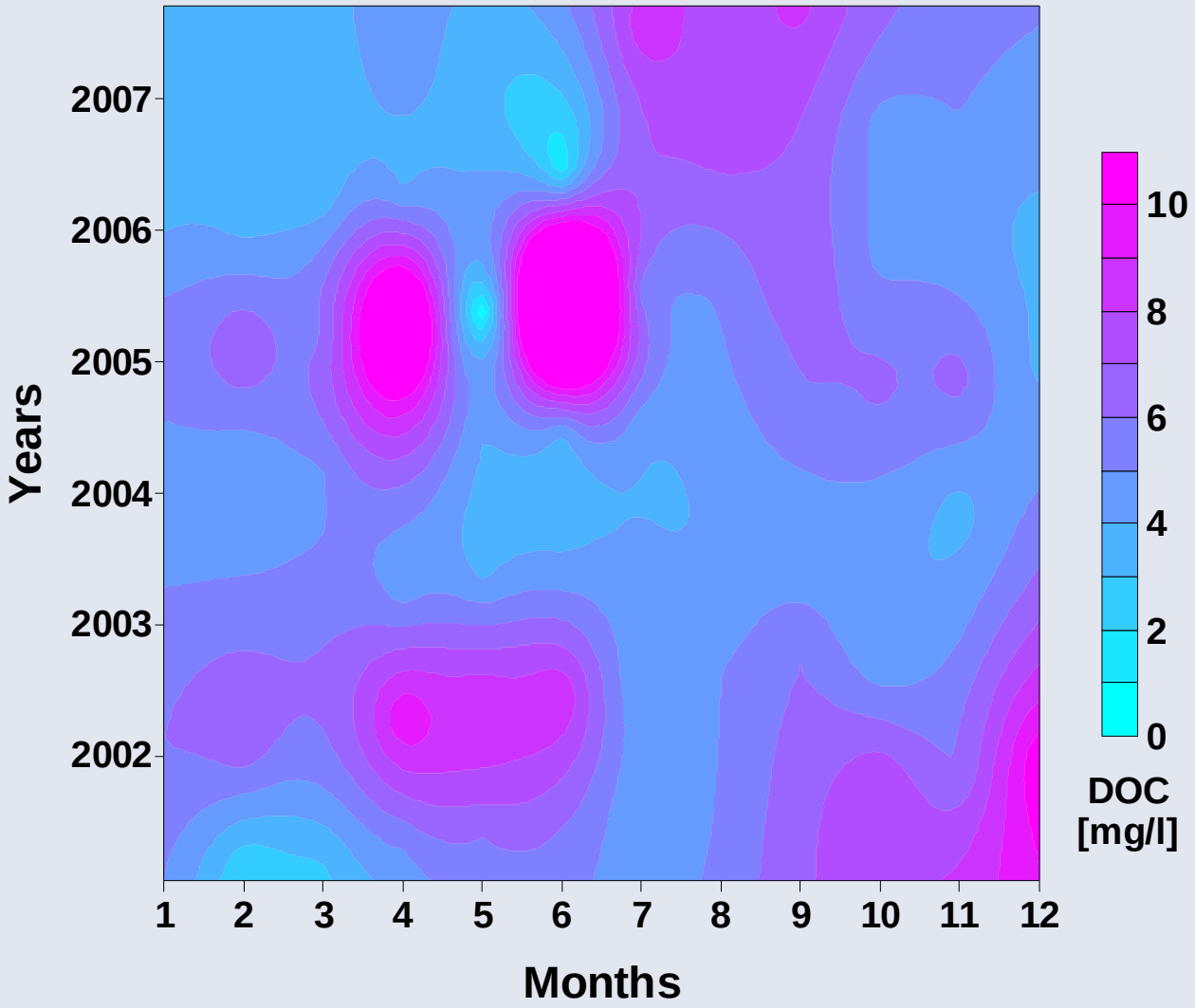


Nutrient Data at OB4

- Dissolved Organic Carbon (DOC)
- Total Organic Carbon (TOC)
- Nitrate
- Nitrite
- Ammonia
- Total N
- Phosphate
- Total phosphorus
- Silicate

