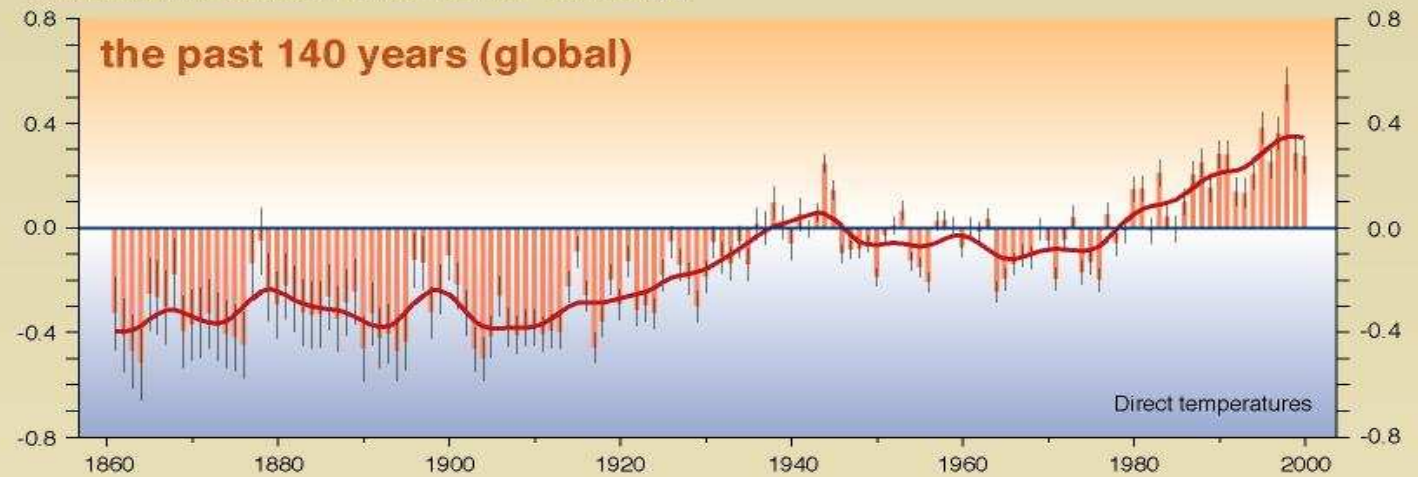


Temperature

Variations of the Earth's surface temperature for...

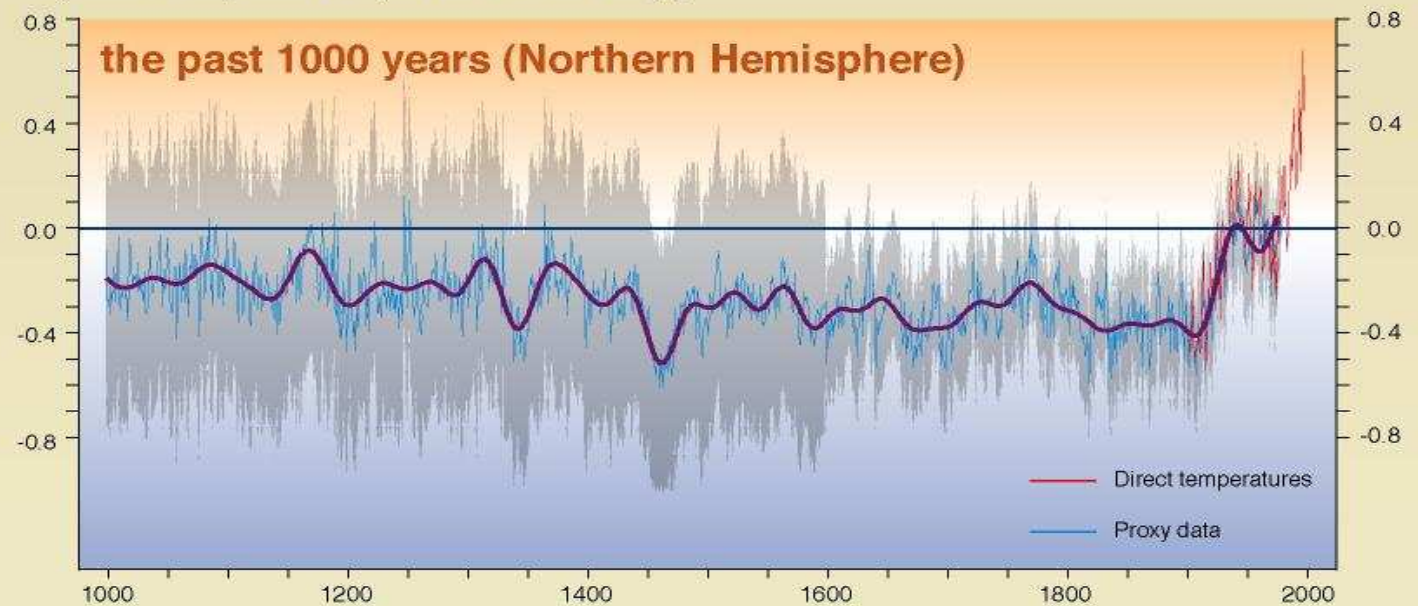
Departures in temperature in °C (from the 1961-1990 average)

the past 140 years (global)

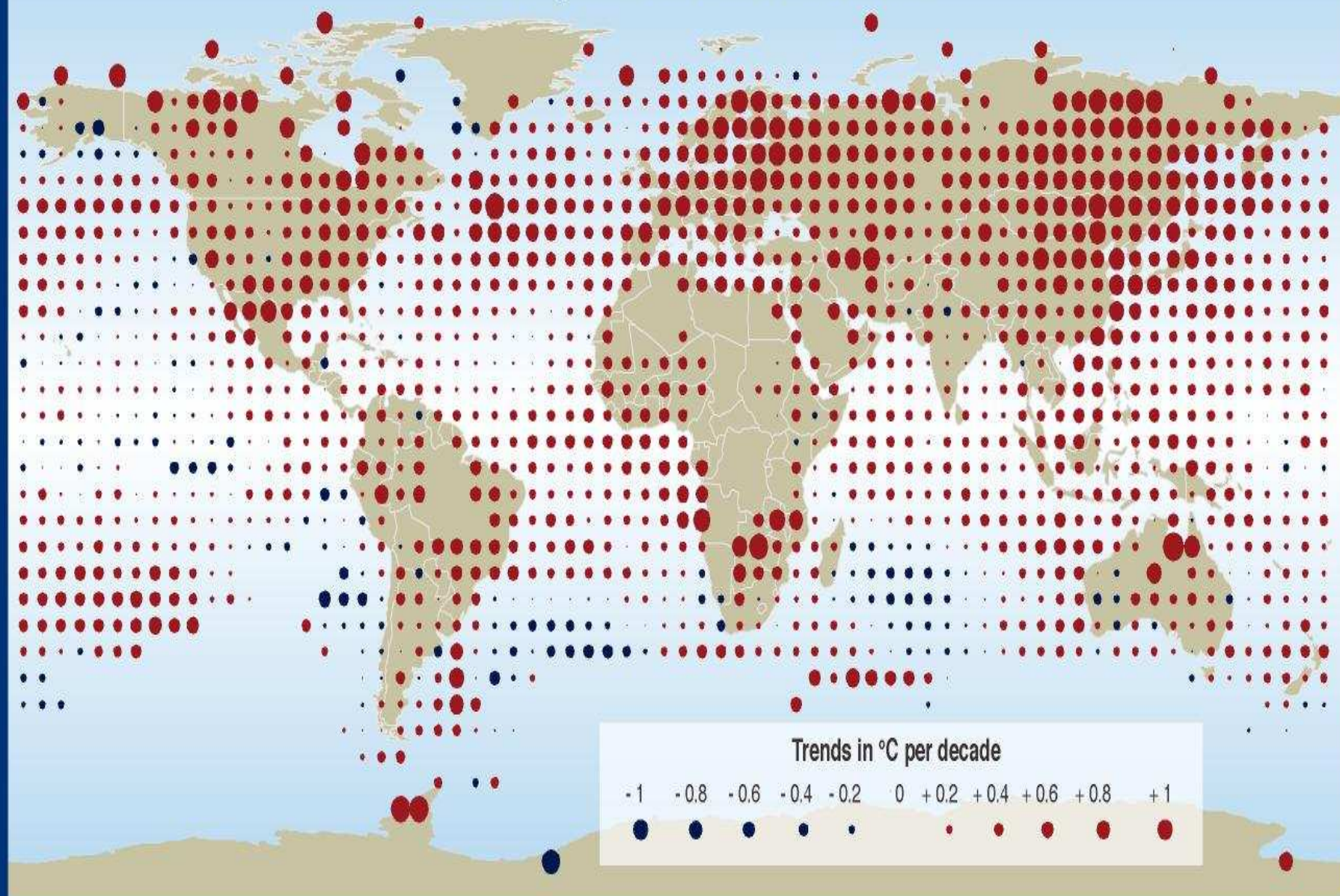


Departures in temperature in °C (from the 1961-1990 average)

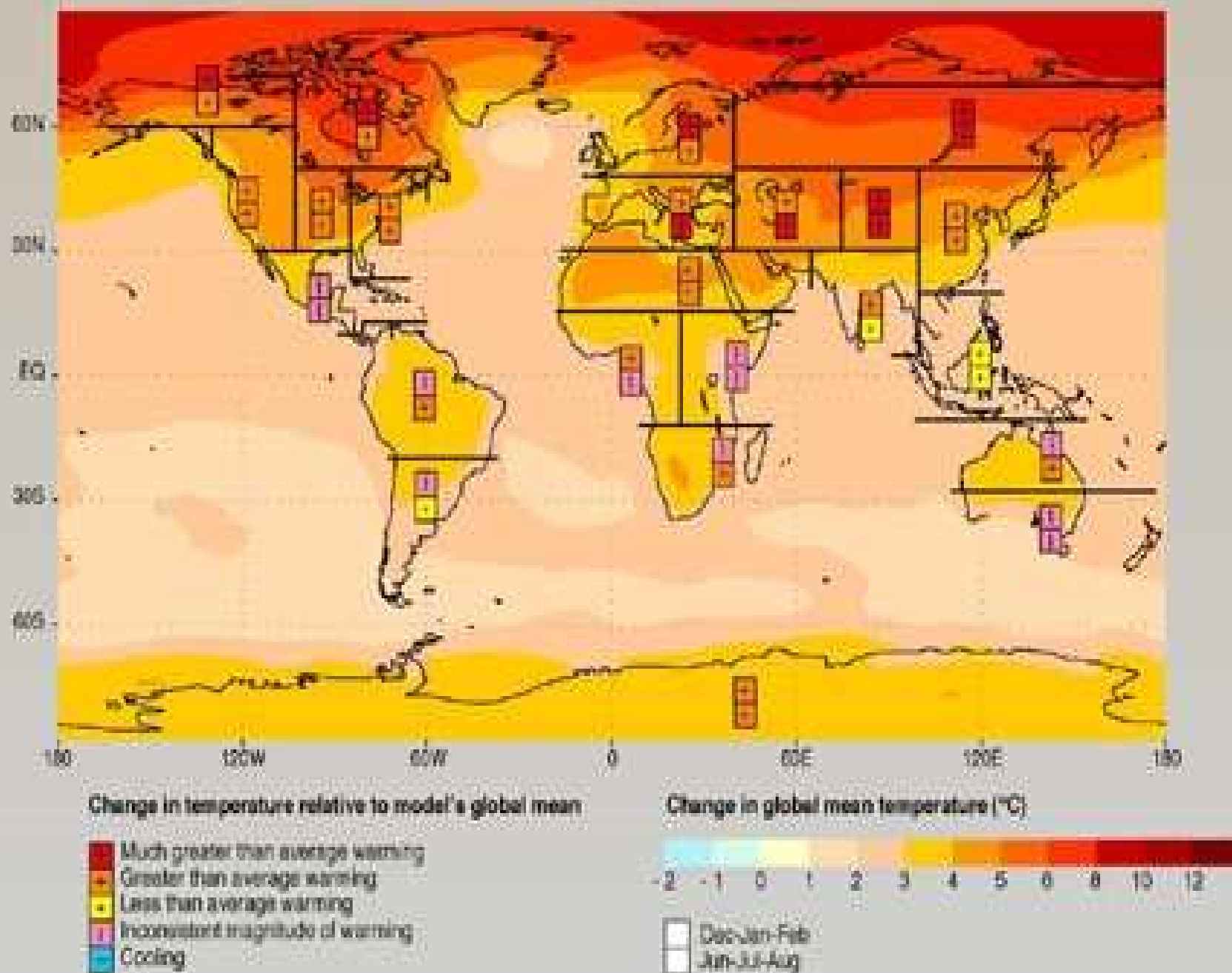
the past 1000 years (Northern Hemisphere)



