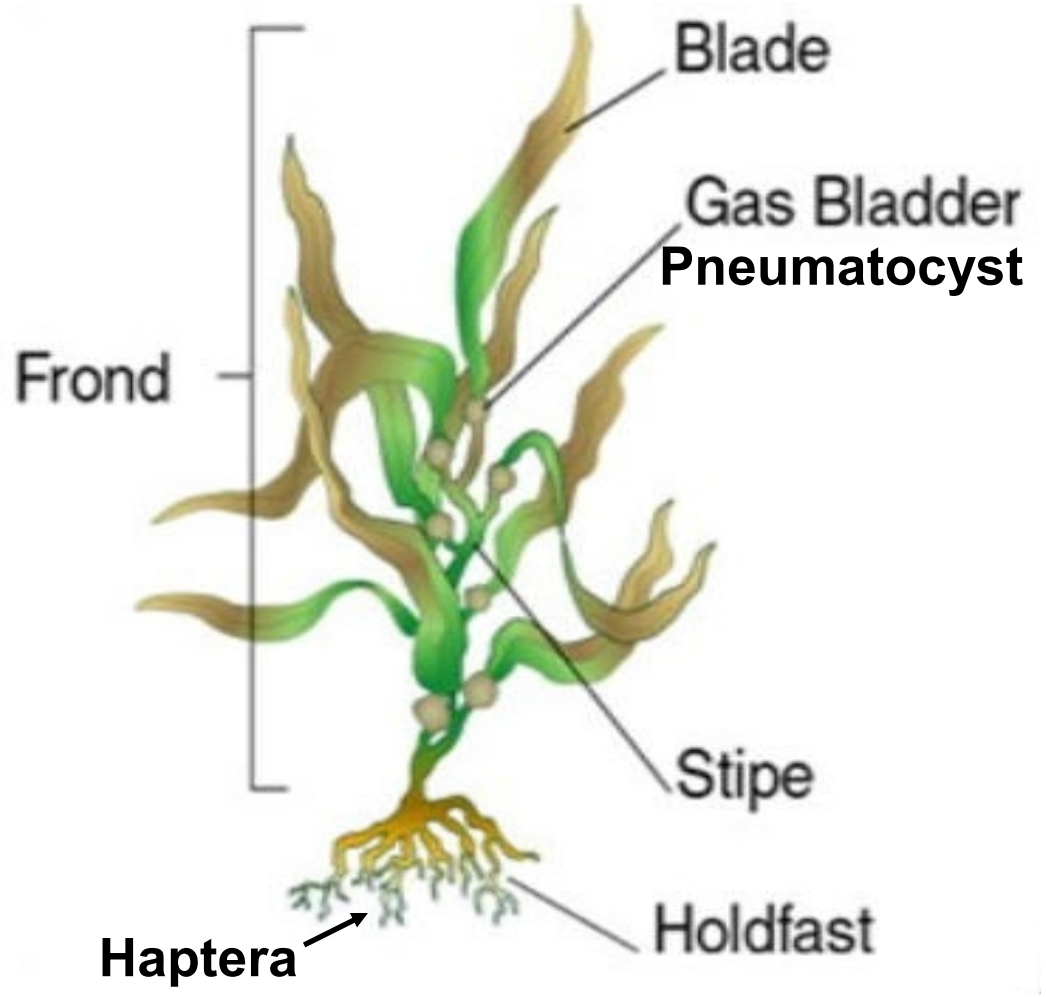
Kelp Forests

Original Powerpoint by Feryal Jamal Kherissat.

Additional slides, text, and graphics added by Tom Clauset for 6th Grade marine biology unit on Kelp Forests of Southern California.

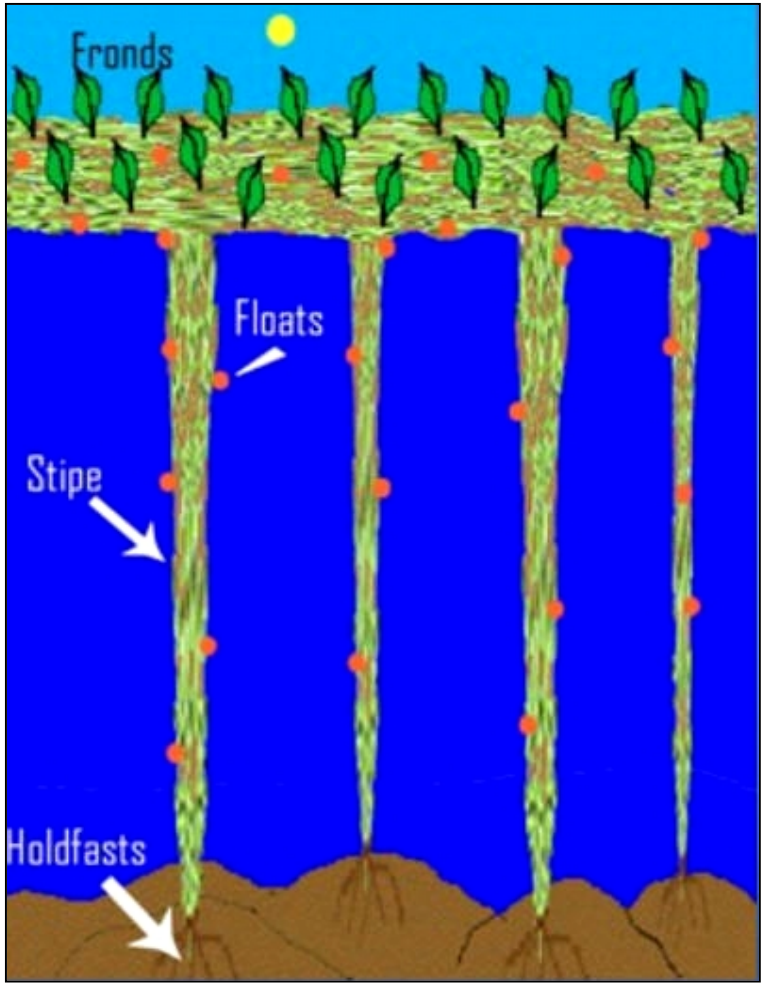
Anatomy



- blade – leaf-like structure
- stipe – stem-like structure
- pneumatocyst – gas bladder filled with N_2 and O_2 and 10% CO
- frond – part of algae above holdfast
- holdfast - part which holds plant to ocean floor. It is NOT a root!
- haptera – branches on the holdfast

