SEAWEED ECOLOGY

Oh! Call us not weeds, but flowers of the sea…
Mary Matilda Howard (1846)
M. M. Howard (1846), Ocean Flowers and Their Teachings, p. 46, Binns & Goodwin, Bath. ,

The life conditions in the marine environment are different from those of terrestrial or freshwater environments

Factors with ecological importance for terrestrial vegetation are of little or no importance to marine algae:

- ✓ **rainfall and humidity of the air have no effect on seaweeds**
- ✓ **temperature is less variable in the oceans, and**
- ✓ **chemical composition of the seawater is almost constant**

However, certain factors such as wave action and periodic emersion by tides present problems peculiar to seaweeds

Factors affecting the distribution of seaweeds

1. Physical factors
   - Substrate
   - Temperature
   - Illumination
   - Pressure

2. Chemical factors
   - Salinity
   - Chemical substances

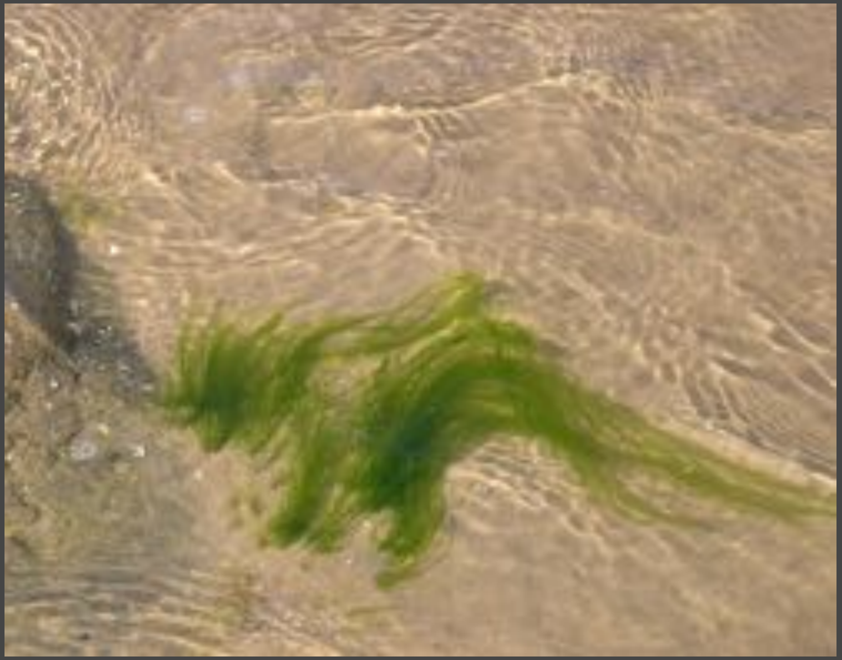
3. Dynamic factors
   - Wave action
   - Emersion
   - Biological effect of emersion

4. Biological factors

PHYSICAL FACTORS: SUBSTRATE

Marine algae are *not dependent* on the chemical nature of the substrate to obtain nutrients, they are dissolved in the surrounding water

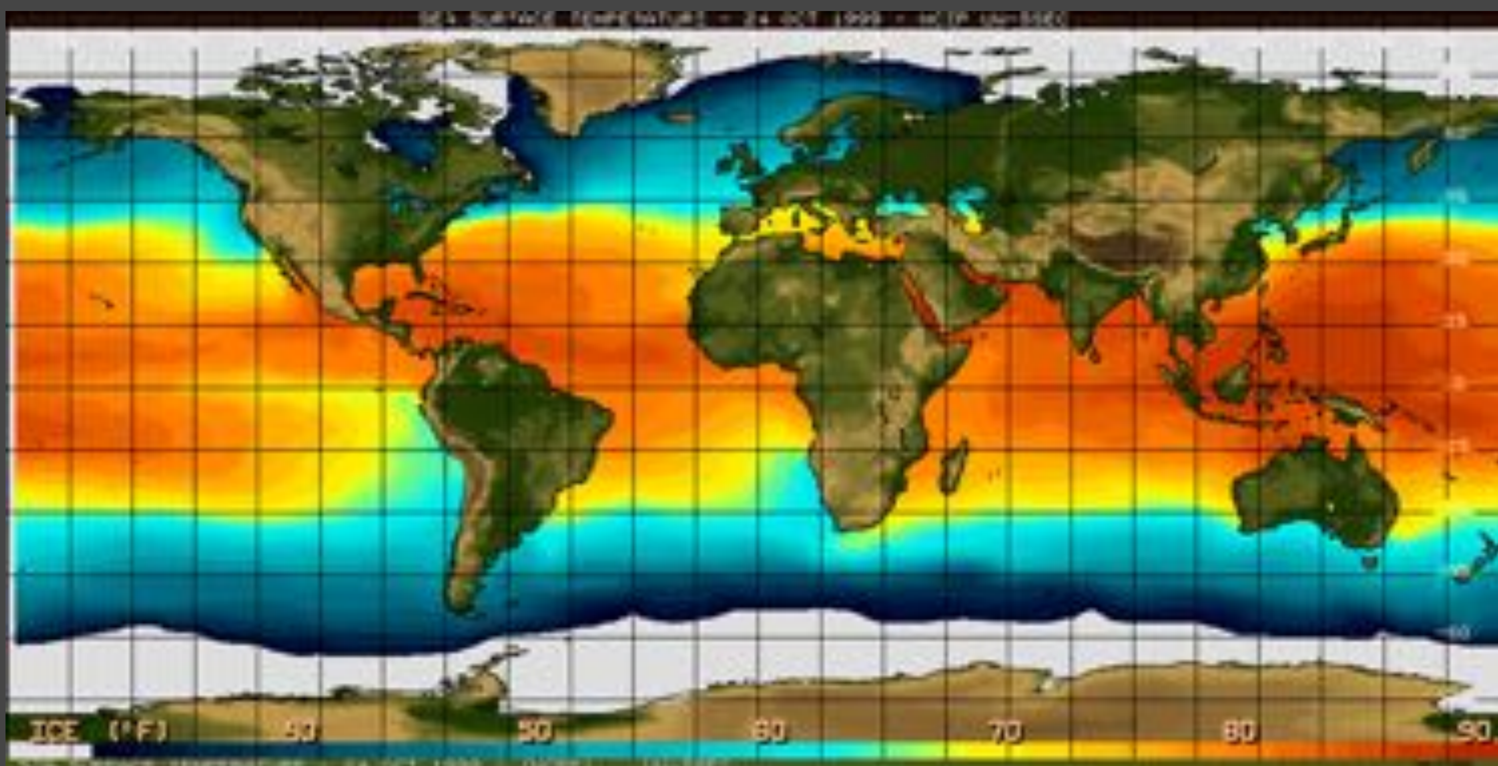
However the <u>physical nature of the substrate</u> (hard, smooth or irregular) is of fundamental importance. Each seaweed has preference for a type of substrate: solid rock, isolated blocks, boulders, gravels, sand or mud, animal or plant!



