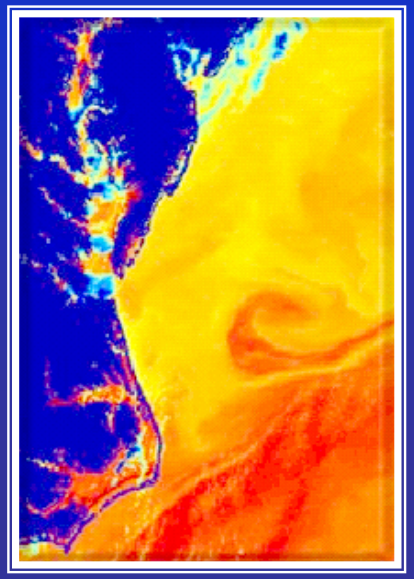

Between SST and bathymetry: Spatial techniques for defining the aquatic landscape

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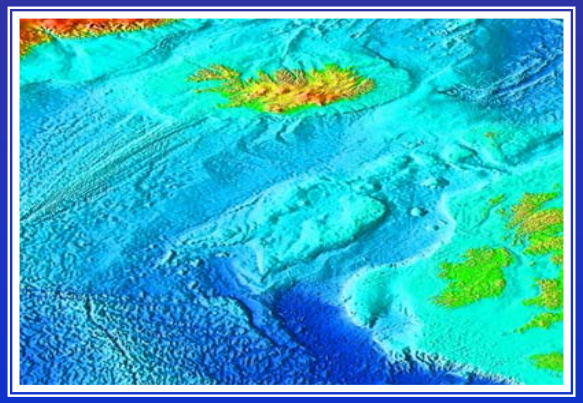
Second International Symposium on GIS/Spatial Analyses in Fishery and Aquatic Sciences
September 2002
University of Sussex,
Brighton, United Kingdom



Sampling the water column

Sigsbee Sounding Machine. Basic design of ocean sounding instruments stayed the same for the next 50 years. Used here to set Pillsbury current meter at known depth. Photo Date: 1880?
Publication of NOAA Central Library

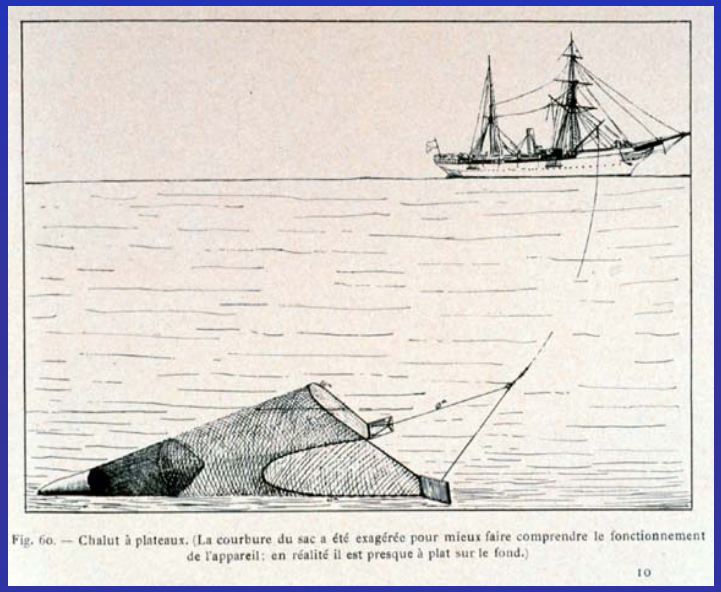


Fig. 60. — Chalut à plateaux. (La courbure du sac a été exagérée pour mieux faire comprendre le fonctionnement de l'appareil; en réalité il est presque à plat sur le fond.)

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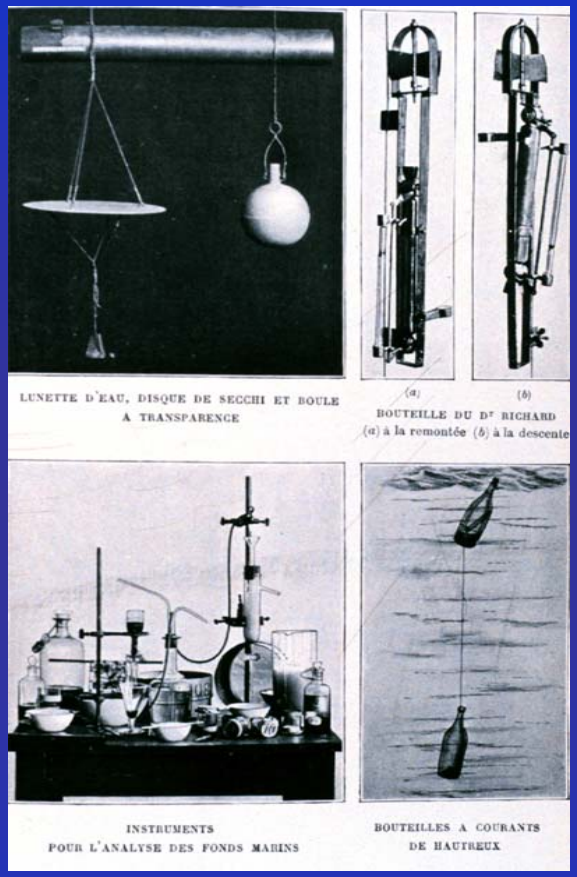
Trawling apparatus deployed on the PRINCESS ALICE. In: "From the Surface to the Bottom of the Sea" by H. Bouree, 1912
NOAA Ship Collection



A secchi disk; water sampling bottles; water chemistry laboratory; and bottles for studying subsurface currents. In: "L'Ocean" by J. Thoulet 1904
NOAA Ship Collection

A spatial perspective

Location matters

Spatial aspects of an ecosystem, such as heterogeneity, proximity, and configuration, impact the functional role of that system