Structure

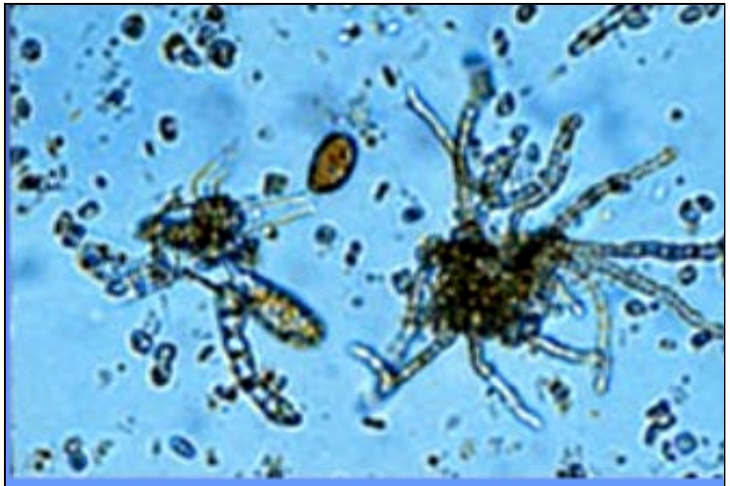
- A complex, strong holdfast anchors kelp to substrate.
- A flexible blade moves with the motion of the waves.
- Growth occurs between stipe & blade instead of at the blade tip, where erosion occurs.
- A hollow stipe offers some buoyancy to the kelp structure.



Reproduction

- Special blades called "sporophylls" close to the holdfast produce billions of algae spores.

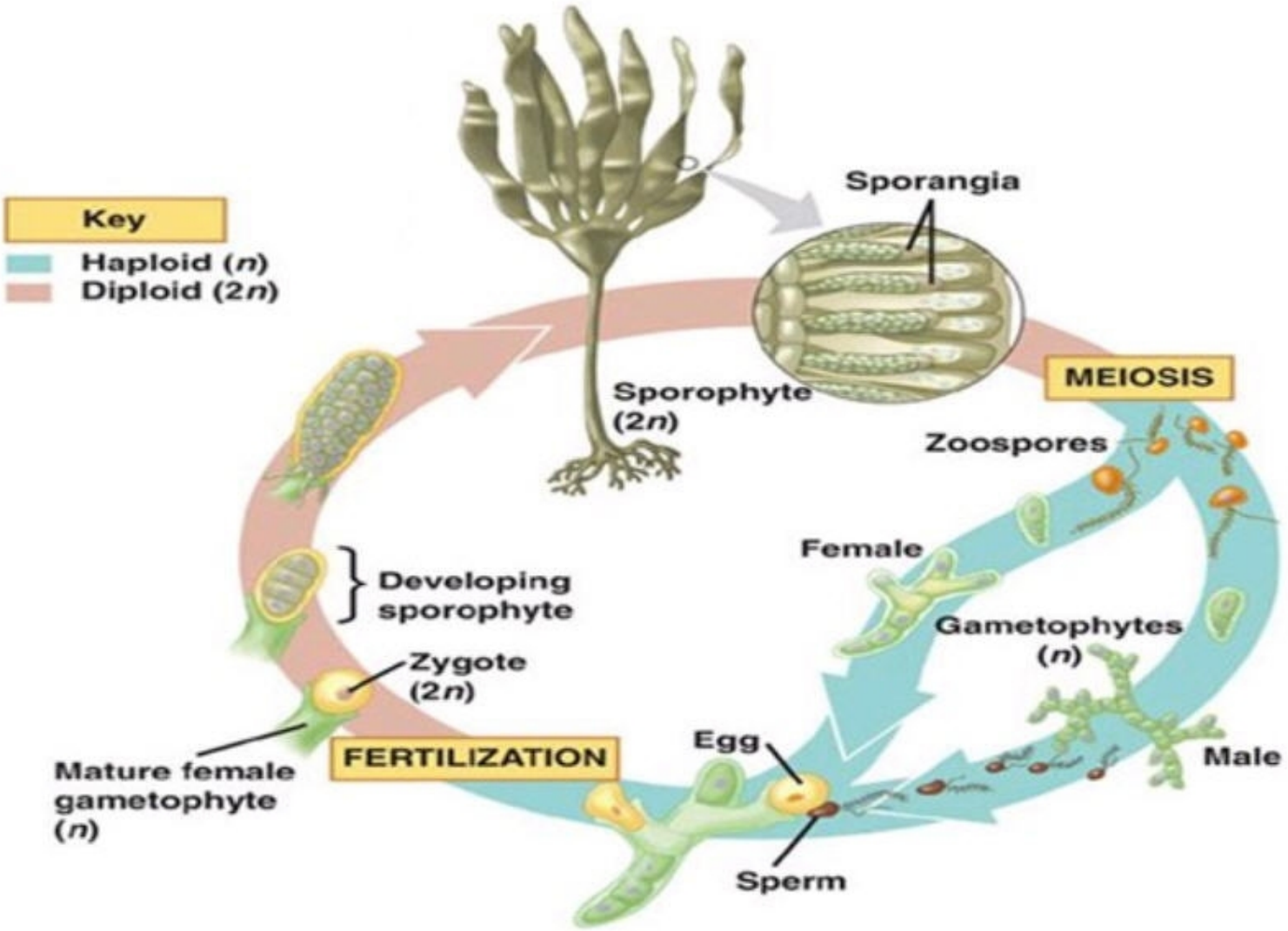
- These spores are released into the water where they are fertilized & become tiny kelp.