PHYSICAL FACTORS: TEMPERATURE

The average temperature of seawater and especially its minimum and maximum play and important role on the geographical distribution of seaweeds

In tropical areas this range is very small (2-3^{o}C); however in temperate areas such as the Atlantic coast from Cape Hatteras to Newfoundland, this range is wider (18^{o}C)



These variations can induce a migration from one level towards another:

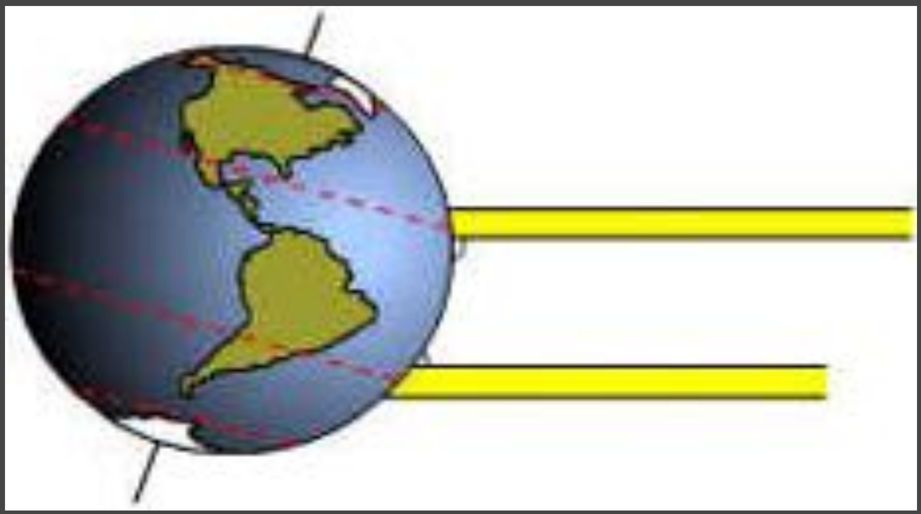
Some Mediterranean algae found in winter in higher levels, are found in summer at lower levels

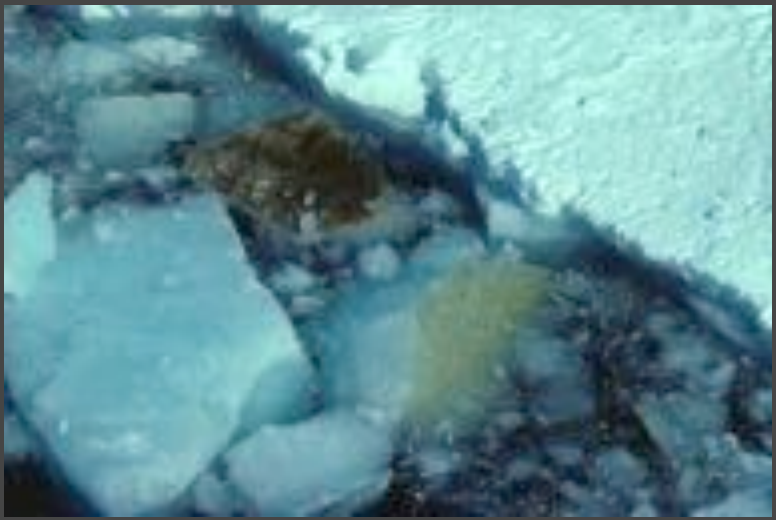
In Swedish seas, the low winter temperatures of the surface prevents the upward extension of certain seaweeds, which again reappear at much higher levels in summer

PHYSICAL FACTORS: LIGHT

Weak intensities such as those in polar areas can eliminate some species living in lower latitudes

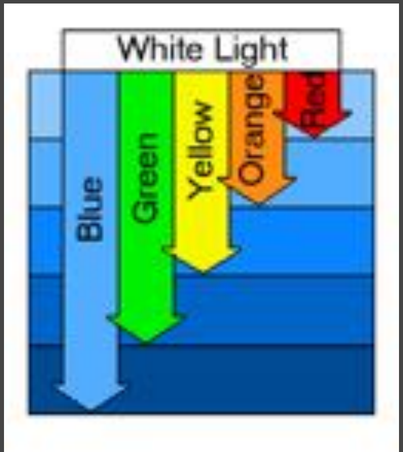
Most of the Nordic species are less limited by light extending more south (or to the north in austral hemisphere), if the intensity becomes stronger these seaweeds can find refuge into less lighted depths

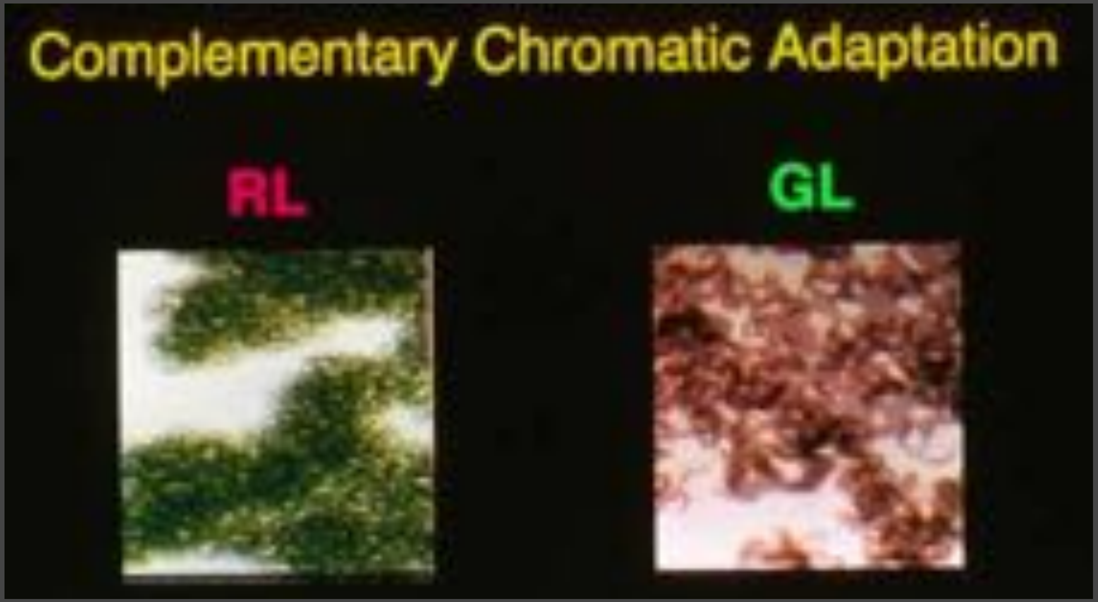




As with the phytoplankton, the qualitative and quantitative absorption of light by the water column has an important effect on the vertical distribution of seaweeds (chromatic adaptation)

