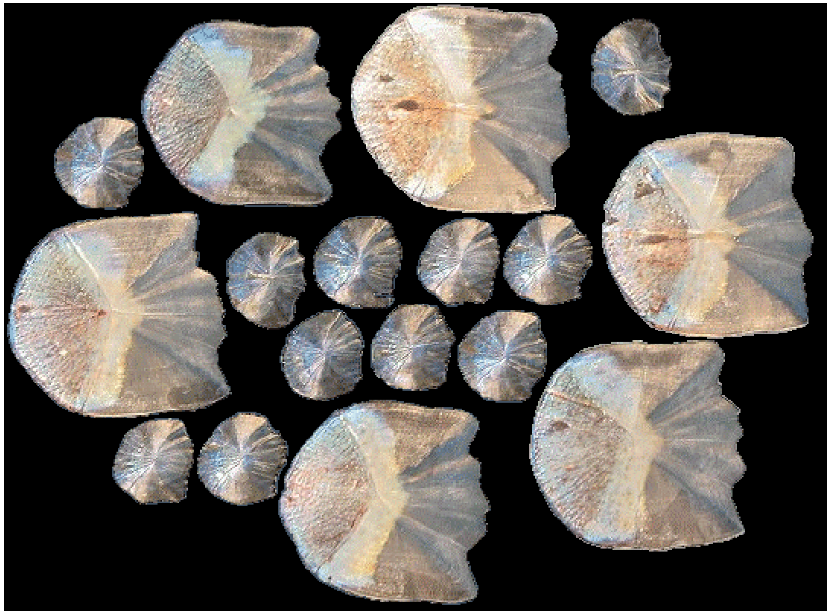
Scales of Fisheries Oceanography



LO: identify relevant spatial and temporal scales of physical and biological processes for ELH fish

Fisheries Oceanography Research

What quantities need to be sampled for Fisheries Oceanographic studies?

Nekton Definitions

1. organisms capable of moving independent of fluid motions

2. Reynolds Number R_e = advection/friction

Low	High
high friction and low velocity or short length scales (molecular viscosity is important)	high velocity or long length scales and friction is low

laminar flow

Transition

R_e=1000

turbulent flow

Nekton Definitions II

3. Velocity ratios: locomotion / fluid

Locomotion

$V_{loc} = 2.69\ L^{0.86}$

(Okubo 1987)

Passive Fluid

$V_{fl} = 0.168\ cm\ s^{-1.17}$

(Okubo 1971)

V = 1 when L < 0.5 mm

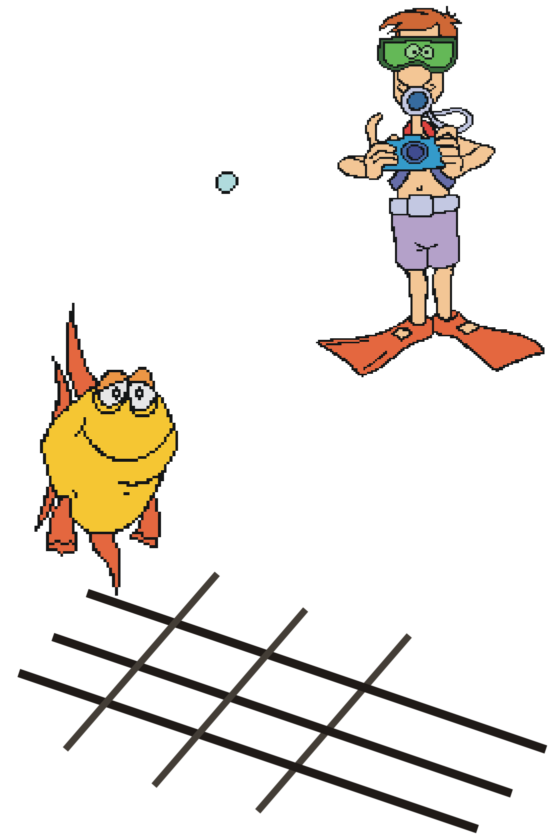
micronekton: V < 10, L < 5mm
macronekton: V > 100, L > 8 cm
meganekton: V > 1000, L > 1 m

(Schneider 1994)

Reference Frames

Lagrangian: follow the particle

Eularian: impose a grid



Why Examine Patterns?