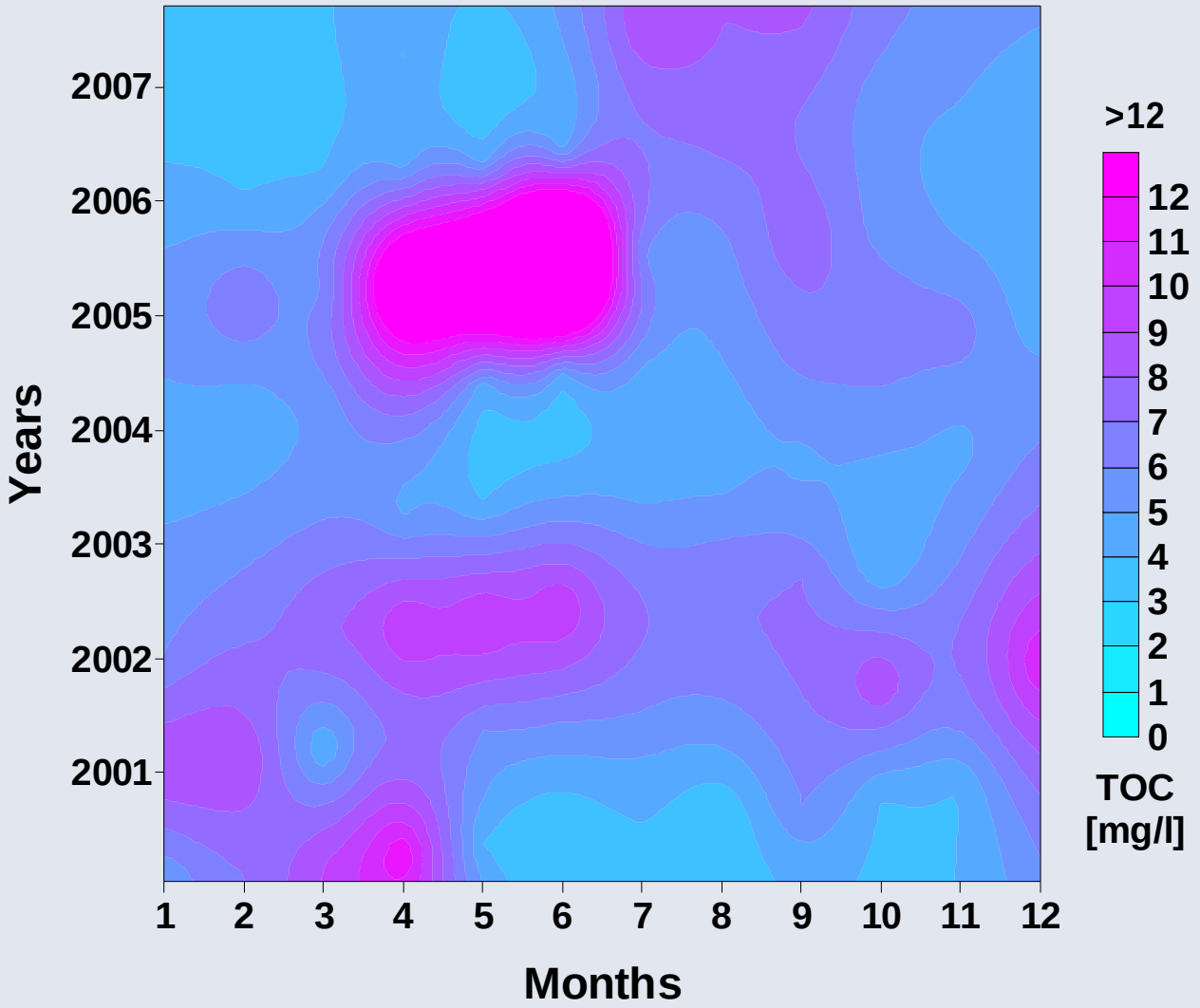
Updated version from September 25, 2010

Dissolved Organic Carbon OB4



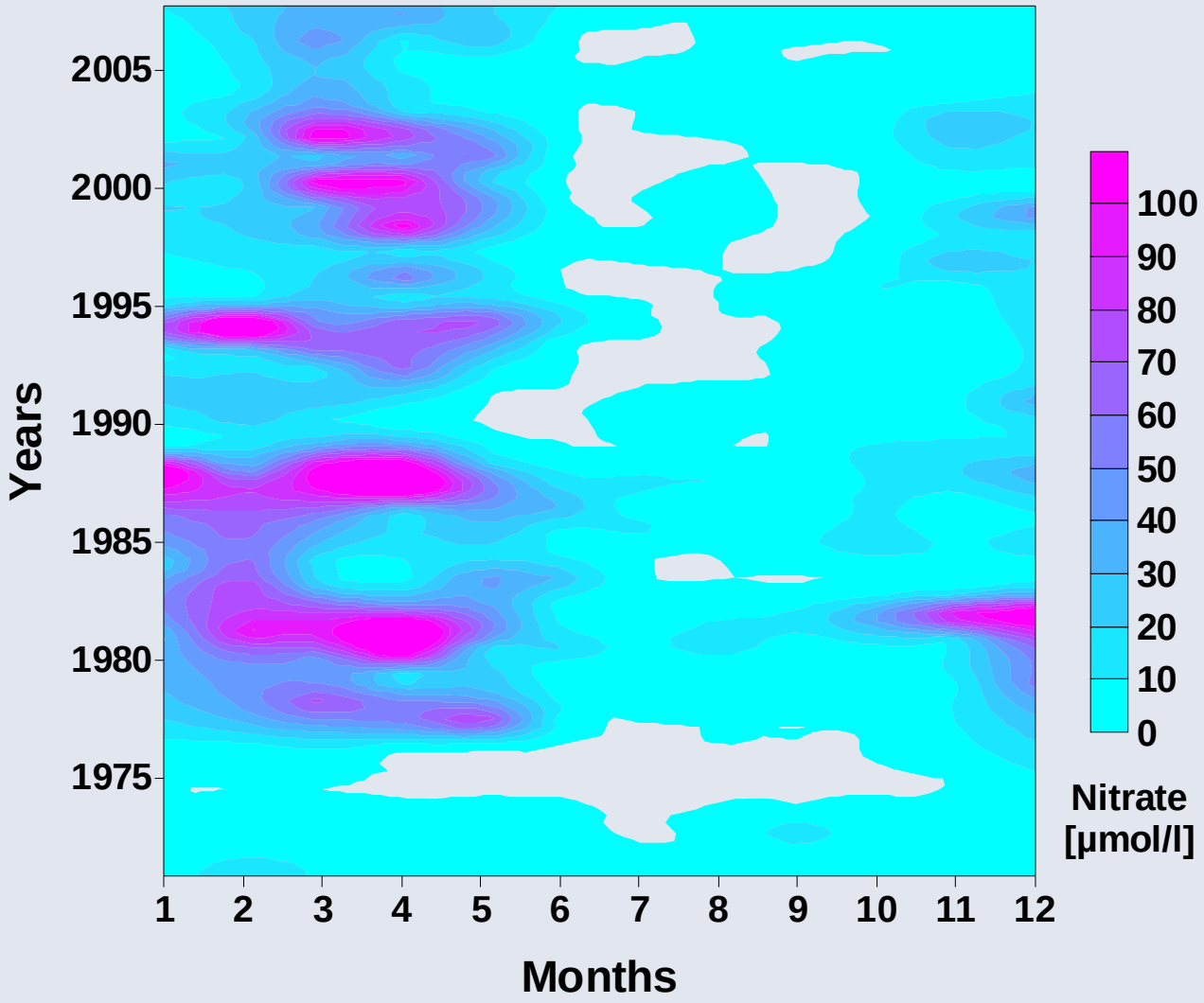
Updated version from September 25, 2010

Total Organic Carbon OB4



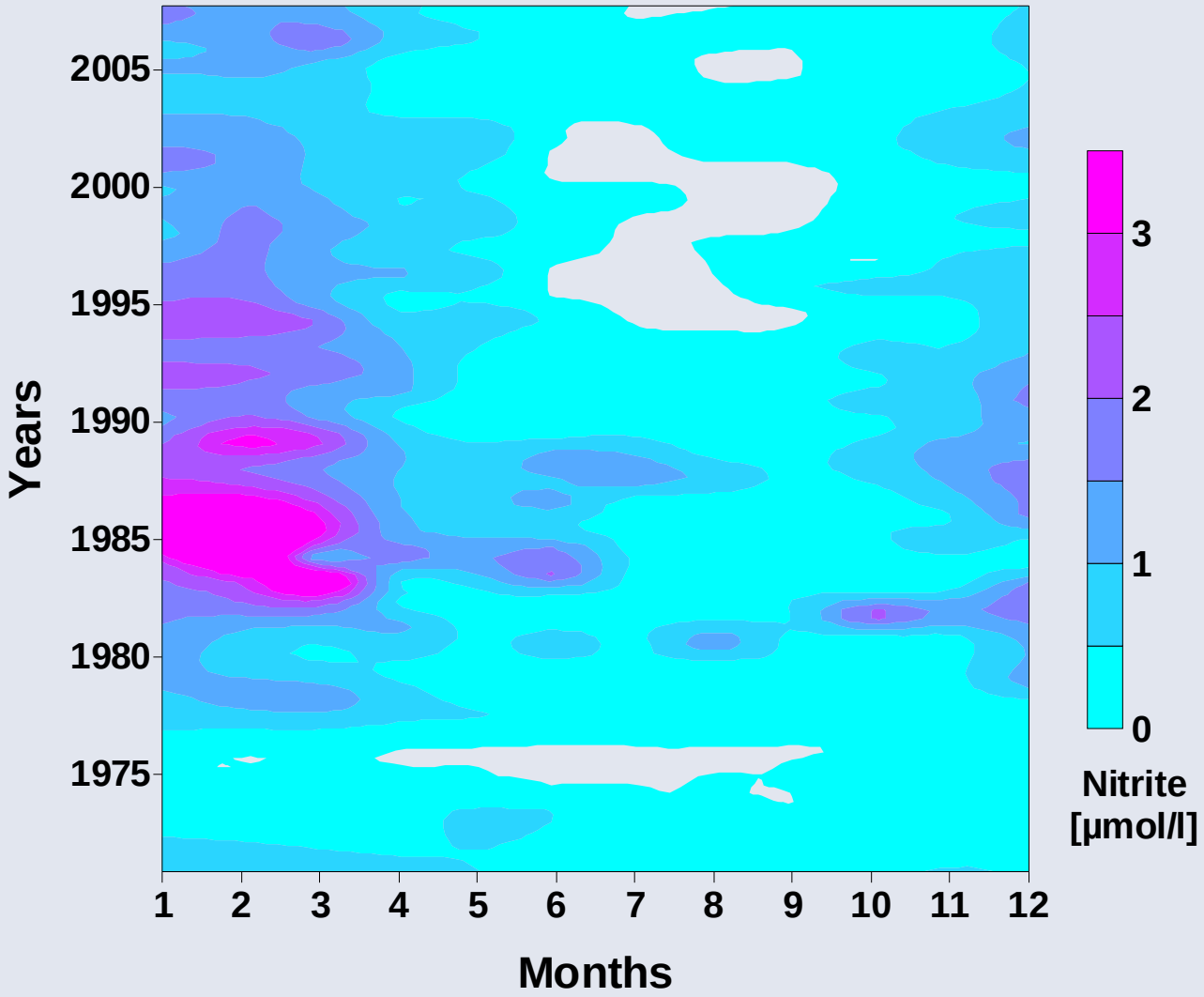
Updated version from September 25, 2010