This adaptation is not dependent on the taxonomic group since there are both red and green algae growing both in full sunlight and very weak light at great depths





PHYSICAL FACTORS: PRESSURE

The pressure increase with the depth, however this has almost no effect on seaweeds, except those algae with pneumatocysts

Water pressure can, at high tide for example, squeeze the pneumatocysts and the oxygen accumulated in the bladders and utilized by the plant during the night can escape

CHEMICAL FACTORS: SALINITY

In marine waters this factor can impede the development of freshwater algae that arrive by rivers

Euryhaline seaweeds may survive some saline dissolution at the mouth of some rivers, especially *Ulva*, *Enteromorpha*, *Fucus*, and some Rhodophytes, in particular Ceramiales

Seaweeds from the intertidal are euryhalines, they are exposed to long emersions; at low tide and sun exposure the evaporation increase the salinity; during a rainfall the rain water dilute the seawater decreasing its salinity

This euryhaline capability of some seaweeds (*Enteromorpha*) is really tested in littoral pools where evaporation and rainfall have a pronounced effect in the salinity

CHEMICAL FACTORS: CHEMICAL SUBSTANCES

Since the chemical composition of the oceans is more or less constant these factor is not of great importance to seaweeds

The abundance of nitrogenous matter affect the algal vegetation permitting the lush development of different species, certain of which (*Prasiola*) are hardly ever found except at such favored stations

DYNAMIC FACTORS: WAVE ACTION

This factor has a primarily mechanical effect on seaweeds preventing the fixation of spores or the persistence of fragile algae on heavily battered rocks

On the other hand, at calm stations, the absence of turbulence permits the deposition of a more or less thick layer of sediment (mud) on the rocks. The mud is an obstacle to the development of certain algae but, favors other species

Turbulence acts indirectly modifying the physical and chemical qualities of the water and has a regulatory effect on the temperature. In calm stations, the superficial layers are hotter during summer excluding stenothermal species

Some species are restricted to violently battered rocks, a "surf-loving alga" is *Postelsia palmeaformis* (sea palm kelp)

DYNAMIC FACTORS: EMERSION

The shore area that is exposed during low tide and reflooded at high tide undergoes an alternation of emersion and submersion and its biological effect is manifested by the "zonation" of seaweeds living in this zone with oscillating tides

The conditions along the vertical of this area are not homogenous, all degrees can be found between the continuous immersion below the level of the low spring tides and the continuous emersion above the limits of the highest high tides

In between these extreme levels the duration of emersion determines the localization of different groups of seaweeds where each finds favorable conditions

However, algal zonation rarely coincide perfectly with tidal levels!

Orientation and inclination of the coast, turbulence of the water, humidity persistence of substrate, flora and fauna, all these factors interact with emersion to form characteristic algal zonation types

BIOLOGICAL EFFECTS OF EMERSION

Intertidal seaweeds are subjected to desiccation, depending on the duration of the emersion and the humidity of the air

Some species mitigate this desiccation by finding shelter under other larger species

For other species (*Fucus spiralis*) emersion is a necessity, they will die if continuously submerged

Certain species living at high levels can withstand emergence for a long time (15 days), such as *Bangia fuscopurpurea*

BIOLOGICAL FACTORS

***Succession*: In early stages, opportunistic species are common; more persistent species replace these opportunistic species later in succession**

Table 9.3 *Survival Strategies of Macroalgae*

	Opportunistic Forms	Late Successional Forms
Functional forms	Sheets and filaments	Jointed-calcareous and encrusting
Colonizing ability	Rapid	Slow
Growth	Rapid	Slow
Net primary production	High	Low
Thallus form	Simple	Differentiated
Area: Volume	High	Low
Resistance to physical stress	Low	High
Escape from herbivory	Temporal and spatial unpredictability; rapid growth	Reduced palatability, toughness, chemical defenses
Reproductive capacity	High	Low
Life cycle	Simple	Complex
Alternation	Isomorphic	Heteromorphic

Source: After Littler and Littler (1980).

Example: denuded rocks are populated rapidly by *Enteromorpha* which facilitates the later development of *Fucus* germlings that eventually eliminates the *Enteromorpha*

Epiphytes

Epiphytes often find on their host the protection against a rough sea or excessive illumination

But often is the host alga which benefits from protection provided by the epiphytes

However, excessive overload of epiphytes may facilitate the host alga being torn away by the waves