Patchily distributed organisms is a long recognized attribute of aquatic environments.

History of pattern analysis is nearly 100 years old. Evolved from annoyance to important biological quantity.

Observed distribution patterns are dependent on scale of measurement.

Attributes of Spatial & Temporal Data

Temporal samples require little space.

Space has 3 Euclidean dimensions. Time has 1.

Time can not be re-sampled.

Temporally indexed variables are vector quantities.
Spatial variables are scalar or vectors.

Scale

- many definitions, ambiguous use, not often defined when used

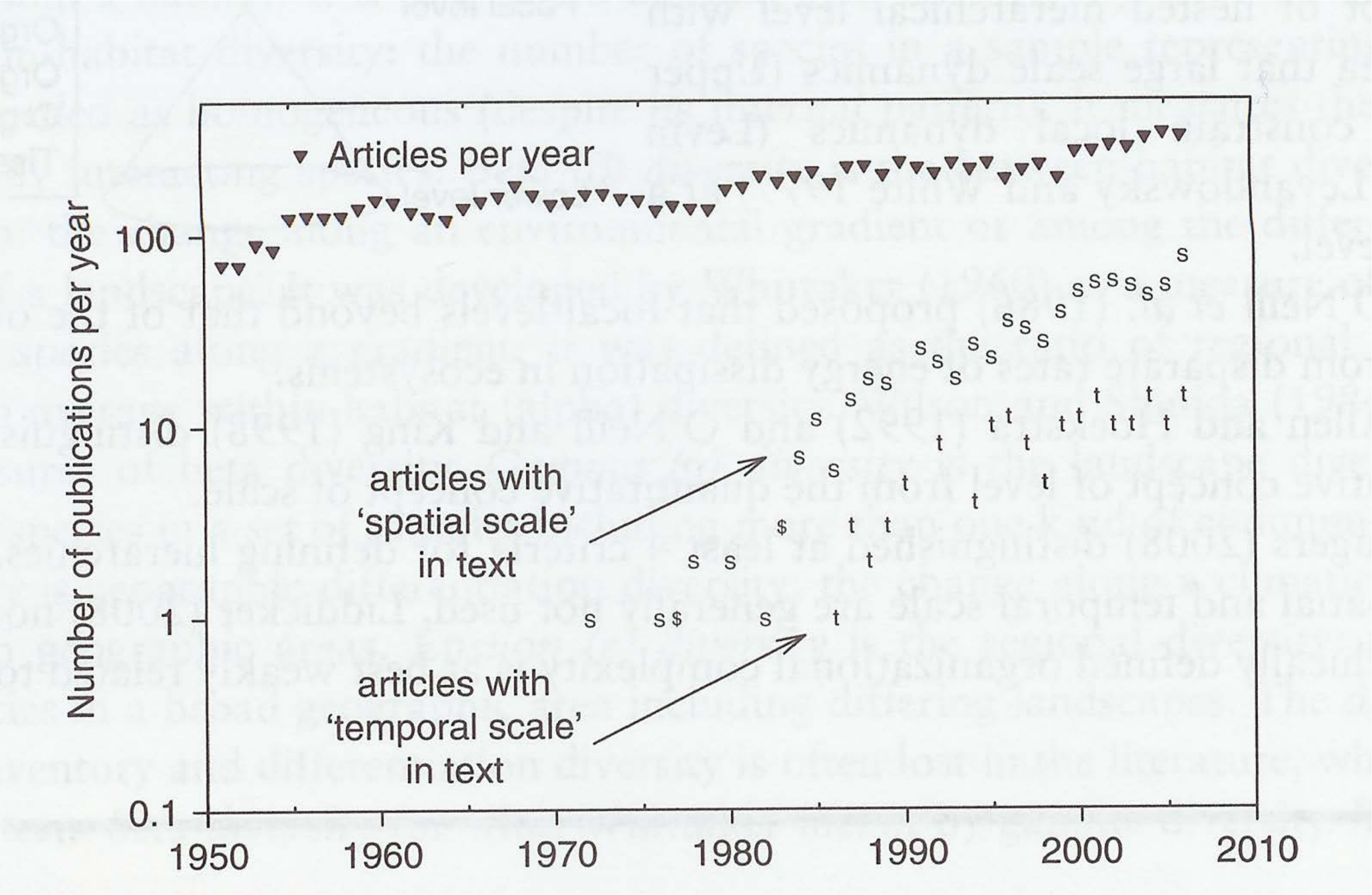
skal (Old Norse): bowl → fish scale, scales of justice, comparison

scala (Latin): ladder → musical scale, scaling a wall, measurement

2 components: range (extent), resolution (grain) (Wiens 1989)