Nitrate OB4



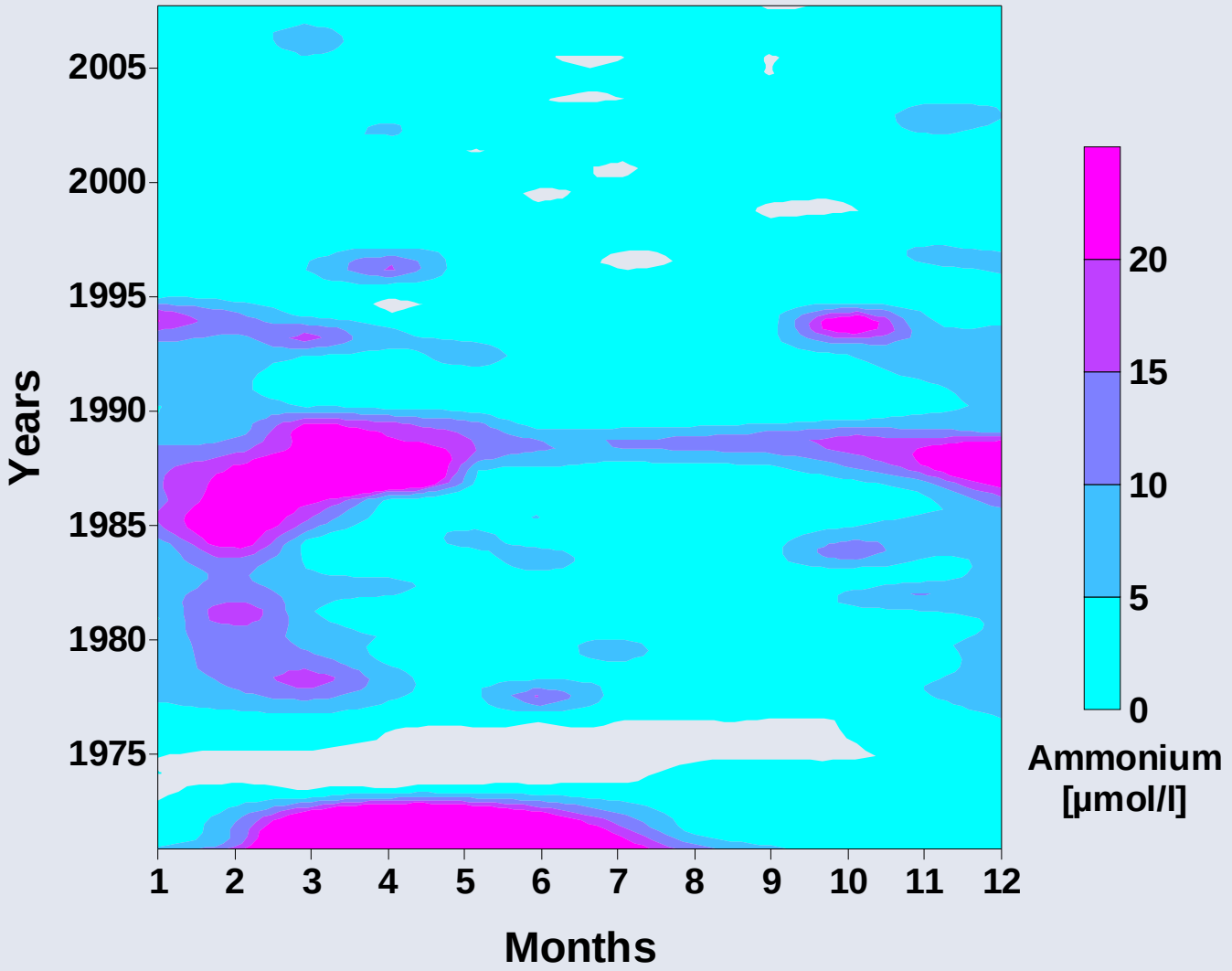
Updated version from September 25, 2010

Nitrite OB4



Updated version from September 25, 2010

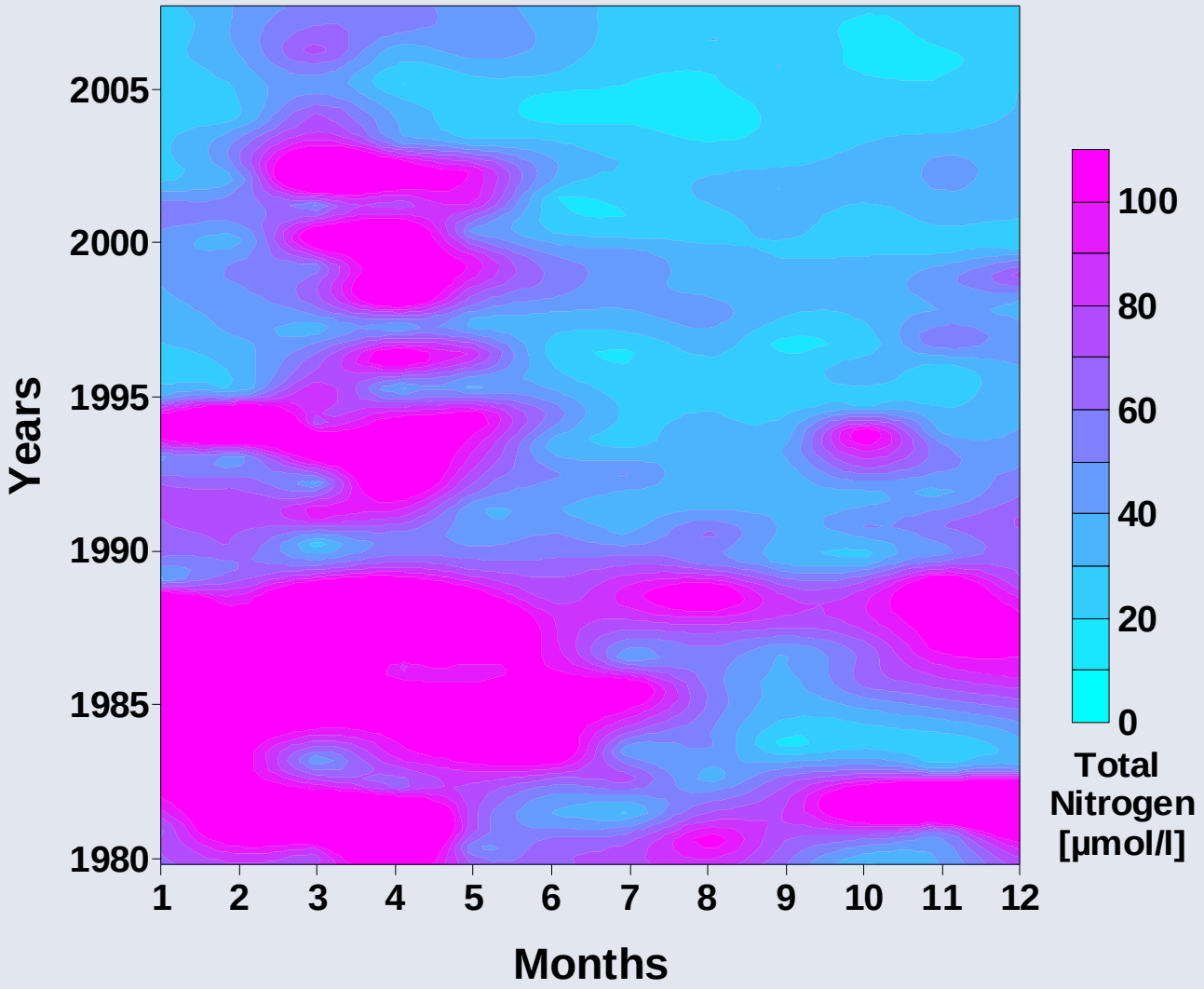
Ammonium OB4



AMBER
BONUS
BALTEX
Federal Ministry of Education and Research