Sphacelaria* on *Sargassum

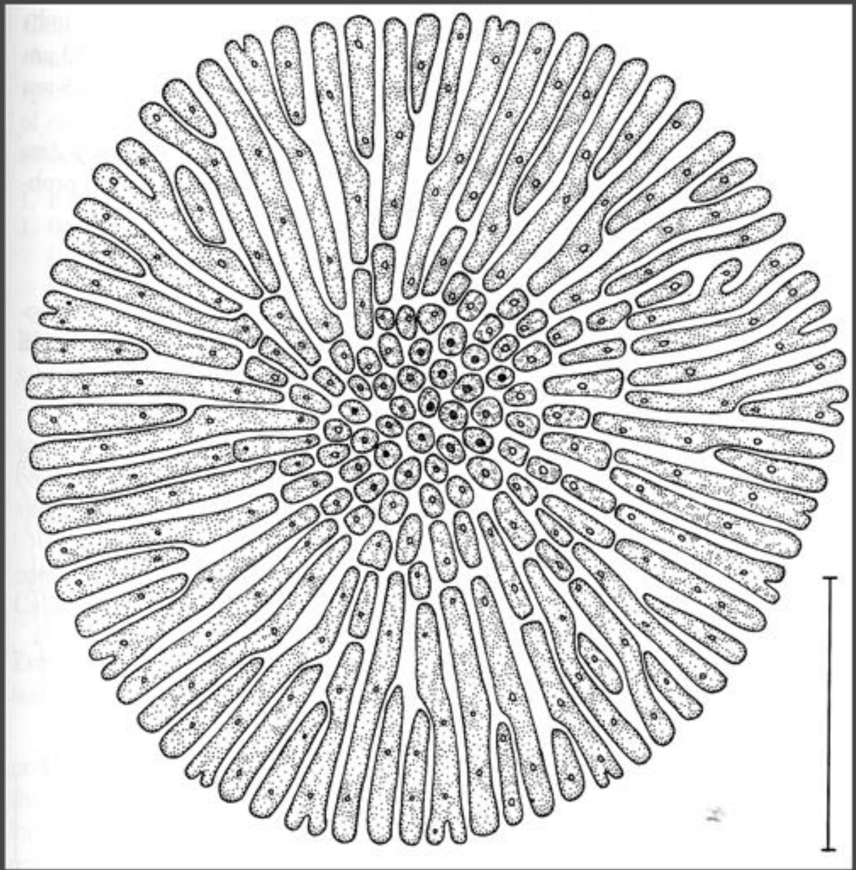
Morphological convergence

Many epiphytic algae belonging to different lineages exhibit the same form of thallus: a delicate disk-like form completely adnate to the host plant

Chlorophyta: *Ulvella*

Phaeophyceae: *Myrionema*

Rhodophyta: *Erythrocladia*



BIONOMIC DIVISIONS: Classification of different types of stations inhabited by marine algae

BELTS. An ensemble of stations in which the ecological conditions in respect to the level of the water are essentially the same:

1) **Supralittoral belt: Between the upper limit of the marine vegetation and the mean level of the high tide**

2) **Littoral belt: With a regular alternation of emersion and submersion**

3) **Infralittoral belt: Below the the mean level of the low tides**

FACIES. The nature of the substratum, and especially the size of the particles of unconsolidated material, permits the distinction of facies:

1. Rocky facie: Solid rock or isolated blocks
2. Unconsolidated facie: Sandy, gravel, mud

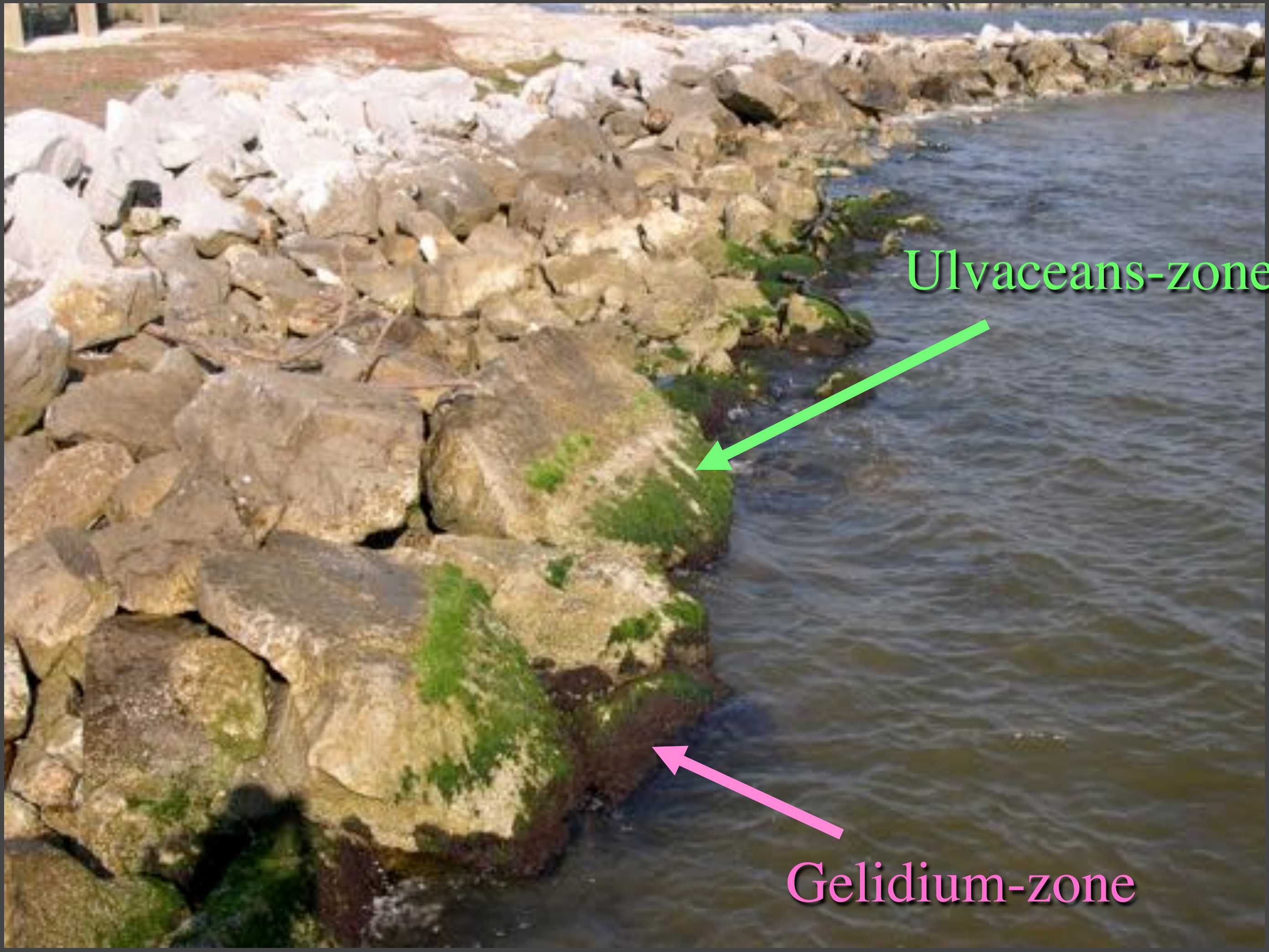
MODES. Variation in the composition of the water and its degree of turbulence:

1. Brackish
2. Saline
3. Exposed
4. Protected

ASSOCIATIONS

In any type of station defined according to its location in a belt, facies, or mode, the algal flora is in general composed of algae which, in a floristically homogenous region, are always the same and form an ecological unit generally called *Association*

ZONES. **Associations usually in the littoral belt often form conspicuous horizontal bands of variable height, continuing in general along the coast**