Interdisciplinary framework

Considers “all” factors within a space

Things behave spatially

Patterns may reveal underlying processes

Implications

Understanding ecological function

Sampling strategies

Growth/productivity and animal behavior models

Aquatic Landscapes

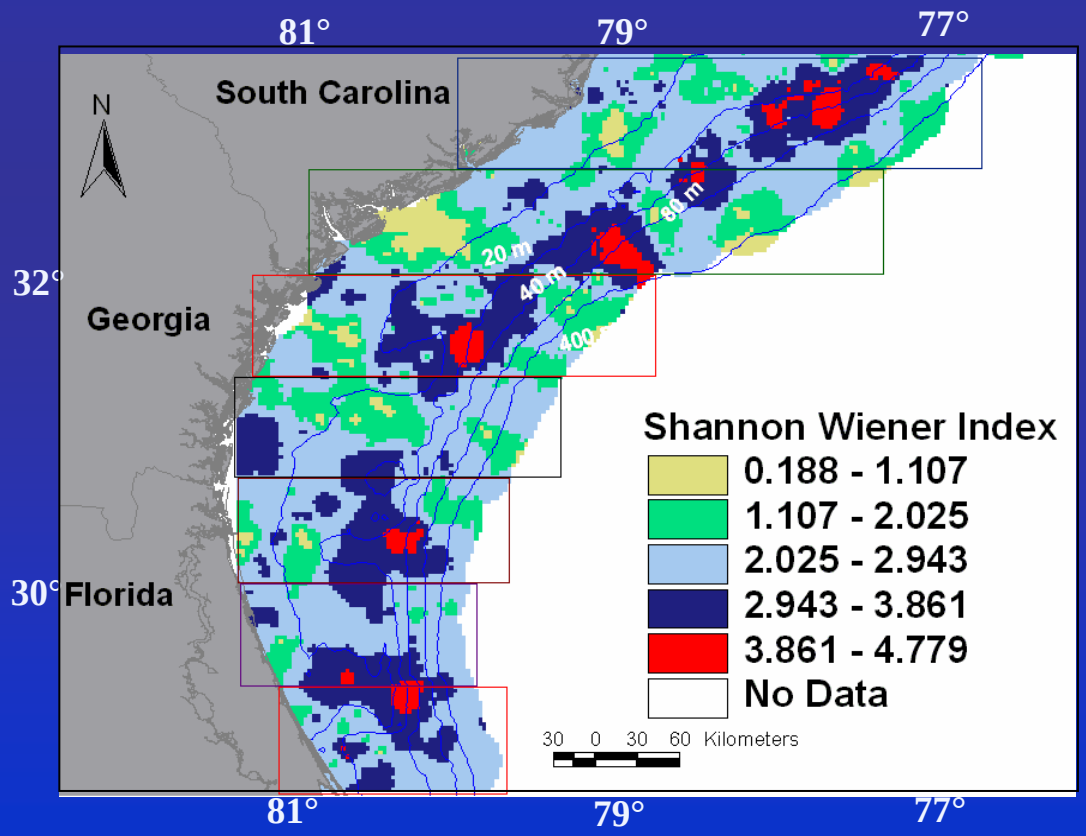
- Is the aquatic environment ‘structured’?
- If so, how does structure affect function?
- How can we quantify the organization of elements in the aquatic environment?

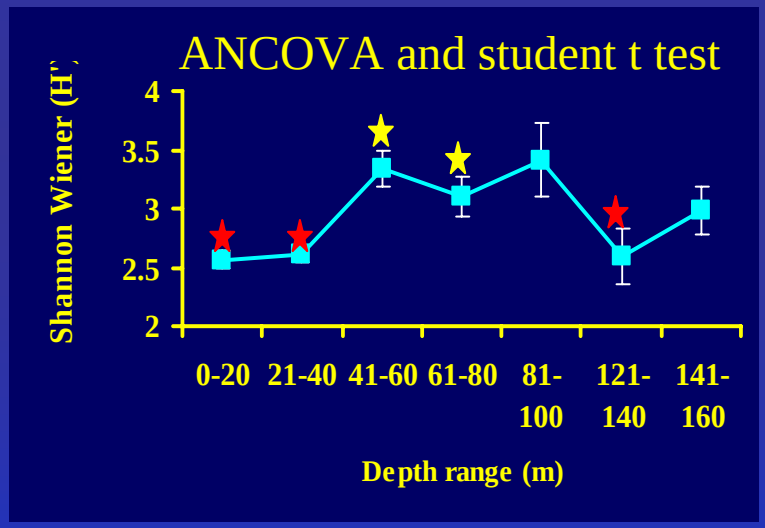
Examples of spatial techniques for defining the aquatic landscape

- Visualization of biological diversity in conjunction with inferential statistics
- Spatial statistics (k-means clustering) --> biodiversity
- Geo-statistics (kriging) --> contaminants, fish density
- Landscape ecology approach and underwater acoustics to retain information about heterogeneity and quantify ecologically relevant spatial relationships

GIS and inferential statistics

Visualization of fish biodiversity in relation to bathymetry supported by inferential statistics

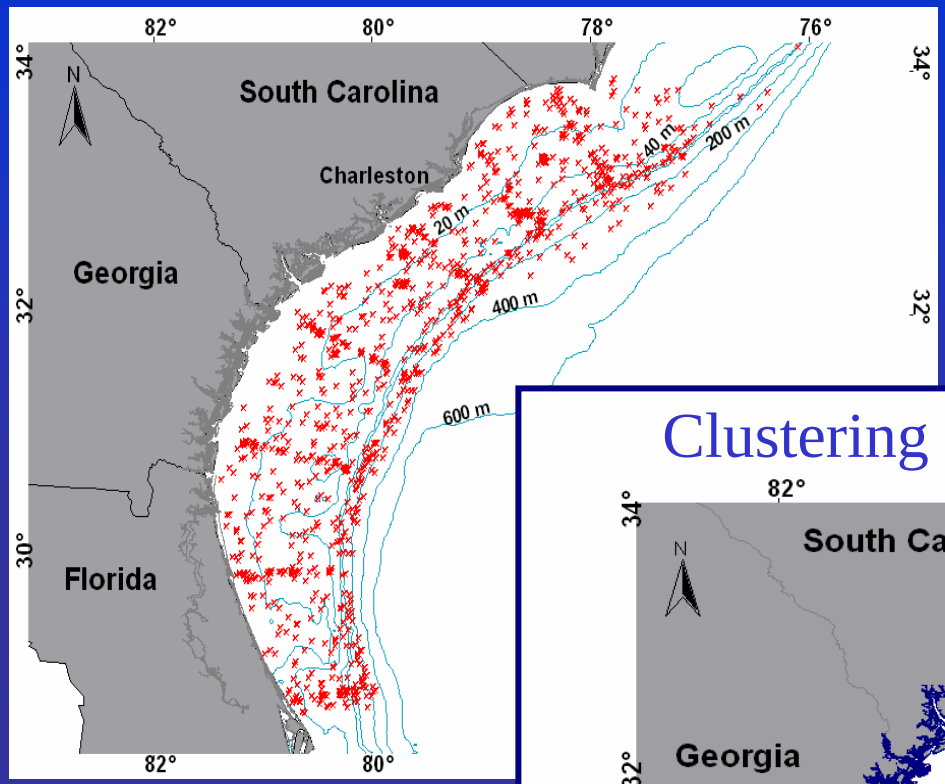




Species diversity (H') MARMAP Yankee trawls (1973-1980)