Annual temperature trends: 1976 to 2000

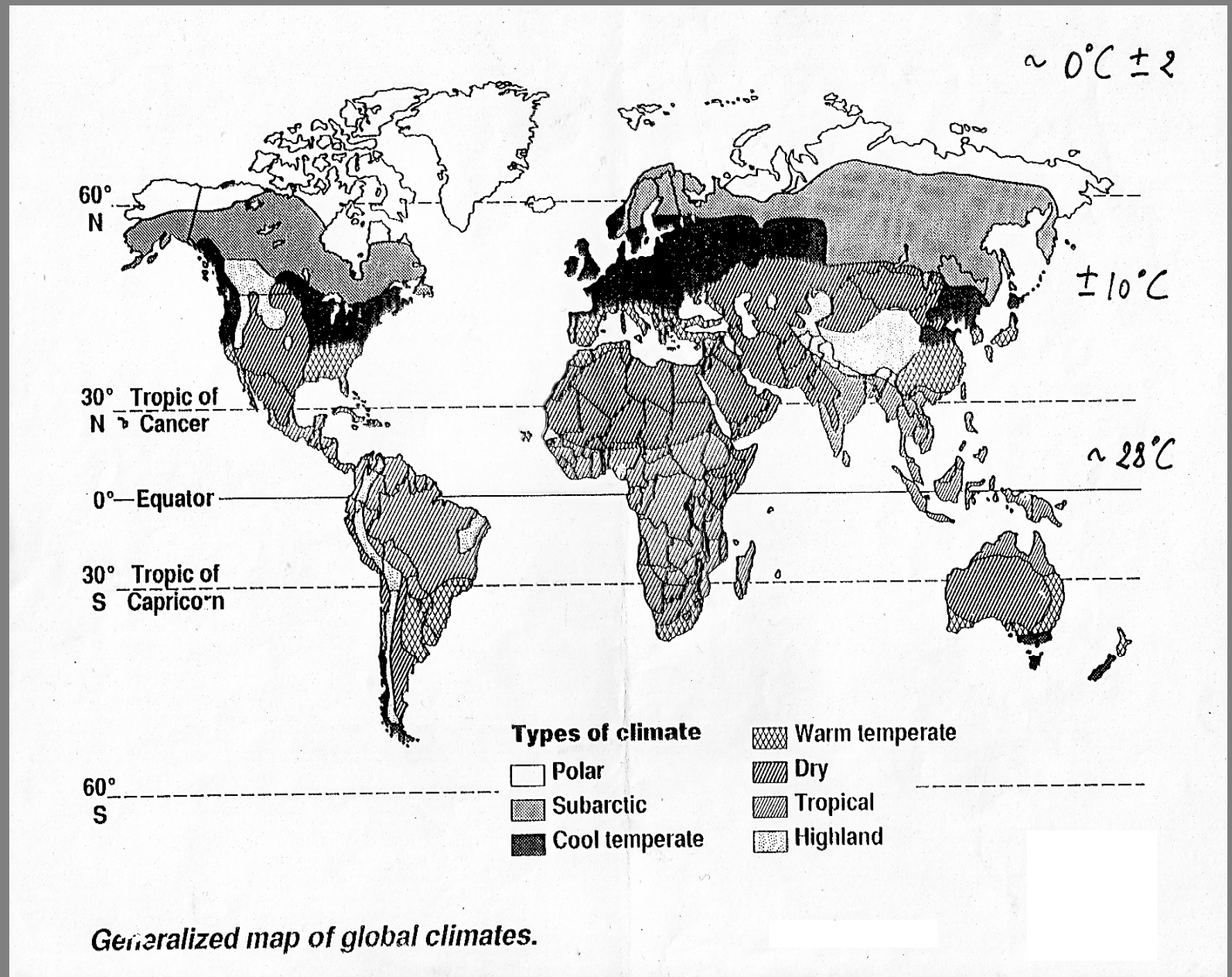


Change in temperature for scenario A2

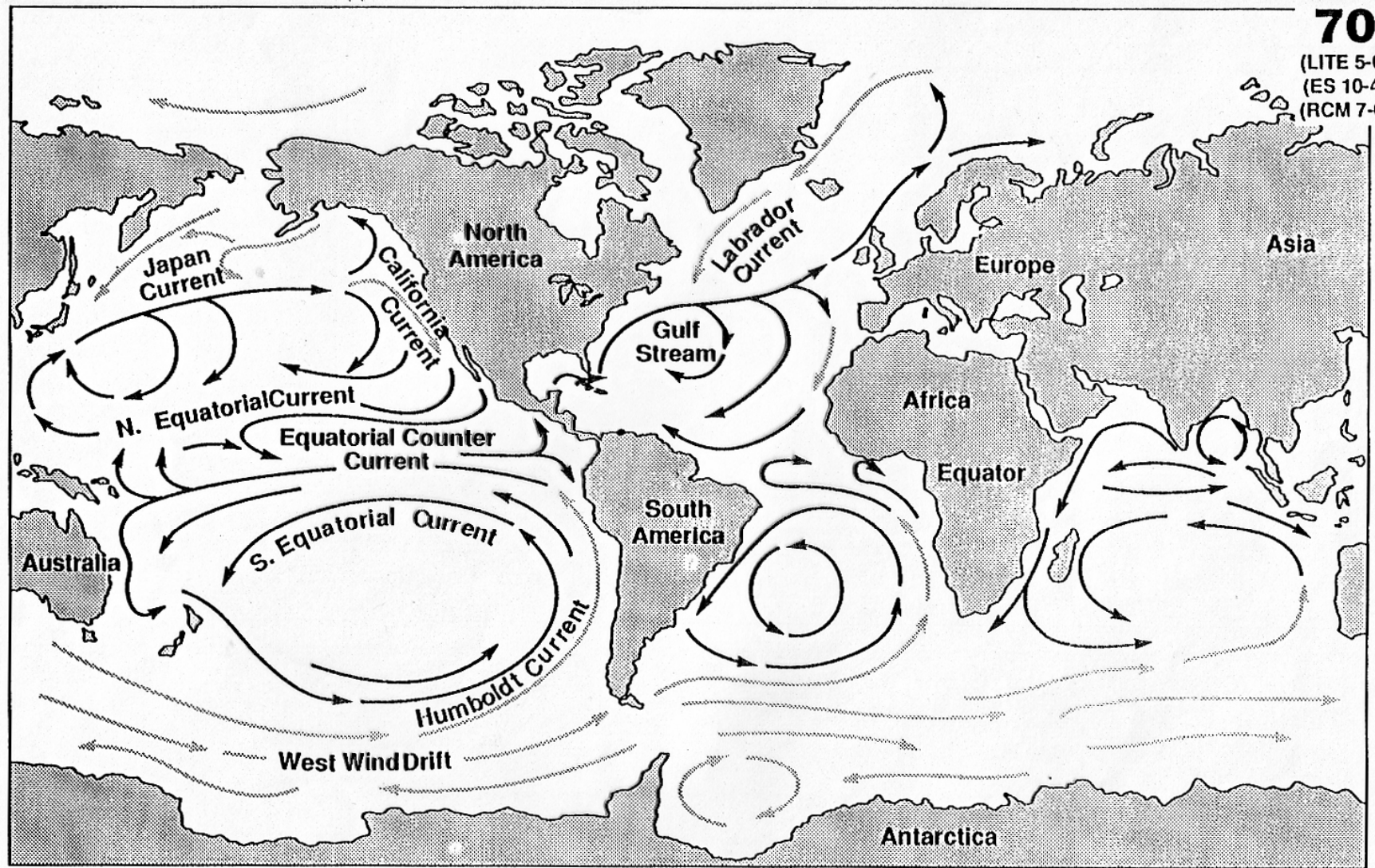


Origine:

solar
geothemic
anthropic



Ranges in oceans, intertidal zones, littoral pools, lakes



—————> Warm water current

- - - - -> Cold water current

***Major warm and cold surface currents
of the world's oceans.***

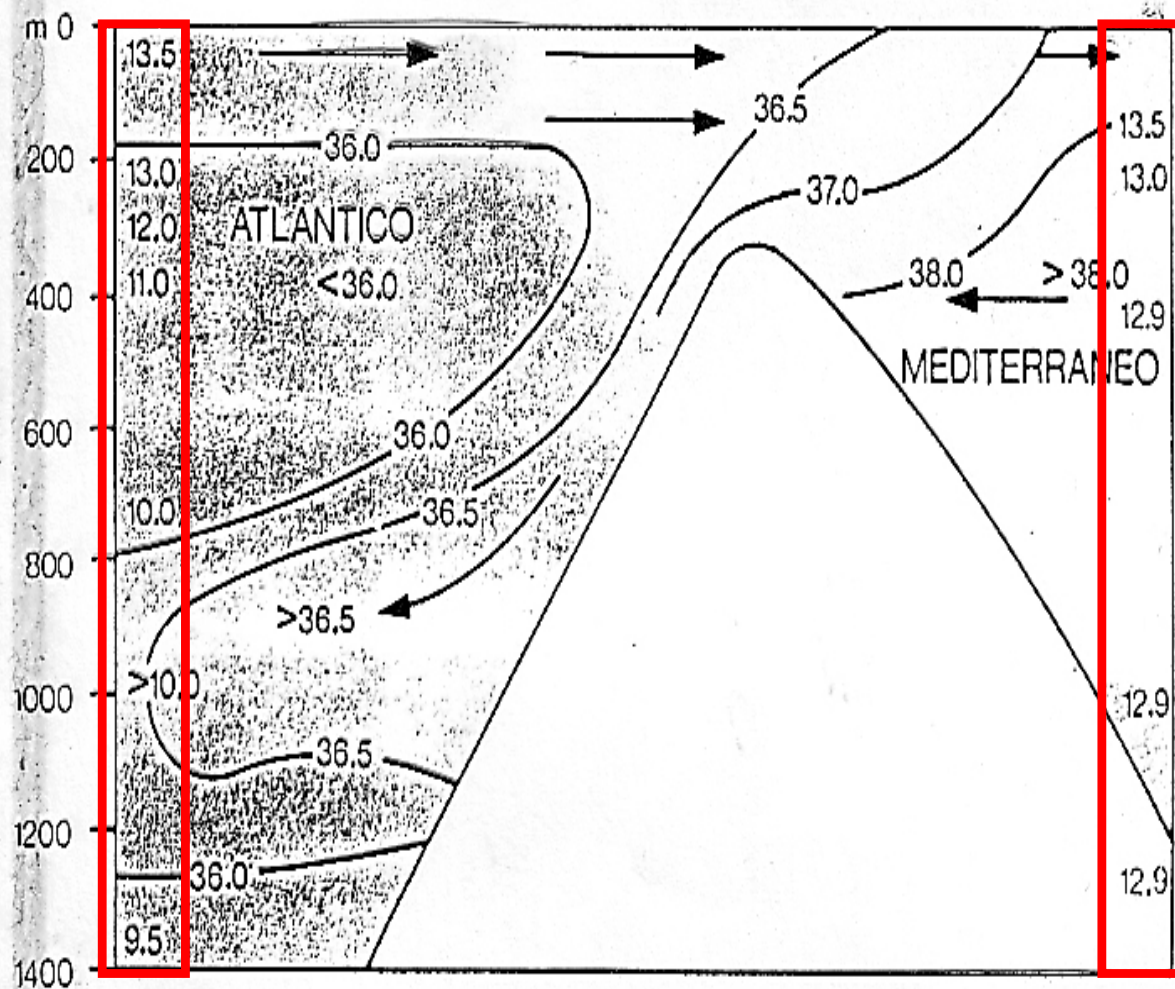


Fig. 2.4 - La soglia di Gibilterra, stretta e alta, impedisce l'afflusso delle acque profonde fredde dell'Oceano nel Mediterraneo. Per tale motivo le temperature minime in questo mare non scendono mai sotto i 13°C creando una caratteristica omotermia. Infatti a oltre 1.000m di profondità la temperatura si mantiene sui 13°C valore raggiunto dalle acque superficiali nei mesi invernali quando alla stessa profondità nell'Atlantico si hanno -2°C.

Seaweeds experience temperature changes in the intertidal zone

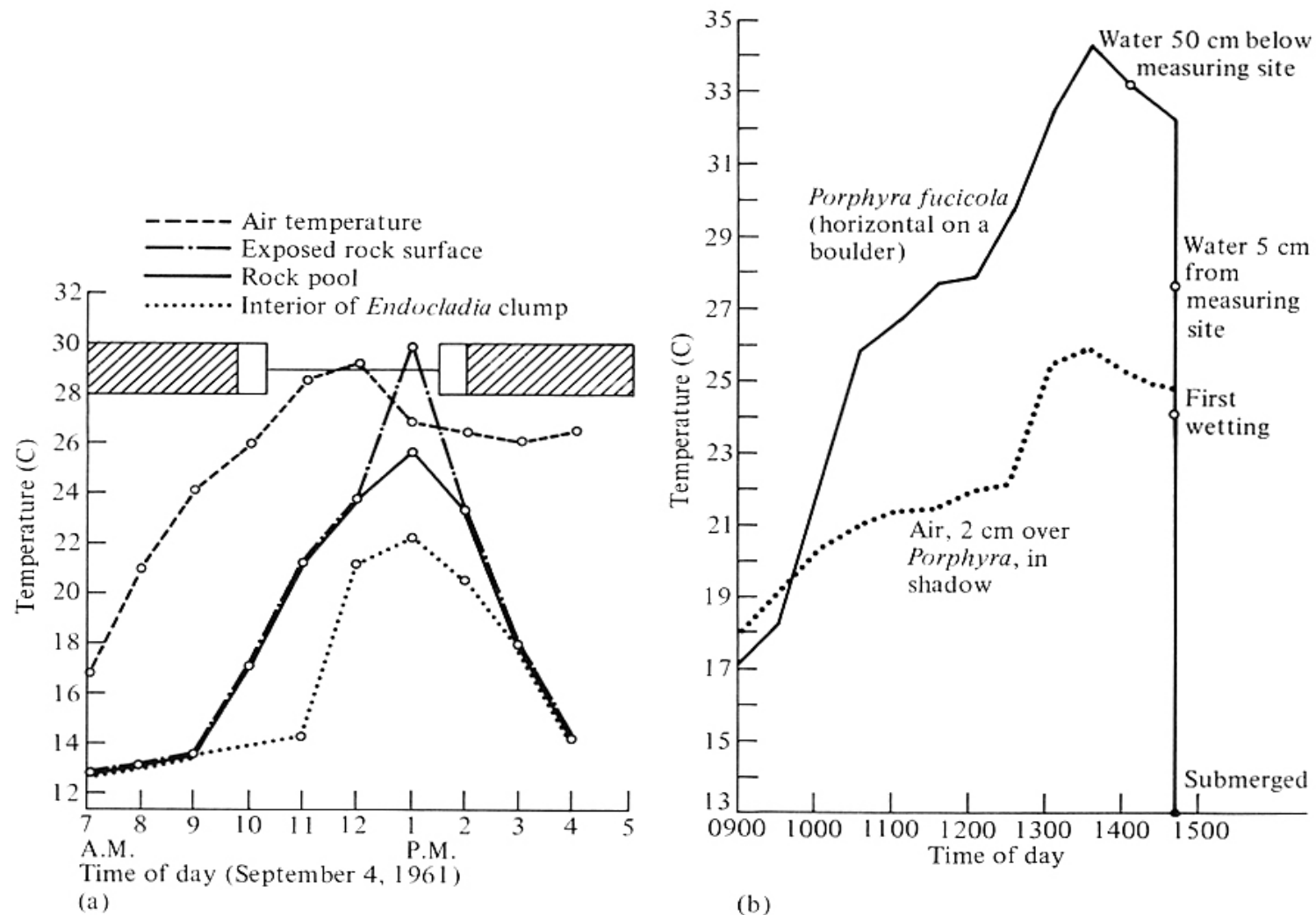


Figure 6.5. Temperature climates of two high-shore red algae. (a) Temperature observations of three microhabitats in the high-intertidal *Endocladia-Balanus* association at Monterey, California, as related to low-water exposure. Also shown is the air temperature at a nearby weather station during the observation period. The horizontal bar and line at the top of the graph show, for the level observed, the approximate durations of the submerged (cross-hatching), awash (clear), and exposed (line) periods. (b) *Porphyra fucicola* thallus temperature during ebb tide on a calm, sunny day.