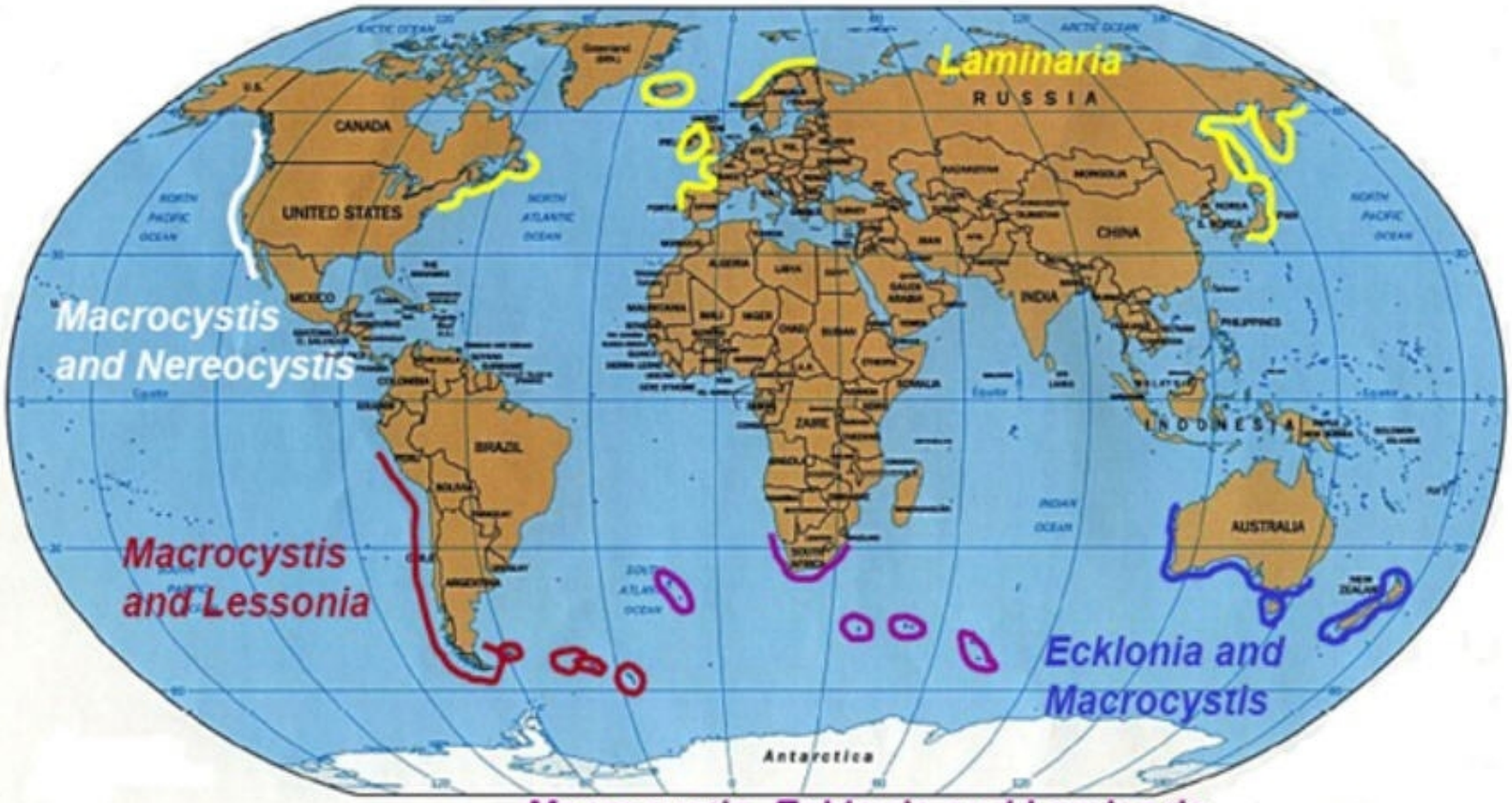
Microscopic gametophye, Giant Kelp

Microscopic sporophyte, Giant Kelp

Life Cycle of a typical kelp – Laminaria sp

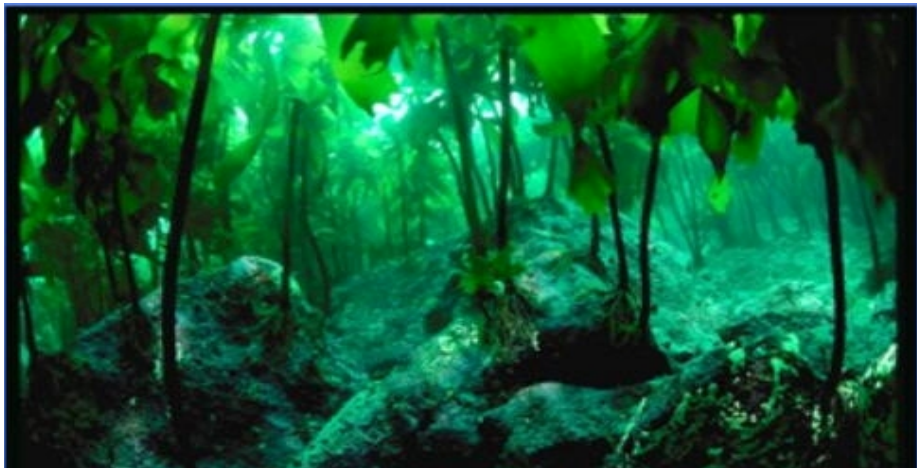


Kelp Forest Distribution



Kelp Depends on…

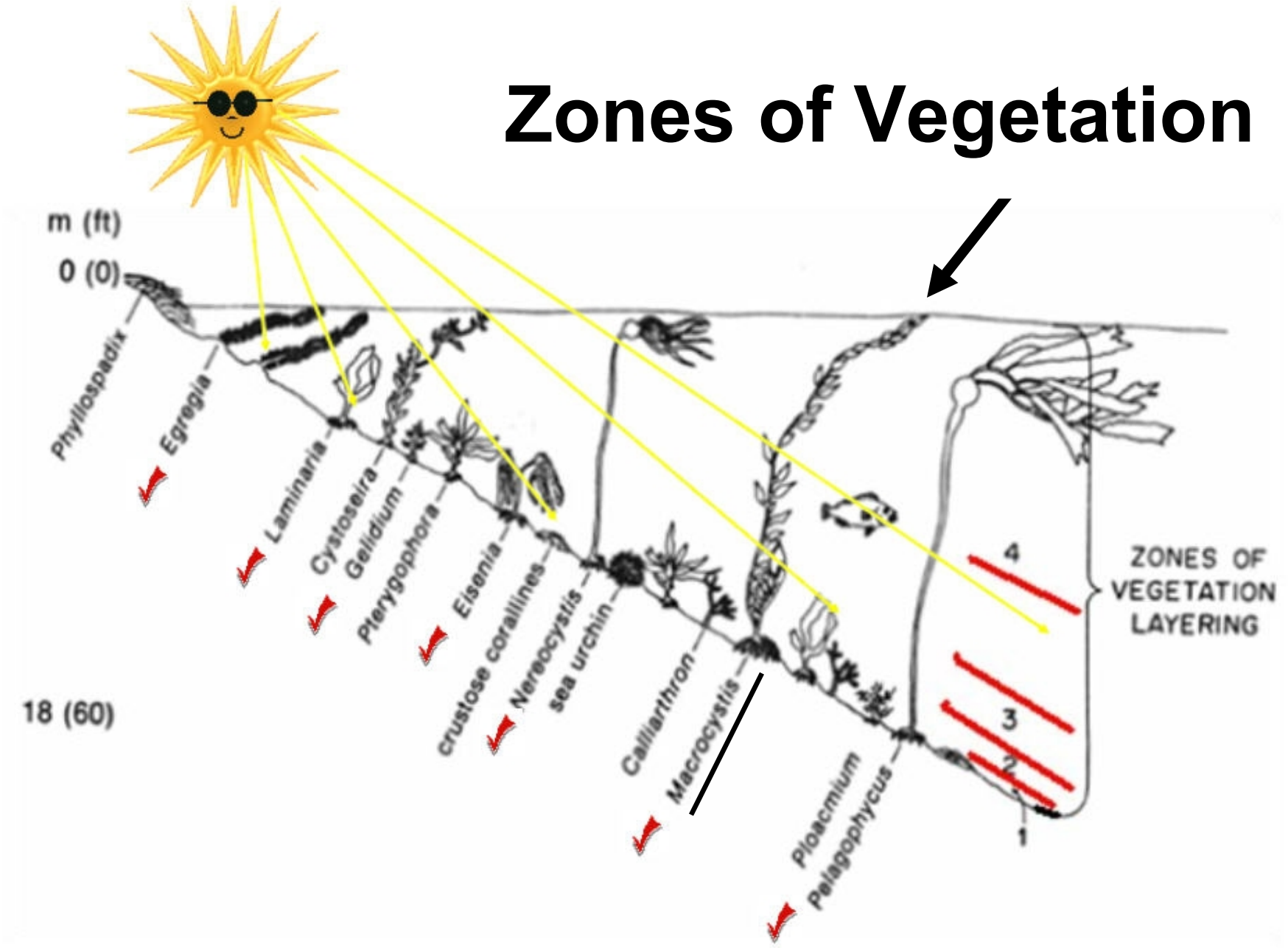
- Hard substrate
- Enough Light (Clear water)
- Cool temperatures
- Nutrients from ocean up-welling (particularly nitrates & phosphates)



Growth and Translocation

- Kelps translocate (move) photosynthesis from the areas of the blade exposed to light to areas that need energy for growth or other activities.
- Translocation allows for blades to be very large to maximize photosynthesis.
- Kelps store energy which can be used in dark periods to construct new blades in anticipation of the return of light.

Zones of Vegetation



Kelp Productivity

- Kelp are among the fastest growing plants in the world in either marine or terrestrial habitats.
- Maximum growth in Macrocystis Pyrifera is 12-18 inches per day. Kelp is a type of brown algae (phylum phaeophyta). Other types of algae are green (phylum chlorophyta) and red (phylum rodophyta).
- Kelp forests, along with coral reefs, are among the most productive communities in the world.

Drift Kelp

- Kelp that has been ripped off its moorings will sometimes gather into what is known as drift kelp.

- This kelp floats and drifts with the currents. Under the right circumstances, it can re-anchor itself in a new area.

Detritus

- The apex (end) of the kelp blade is the oldest part of the blade.
- The apex continuously erodes away releasing large quantities of organic detritus as well as dissolved organic compounds.
- Kelp detritus contributes greatly to the ocean food web.