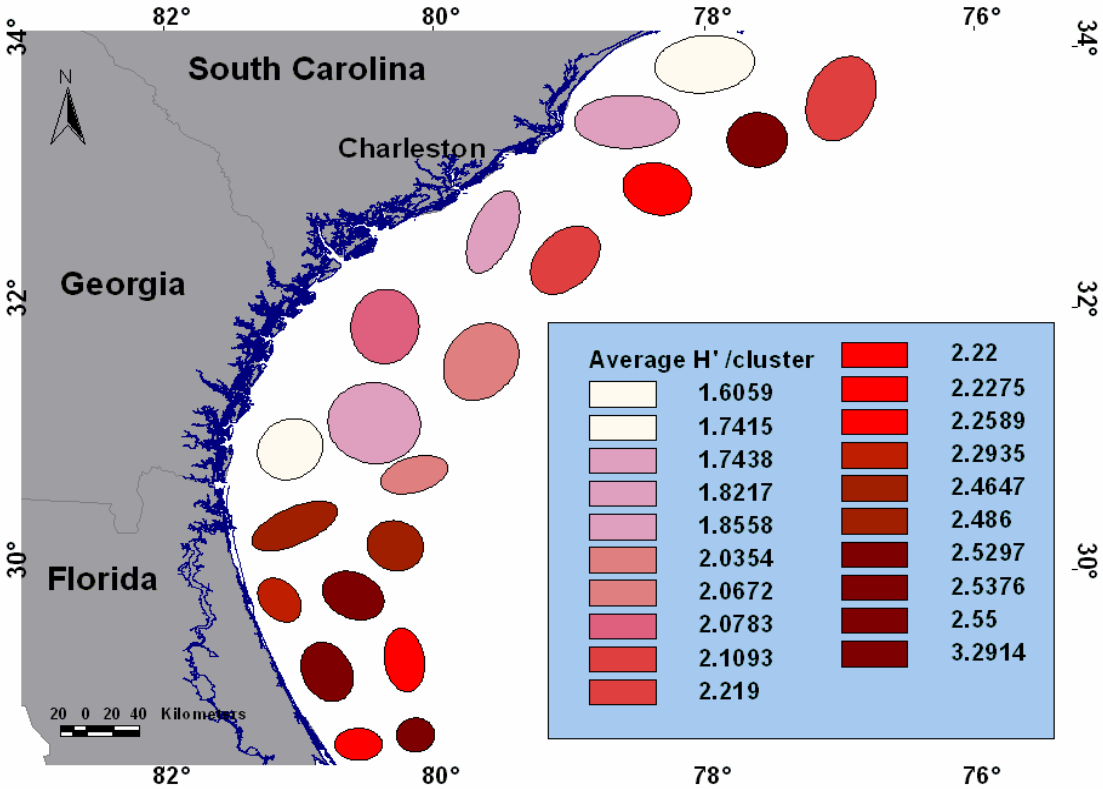
J. Jennings

Spatial K-means clustering to differentiate regions of high biological diversity



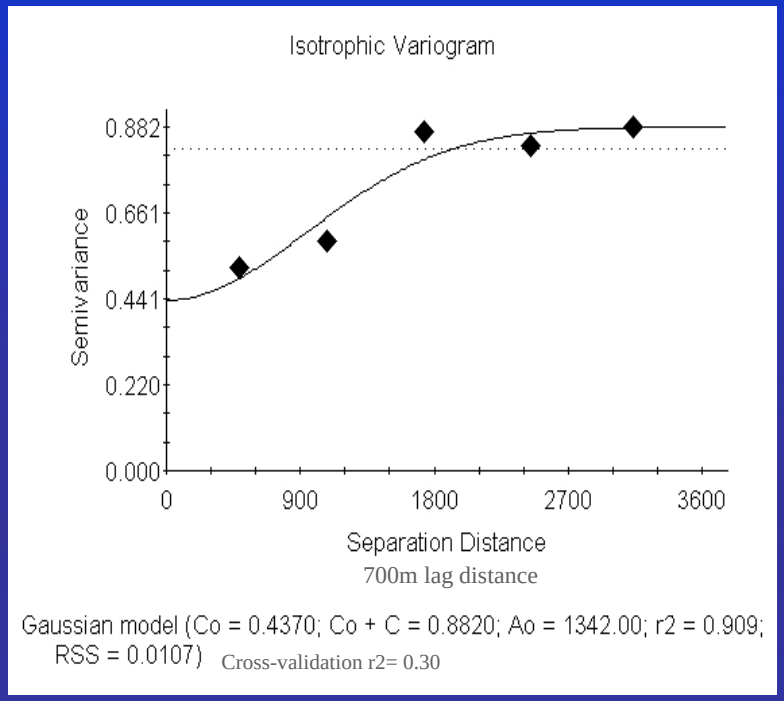
Based on Yankee Trawls Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP) 1973-1980