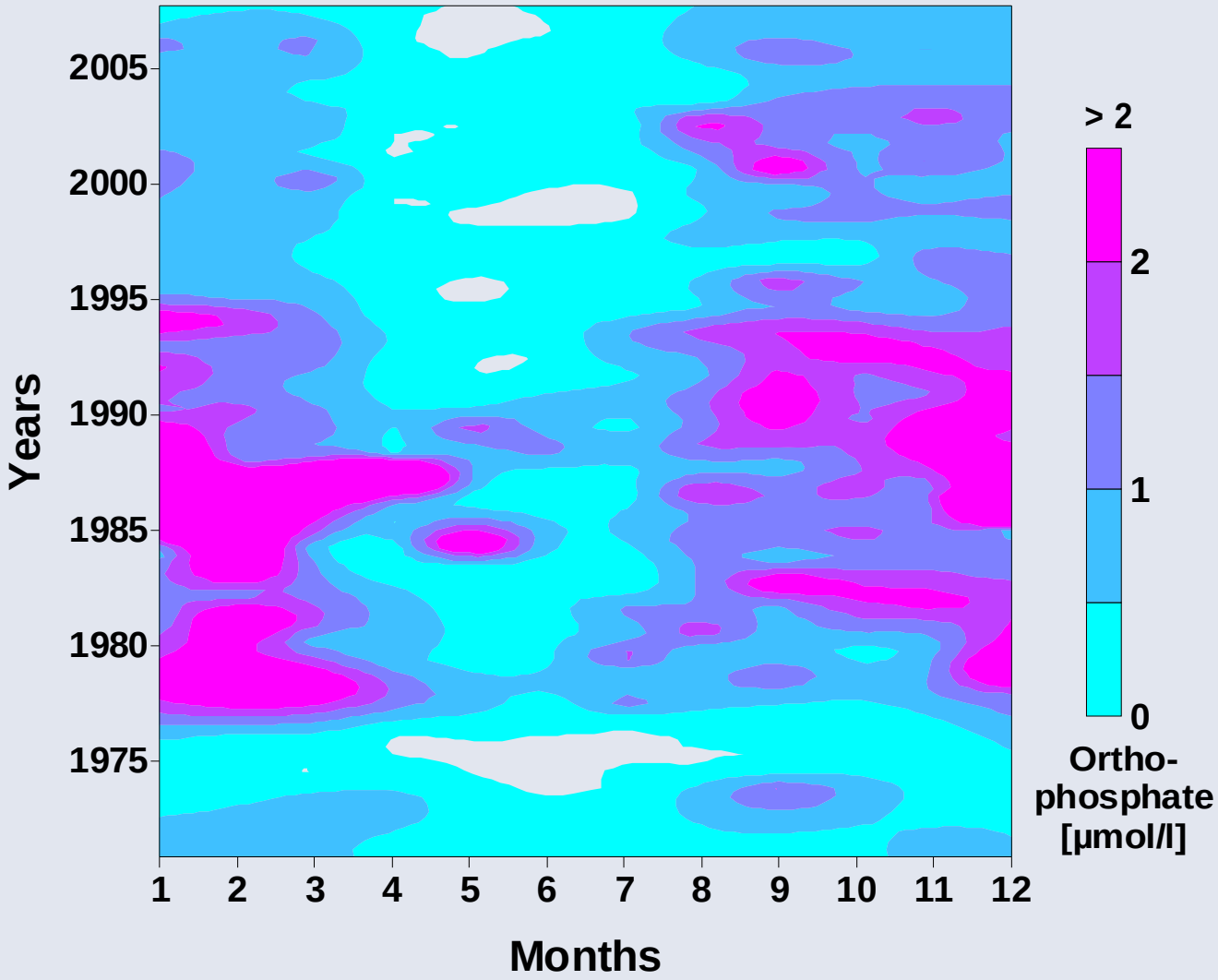
Updated version from September 25, 2010

Total Nitrogen OB4



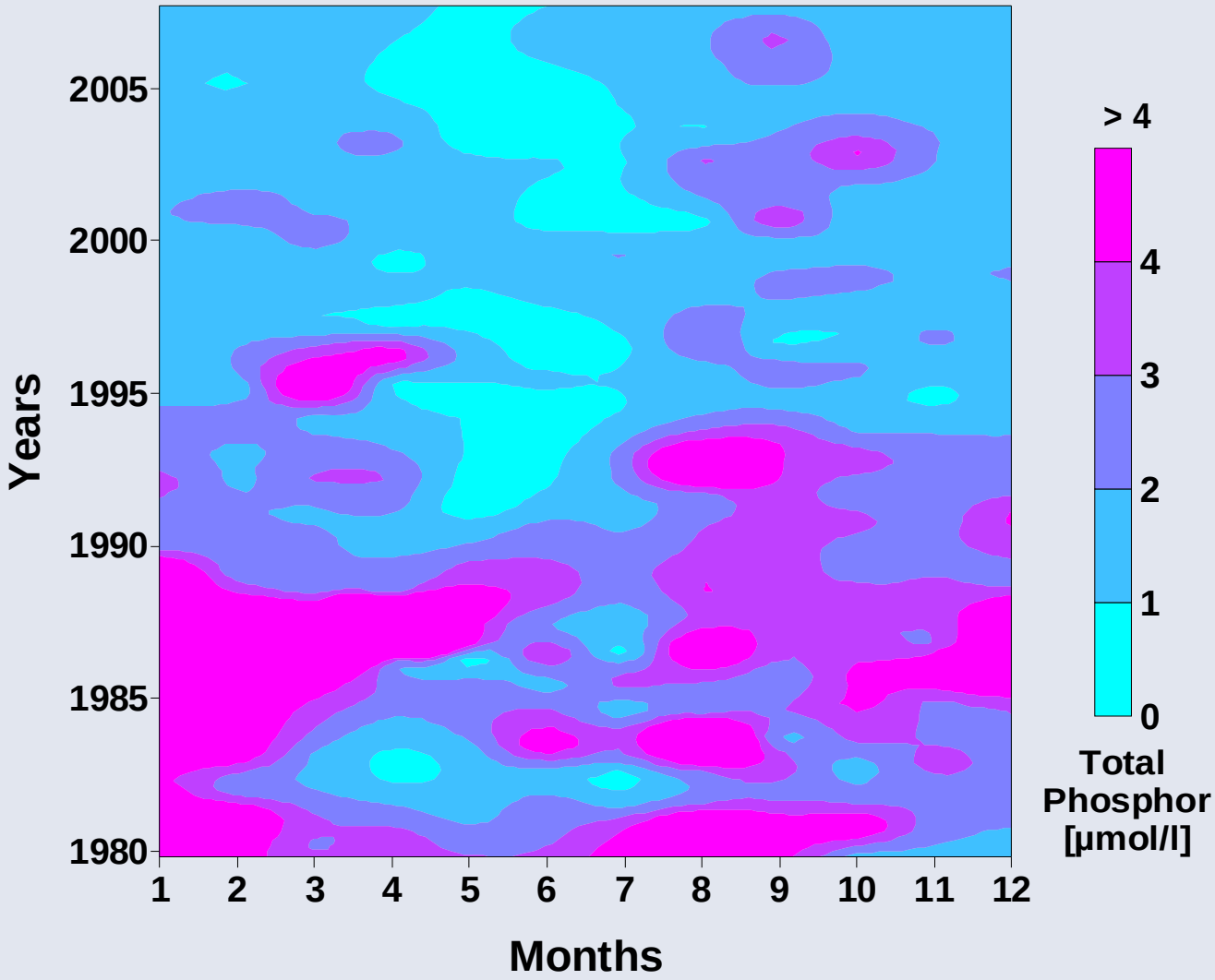
Updated version from September 25, 2010

Phosphate OB4



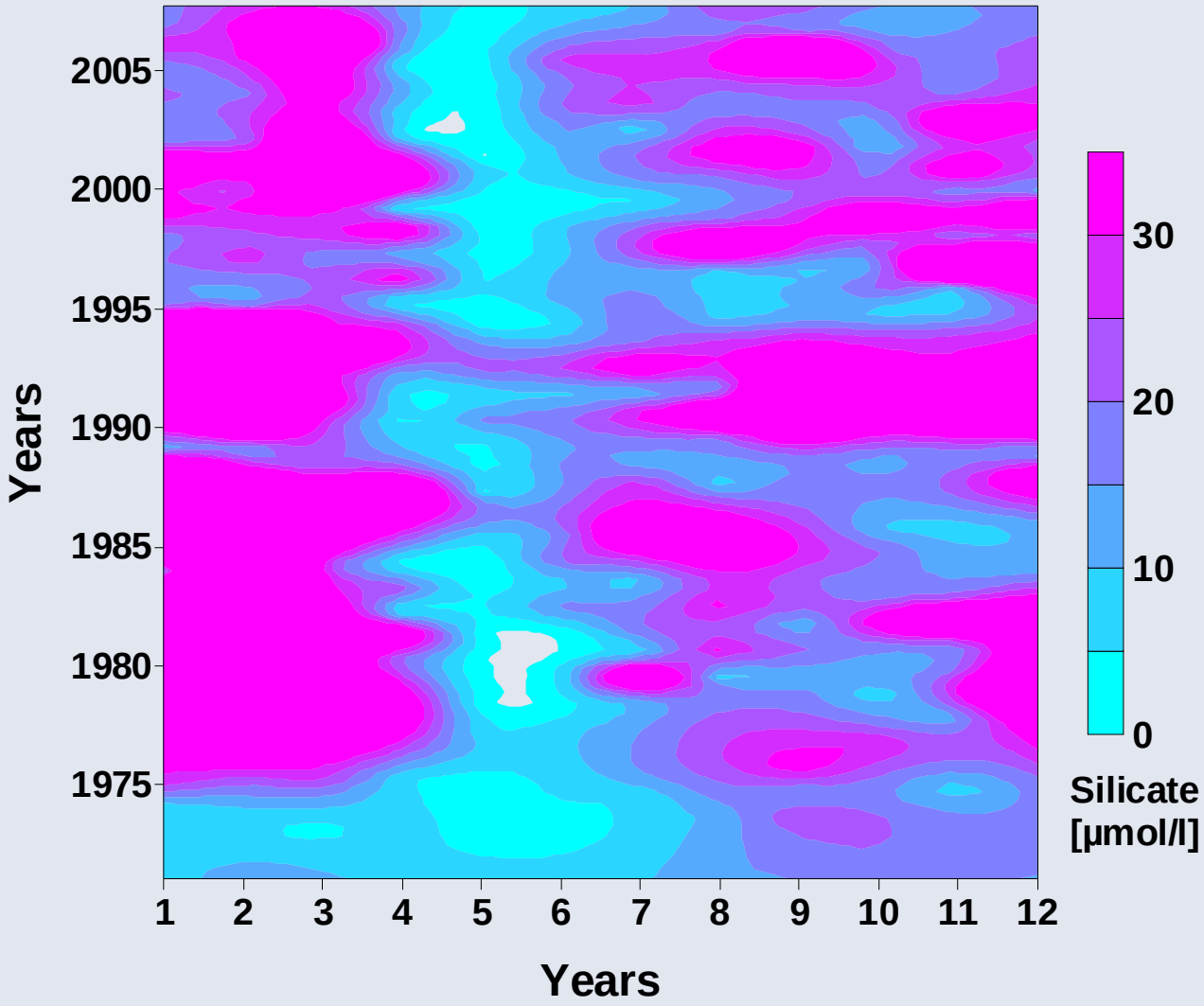
Updated version from September 25, 2010