Charles Darwin

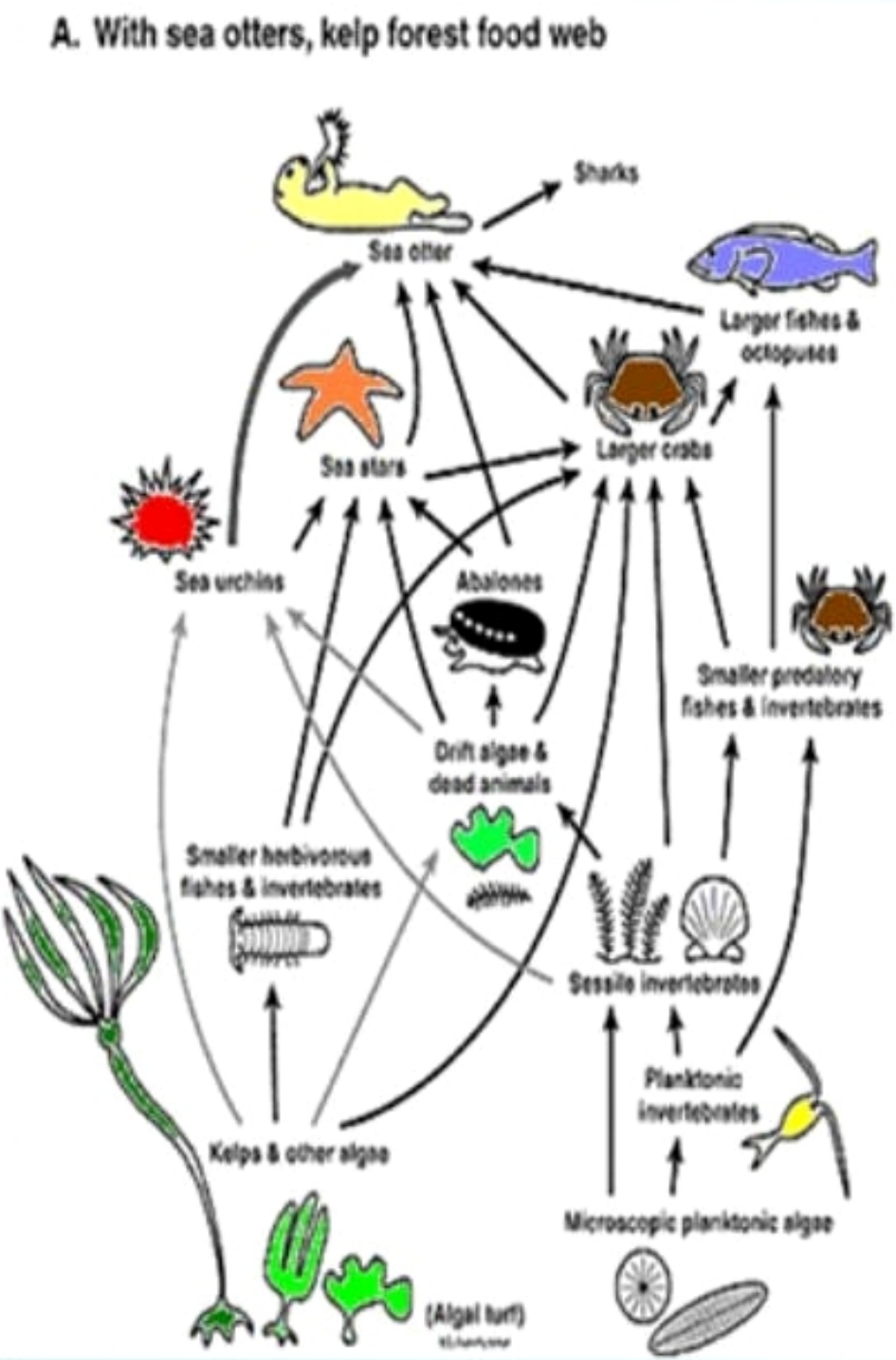
1860 -- The Voyage of the Beagle

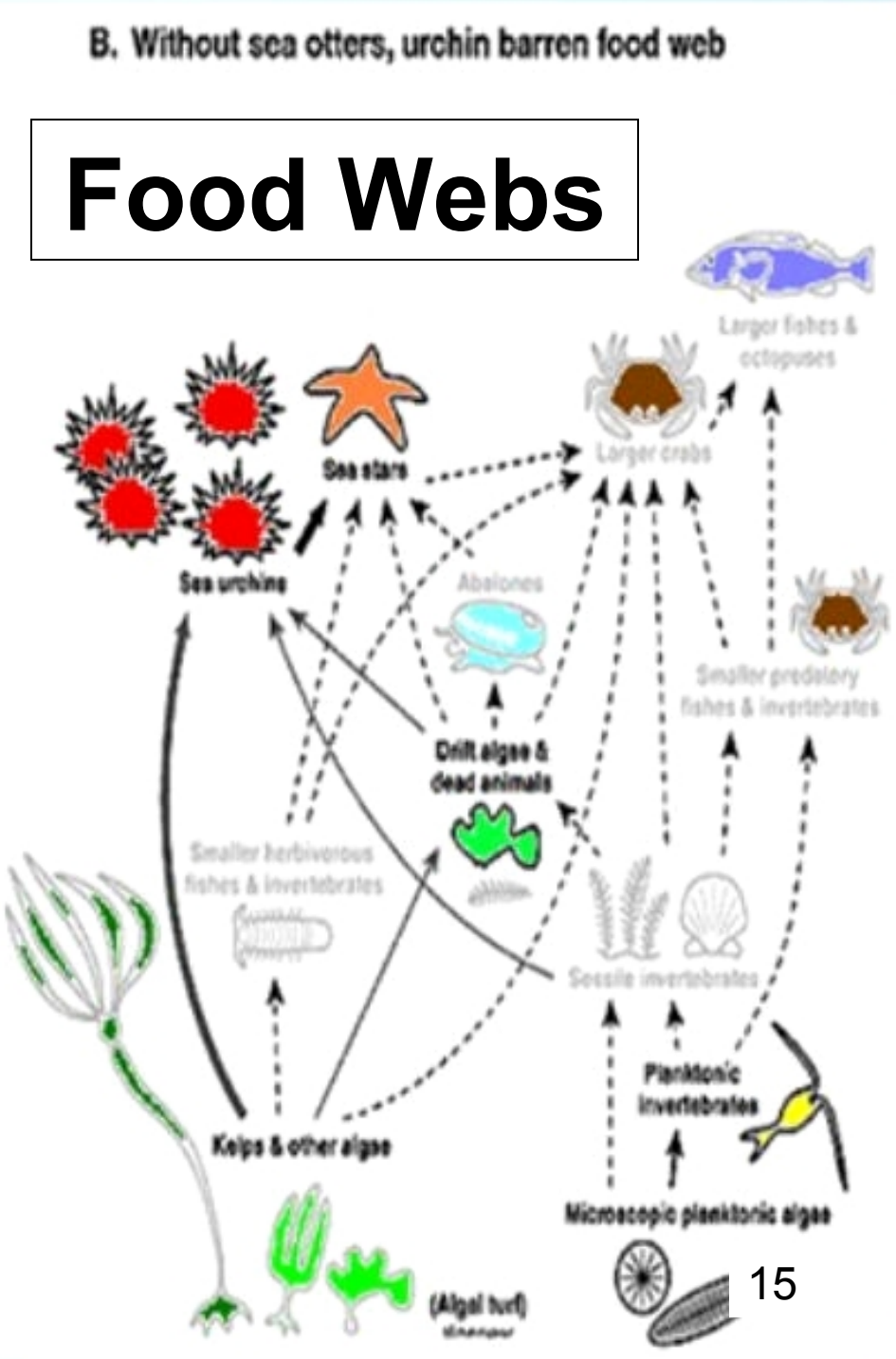
"The numbers of living creatures of all Orders whose existence intimately depends on kelp is wonderful… I can only compare these great aquatic forests with the terrestrial ones in the inter tropical regions. Yet if in any country a forest was destroyed, I do not believe nearly so many species of animals would perish as would here from the destruction of kelp."