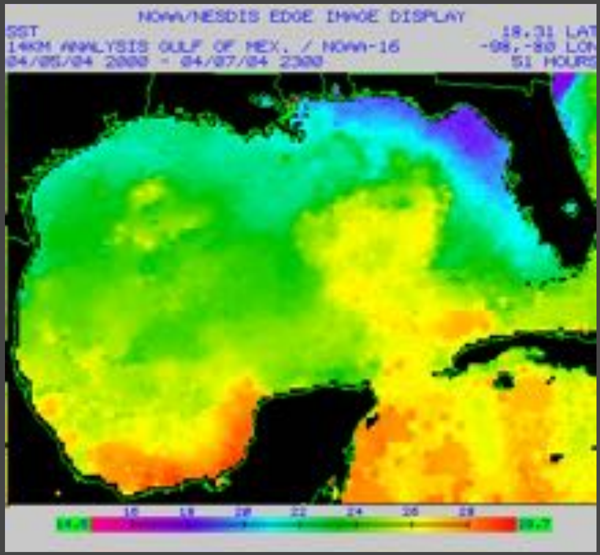


Bionomic Classification: Higher Littoral, Isolated Block, Saline, and Exposed

In the Gulf of Mexico the rocky facies of the exposed mode of the upper littoral region is occupied by an association characterized by the Ulvaceans *Enteromorpha and Ulva*

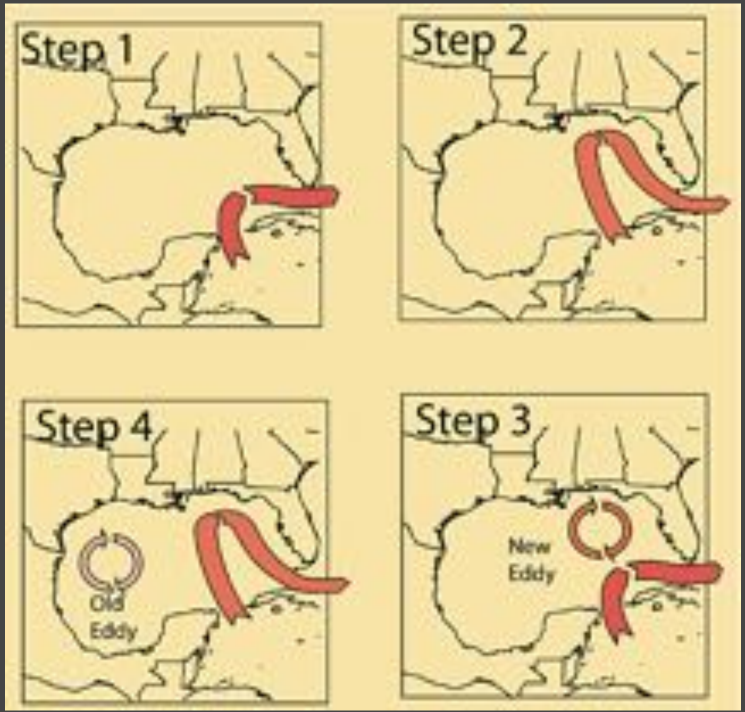
SEAWEEDS OF THE GULF OF MEXICO

The average surface water temperature in GOM from June-Sep is tropical 25-30^{o}C. During winter months, in the northern Gulf from Nov-March 13 to 15^{o}C (comparable to the average summer temps in New England)



Tides are diurnal (one high and one low each day) between 0.4-0.7m

Salinity: The incoming currents are 36.5 o/oo and decreases in the northern GOM



Surface currents: incoming between Yucatan and Cuba, outgoing between Cuba and Florida

Substrates: Hard substrates (rocks, jetties, coral reefs, natural outcrops, oyster beds, oil rigs, pilings, etc), Soft substrates (sand and mud), and living substrates (mangroves, saltmarshes, seagrasses)

Marine Plant Communities in the Gulf of Mexico

The GOM supports a rich and varied marine flora consisting of both angiosperms and algae

Three distinct algal communities are found in the GOM:

a) Litophytic
b) Sea Grass Beds
c) Mangrove swamps
d) Salt Marshes

Lithophytic algal communities in the Gulf of Mexico: Jetties

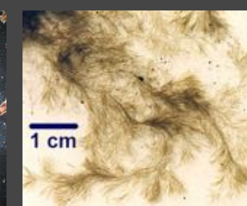
Jetties are common in the GOM and allow the grow of an algal flora otherwise devoid of seaweeds

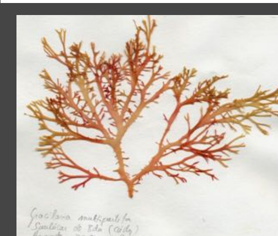
Vertical distribution:

The supralittoral zone is dominated by Cyanobacteria (*Lyngbya* and *Oscillatoria*) and pennate diatoms. *Bangia atropurpurea* and *Enteromorpha minima* were mixed on wave exposed rocks.

In the Littoral zone several species are found from top to bottom: *Enteromorpha spp., Cladophora dalmatica, Ulva lactuca, Gelidium sp., Ectocarpus spp., Gifforida spp.*

The sublittoral zone can be bared in northern locations but is abundant in seaweeds in the southern GOM: *Gracilaria spp., Botryocladia occidentalis, Halymenia agardhii and H. floresia, Caulerpa spp., Padina sp., and Codium, sp.*





Jetties

Correlation with wave exposure: In protected sites, *Enteromorpha linza and Bostrychia radicans* are common

Surf-loving algae are found in exposed rocks: *Cladophora dalmatica*, Ectocarpaceans and particularly *Chaetomorpha media*

The diversity usually is greatest at exposed sites (outer) related probably to salinity; and lowest in protected sites (inner) where the freshwater from the river flows to the sea

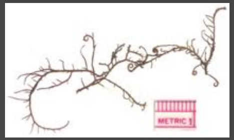
In general terms, the Rhodophyta is the dominant group in number of species followed by the Chlorophyta

The brown algae in tropical or subtropical regions is usually not dominant

Jetties

Seasonality: The composition of the algal communities usually changes during the year, especially in the northern GOM during winter



a) **Species present all year long: *Giffordia spp., Gelidium crinale, Gracilaria tikvahiae, Hypnea musciformis, and Grateloupia filicina***



b) **Species with maximum growth in summer-fall: *Ulva fasciata, Bryopsis spp., Padina vickersiae, Rhodymenia pseudopalmata, Centroceras clavulatum and Bryocladia cuspidata***

c) **Species with maximum growth in winter-spring: *Ulothrix flacca, Enteromorpha spp., Ulva lactuca, Petalonia fascia, Bangia fuscopurpurea and Porphyra leucosticta***

The seasonality of the flora is reflecting its biogeographic affinity

Species growing all year long and with maximum growth during warmer months are the most abundant in the GOM and have a floristic affinity with the tropical Caribbean

Species of colder months, especially *Porphyra* and *Petalonia*, are cold temperate algae. They occur from Maine to Northern Florida. These species persist the rest of the year as a cryptic phase