Clustering of species diversity measures



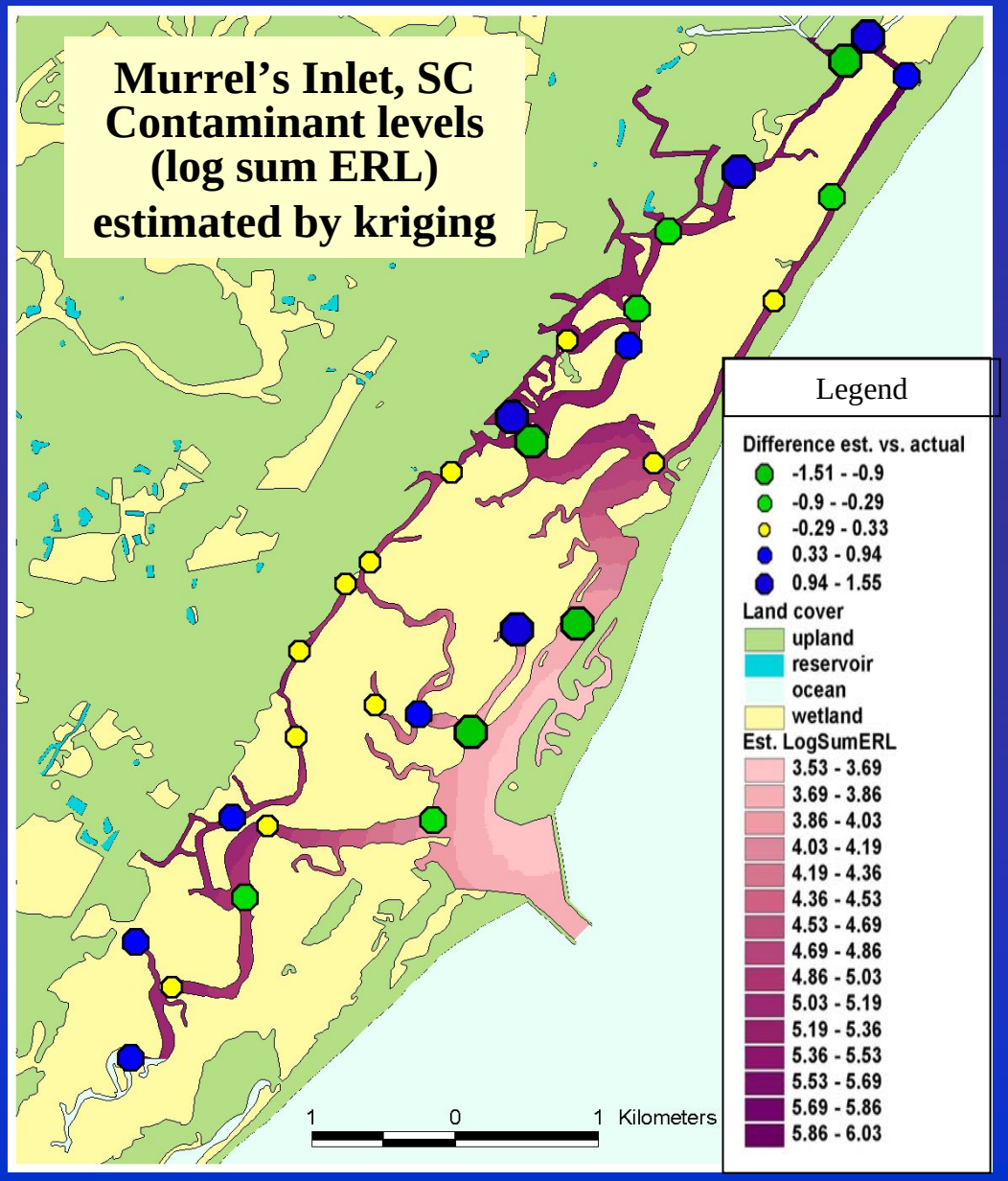
Species diversity (H`) MARMAP trawls (1973-1980)

Geostatistics for modelling continuous data

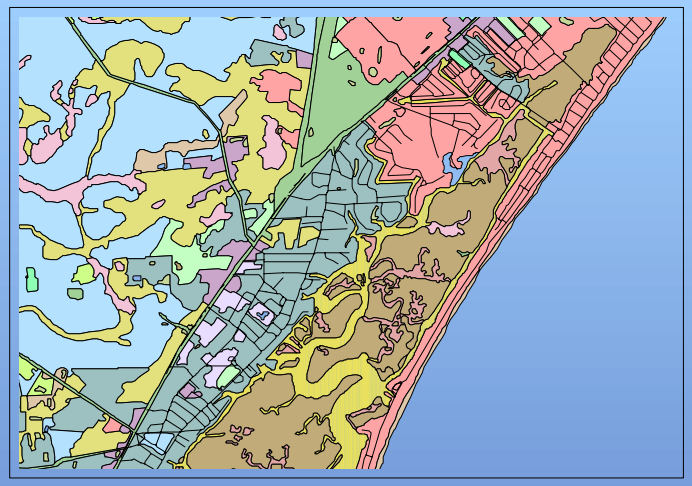


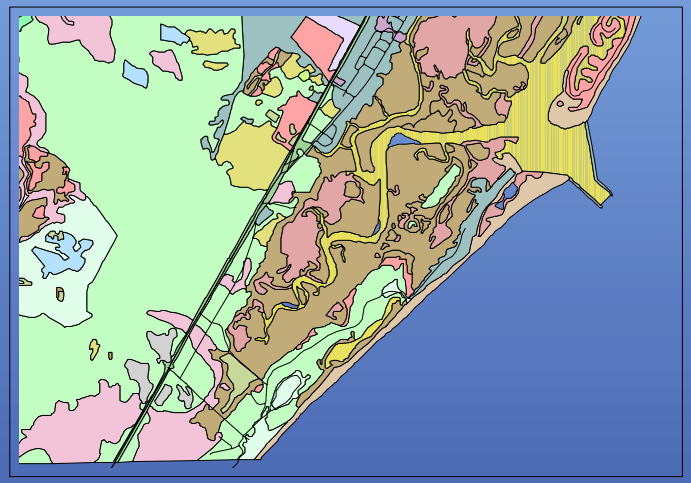
A semivariogram models the behavior of a variable across space.

Kriging interpolates that to unsampled locations.



A Landscape Ecology Approach: Applying terrestrial landscape metrics





Nice maps….But, how does one landscape differ from another?