Kelp as a Nursery

- Kelp slow down waves and currents (rock lobsters, abalone, snapper, & wrasses like this…)
- The shade provides areas of growth for delicate red and pink algae
- Kelp provides food for a range of grazing animals (snails).
- Spaces between kelp are filled with non-moving animals (sponges & sea squirts)
- Blades & stipe provide anchors for small creatures which in turn can be eaten by grazing animals.

Food Webs


A. With sea otters, kelp forest food web
Sharks
Sea otter
Larger fishes & octopuses
Sea stars
Larger crabs
Sea urchins
Abalones
Smaller predatory fishes & invertebrates
Drift algae & dead animals
Smaller herbivorous fishes & invertebrates
Sessile invertebrates
Planktonic invertebrates
Kelps & other algae
Microscopic planktonic algae
(Algal turf)


B. Without sea otters, urchin barren food web
Larger fishes & octopuses
Sea stars
Larger crabs
Sea urchins
Abalones
Smaller predatory fishes & invertebrates
Drift algae & dead animals
Smaller herbivorous fishes & invertebrates
Sessile invertebrates
Planktonic invertebrates
Kelps & other algae
Microscopic planktonic algae
(Algal turf)

Kelp vs. Herbivores

- Gastropods (single-shelled molluscs) are less destructive than sea urchins.

•**Sea Urchins**, if left unchecked, will totally consume kelp beds. The result is called a sea urchin barren.

•In Nova Scotia over-fishing of lobsters caused an explosion of sea urchins, thus wiping out the kelp beds. In the early 1980's the sea urchin population died and kelp beds were able to re-establish themselves.

Kelp & Carnivores

A carnivore is a "predator" – it eats other animals.

- Fish: seahorses, sea dragons, wrasse, sharks, rays
- Molluscs: carnivorous snails such as the tulip snail, whelks, & cone shells
- Cephalopods: (mollluscs without a shell) cuttlefish and octopus
- Echinoderms: sea stars which feed on bivalves or encrusting filter feeders.

If all of the species listed above are "predators," what species would be the "prey?"

Kelp vs. Other Forest Types

FOREST TYPE	(dry kg / m2/ yr)	kg / m2)	/ m2)
Tropical rain forest	2.2	45	0.2
Tropical seasonal forest	1.6	35	0.5
Temperate evergreen forest	1.3	35	3.0
Temperate deciduous forest	1.2	30	2.0
Boreal forest	0.8	20	4.0
Giant kelp forest	2.2	0.35	0.015