Disjunct distribution

Some species are not continuous in their geographic distribution

***Petalonia fascia* and *Porphyra leucosticata* represent *relict* distributions**

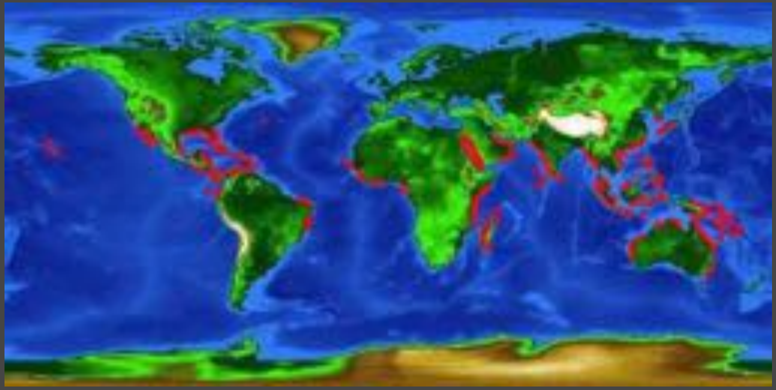
Their distribution was continuous in the past (representing a cold temperate flora) along the Atlantic coast during Pleistocene

After the last Ice Age the populations were separated when water temperatures arose, the water level fall, and the Florida peninsula emerged

Mangrove Swamps

This forest-swamps are dominated by trees: *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove) and *Laguncularia racemosa* (white mangrove)

The aerial roots are populated by algae, in particular the *Bostrychia-Caloglossa* association



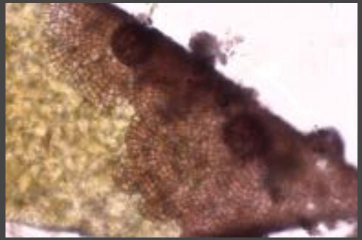
Seagrass Communities

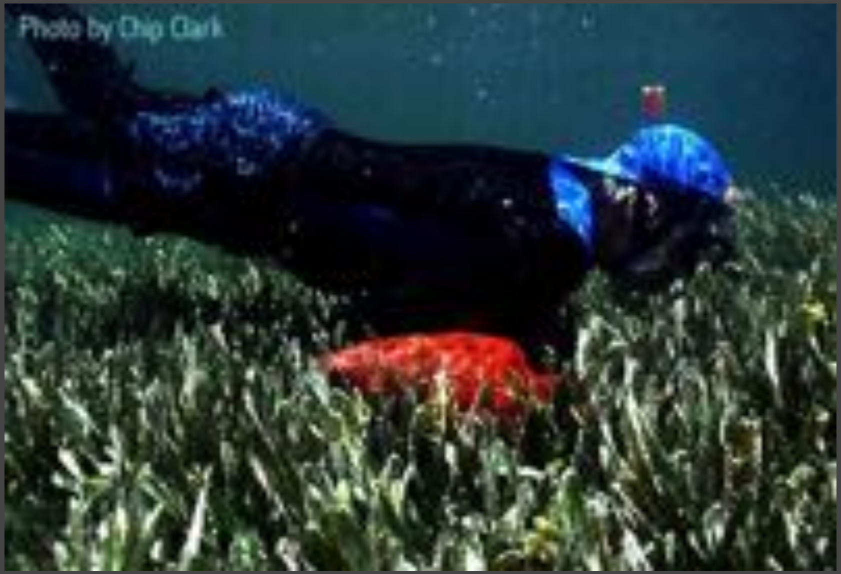
These monocots are not true grasses

They are important in the ecology of sublittoral communities

Thalassia (turtle grass), *Halophila*, *Diplanthera* (shoalgrass), *Ruppia* (ditch grass) and *Syringodium* (manatee grass) are common

Algal epiphytes are common on the leaves of seagrasses: *Champia, Lomentaria, Polysiphonia, Fosliella, Spyridia, Ectocarpus and Cladophora*



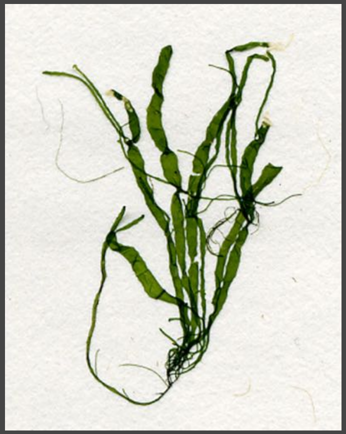


Salt Marsh Communities

Littoral zone communities with low wave energy (protected bays)

Salt marshes are dominant coastal vegetation north of Mobile Bay

Common angiosperms are: *Juncus* and *Spartina*



Algae found on plant stems are *Bostrychia*, *Catenella* and *Polysiphonia*. On the mud are common *Cladophora* and *Vaucheria*. On shells or limestone: *Bathophora* and *Enteromorpha*.

Coral Reefs

Coral reefs are usually found in the southern GOM

Coral reefs are among the most diverse and productive communities

They are found in the warm, clear, shallow waters

Through symbiosis with unicellular algae (zooxanthellae), reef-building corals are the source of primary production in reef communities