- Patch size / variability
- Landscape complexity
- Interspersion of patches
- Connectivity of landscape elements

A Landscape Ecology Approach

- Define landscape ‘elements’ (eg. patches)

- And quantify landscape ‘structure’

  => the characteristics and arrangement of elements

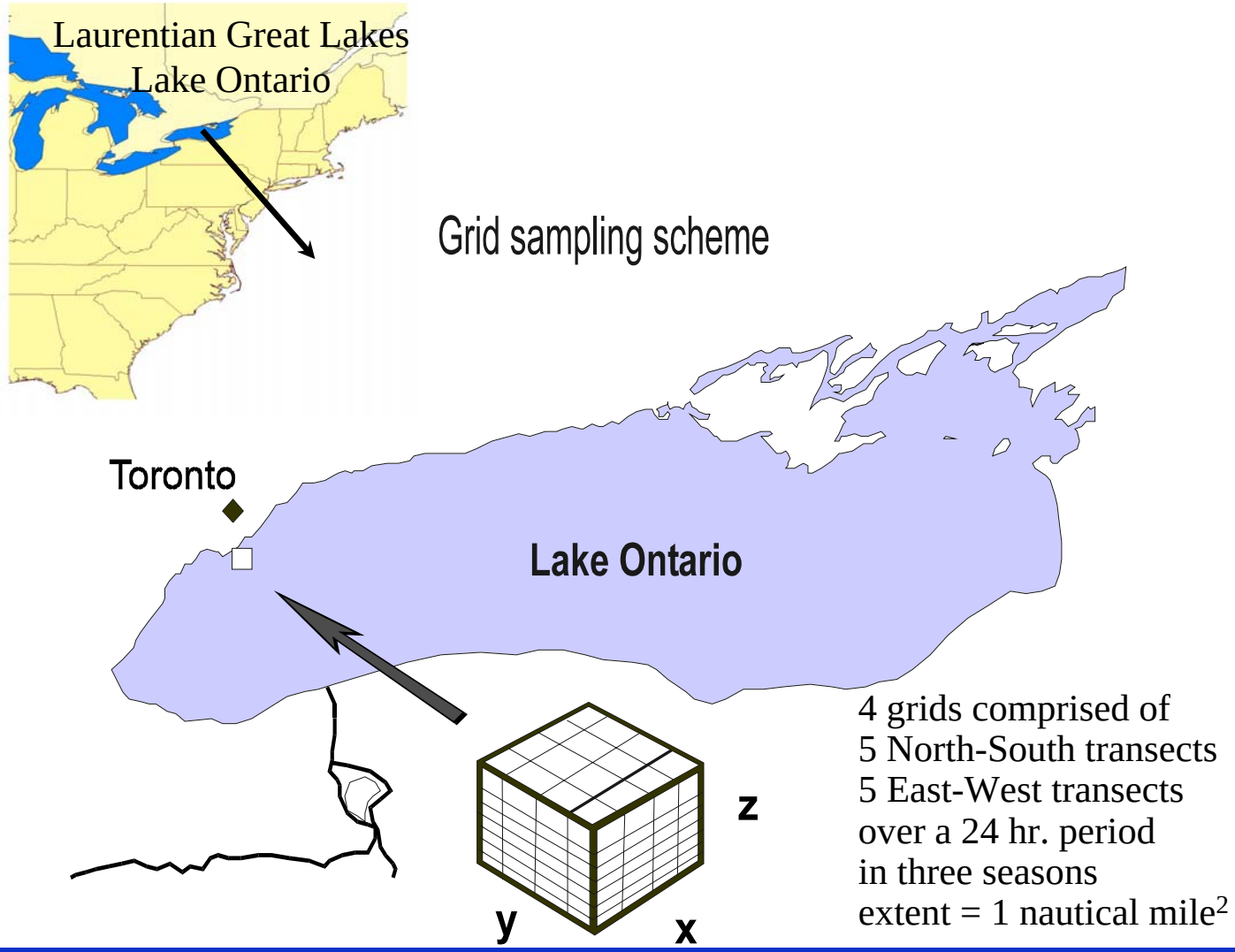
- To better understand landscape ‘processes’

  => how these elements interact

Defining aquatic landscape elements and metrics to quantify structure related to predator-prey interactions

Landscape Elements	Landscape Metrics	Ecological Significance
Thermal Regime	mean temperature, depth of thermocline	bioenergetics / refuge
Prey patches	patch variation / fractal dimension cluster scale of prey patch NND to predators	heterogeneity / defense schooling / predator avoidance predation pressure
Predators	temperature in which predator resides NND to predators / prey	optimal temperature / consumption competition / available prey

Lake Ontario acoustic survey



4 grids comprised of
5 North-South transects
5 East-West transects
over a 24 hr. period
in three seasons
extent = 1 nautical mile^2

Underwater acoustics

High-resolution mapping of the water column

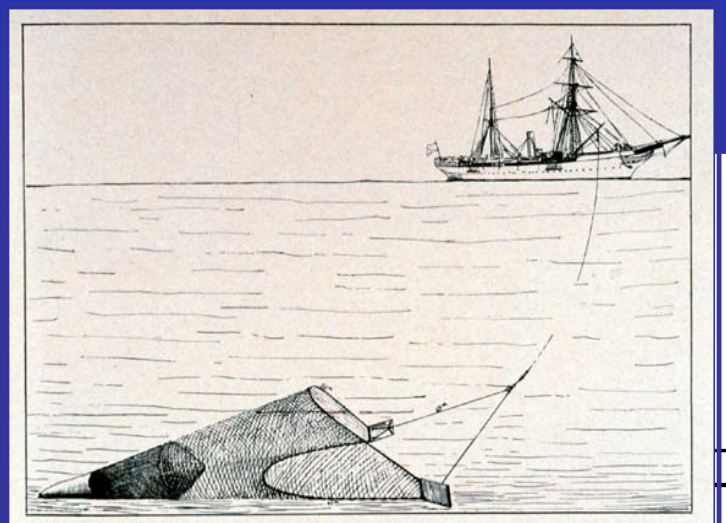


Fig. 60. — Chalut à plateaux. (La courbure du sac a été exagérée pour mieux faire comprendre le fonctionnement de l'appareil; en réalité il est presque à plat sur le fond.)