Growing Awareness of Scale

in the journal Ecology



Schneider 2009

Scale in Aquatic Science

- choose measurement scale relative to quantity of interest (Smith 1978)
- scale range depends on organization level (Shugart 1978)
- biological variances are linked to scales of physical quantities (Haury et al. 1978)
- scale linkages can include mass of organism (Steele 1978)

Scale-Dependent Observation

pattern observed depends on measurement scale

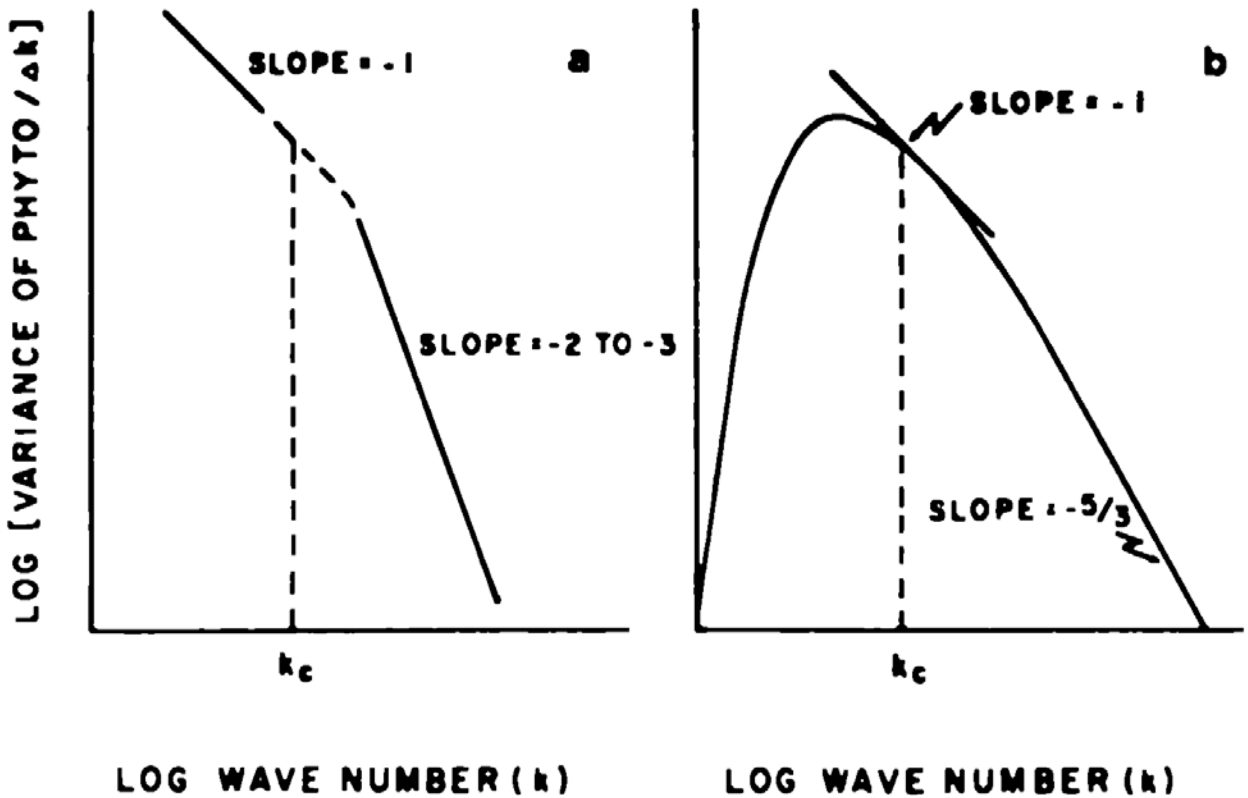
e.g. microscope or camera: zoom in and out