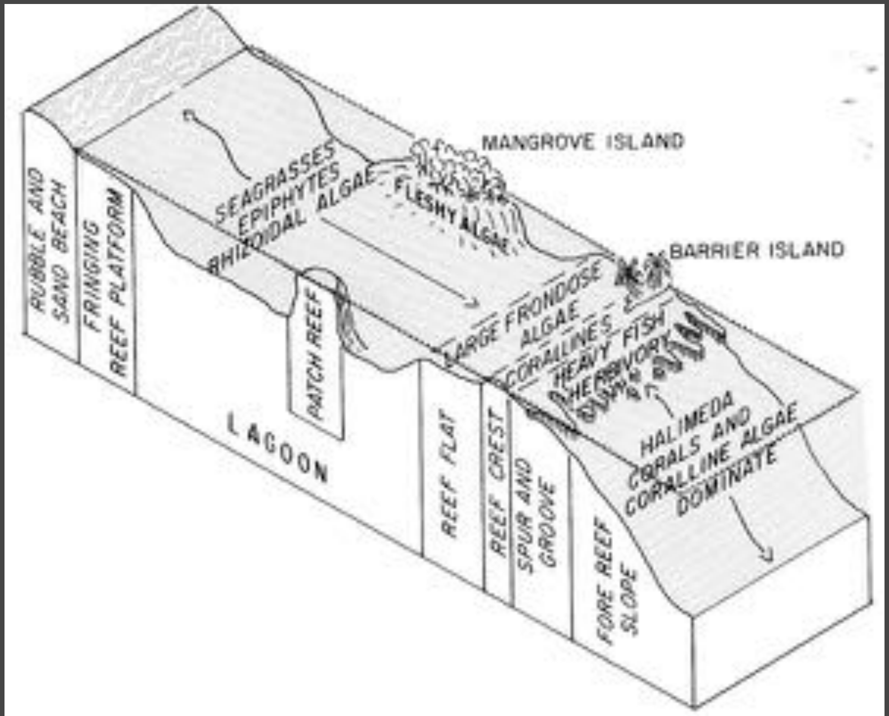


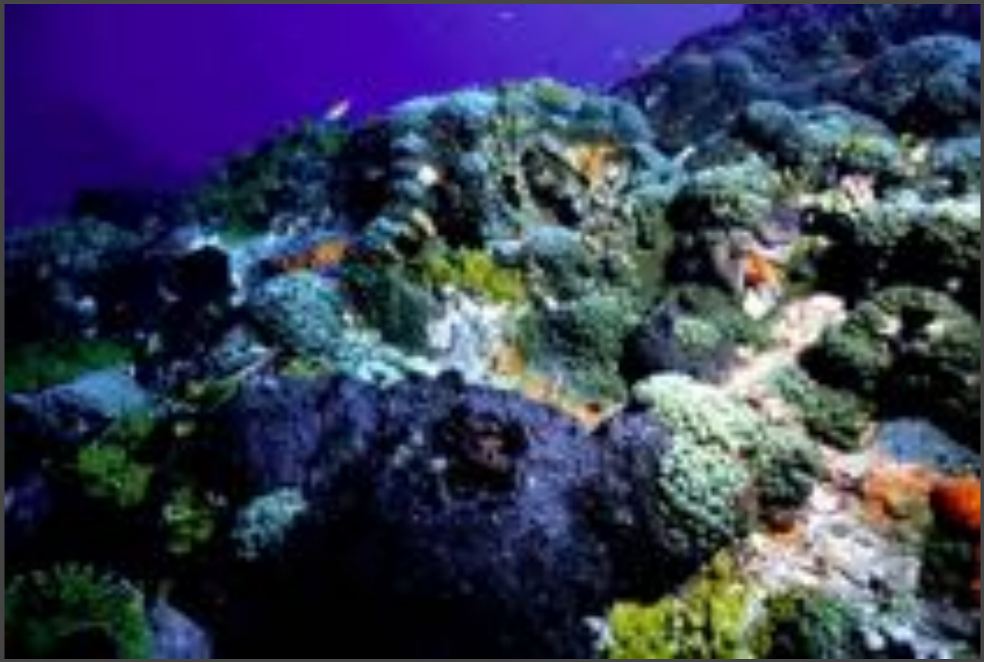
Figure 6. Sectional view through a tropical continental shelf containing characteristic reef and mangrove systems. Dominant plant types are indicated for the various habitats.

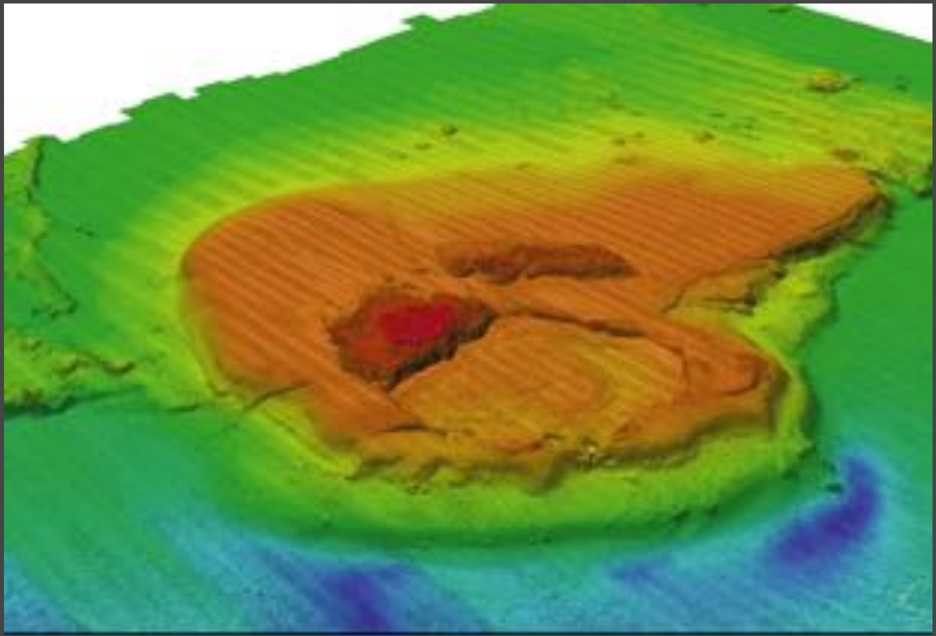
The most common red algae in coral reef environments are the calcareous coralline algae




Deep-water Hard banks

The Northwestern area of the GOM contains an extensive system of hard banks (50-80 m): Texas Flower Gardens, Stetson TX, and Sonnier LA Banks