Kelp Forest Habitats

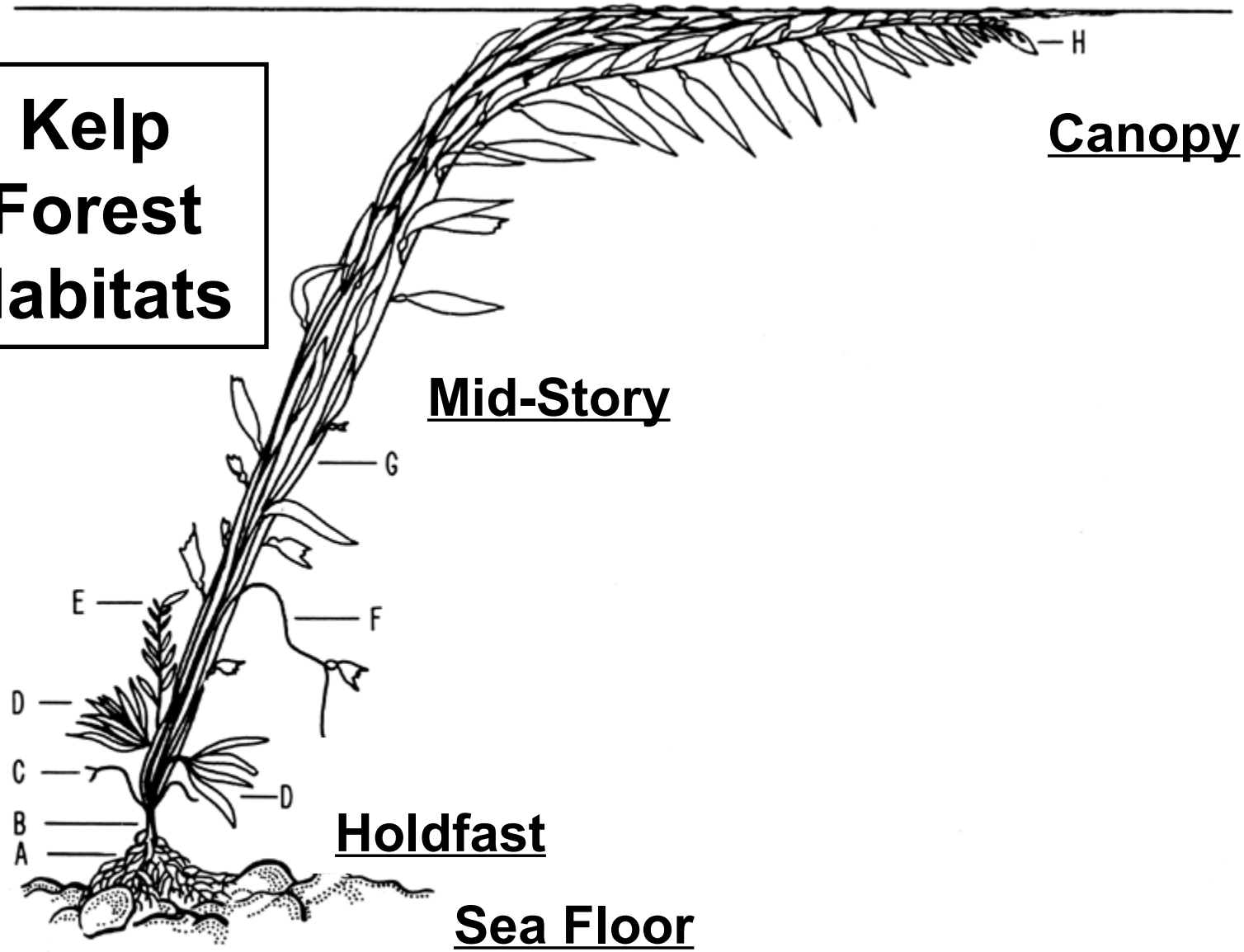


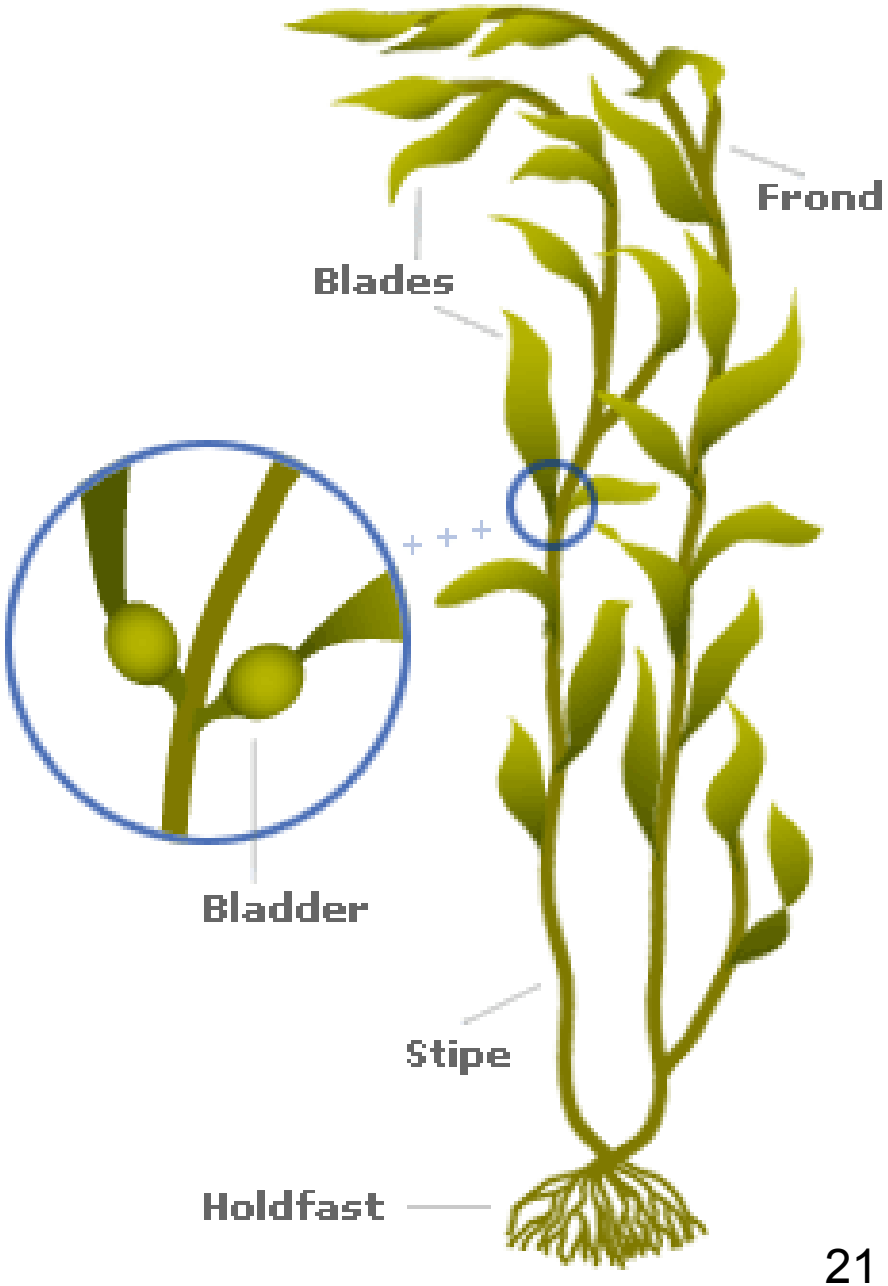
FIGURE 1. Diagram of a mature plant of the giant kelp, *Macrocystis pyrifera*, one to two years old, standing in 20 to 30 feet of water. A, holdfast; B, primary stipe; C, stub of an old frond; D, sporophyll clusters; E, juvenile frond; F, senile frond; G, stipe bundle; H, apical blade of mature frond, giving rise to additional blades.

Canopy

- Isopods
- Seastars
- Sea urchins
- Sea snails
- Bryozoans
- Wrasse
- Bridled Leatherjacket
- Butterfly Perch
- Weedy Sea Dragon

Mid-Story

- Octopus
- Cuttlefish
- Seahorses
- Fish
- Jellyfish
- Crustaceans
- Fish larvae
- Nudibrachs