Scale-dependent pattern = statistical characteristics change with a change in the range or resolution of measurement

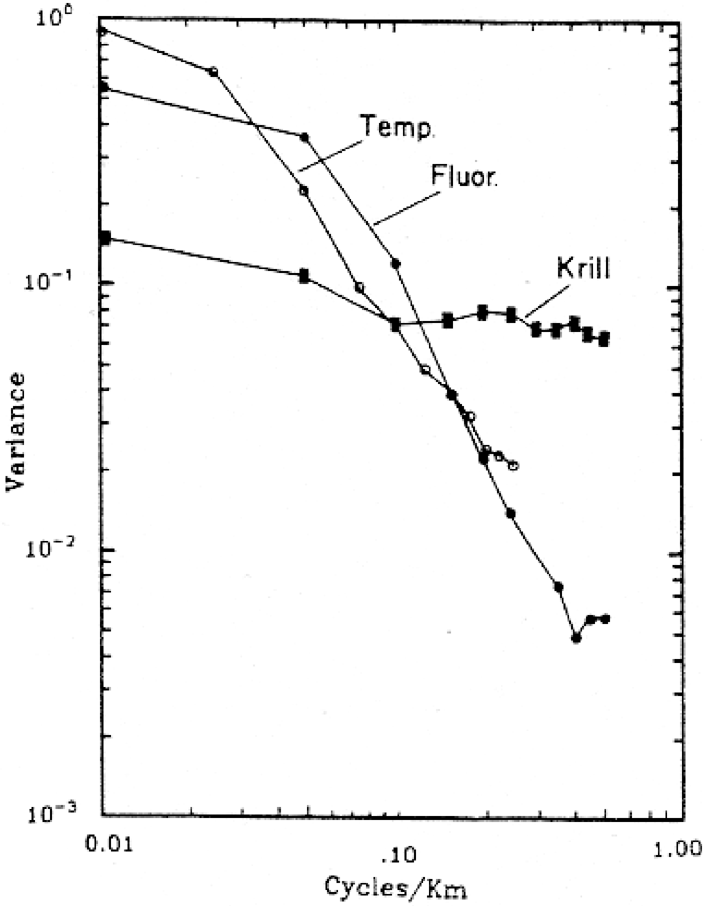
Scope = range/resolution (Schneider 1994)