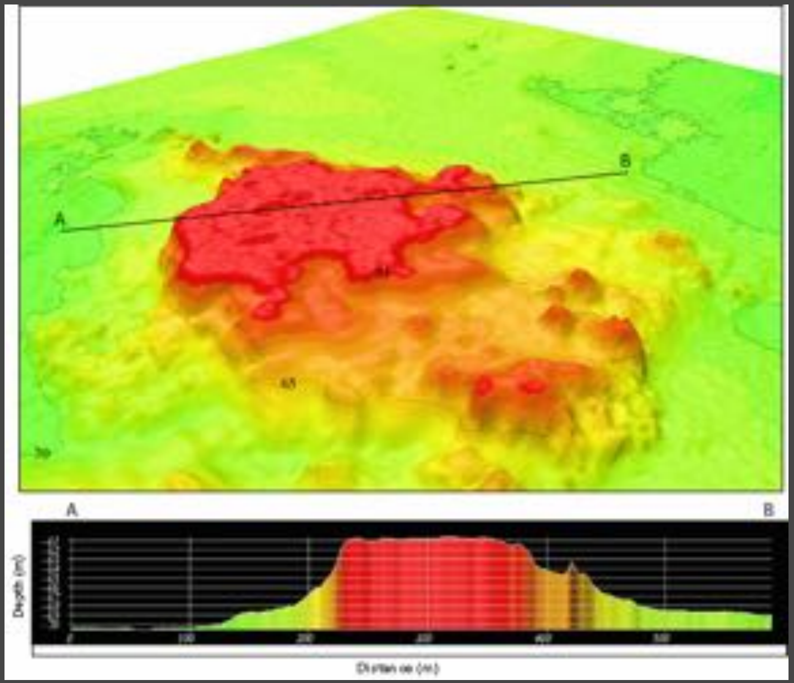


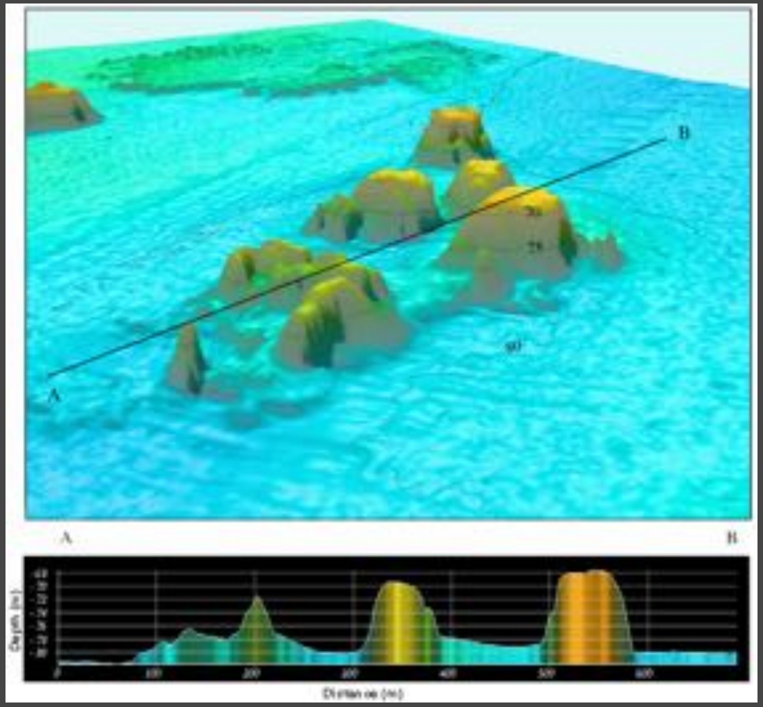


50 species of seaweeds were found recently

Pinnacles in Northern GOM

The Alabama "Alps"





An extensive deep (~100 m) reef tract occurs on the Mississippi-Alabama outer continental shelf

Algae unknown!!! ***Terra Incognita***

Artificial Reefs

- Oil and gas platforms
- Largest steel archipelago in the world (4,000 platforms)
- Provide substratum for algae and others

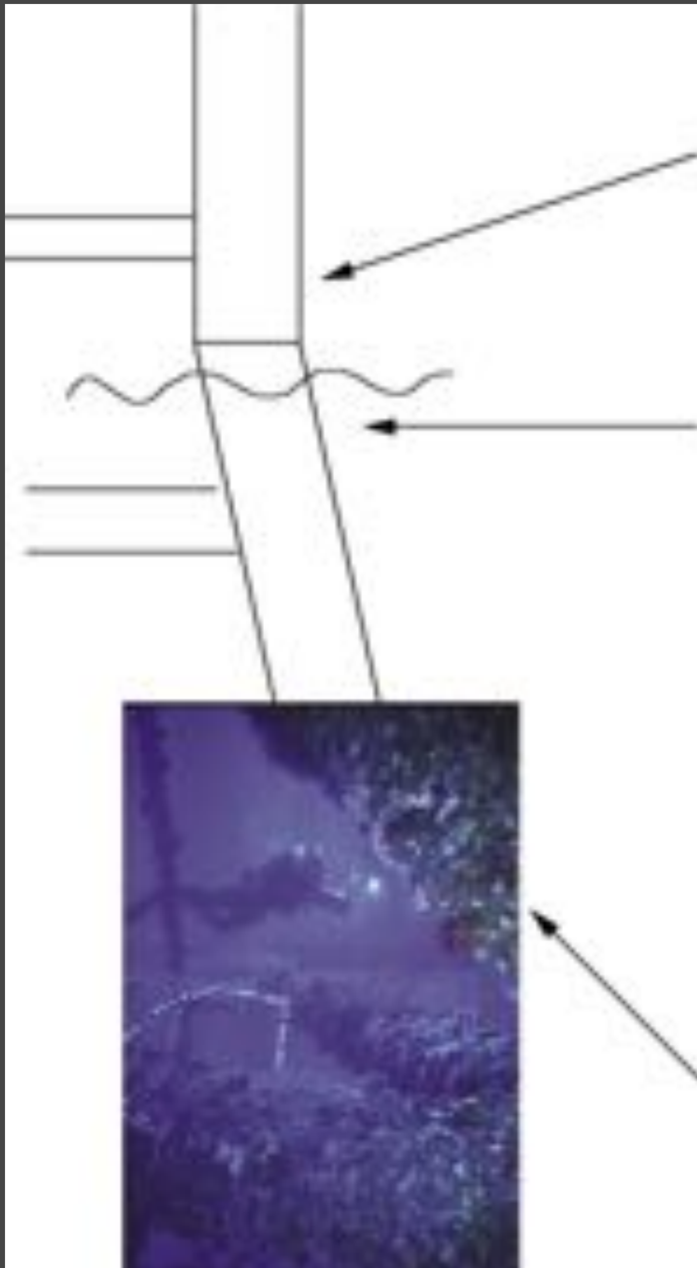
Grand Isle 42C

- Biodiversity And Distribution:

  Increased from nearshore to offshore

  Decreased from intertidal to bottom

Vertical Distribution of Algae



Representative Species:

Above Intertidal

Enteromorpha spp.
Ulva fasciata

Low Intertidal to Shallow Intertidal

Chaetomorpha aerea

Cladophora sp.

Kuetzingiella elachistaeformis

Gelidium pusillum and epiphytes

Antithamnionella breviramosa

Herposiphonia secunda f. tenella

Centroceras clavulatum

10m Below Mean Low Water

Oscillatoria acuminata

Jania capillacea

Bryopsis pennata

Algae of the GOM

Dinoflagellates	644
Diatoms	948
Cyanobacteria	78
Phaeophyceae	86
Chlorophyta	195
Rhodophyta	392
TOTAL:	2,343

2009 Felder & Camp

Plan for your future

- Plan A, B, C and D
- Organize, organize and organize
- Prioritize, prioritize and prioritize
- Interact with faculty
- Letters of recommendation
- Graduate school is a great option too
- GRE
- Enjoy what you do and be good at it
- Follow your own ideas but take suggestions
- Plan for the best but prepare for the worst
- Any questions?