Holdfast

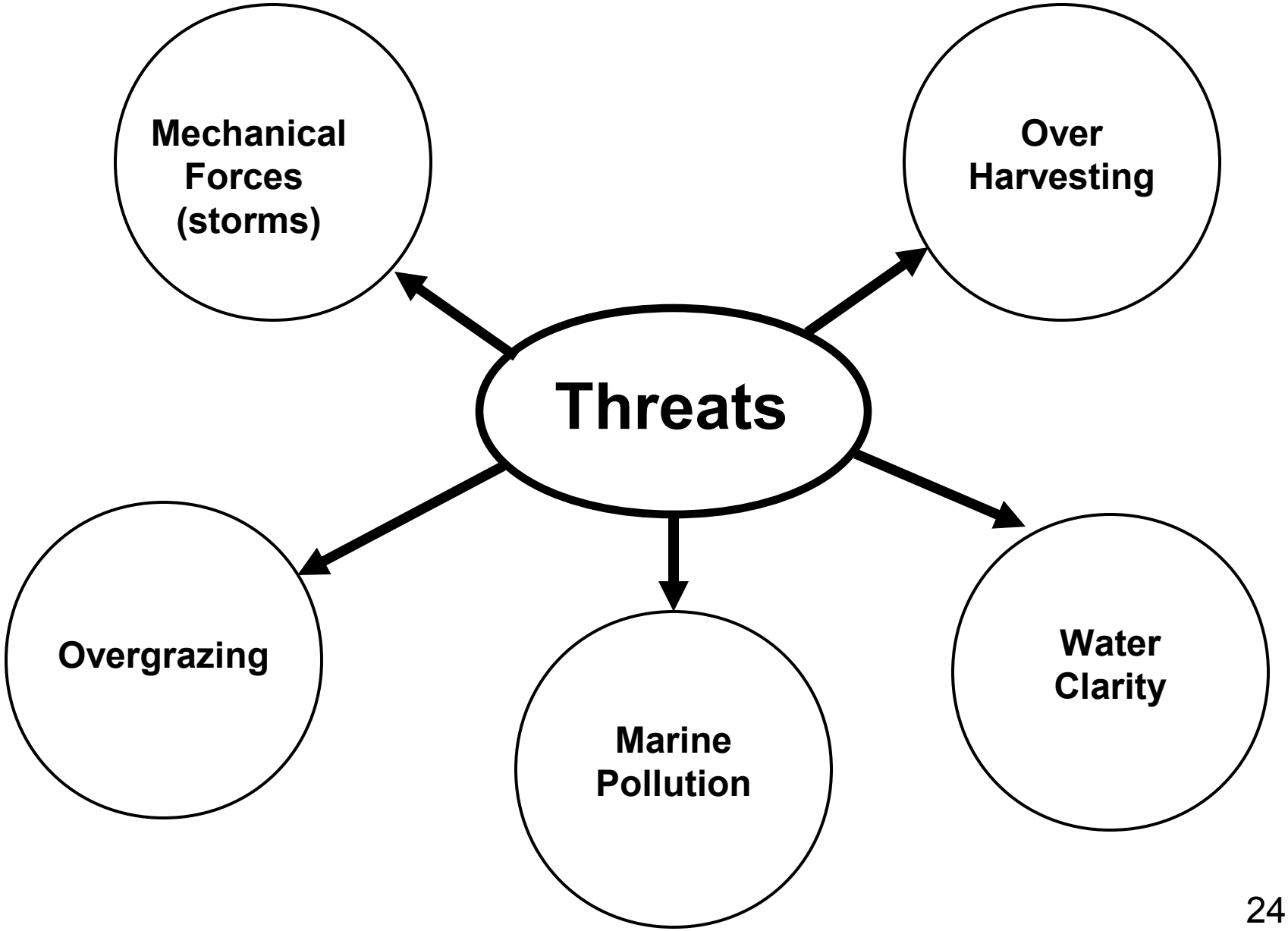
- Isopods
- Amphipods
- Crabs
- Sea urchins
- Polychaetes (worms)
- Brittle stars
- Eels
- Hydroids
- Bryozoans
- Molluscs
- sponges

4,600 individuals (from 9 invertebrate phyla) have been recorded living in one giant kelp holdfast.

Sea Floor

- Sea urchins
- Sponges
- Tunicates
- Anemones
- Cup corals
- Coralline algae
- Feather star
- Sea stars
- Sea cucumber
- Spiny lobster
- Abalone
- Blackfish
- Snapper
- Striped trumpeter

Threats to Kelp Forests



Mechanical Forces (storms)

- When storms rip the stalked kelp from its position on the rocks, only a few will end up washed up on the beach.
- Most will roll around in a depression on the sea bottom as “tumble kelp.”
- Because the plants are “tumbled,” leaves get a little light and the whole bunch survives as a significant food source.

Overgrazing

- In healthy environments, the kelp is constantly grazed.
- Here we see the characteristic bite holes of the butterfish who lives mainly from kelp blades.
- The strategy of biting a round hole from the middle of the blade by doubling it and biting a half-circle, helps to preserve the food source.
- A bite on the side of the blade would weaken it considerably.

Sea Otters & Sea Urchins

Kelp Forests are "producers" and provide protection and habitat for sea otters, a keystone species.

Sea urchins are "herbivores" and act as "consumers"

feeding on kelp.

Sea otters are "carnivores" feeding on sea urchins.

Marine Pollution & Water Quality

- Kelp is susceptible to eutrophication.

- Kelp deteriorates in the presence of organic enrichment in the form of sewage and fertilizers.

- Dredging, erosion, and industrial wastes also degrade kelp beds becauses suspended sediments cut down on sunlight needed for kelp photosysnthesis.

Water Clarity

Murky water causes kelp death. The lower blades are starved of light first. This kelp forest is symptomatic of habitat degradation.

- A severe plankton bloom lasting over 6 weeks caused visibility to drop to 4 m.
- The next year a similar disaster happened & it took the kelp beds 6 years before the kelp canopy was restored.

Kelp Harvesting & Fisheries

- Aqua culture relies on kelp as a food source for lobster, rock fish, and abalone.

- Humans also harvest kelp directly to extract alginic acid used to make products like toothpaste and antacids.

Kelp Forest Vocabulary #1

- canopy
- blade
- frond
- stipe
- pneumatocyst
- holdfast
- haptera
- substrate
- spores
- sporophylls

Kelp Forest Vocabulary #2

- drift kelp
- upwelling
- nitrates & phosphates
- translocation
- Macrocystis Pyrifera
- phylum phaeophyta
- photosynthesis
- apex
- food web
- mollusc
- Charles Darwin
- Nursery (5 ways)
- 5 threats to kelp
- sea urchin barrens

Kelp Forest Vocabulary #3

- gastropods
- echinoderms
- producer
- consumer
- herbivore
- carnivore
- decomposer
- tumble kelp
- eutrophication
- suspended sediments
- plankton blooms
- algin

Kelp Forest Vocabulary #4

- predator
- prey
- keystone species
- growth rate of giant kelp
- detritus
- 4 habitats in a giant kelp forest
- list 5 kelp CANOPY species
- list 5 kelp MID-STORY species
- list 5 kelp HOLDFAST species
- list 5 kelp SEA FLOOR species