Scale Spectrum: Variance Cascade

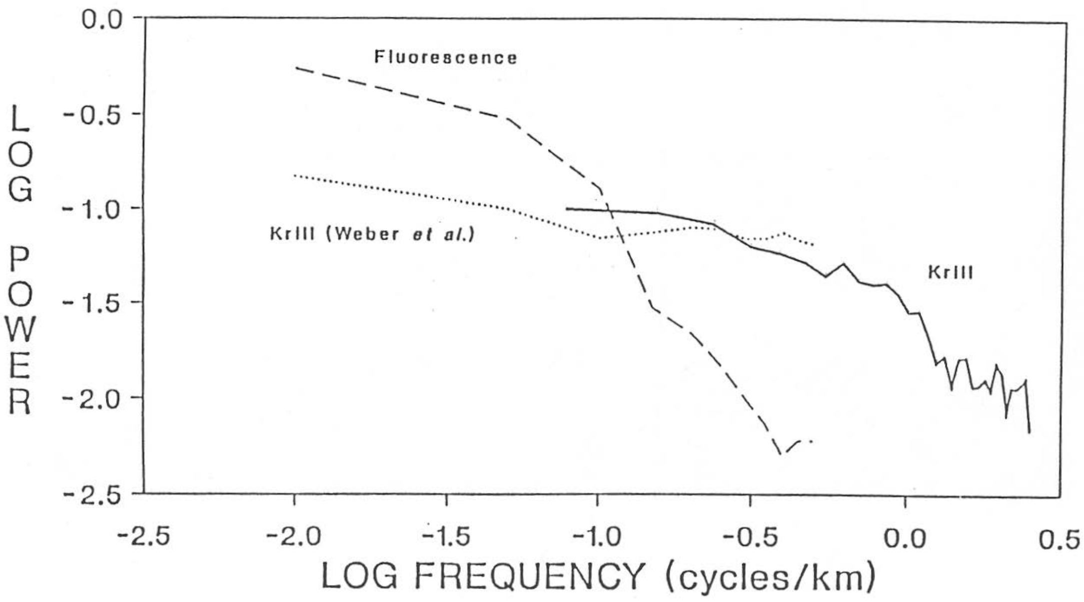
Phytoplankton



Scale-Dependent Pattern: Krill

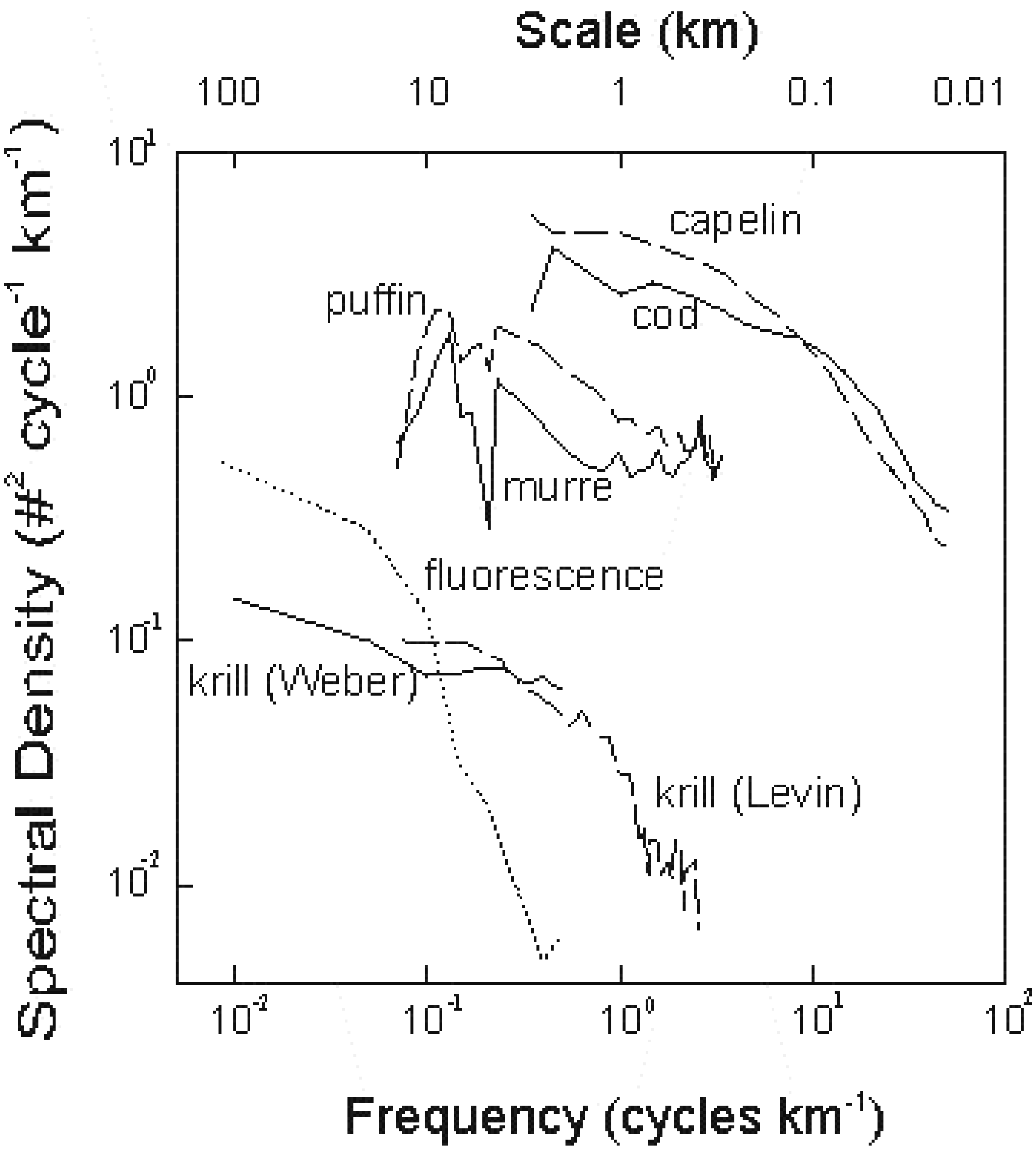


Weber et al. 1986



Levin et al. 1989