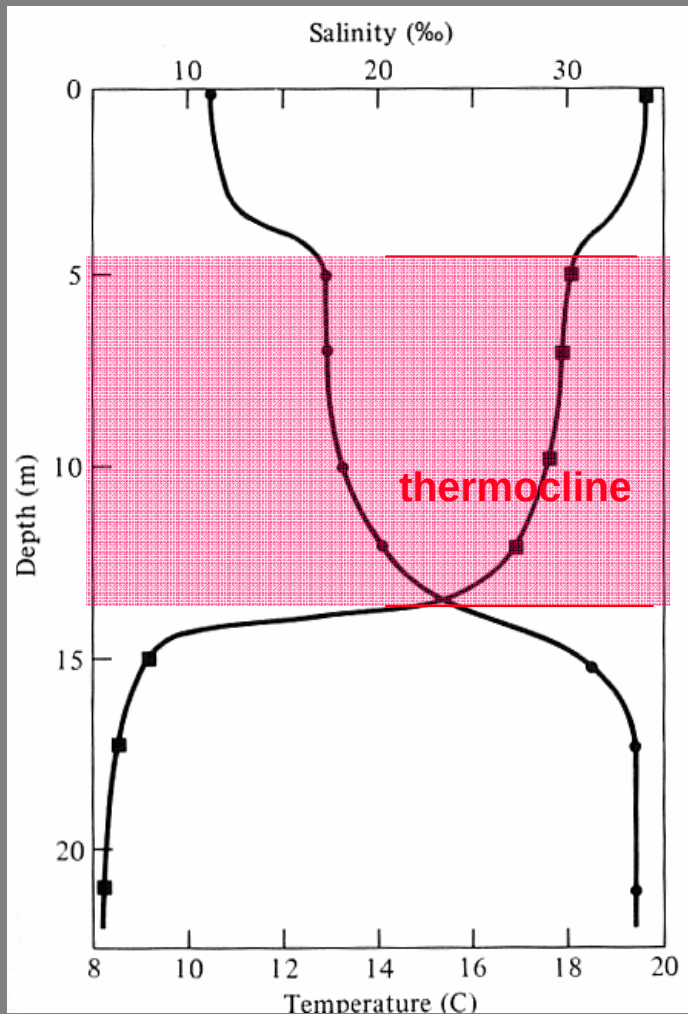
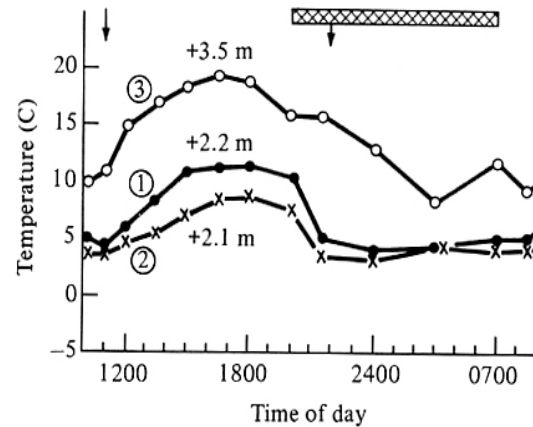


Figure 6.1. Thermoclines and haloclines as seen in temperature and salinity profiles at a station between Copenhagen and Elsinore, Denmark. Rapid changes in temperature (squares) and salinity (circles) are seen at 4 m and 14 m below the surface, at the boundaries between three overlying water masses.



(a)

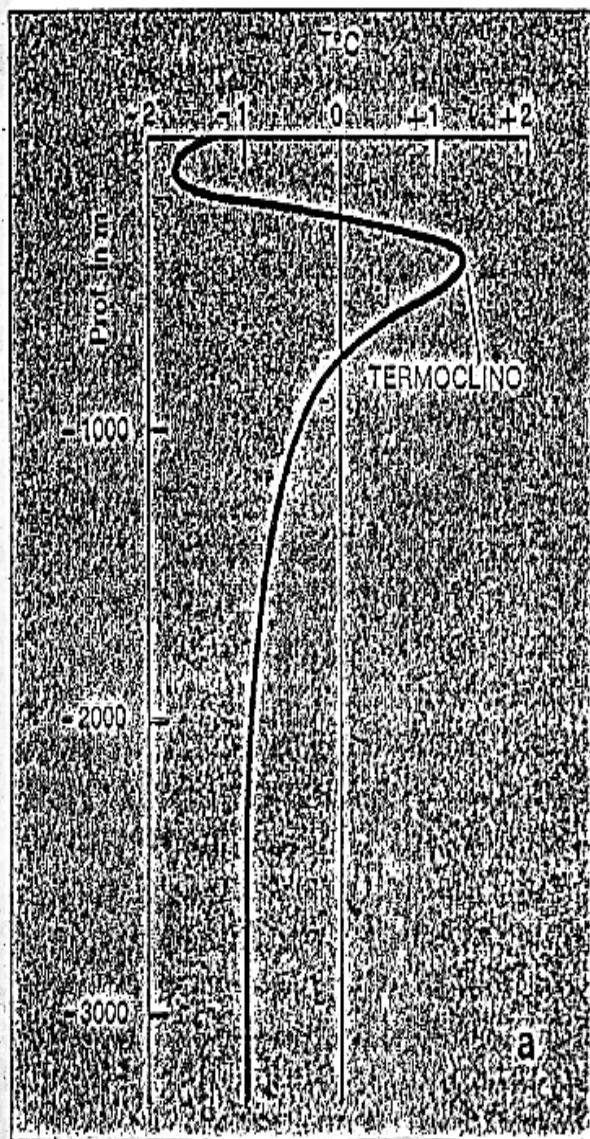
Supralittoral pool

Water
temperature
changes
with depth
and time

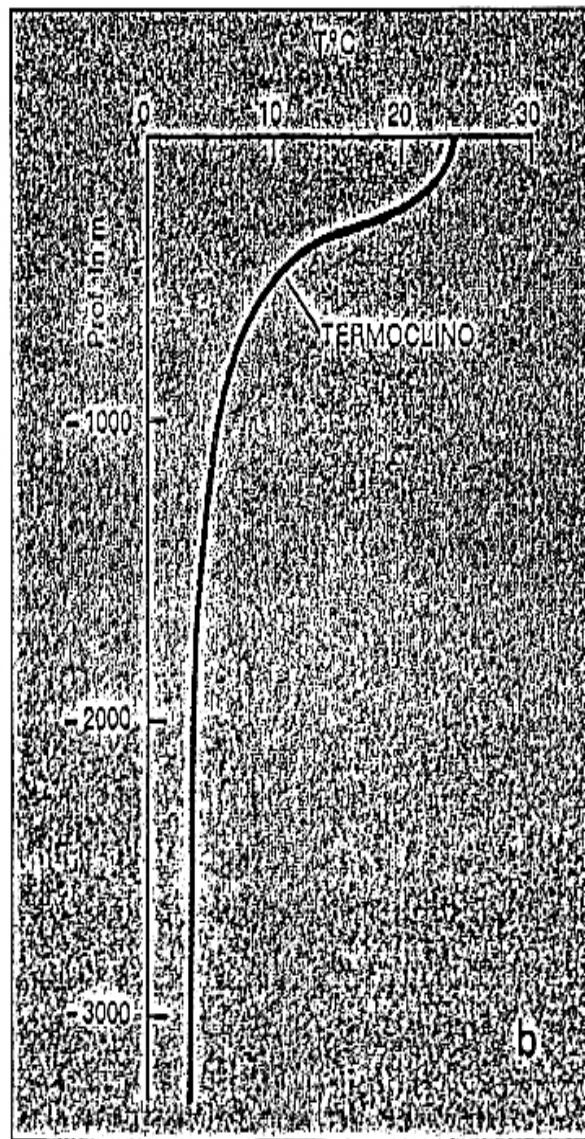
Table 6.1. Salinity and temperature gradients in a major estuary, the Great Bay estuary system in New Hampshire

Study stations (nautical miles inland)	Temperature ^a (°C)	Salinity ^a (‰)
1. Jaffrey Point (0.0)	10.2 23.0 1.0	30.3 32.5 26.0
2. Pierce Island (2.0)	10.5 21.5 0.0	27.0 32.0 19.0
3. Newington Town Landing (5.5)	11.7 24.0 0.4	24.5 31.0 16.0
4. Dover Point (7.0)	12.5 25.0 0.0	23.7 32.0 15.0
5. Cedar Point (8.3)	13.6 27.0 0.0	22.1 32.0 6.0
6. Adams Point (10.7)	13.8 28.0 0.5	21.0 31.5 8.0
7. Chapman's Landing (15.2)	14.2 26.5 0.0	5.7 22.0 0.0
8. Exeter (19.0)	14.4 28.1 0.0	3.4 20.0 0.0

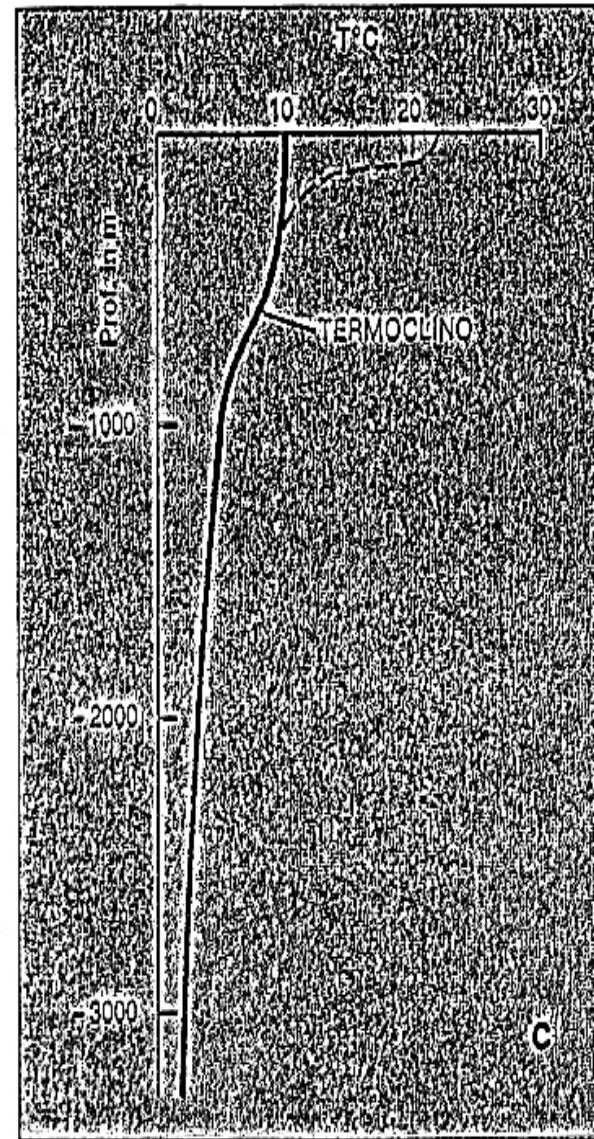
^aFirst, second, and third values represent mean, maximum, and minimum values, respectively.



Elevate latitudini



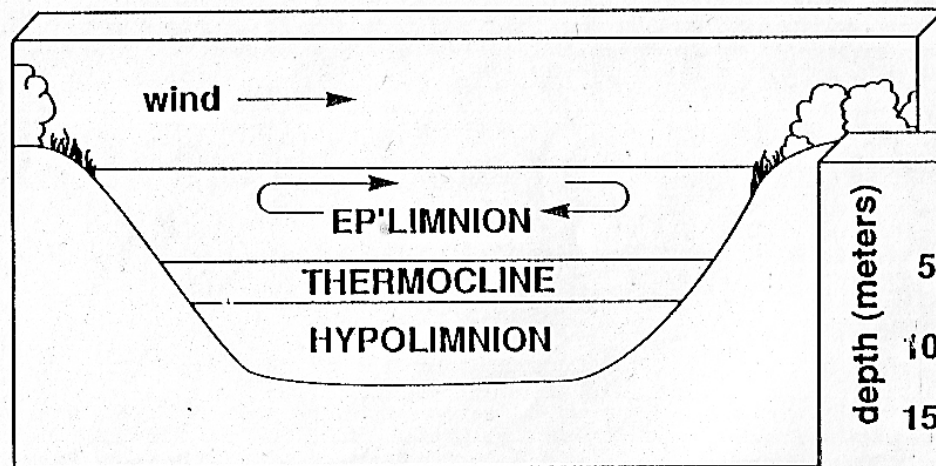
Basse latitudini



Medie latitudini

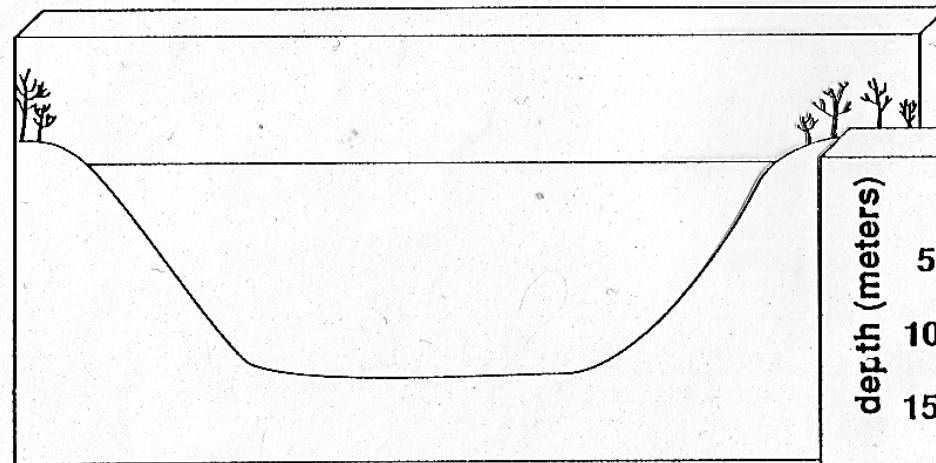
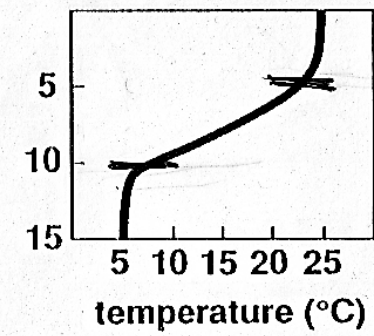
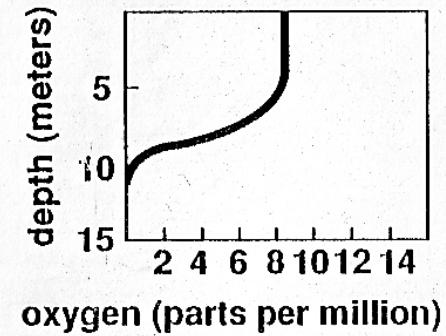
No seasonal variation

Summer stratification



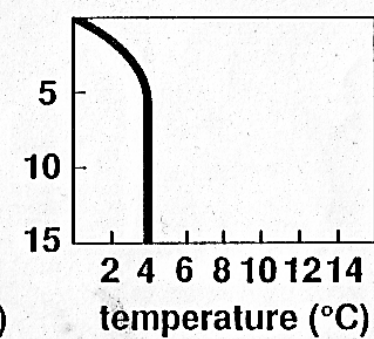
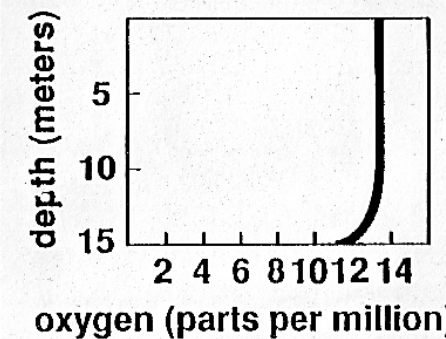
Summer

THERMAL STRATIFICATION IN SUMMER



Winter

NO THERMAL STRATIFICATION IN WINTER



Effect of seasons on a northern temperate lake.