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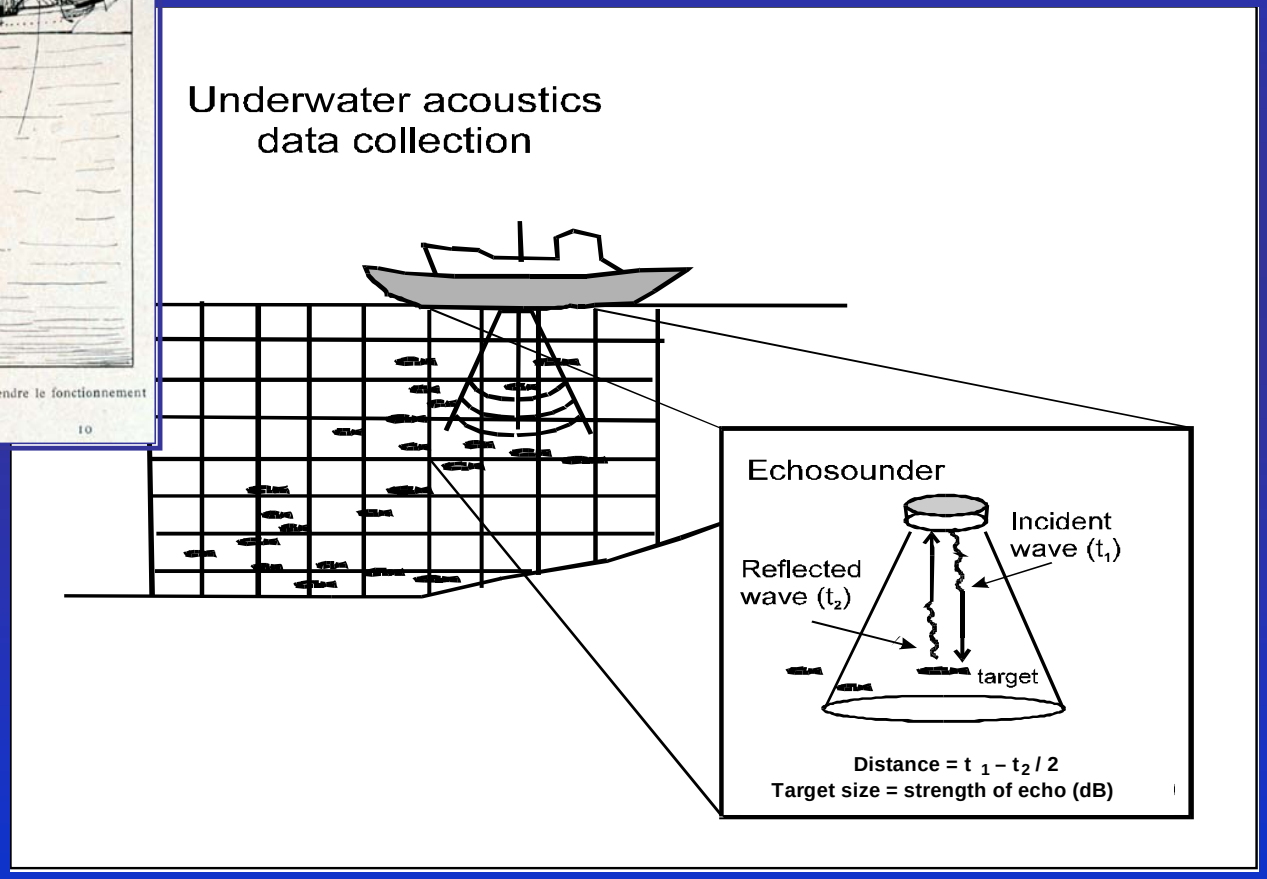
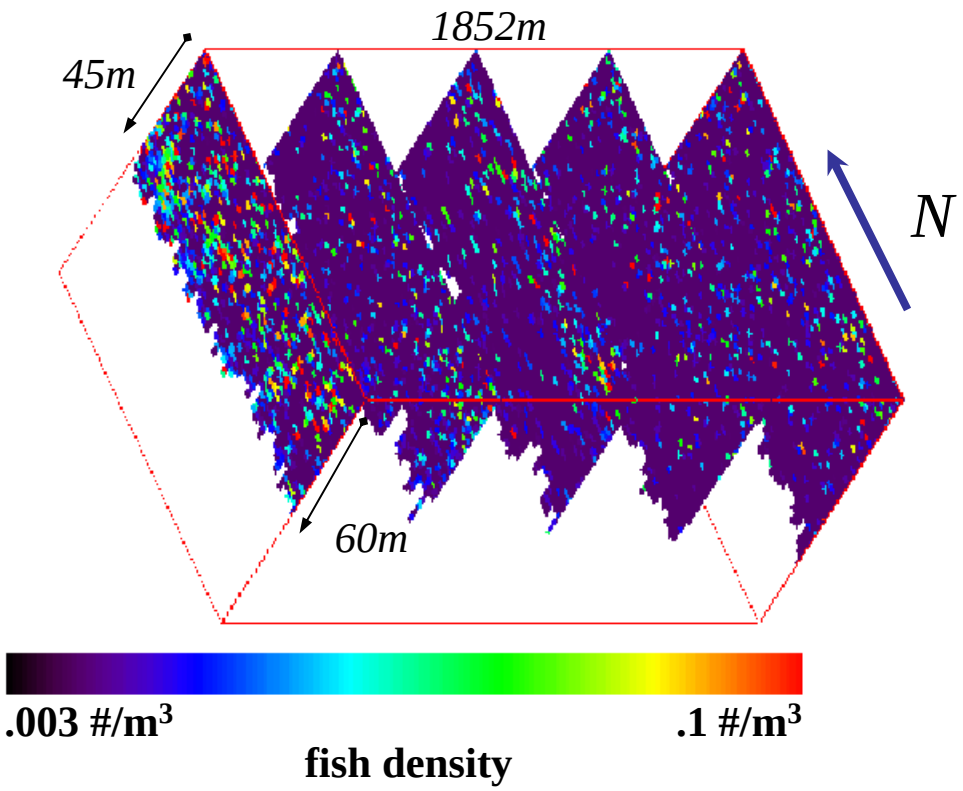