Scale-dependent distribution patterns: Mobile Organisms

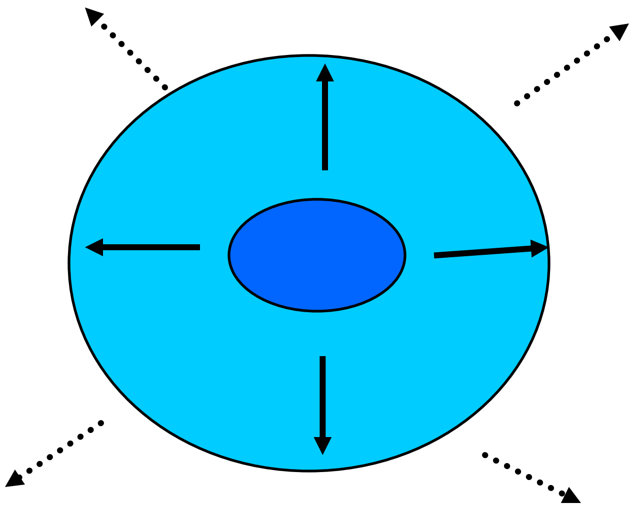


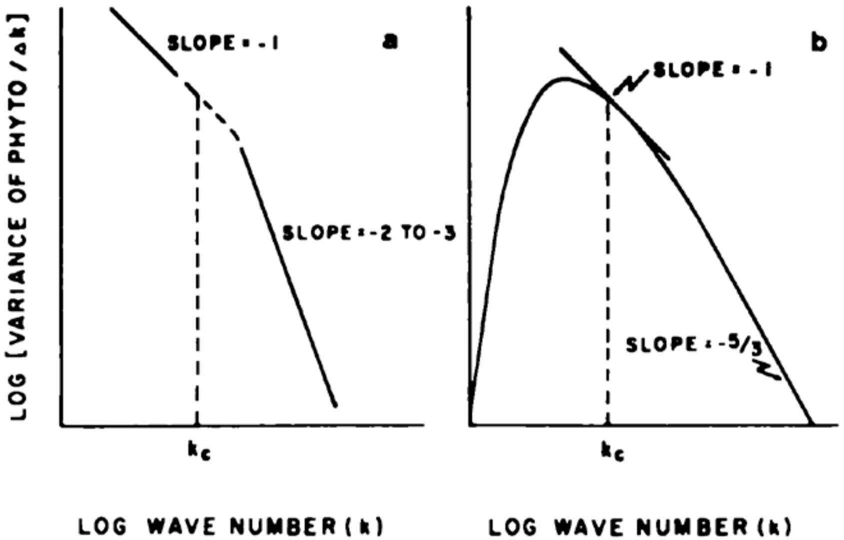
Horne & Schneider 1997

Characteristic Scales: Phytoplankton

KISS Model (Kierstead, Slobodkin, Skellam)