Temperature influence on:

- rate of chemical reactions
- rate of enzymatic reactions ($Q_{10} \sim 2$)
(cell metabolism)
- cell growth and morphogenesis
- reproduction
- geographical distribution

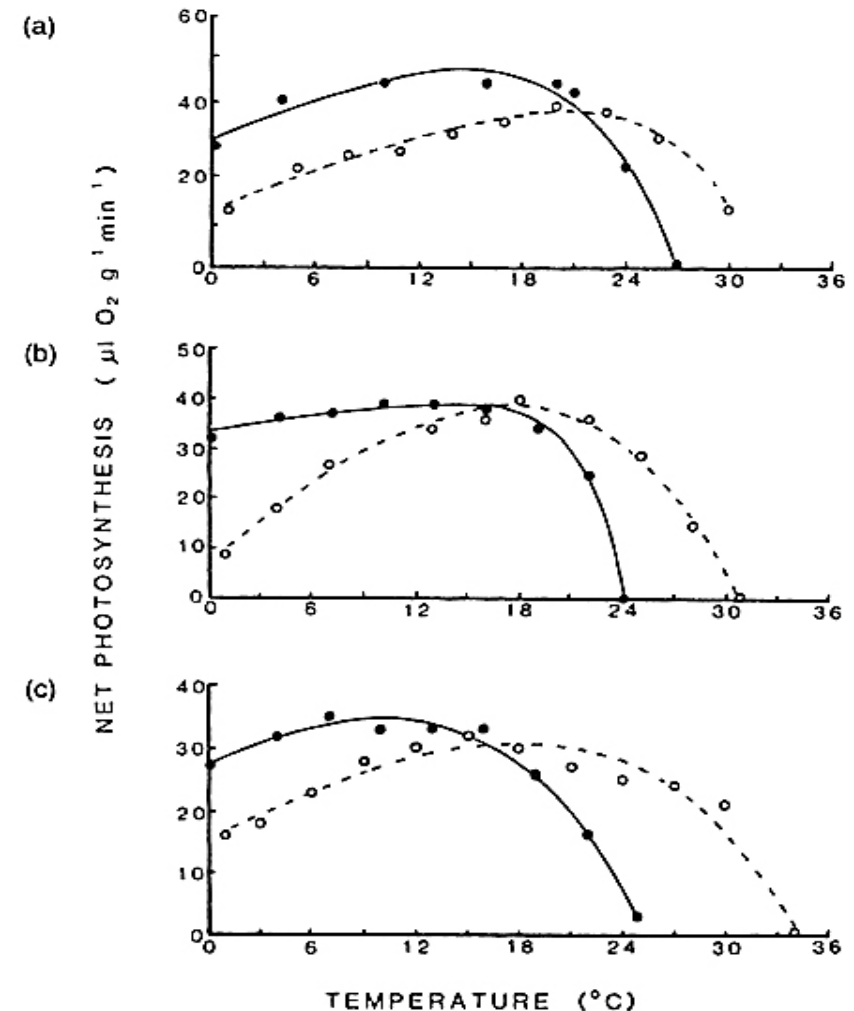


Figure 6.9. Actual data (winter, filled circles; summer, open circles) and model predictions (curves) of photosynthesis in three red algae: (a) *Callophyllis cristata*, (b) *Phycodrys rubens*, (c) *Chondrus crispus*.

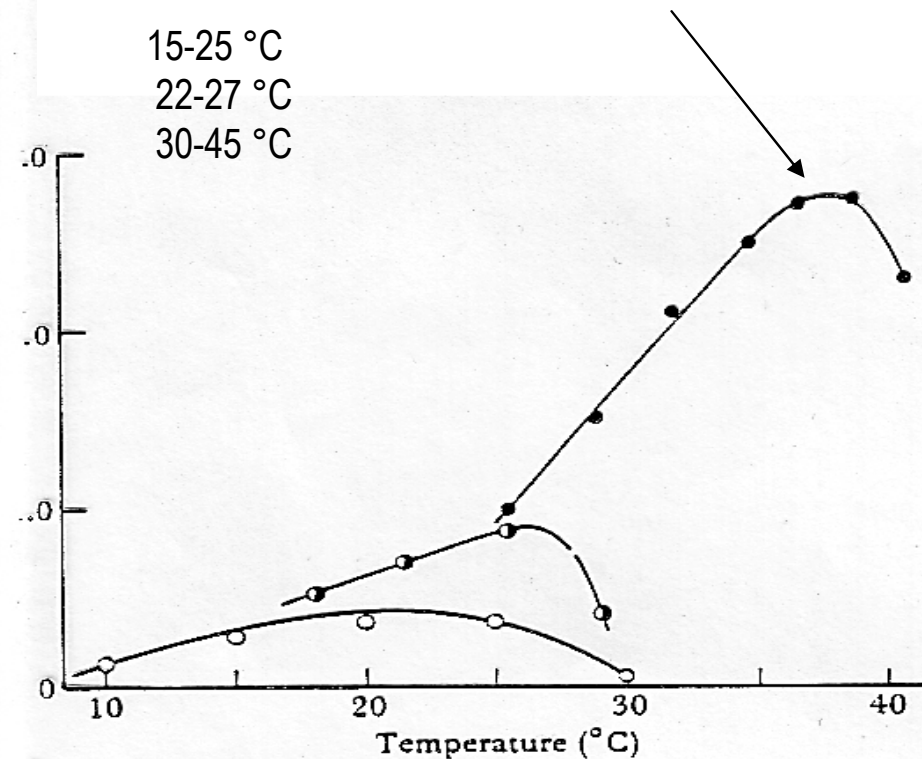
Temperature influence on growth

Eurytherm ($> 10\text{ }^{\circ}\text{C}$)
Stenotherm

Thermophilic and
thermotolerant algae

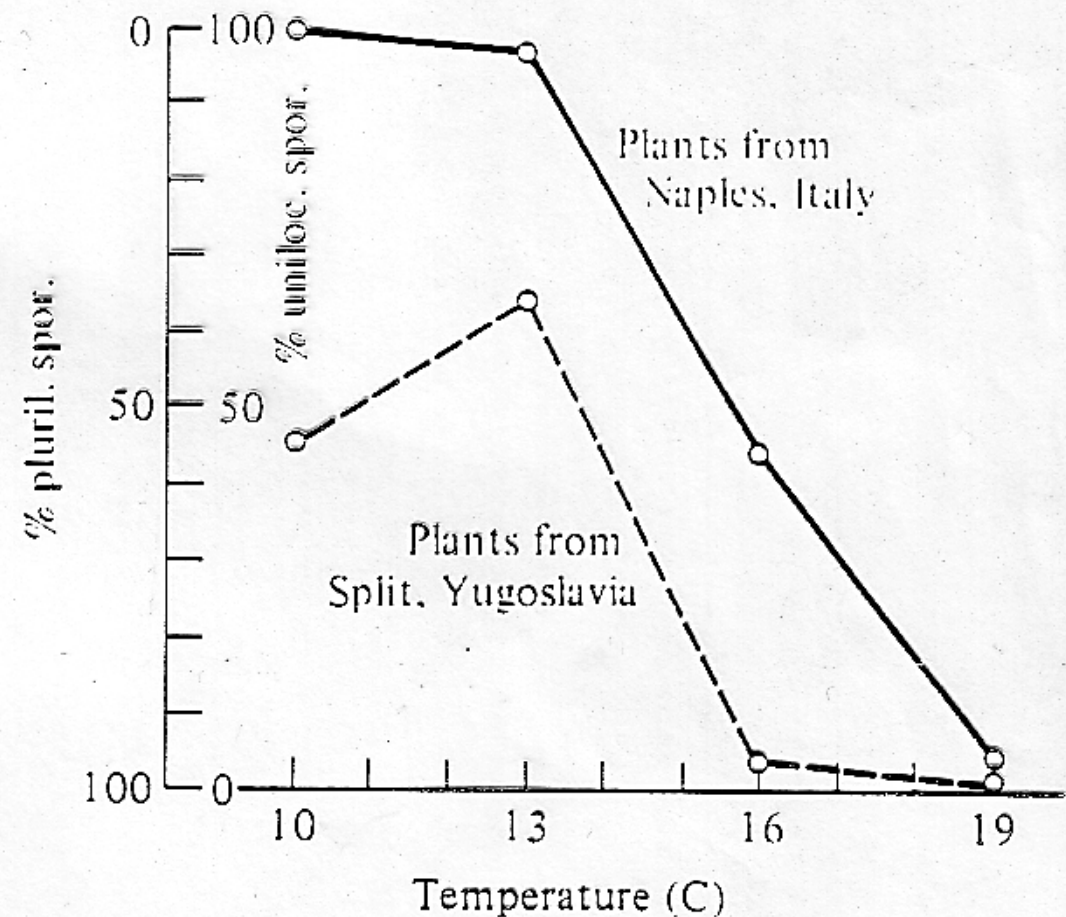
Fig. 7.45. a. Relative growth rates ($\log_{10}\text{ day}^{-1}$ units) at approximately 15000 lux of three strains of *Chlorella* as a function of temperature. *Chlorella pyrenoidosa* (○) cold water strain, *C. pyrenoidosa* (◐) Emerson strain and *C. sorokiniana* (●) high temperature strain.

Growth range and growth optimum



Temperature influence on reproduction

Figure 3.10. Percentages of unilocular and plurilocular sporangia on *Ectocarpus siliculosus* after 26 days culture at various temperatures. (From Müller 1963, courtesy of the Zoological Station of Naples)



Temperature effect on development of brown seaweeds

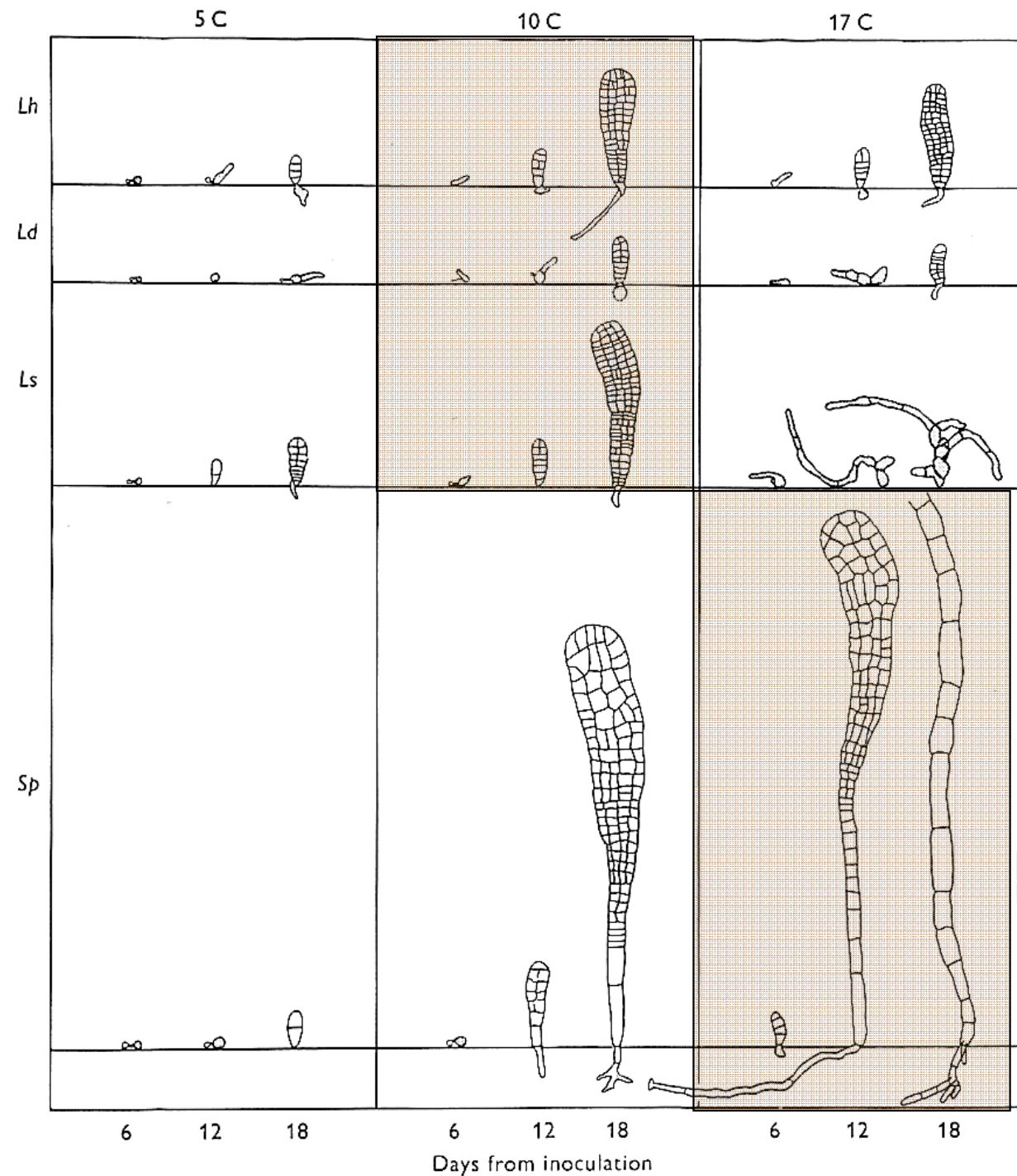


Figure 6.10. Growth and stipe elongation of juvenile kelp sporophytes after 6, 12, and 18 days in culture at 5°C, 10°C, or 17°C. Lh, *Laminaria hyperborea*; Ld, *L. digitata*; Ls, *L. saccharina*; Sp, *Saccorhiza polyschides*.