Total phosphorus OB4



Updated version from September 25, 2010

Silicate OB4

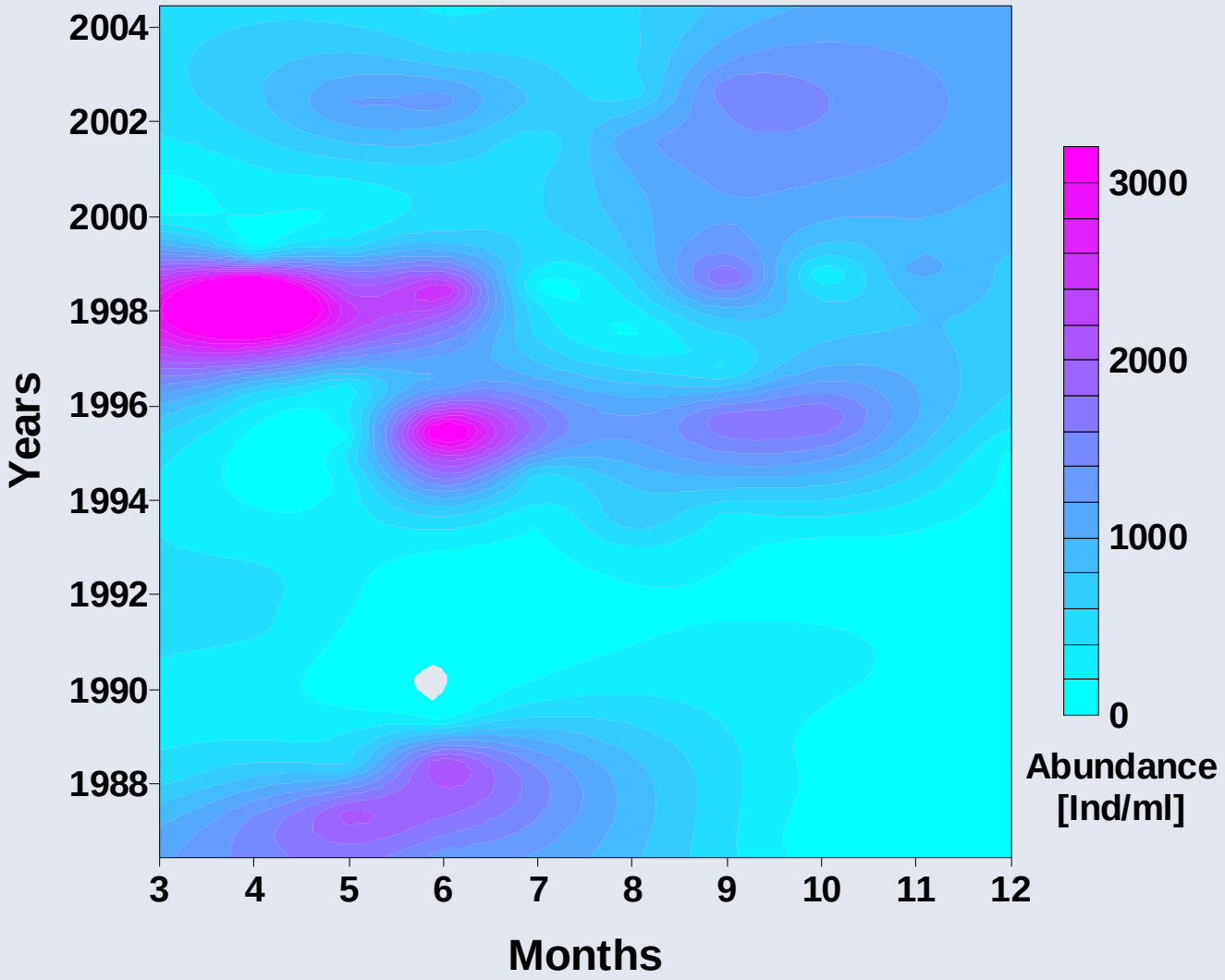


List of taxonomic divisions OB4

- Chlorophyta
- Heterokontophyta
  - class Chrysophyceae
  - class Bacillariophyceae
- Cryptophyta
- Dinophyta
- Euglenophyta
- Cyanophyta