Horizontal diffusion = growth rate





Platt’s knee = patch size

Characteristic Phytoplankton Patch Scales

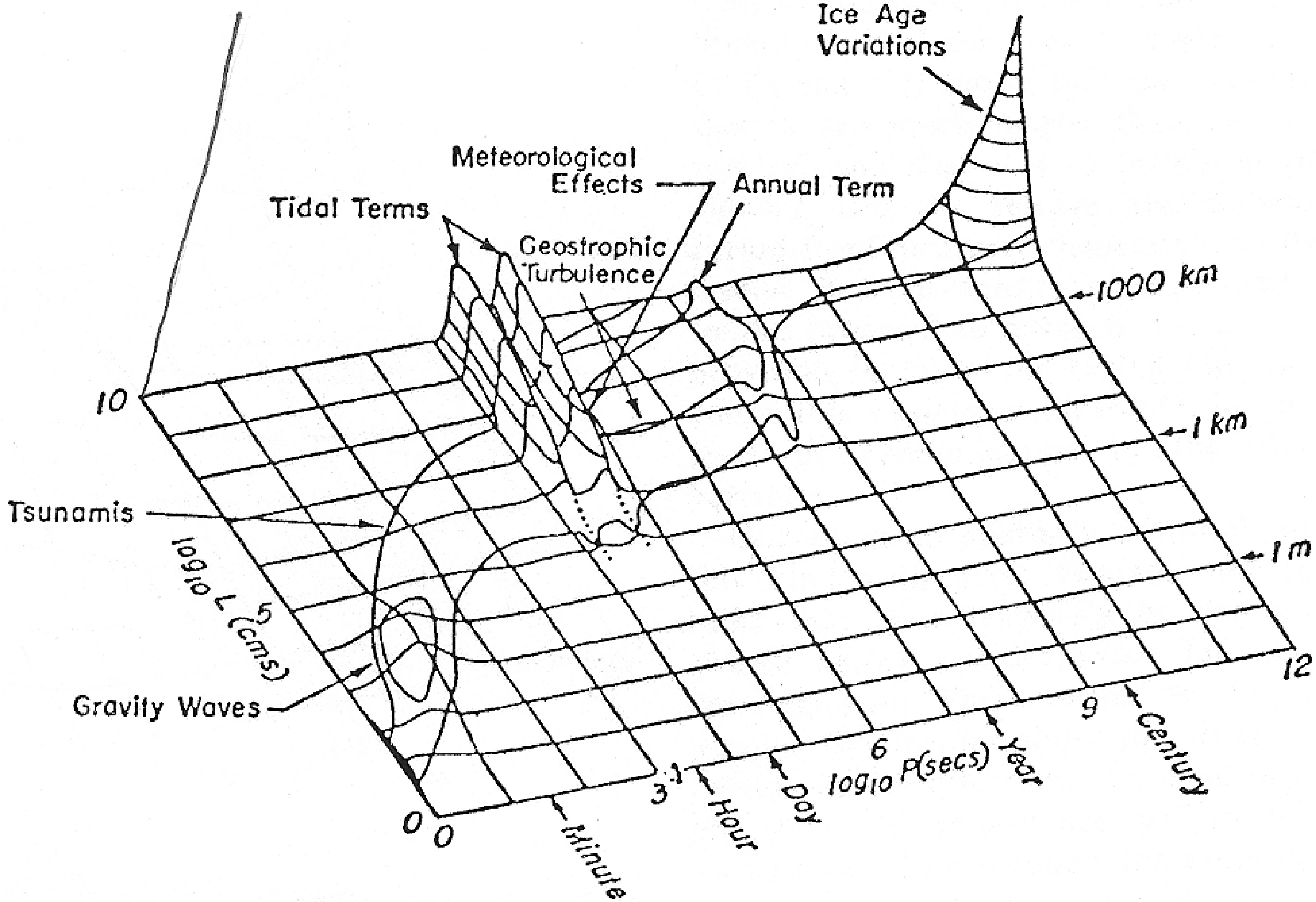
TABLE 1. Characteristic scales of phytoplankton patches.

Sampling area and season	Scale (km)	Source
Bedford Basin, summer	0.8–1.9	Platt and Filion 1973[a]
Long Island Sound, August	1–5	Lekan and Wilson 1978
North Atlantic (temperate), spring[b]	~1	Fasham and Pugh 1976
North Atlantic (tropical), August[b]	~1	Fasham and Pugh 1976
North Sea, spring	None[c]	Horwood 1978
St. Lawrence Estuary, June	0.1–1	Denman 1976
St. Lawrence Estuary, June	≤5	Denman and Platt 1975
St. Lawrence Estuary, August	~0.75	Fortier et al. 1978
St. Lawrence Estuary, July	0.2–6	Levasseur et al. 1983
St. Lawrence Estuary, August	None[d]	Sinclair et al. 1980
St. Margarets Bay, autumn	~1–3	Platt et al. 1970
St. Margarets Bay, summer	0.5–1.6	Platt et al. 1970[a]
Lake Tahoe, September	~0.1	Powell et al. 1975
Lake Tahoe, September	>0.1–<10	Richerson et al. 1978
Castle Lake	0.06	Richerson et al. 1978

Patch Size Range: 0.06 km - 6 km (3 Orders of Magnitude)