Temperature
influence
on the
geographical
distribution of
Seaweeds

Min-max survival
Min-max reproduction

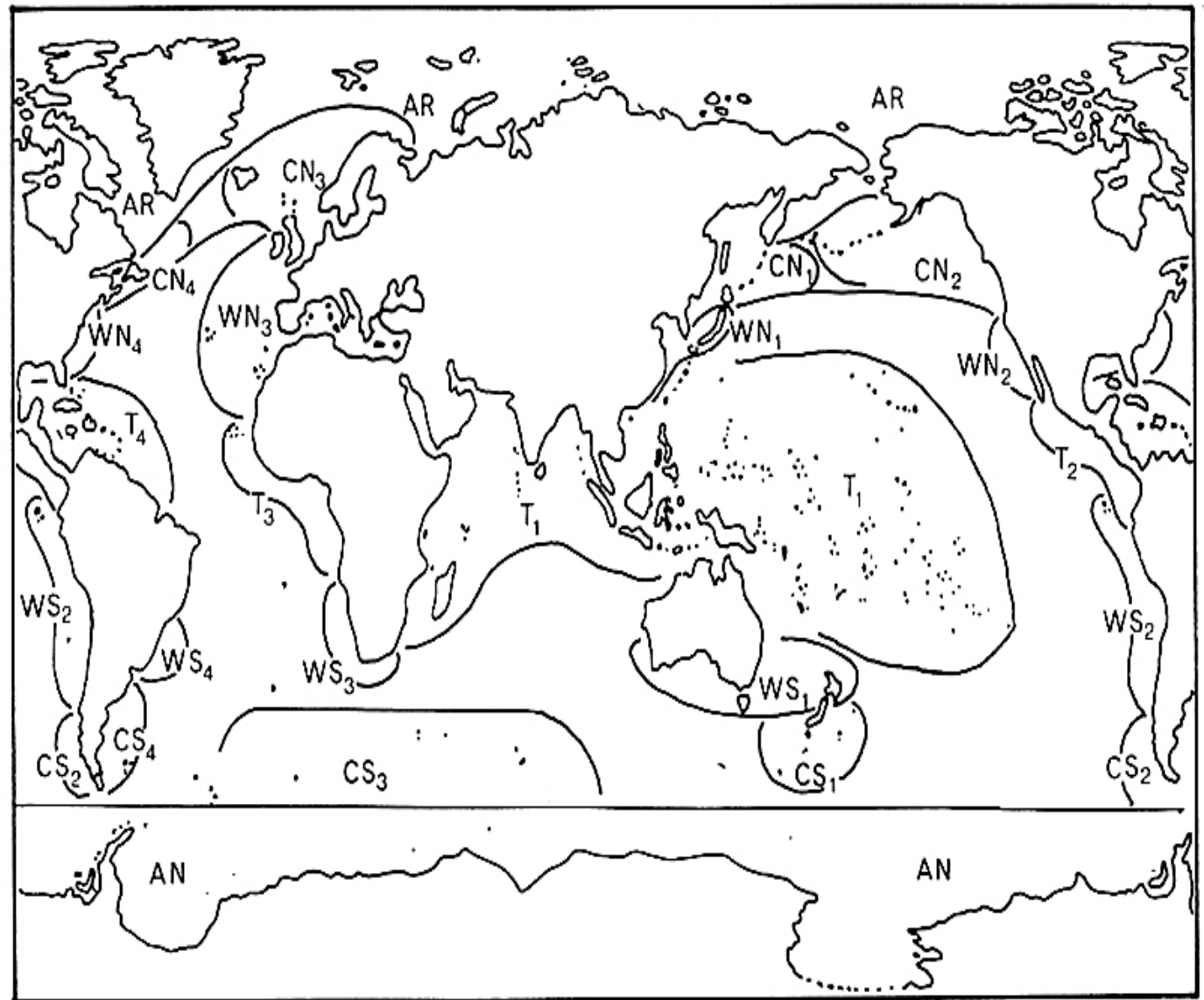


Figure 6.11. Phylogeographic regions for seaweeds

- 
- $S \text{ ‰} = 1.8065 \text{ Cl ‰}$
 - light refraction
 - Density (mass /volume)

NaCl gr/Kg

Salinity

open oceans

34-37 ‰

coastal waters

28-30 ‰

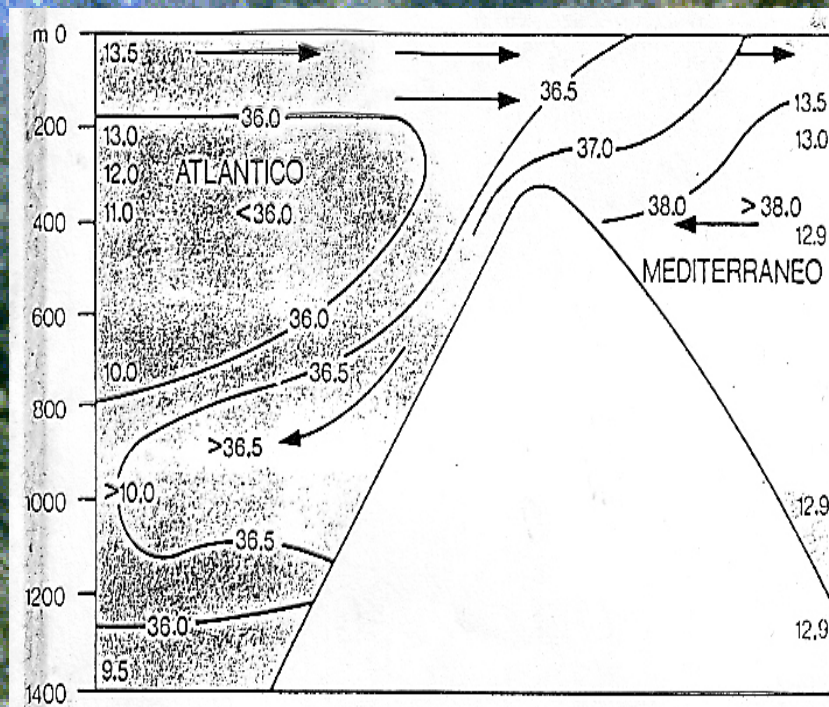
Mediterranean Sea

38.4-39 ‰

Baltic Sea

3-12 ‰





Tab. 2.3 La salinità dei mari a differenti latitudini

LOCALITA'	SALINITA' g/Kg
OCEANO ATLANTICO (ALL'EQUATORE)	35,67
" " (AI TROPICI)	36,54
" " (50° Lat. S.)	33,84
MAR BIANCO	25,98 - 29,68
MAR BALTICO (NEL GRAN BELT)	12,7
" " (NEL SUND)	9,2
" " (PRESSO SOTHLAND)	7,21
" " (GOLFO DI FINLANDIA)	3,5
MAR MEDITERRANEO (PRESSO TUNISI)	38,97
MAR NERO	18,26 - 22,23
MAR DI MARMARA	25,10 - 40,61
MAR ROSSO (AL CENTRO)	39,76
CANALE DI SUEZ (PRESSO ISMAILIA)	51,03
OCEANO INDIANO (EQUATORE)	35,14
STRETTO DI MALAGA	27,96
OCEANO PACIFICO (ALL'EQUATORE)	34,85
" " (AI TROPICI)	35,5
" " (48° LAT. N.)	33,64
MARE DELLA CINA	32,08
MAR CASPIO	163,96
MAR MORTO	188,45
GR. LAGO SALATO (U.T.A.H.)	203,49

Latitudinal (seasonal) influence

River runoff

Evaporation

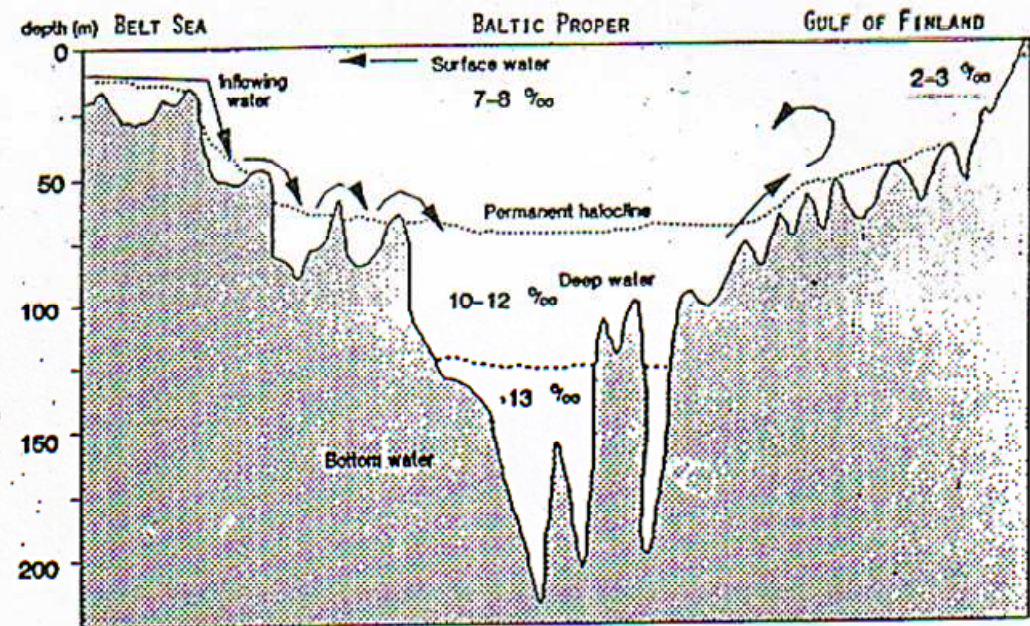
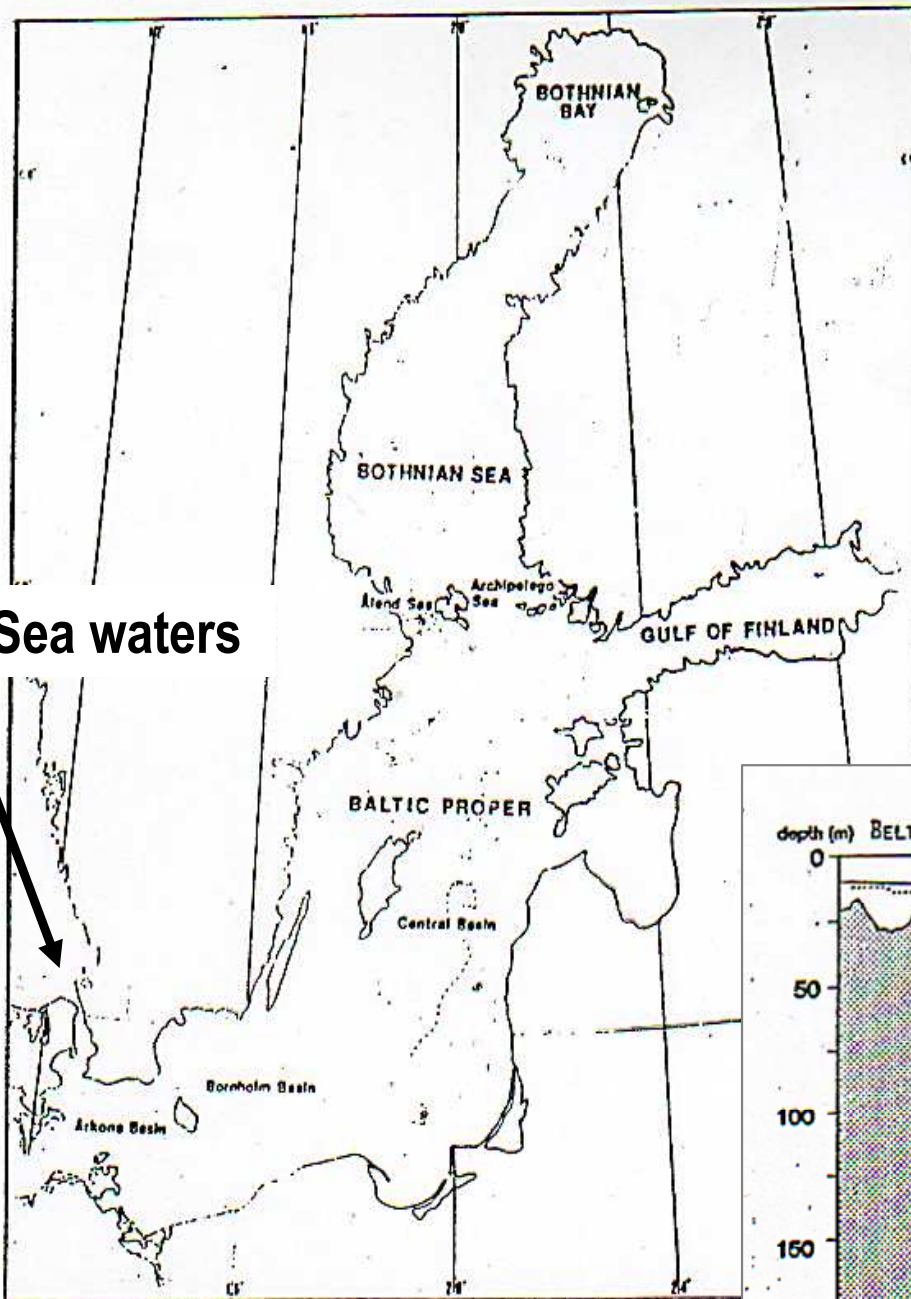
Baltic Sea

semi-closed basin influenced
by rainfall and river discharge

brackish waters
salinity gradients

West- East
surface – depth

North Sea waters



Salinity ranges in algal habitats

Extended ranges in:

- estuaries and bays
- intertidal regions

Table 1. Algal habitats and their natural salinity ranges. Average salinity range expressed in PSU (practical salinity units = ppt), comments refer to special characteristics

Habitat	Salinity Range (PSU)	Comments	Example
Freshwater	0 – 0.5 ‰		rivers, lakes, ponds
Brackish water	0.5 – 25	large seasonal fluctuations	Baltic Sea, lagoons
Estuaries	0 – 32	fluctuating salinity, tidal rhythm	river discharges into the sea
Eulittoral, Tidal zone	25 – 37	exposure to atmosphere and reimmersion, varies with tidal height	rocky shores, coral reefs, Wadden Sea
Sublittoral, open sea	33 – 37	constant salinity over huge areas, decreasing from equator to the poles	oceans: phytoplankton
Sea ice	8 – 150	salinity is a function of temperature; seasonal effects: ice melt	polar seas in Arctic and Antarctica brine pockets in the sea ice
Hyper saline waters	up to saturation	very high but constant salinities, seasonal or long term fluctuation	Dead Sea enclosed lagoons, saline lakes
non-NaCl-waters	0.5 to saturation	Na ⁺ and Cl ⁻ are not the main ions; ionic stress; seasonal fluctuation	sulphate and carbonate lakes
Supralittoral	–	water potential	atmophytic algae;
Terrestrial habitats	(sea water spray)	changed by desiccation and irrigation	salt marshes

Salinity changes with time and depth

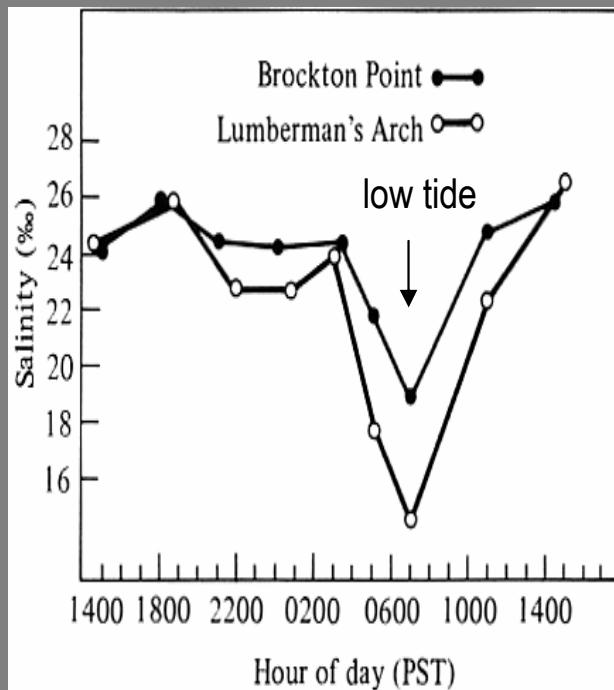


Figure 6.3. Salinity changes during 24-h periods in spring at two sites in Burrard Inlet, British Columbia. Values are averages for 3 days in separate years.

Table 6.1. Salinity and temperature gradients in a major estuary, the Great Bay estuary system in New Hampshire

Study stations (nautical miles inland)	Temperature ^a (°C)	Salinity ^a (‰)
1. Jaffrey Point (0.0)	10.2	30.3
	23.0	32.5
	1.0	26.0
2. Pierce Island (2.0)	10.5	27.0
	21.5	32.0
	0.0	19.0
3. Newington Town Landing (5.5)	11.7	24.5
	24.0	31.0
	0.4	16.0
4. Dover Point (7.0)	12.5	23.7
	25.0	32.0
	0.0	15.0
5. Cedar Point (8.3)	13.6	22.1
	27.0	32.0
	0.0	6.0
6. Adams Point (10.7)	13.8	21.0
	28.0	31.5
	0.5	8.0
7. Chapman's Landing (15.2)	14.2	5.7
	26.5	22.0
	0.0	0.0
8. Exeter (19.0)	14.4	3.4
	28.1	20.0
	0.0	0.0

^aFirst, second, and third values represent mean, maximum, and minimum values, respectively.

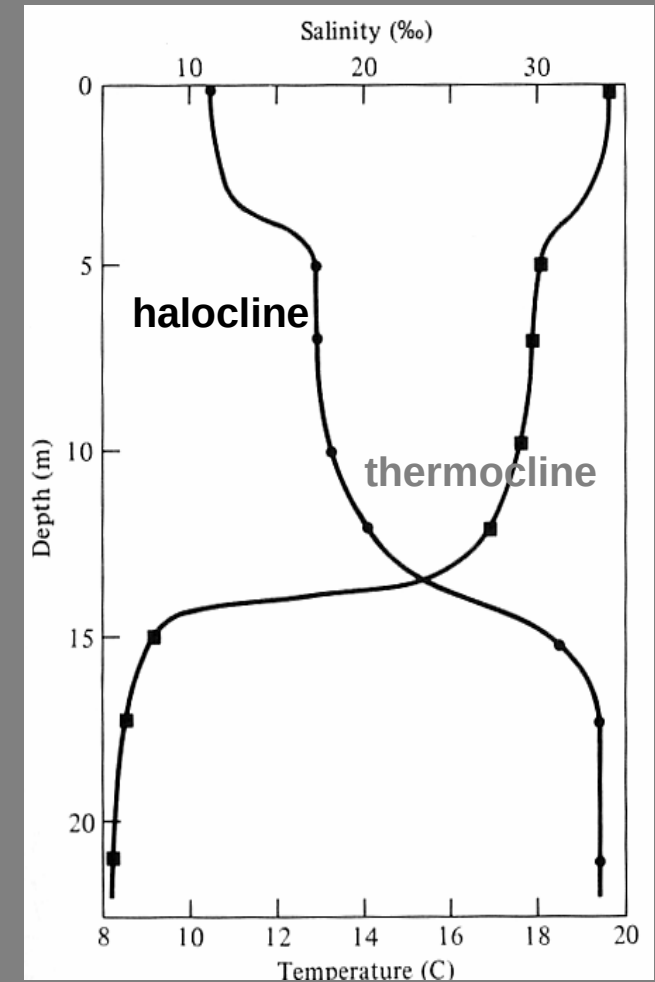
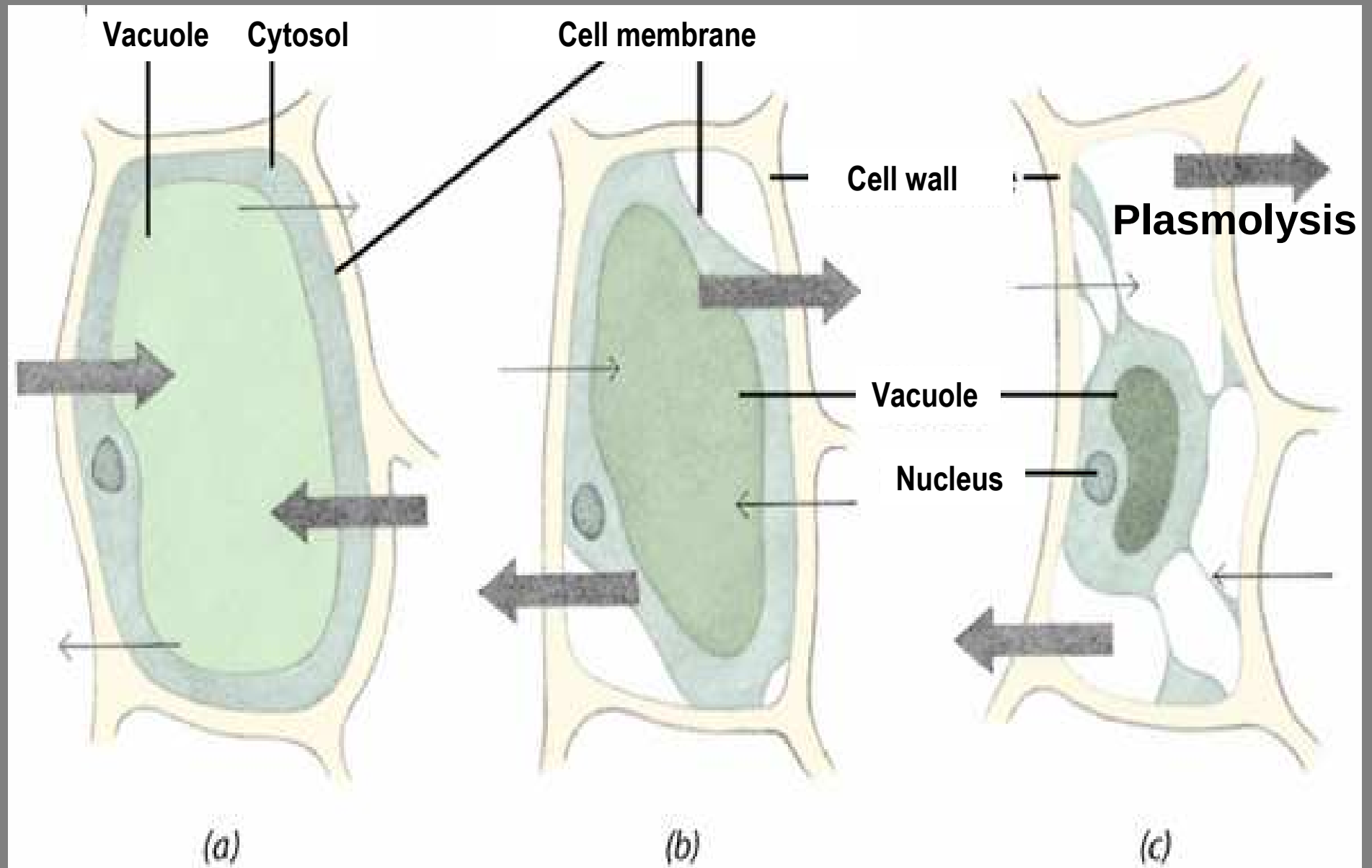


Figure 6.1. Thermoclines and haloclines as seen in temperature and salinity profiles at a station between Copenhagen and Elsinore, Denmark. Rapid changes in temperature (squares) and salinity (circles) are seen at 4 m and 14 m below the surface, at the boundaries between three overlying water masses.



Low salt concentration

High salt concentration

Salinity influence on water content and low molecular-weight photosynthates

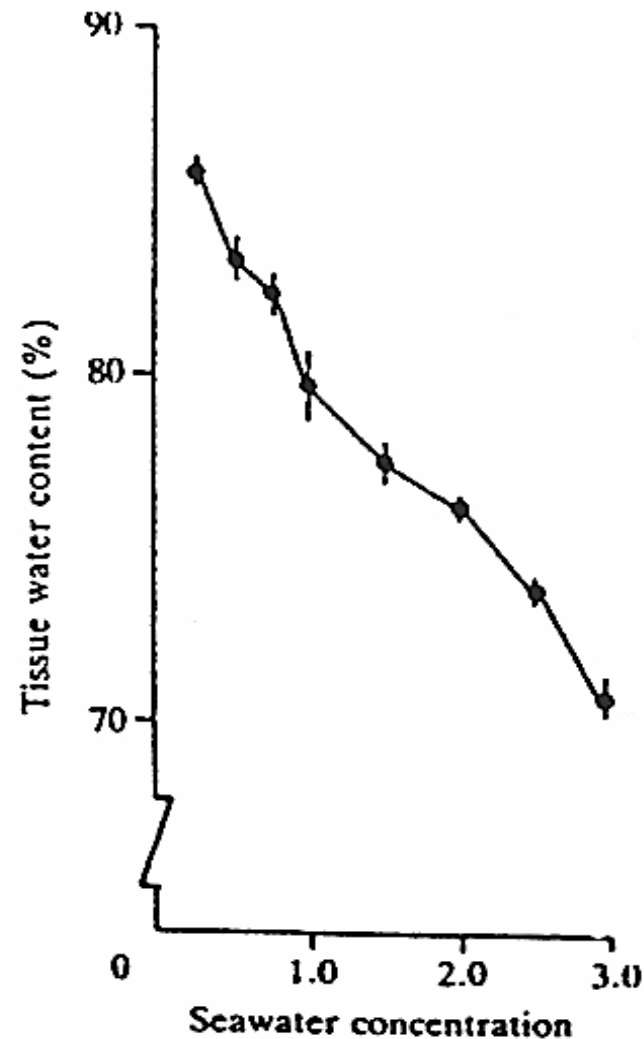


Figure 6.19. Tissue water content [(wet weight – dry weight)/wet weight] $\times$ 100% for *Enteromorpha prolifera* as a function of salinity. Seawater concentration of 1.0 = 35‰ salinity.