Mapping the water column

Nighttime transects from Lake Ontario

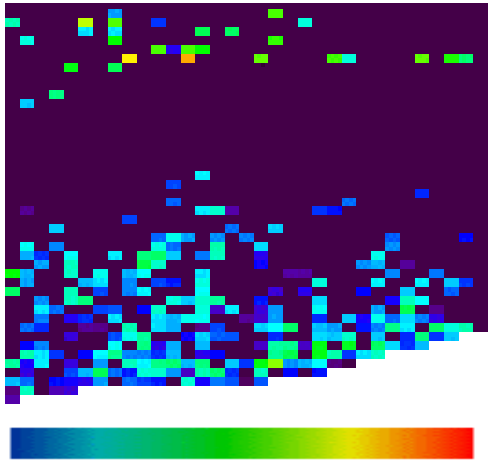
Heterogeneity of fish density in April



Mapping the water column

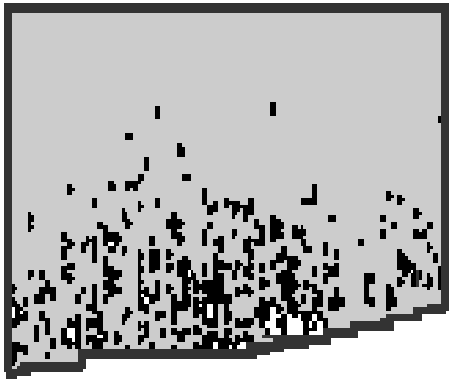
Landscape elements to quantify aquatic structure

Fish density



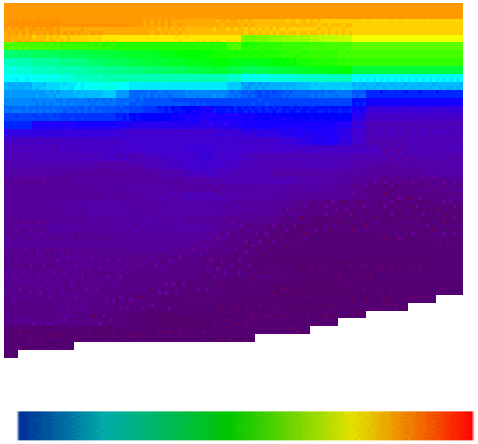
.001 #/m^3 **.1 #/m^3**

Predators



Fish targets > 225mm

Water temperature

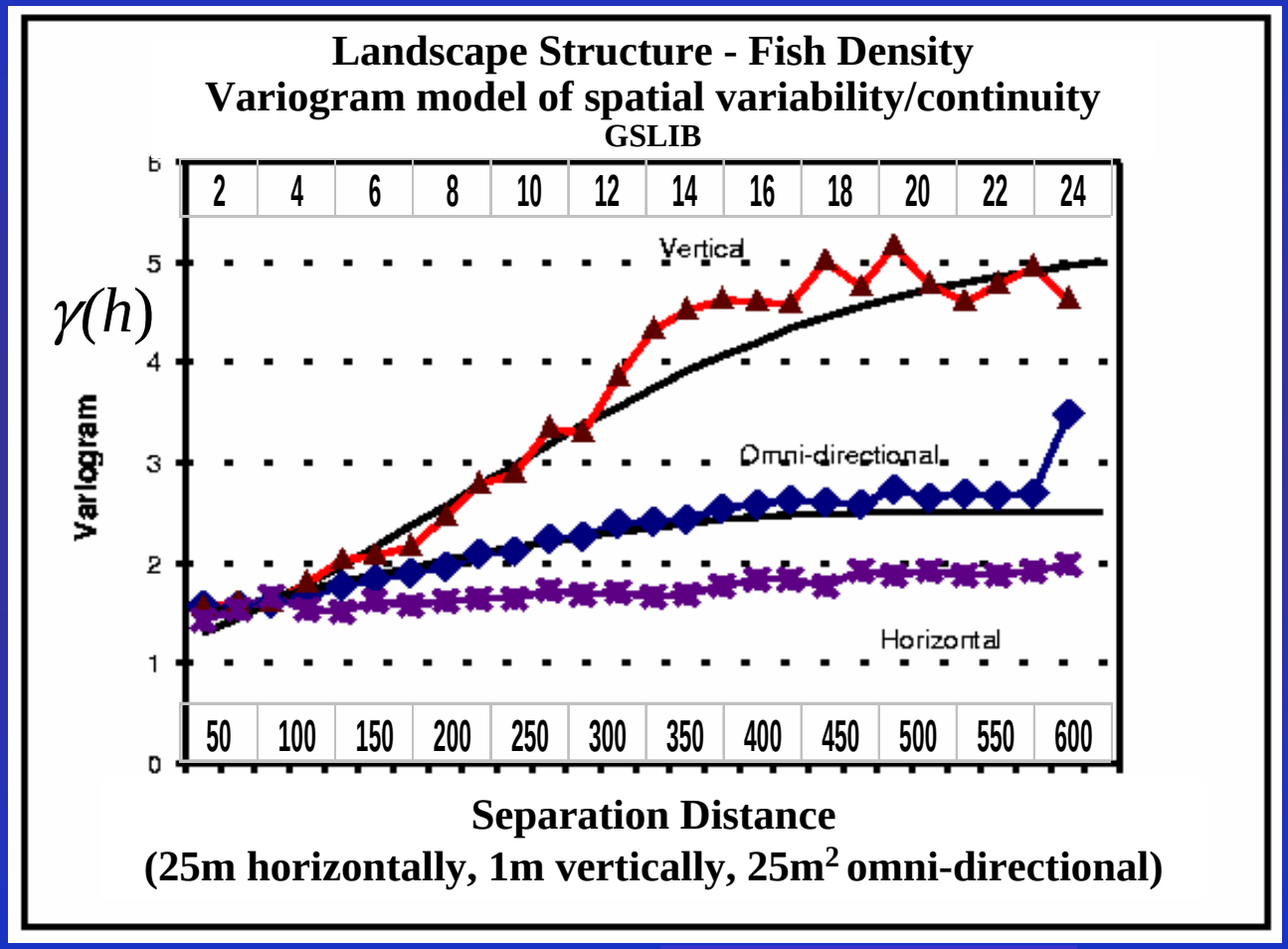


4° C **22° C**

Quantify aquatic landscapes in <u>ecologically significant</u> terms.