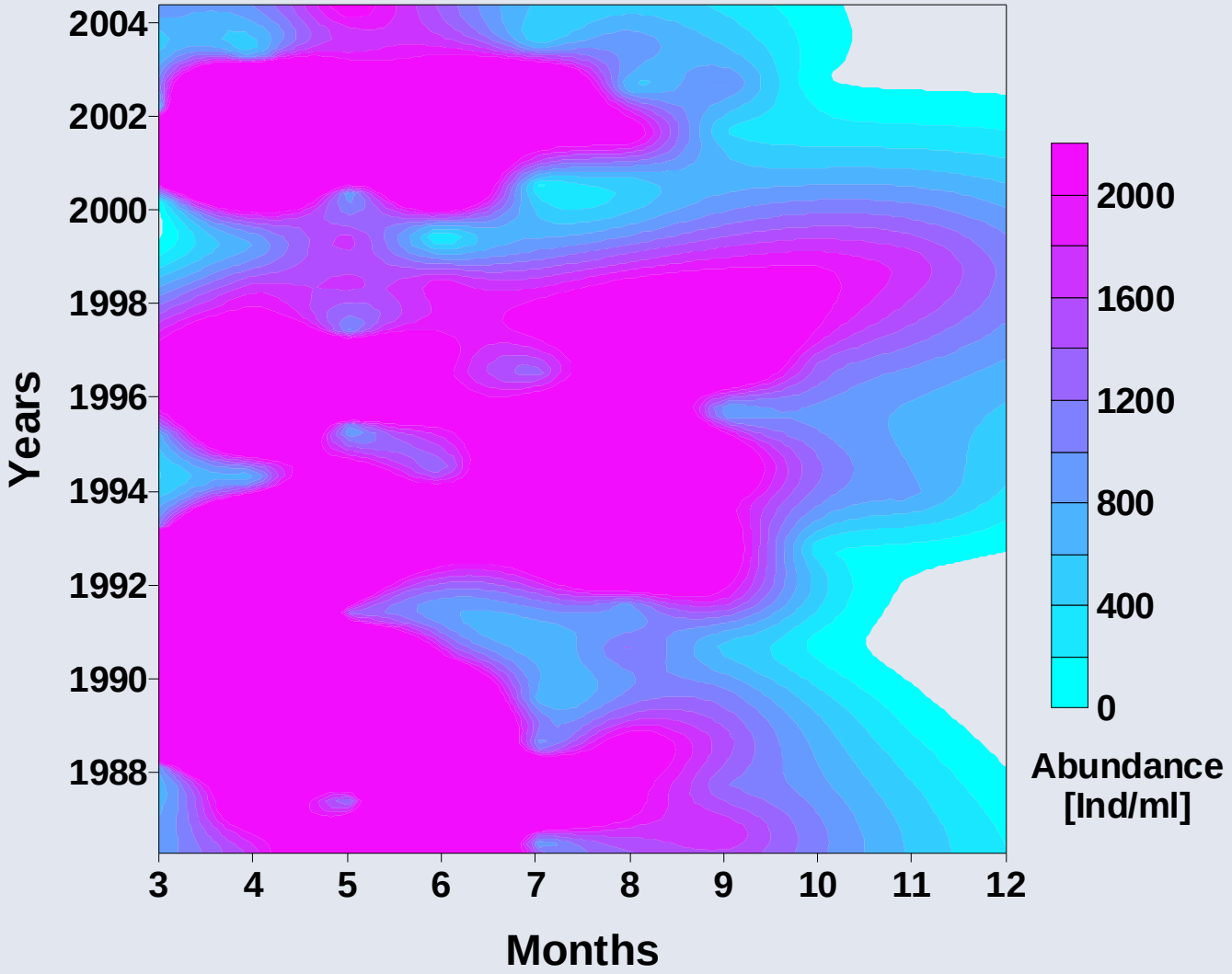
Updated version from September 25, 2010

Chlorophyceae (Abundance) OB4



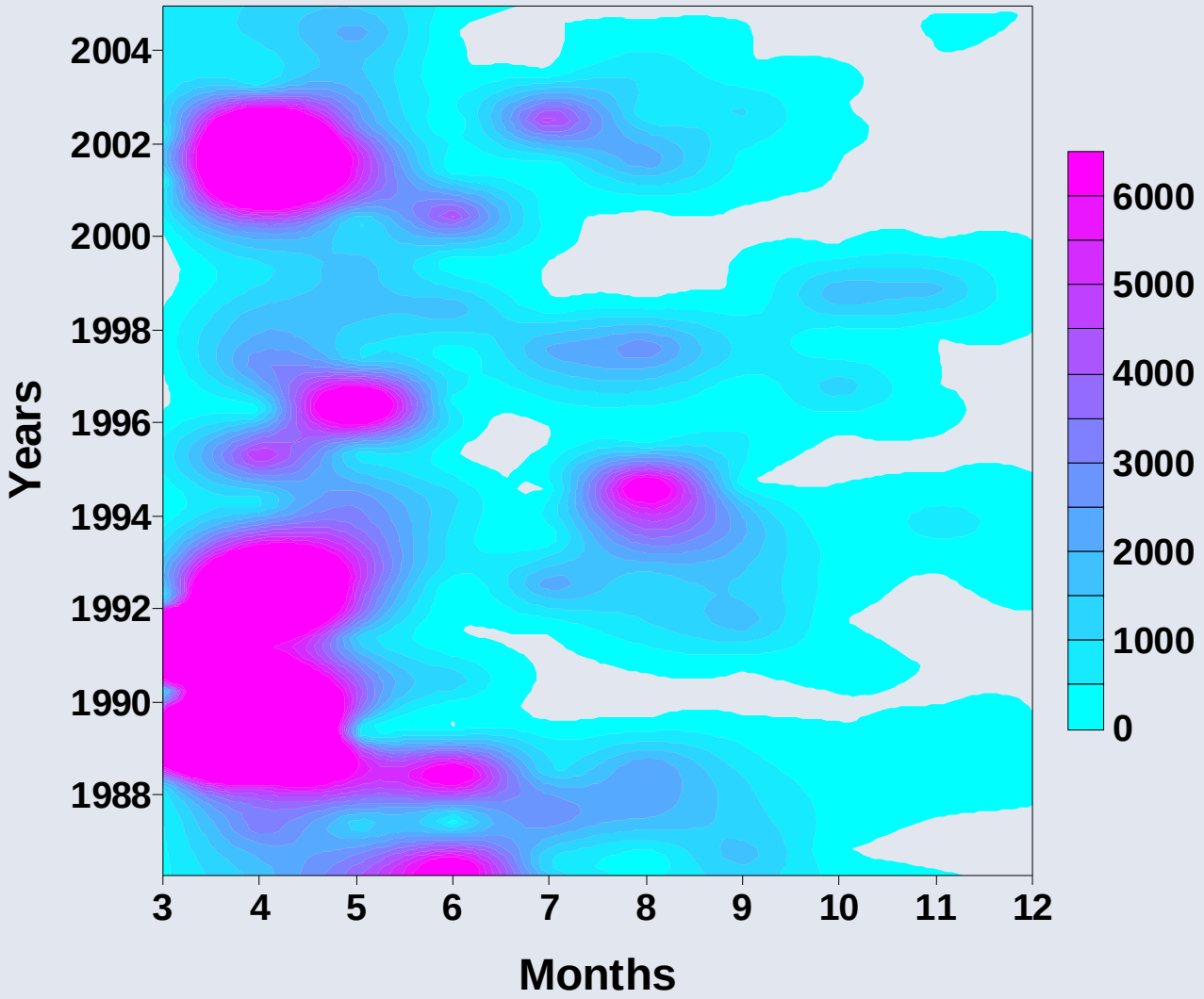
Updated version from September 25, 2010

Chrysophyceae (Abundance) OB4

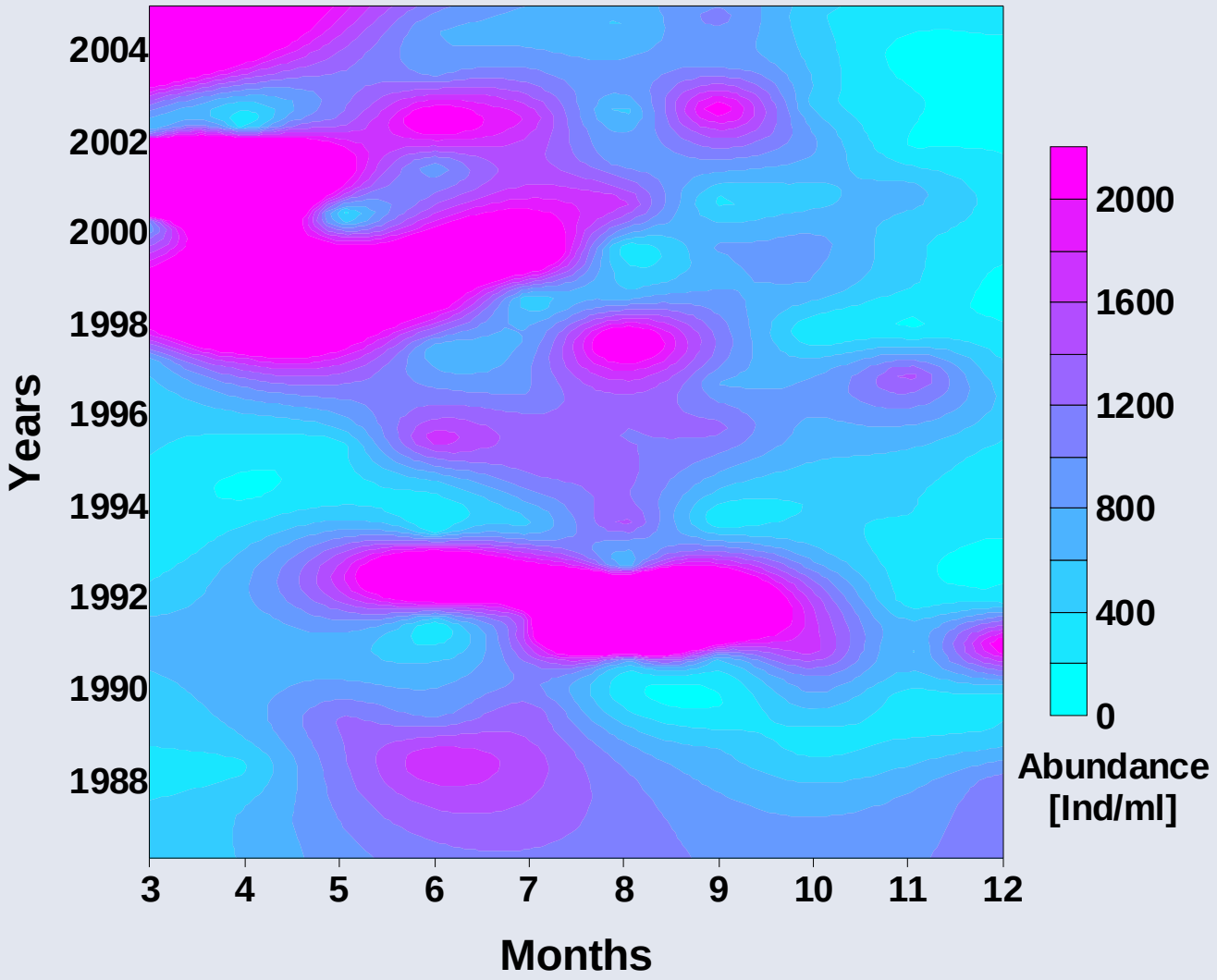


Updated version from September 25, 2010

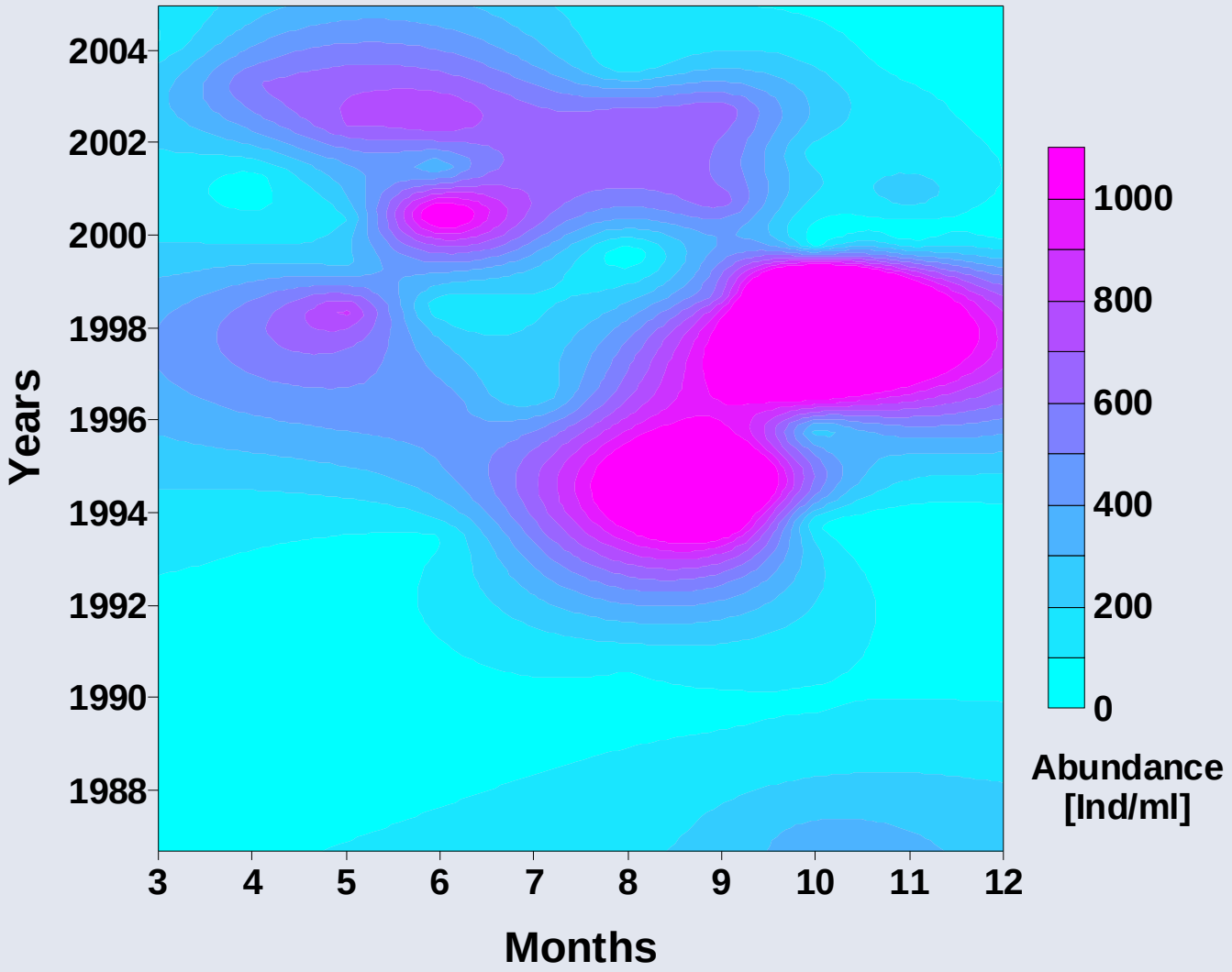
Bacillariophyceae (Abundance) OB4