Table 6.3. Changes in chemical composition of *Fucus vesiculosus* (summer material) after 19 days of incubation in seawater of different salinities (control = 31.03‰)

Salinity ‰	Dry weight as percentage of fresh weight	Percentage dry weight of:		
		Ash	Mannitol	Protein
31.03	17.45	22.60	14.57	15.67
20.94	15.70	22.50	6.61	15.31
15.53	13.21	18.20	5.81	15.54
10.67	12.50	16.20	5.38	16.31
5.15	10.80	15.90	3.18	17.74

Daily fluctuation of salinity and seaweed response

Changes in:
tissue osmolality
turgor pressure
 K^+ concentration

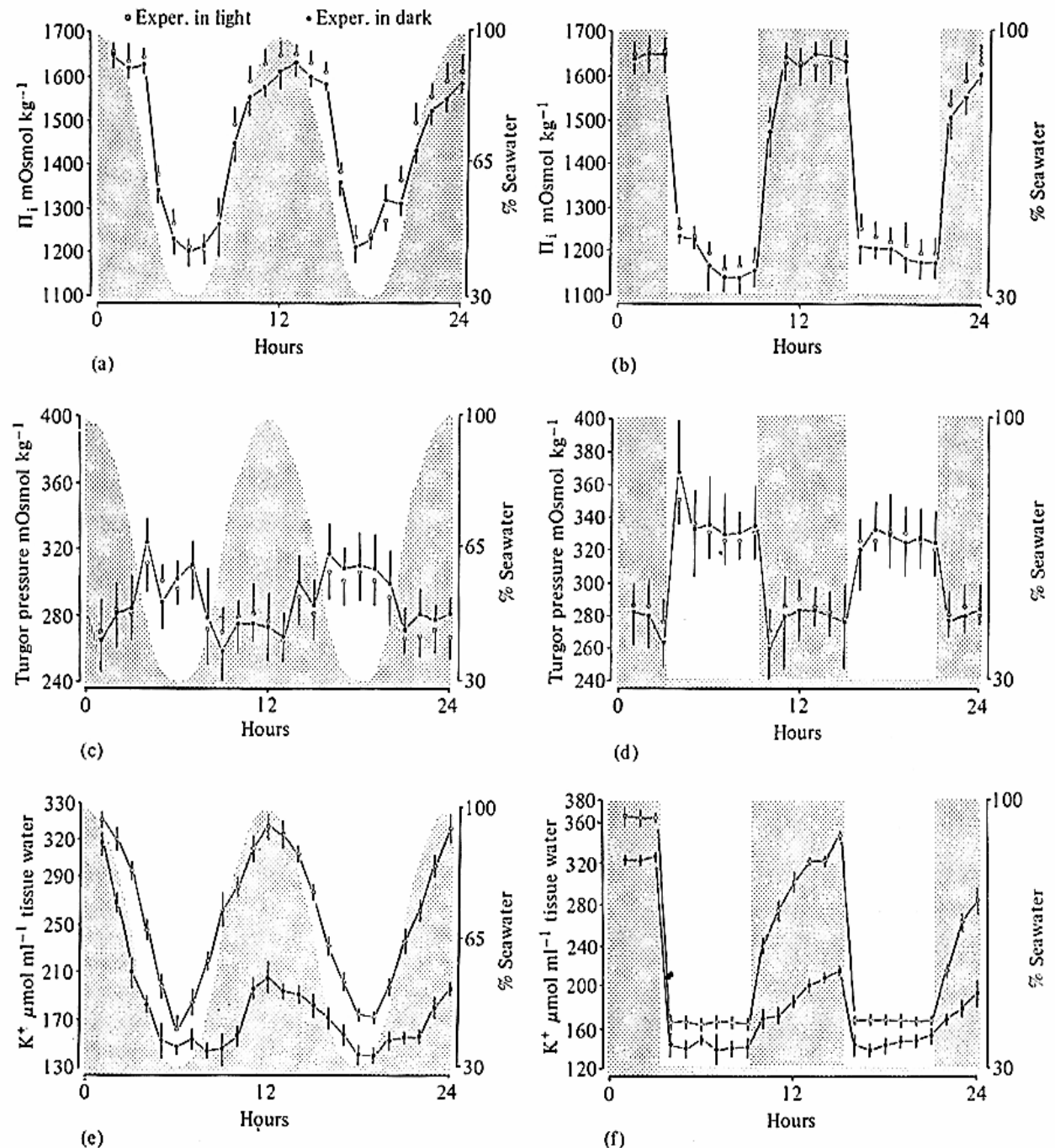
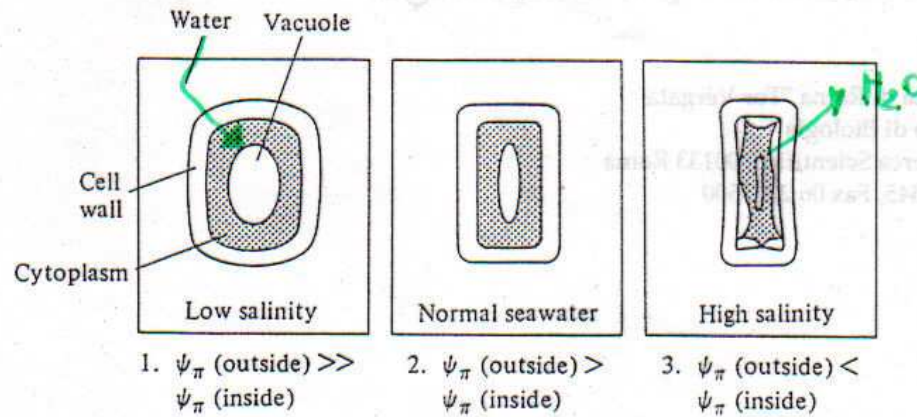


Figure 6.17. Responses of *Ulva lactuca* to fluctuating salinity regimes. The background stippling traces the changes in salinity; two regimes were used: sinusoidal changes (a, c, e) and abrupt changes (b, d, f). Changes in tissue osmolality (Π_i) (a, b), apparent turgor pressure (c, d), and K^+ concentration on a tissue-water basis (e, f) are given for experiments run in light (open circles) and in darkness (filled circles).

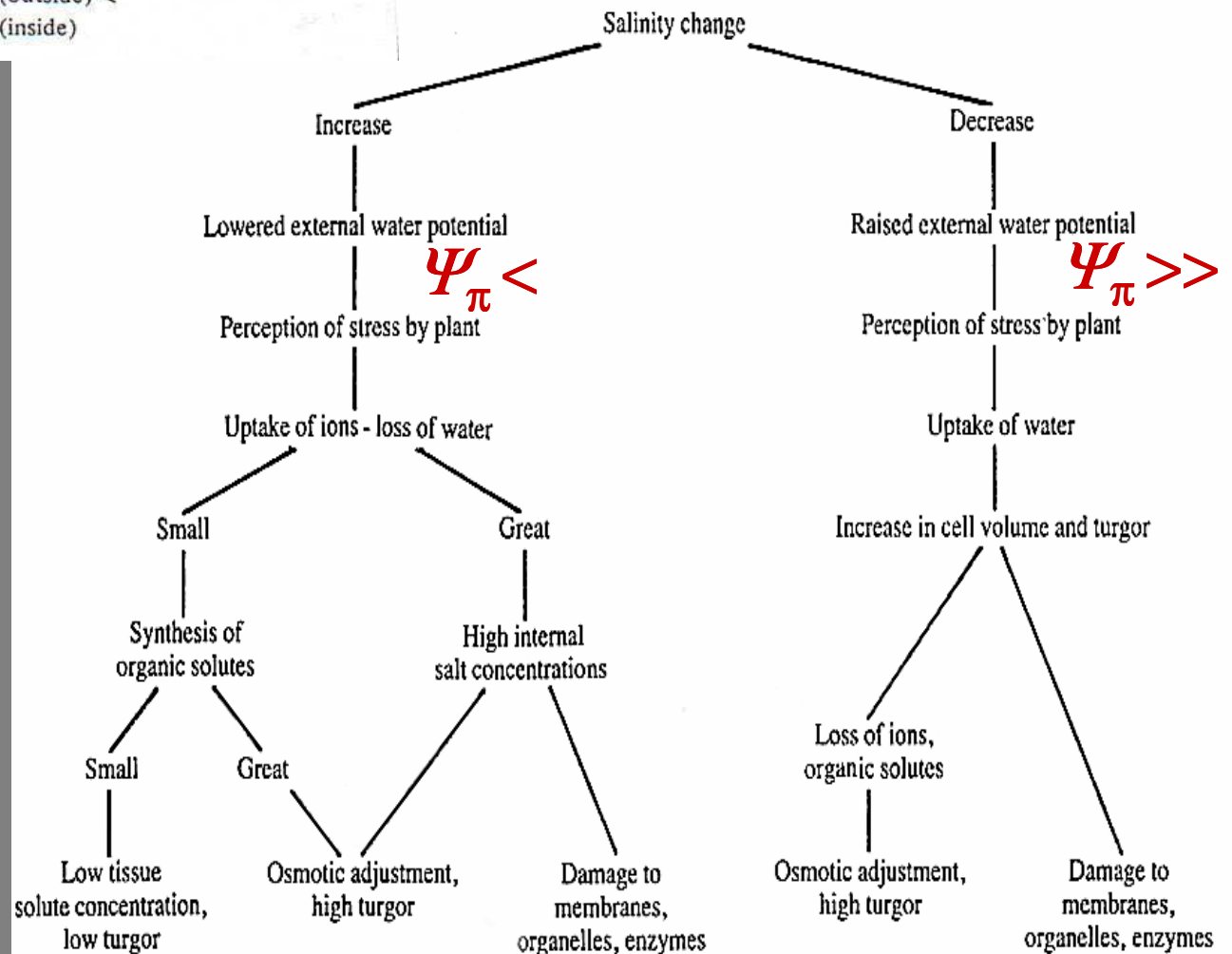
Figure 4.2. Diagram to show the general trend in relationships between internal and external osmotic potential (ψ_{π}) in various salinities.



Seaweed short term responses to salinity changes

Osmoregulation

- Ion concentration (Na^+ , K^+ , Cl^-) for rapid adjustment
- Osmolites (polymers to monomers) for slow adjustment



Controllo osmotico veloce:

ioni come
osmoregolatori

Vantaggi:

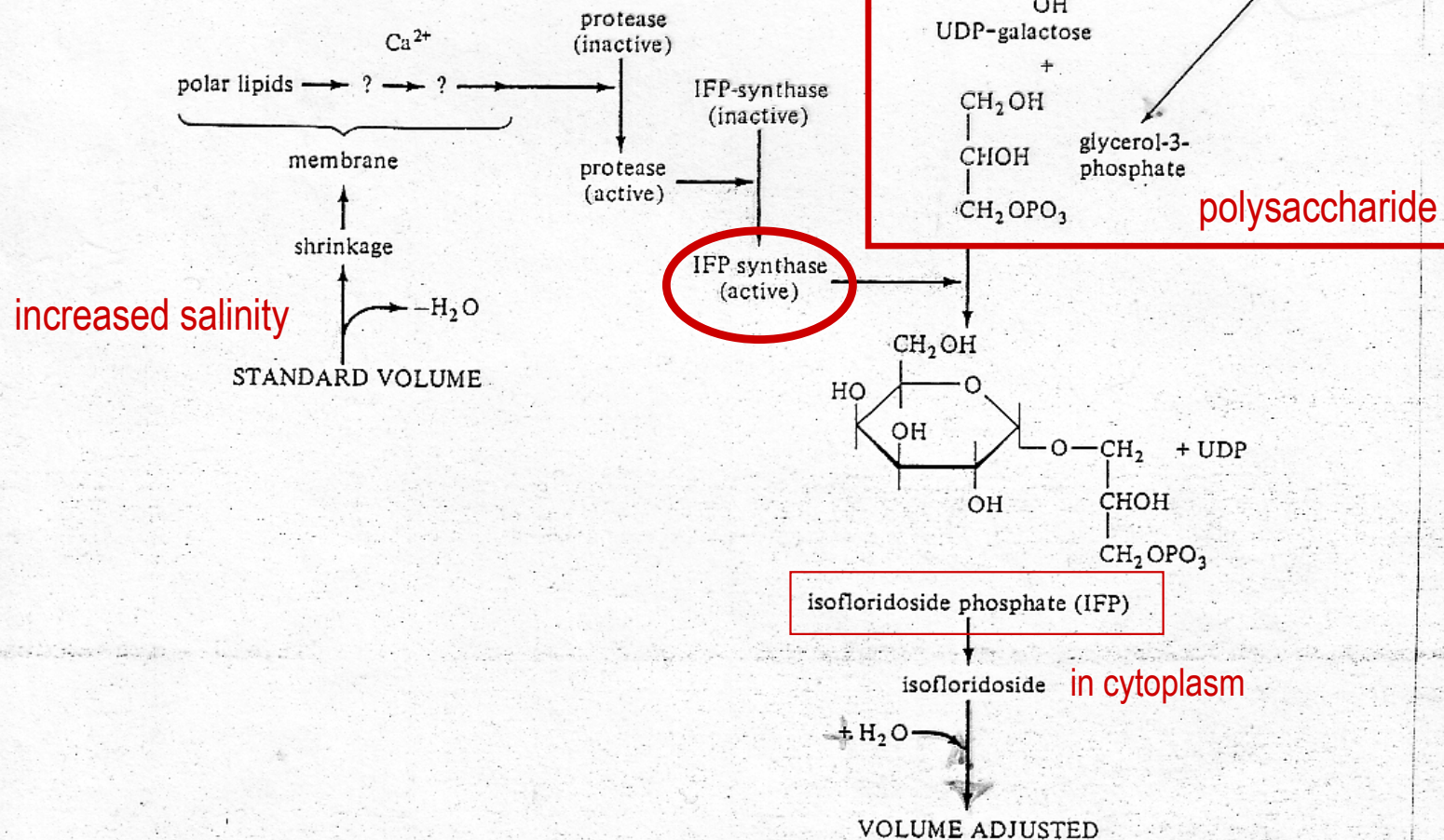
- flusso veloce
- accumulo in alte concentrazioni
- basso costo energetico

Table 2. Salinity tolerance and turgor pressure regulation characteristics of Charophyte species (modified and updated from Winter and Kirst 1991, 1992, and literature quoted there; Winter: unpublished data). L: *Lamprorhamnum*; C: *Chara*; N: *Nitella*; T: *Tolypella*. Salinity expressed in PSU (practical salinity units = ppt).