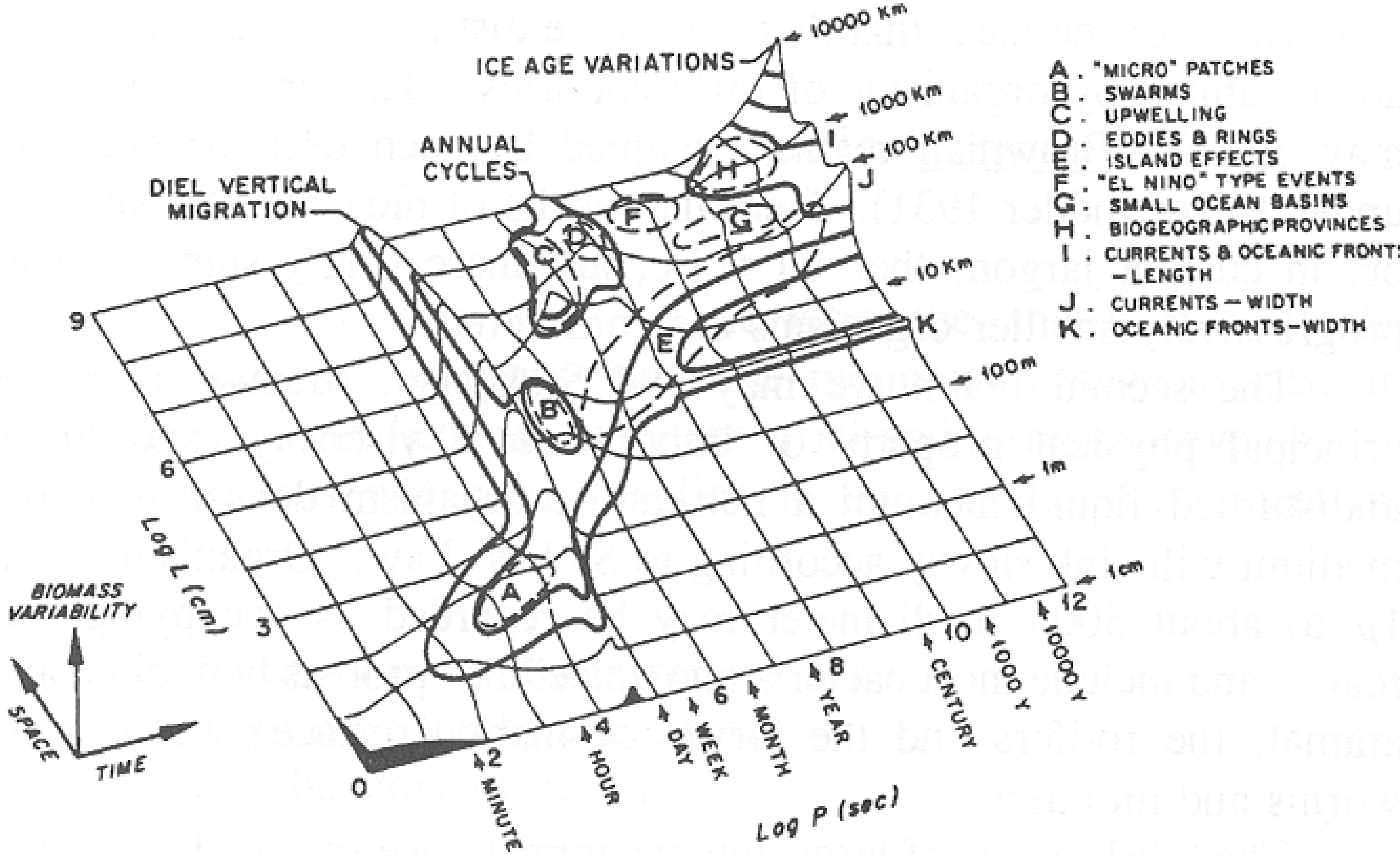
Platt and Denman 1975

Stommel Diagram



Stommel 1964

Stommel Diagram for Zooplankton



Haury et al. 1978

Relevance to Fisheries Oceanography

Observed distribution patterns of aquatic organisms are dependent on scale of measurement (survey design, resource assessment)

Relative importance of physical and biological processes may vary with scale of observation (ecology)

Interactions (e.g. predator-prey) are not observable at all scales (survey design, bioenergetics, resource assessment)

Prey and environmental data can be combined to index habitat suitability (ecosystem management)