Cryptophyta (Abundance) OB4

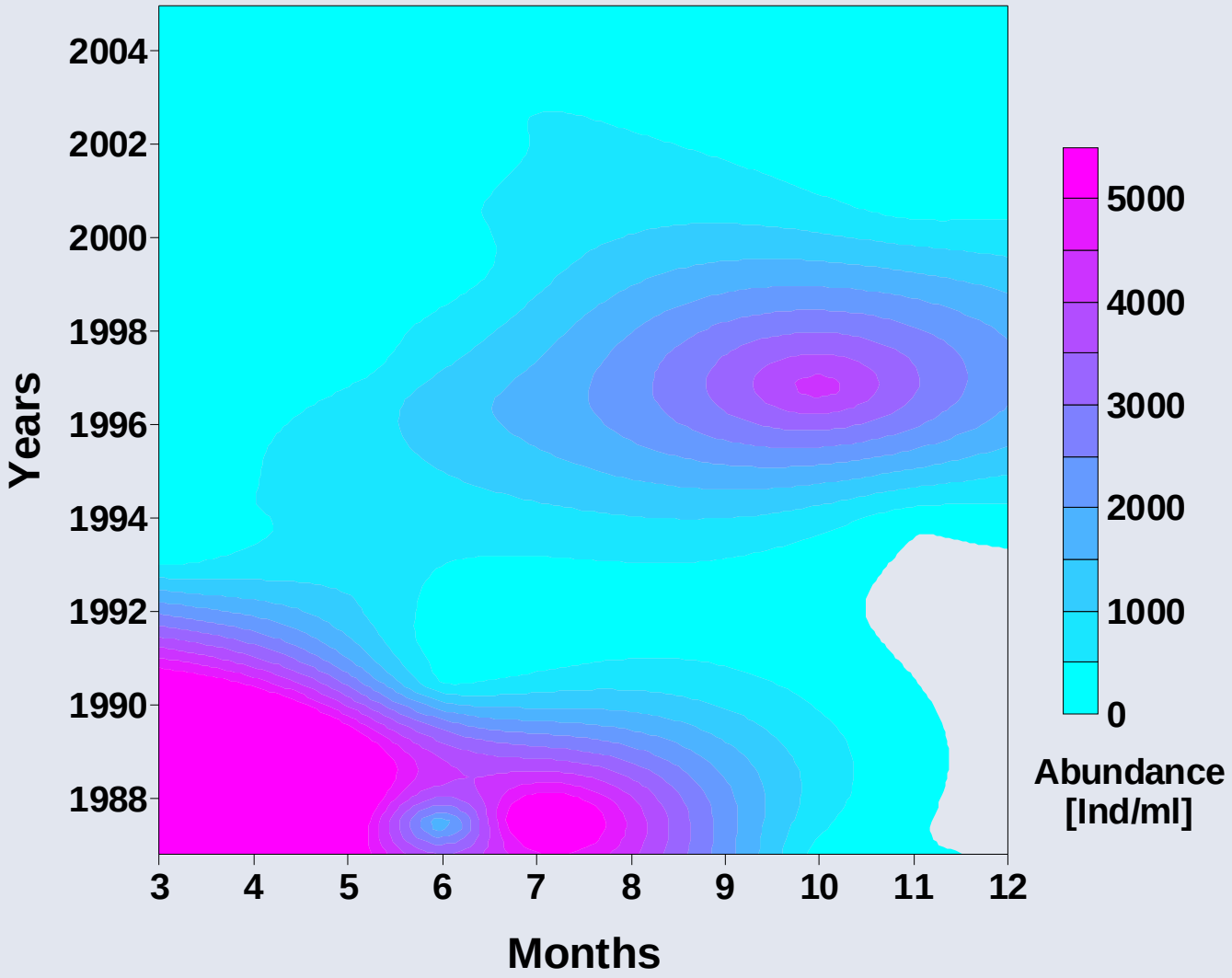


Dinophyta (Abundance) OB4



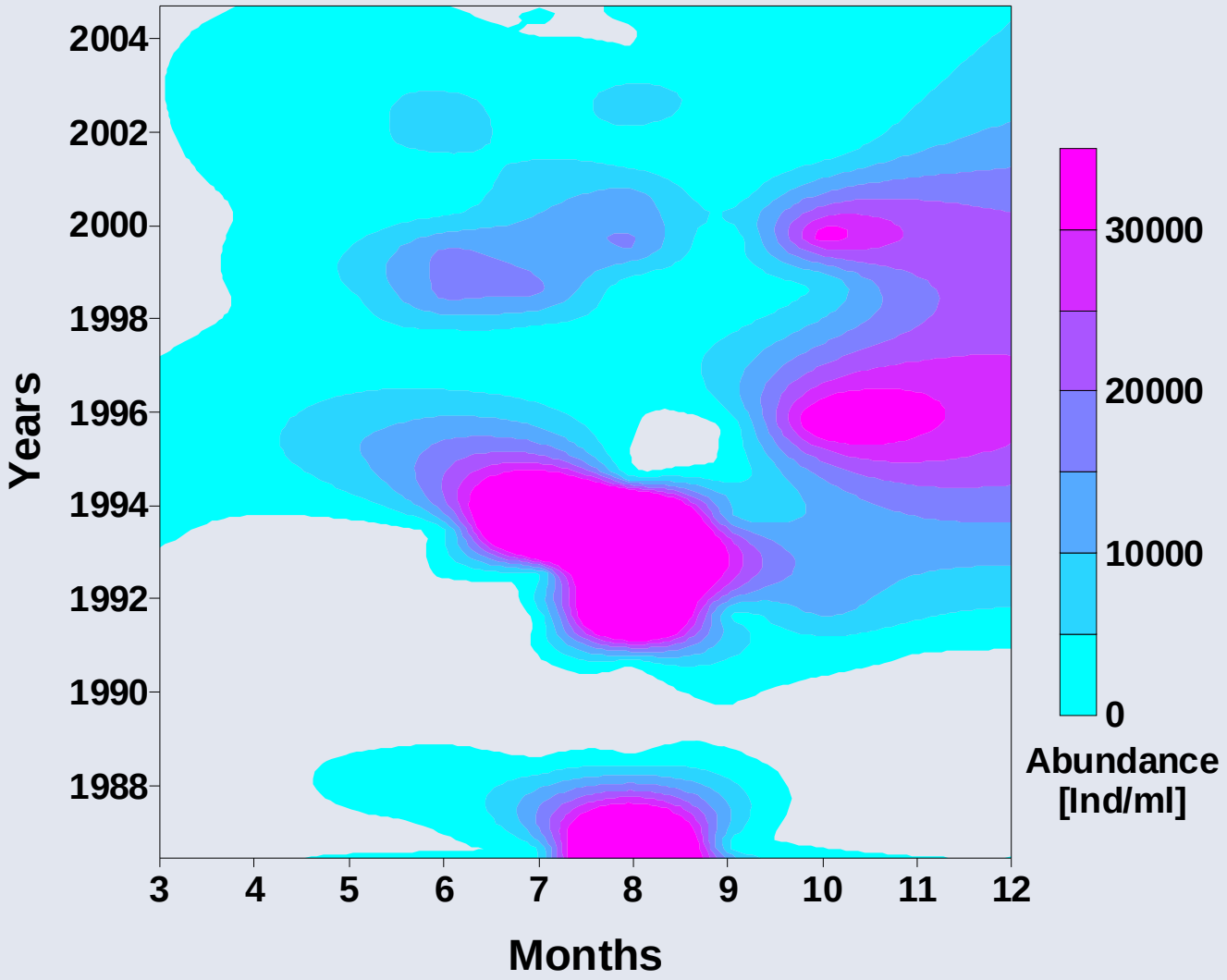
Updated version from September 25, 2010

Euglenophyta (Abundance) OB4



Updated version from September 25, 2010

Cyanophyta (Abundance) OB4



Acknowledgement

We are indebted to Drs. Sigrid Sagert and Norbert Wasmund for helpful comments and suggestions.

Thanks to Susanne Busch for providing us the photos of Mesodinium rubrum.

References

- LUNG (2004) Gewässergütebericht 2000/2001/2002. Landesamt für Umwelt, Naturschutz und Geologie Mecklenburg-Vorpommern 159pp
- Van den Hoek C, Mann DG, Jahns HM (1993) Algae, an introduction to phycology. Cambridge University Press, 623pp