Species	<i>L. papulosum</i> <i>L. succinctum</i> <i>C. buckellii</i>	<i>C. canescens</i> <i>C. aspera</i> <i>T. nidifica</i>	<i>C. vulgaris</i> <i>C. tomentosa</i>	N. spec <i>C. corallina.</i>
Distribution	marine – brackish water	brackish water	freshwater	freshwater
Salinity (PSU): ecological range	24 – 34 ‰	0.5 – 20 ‰	0 – 5 ‰	0 – 1.5 ‰
tolerance limits	0 – 105	0.5 – 34	0 – 22	??
Turgor pressure regulation:	nearly perfect	incomplete; <i>Tolypella</i> : nearly perfect	incomplete	none
Main ions involved:	K ⁺ ; Cl ⁻ minor: Na ⁺	Na ⁺ ; Cl ⁻ minor: K ⁺	Na ⁺ , Cl ⁻	–
K/Na ratio: increasing salinity	from 2 to 3.4 ↑	from 9 to 1.2 ↓ (T: 1.8 to 5.8)	from 2.8 to 0.7 ↓	2.0
ionic content (mM), increasing salinity:				
Chloride:	135 – 723	70 – 380	100 – 310	130
Potassium:	80 – 615	(T: 570)	100 – 160	80
Sodium:	40 – 135	90 – 170 (T: 460) 10 – 150 (T: 80)	35 – 240	40
Classification	euryhaline	brackish water	halotolerant freshwater	freshwater

Controllo osmotico lento

monomeri $\rightleftharpoons$ polimeri



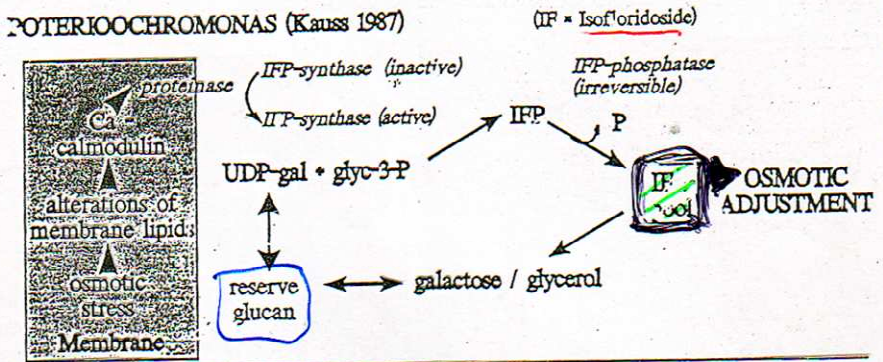
Vantaggi:

- derivano da composti di riserva
- sono soluti compatibili

Mantenimento della pressione di turgore con osmoliti organici in ambienti diversi

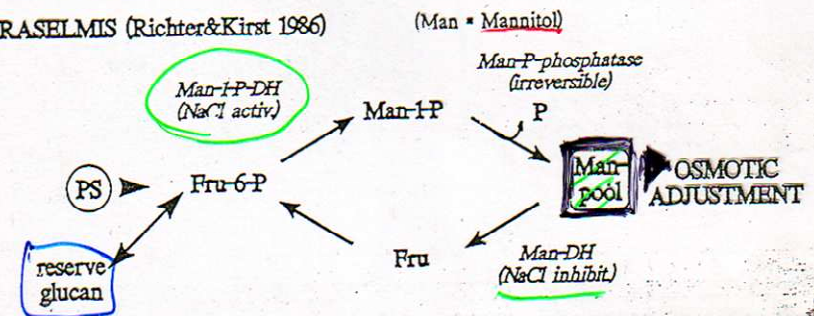
fresh water

POTERIOOCHROMONAS (Kauss 1987)



marine

TETRASELMIS (Richter & Kirst 1986)



high salinity

DUNALIELLA (review: Ginzburg 1987)

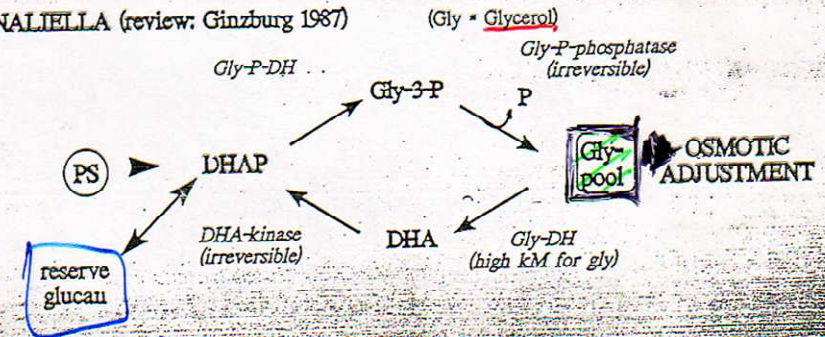


Fig. 2. Comparison of metabolic pathways of organic osmolytes in species inhabiting freshwater (*Poterioochromonas*), a marine phytoplankton (*Tetraselmis* (*Platymonas*)) and a high salinity tolerant *Dunaliella*. Key enzymes involved in regulation of the pool size are given in *italics*. The possible cascade of reactions leading to the activation of *IFP-synthase* on *Poterioochromonas* is thought to be located in the membrane (shaded area; Kauss 1987). P: Phosphate; Gly: Glycerol; Fru: Fructose; Gal: galactose; DHA: Dihydroxy

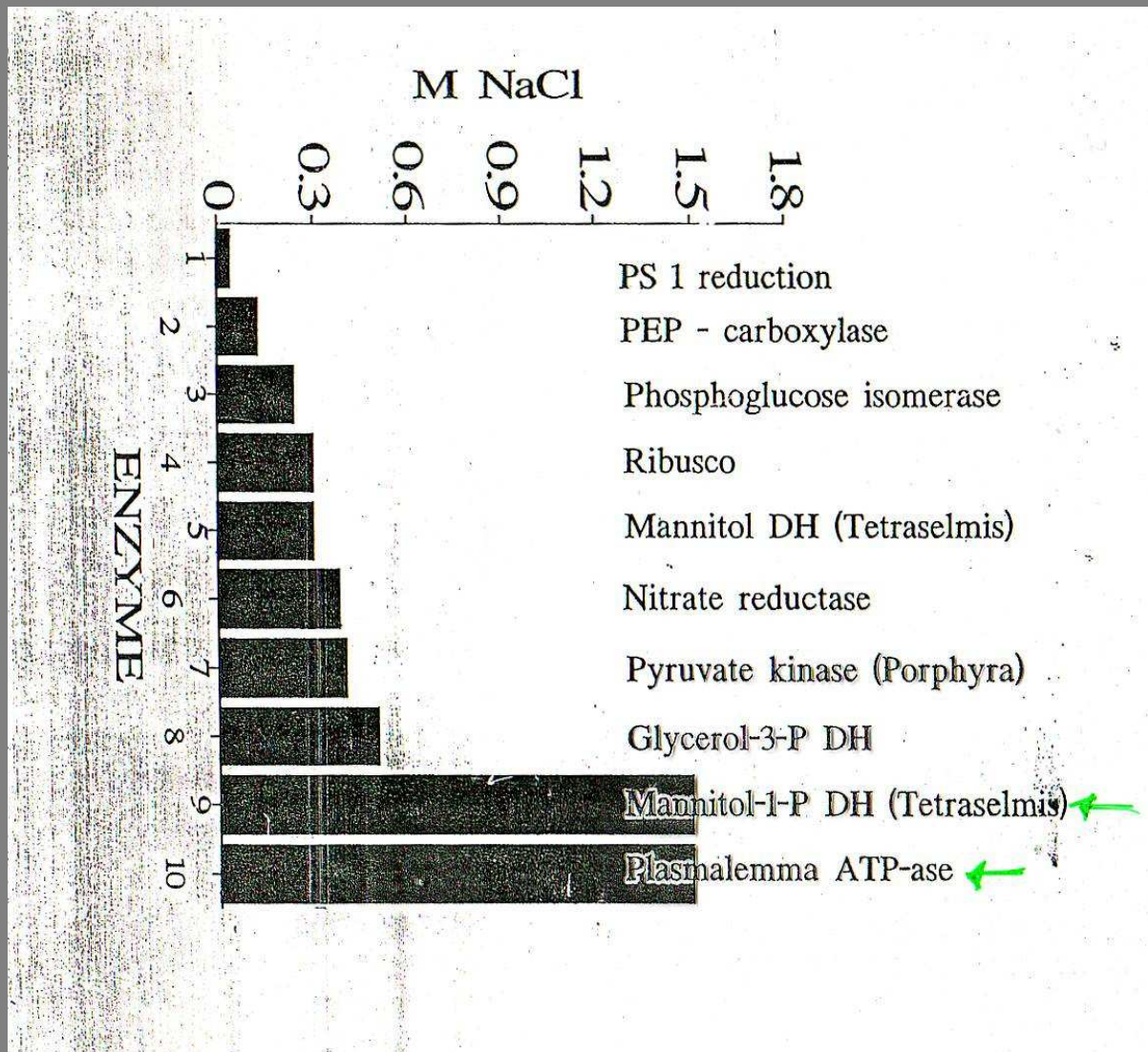
Osmoliti organici

Table 3. Organic osmolytes and range of salinity tolerance.

Organic Osmolyte	Salinity (PSU)	Habitat	Species (Example)
disaccharides: sucrose, trehalose heterosides	0 - 25	freshwater; brackish water	<i>Chara vulgaris</i> <i>Chara canescens</i> <i>Euglena gracilis</i> <i>Poterioochromonas</i> sp. <i>Chlorella emersonii</i> <i>Cyanophyta</i> species
polyols heterosides DMSP betains	0 - 90	brackish water; sea water; tide pools; brine in sea ice	most marine algae <i>Tetraselmis</i> spp. <i>Cyanophyta</i> species
Combination of two or more osmolytes sucrose/proline sorbitol/proline mannitol/DMSP/ betaines	0 - 90	especially: estuaries; intertidal zones; supra-littoral	<i>Enteromorpha</i> spp. <i>Blidingia</i> spp. <i>Pelvetia canaliculata</i> <i>Tetraselmis</i> spp. <i>Prasiola crispa</i>
glycerol proline betaines	325 - 300	saline lakes; saturated brine	<i>Dunaliella</i> spp. <i>Cyanophyta</i> species

Vantaggi:

- alta solubilità
- assenza di cariche a pH fisiologica
- non tossici ad alte concentrazioni
- di rapida sintesi
- metabolicamente regolabili



Salinity effect on enzyme activity and photosynthesis

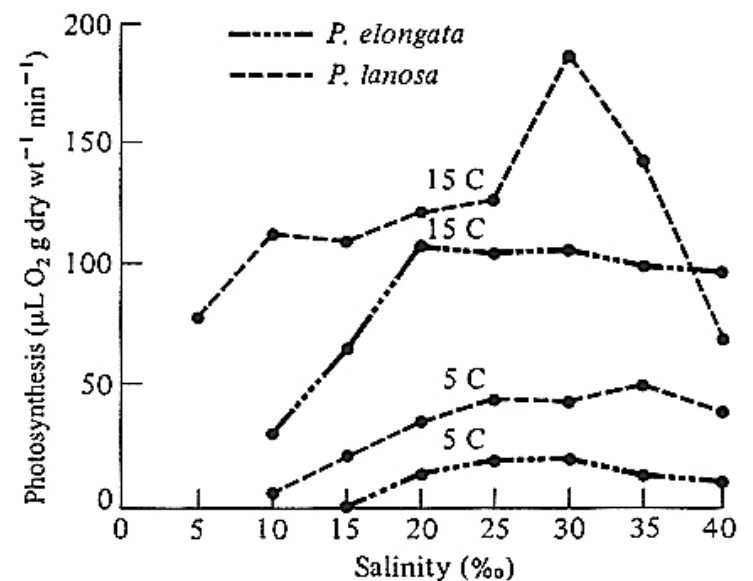


Figure 6.20. Apparent photosynthesis rates for estuarine *Polysiphonia lanosa* and *P. elongata* as functions of salinity at 5°C and 15°C, showing optima near full seawater salinity.

Species diversity
declines at
high salinity

Euryhaline
Stenohaline

Halotolerant
Halophytic

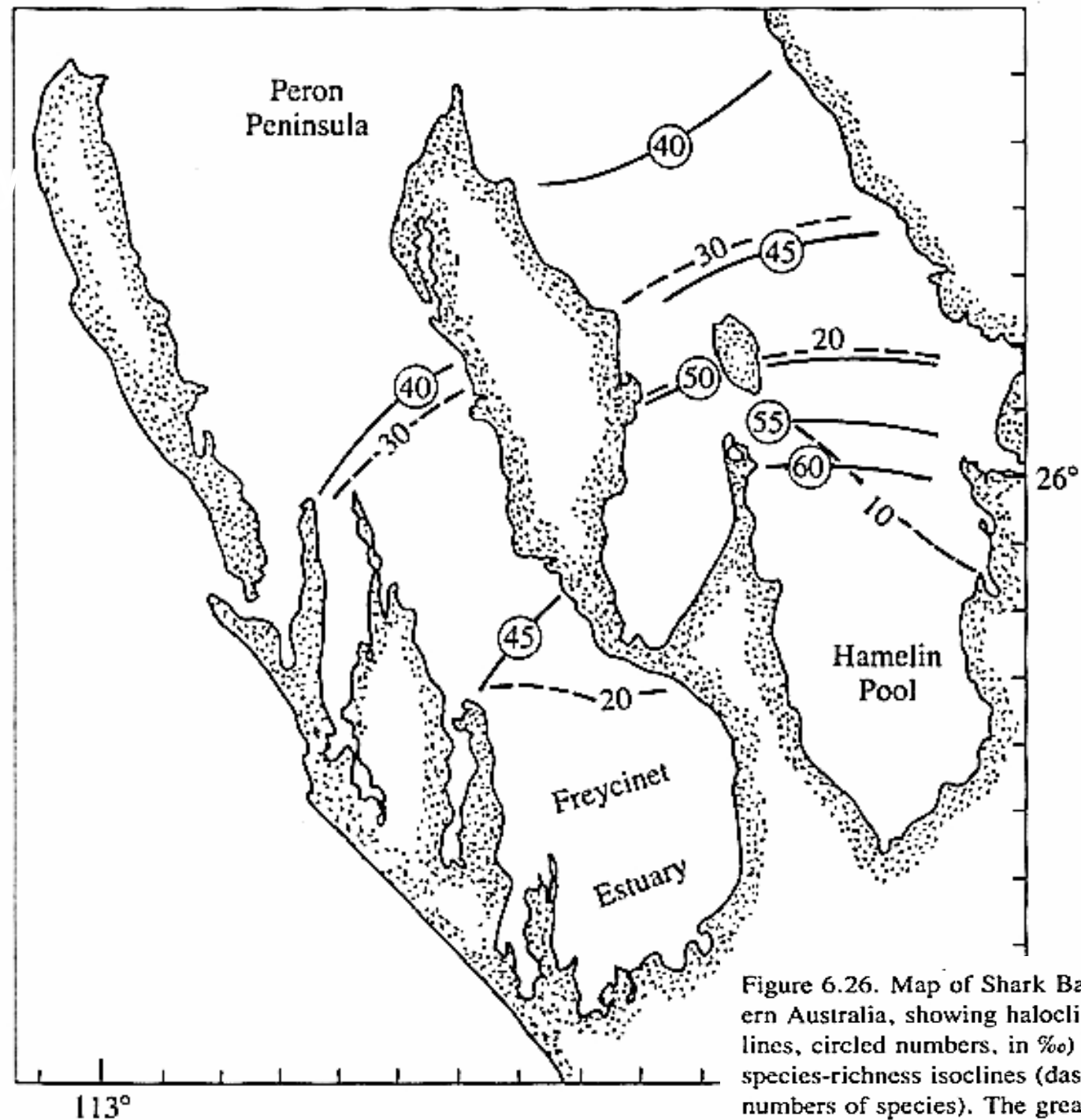


Figure 6.26. Map of Shark Bay, Western Australia, showing haloclines (solid lines, circled numbers, in ‰) and species-richness isoclines (dashed lines, numbers of species). The greater richness in Freycinet Estuary is thought to be due to greater water movement.