Variogram model of fish density

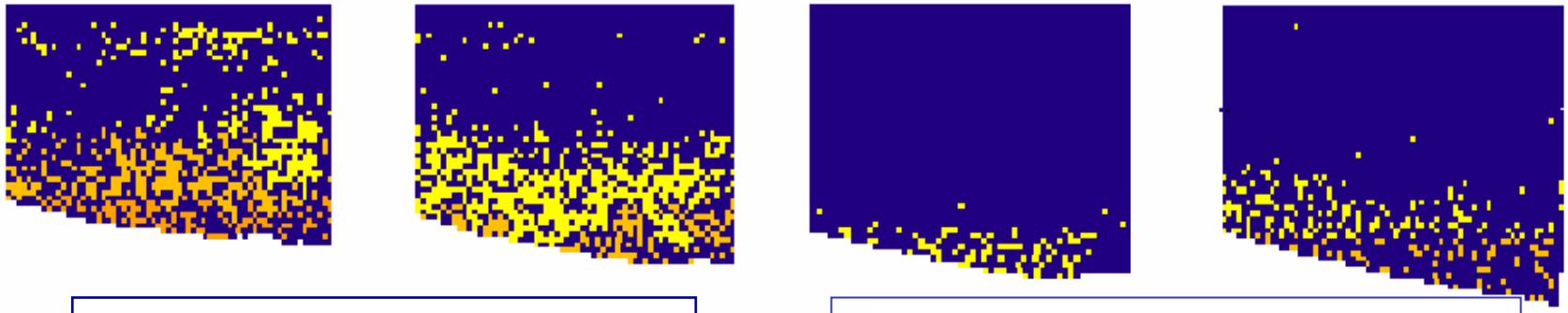
October transect 3:00 am



$$\gamma(h) = \frac{1}{2N(h)} \sum_{(i,j)|h_{ij}=h} (v_i - v_j)^2$$

Transitional aquatic structure

Fish patches

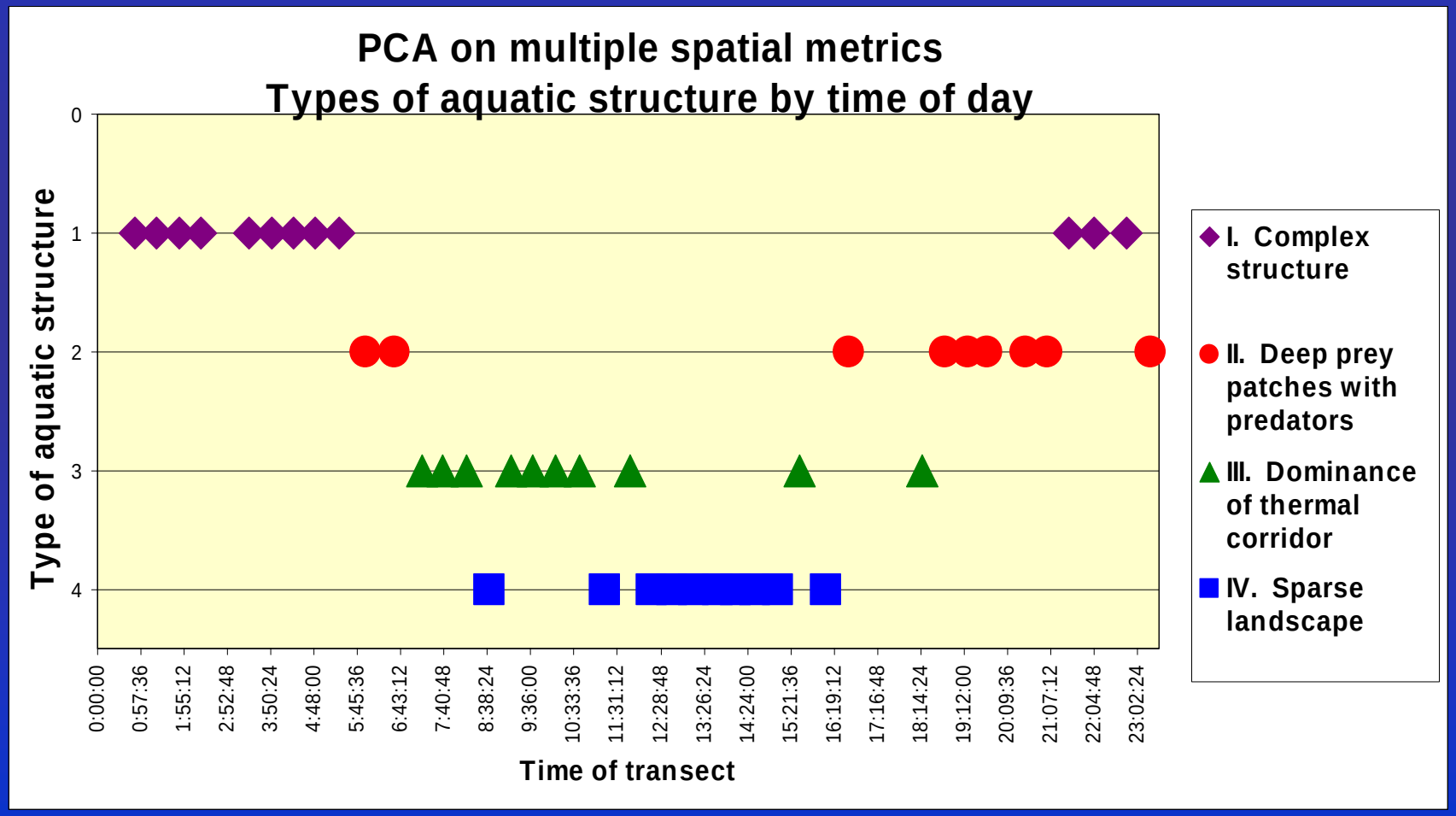


Class I
3:20 am 4:20 am
Complex structure

Class II
7:45 pm 8:30 pm
Deep prey patches with predators

Spatial characteristics of biological and physical landscape elements distinguish one type of landscape from another.

Changes in aquatic structure coincide with time of day



Aquatic landscape structure

- The aquatic environment is a spatially structured landscape that can be quantified.
- Spatial characteristics distinguish one type of aquatic landscape from another.
- This spatial arrangement of resources may have ecological implications (eg. growth rates, animal behavior, sampling strategies, population models).