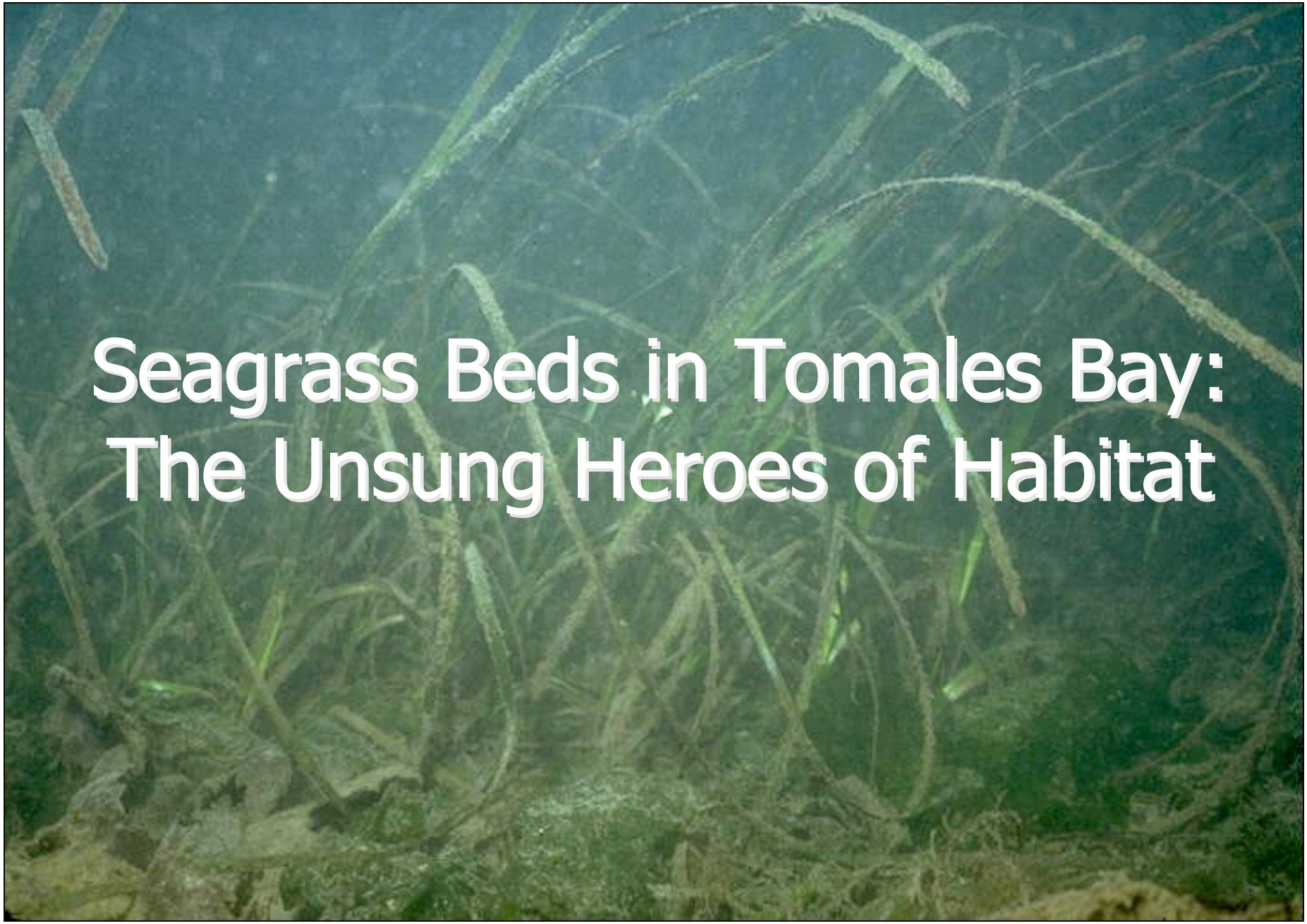
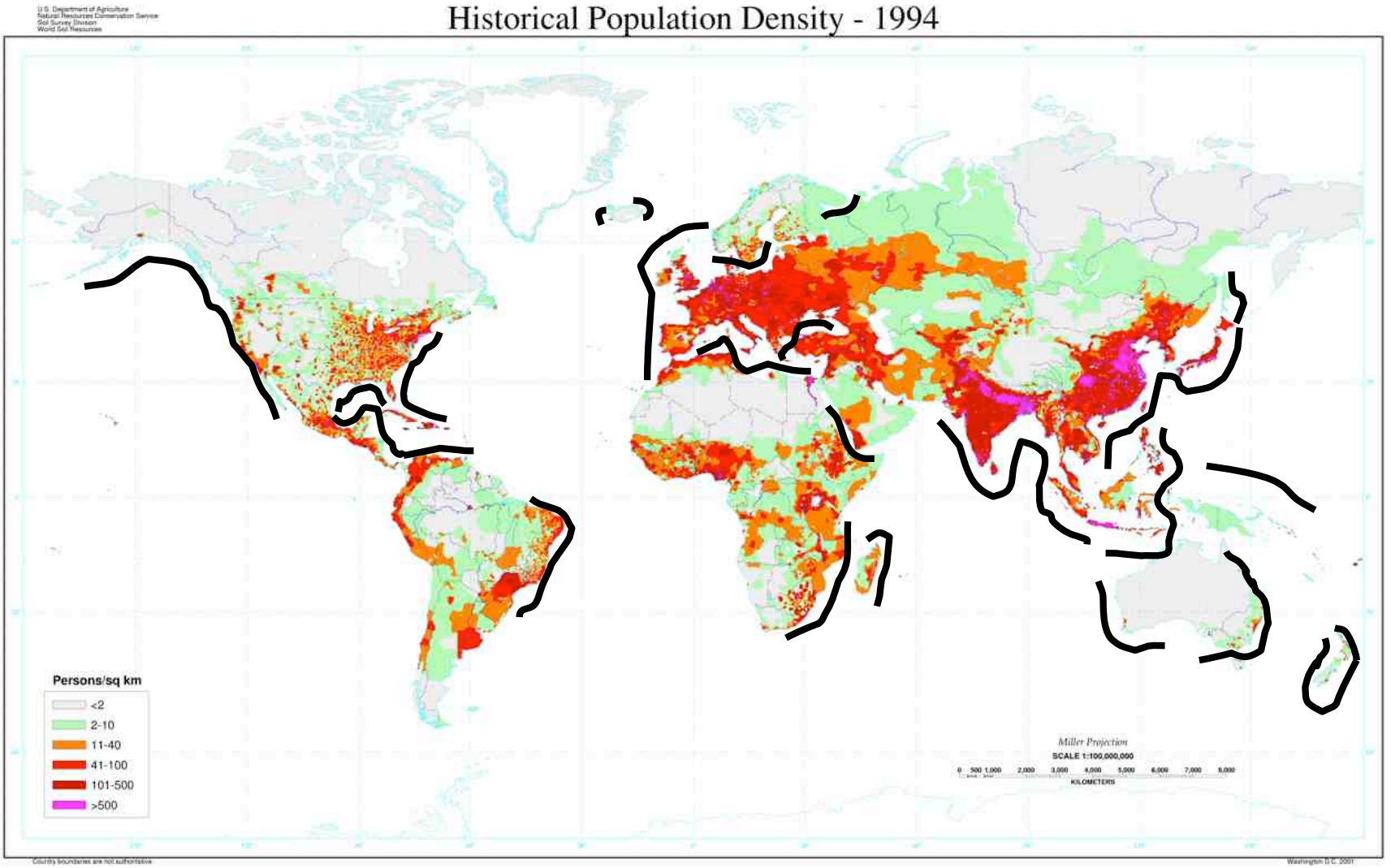

Seagrass Beds in Tomales Bay:
The Unsung Heroes of Habitat

Seagrasses under threat

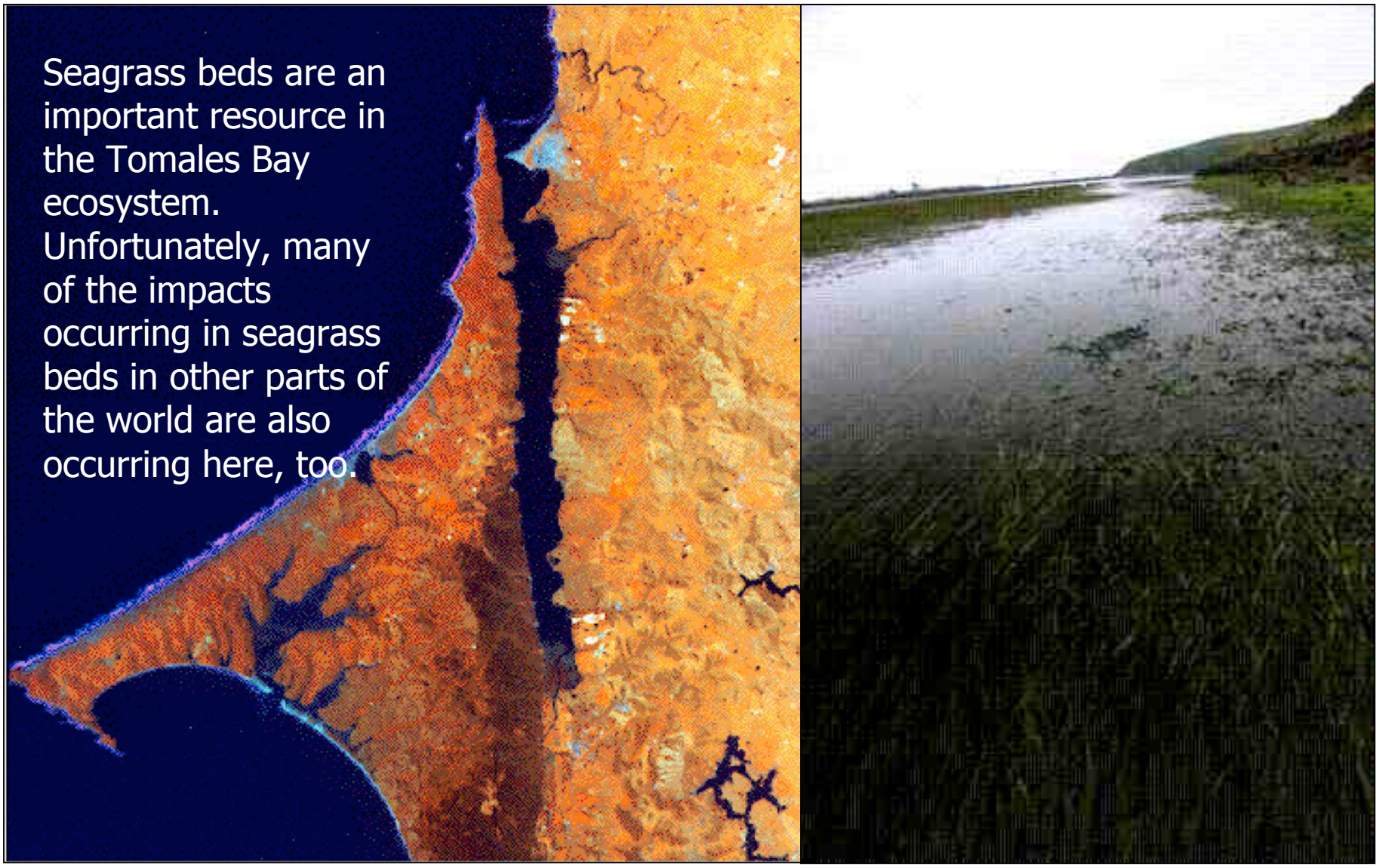
Seagrasses occur in shallow coastal waters across the globe. However their widespread distribution does not ensure seagrasses will be around for the future. Recently scientists have become increasingly concerned that seagrasses are declining worldwide -- it is estimated that we have lost 50% of seagrass from our coastlines over the last century.

Because seagrasses are restricted to shallow waters near land, they have been impacted by human activities as the population has increased along the coastline. Damaging activities include land development, increased sedimentation, increased use of fertilizers, outflow from sewage and septic systems, physical damage from boat propellers, anchors and moorings, etc.

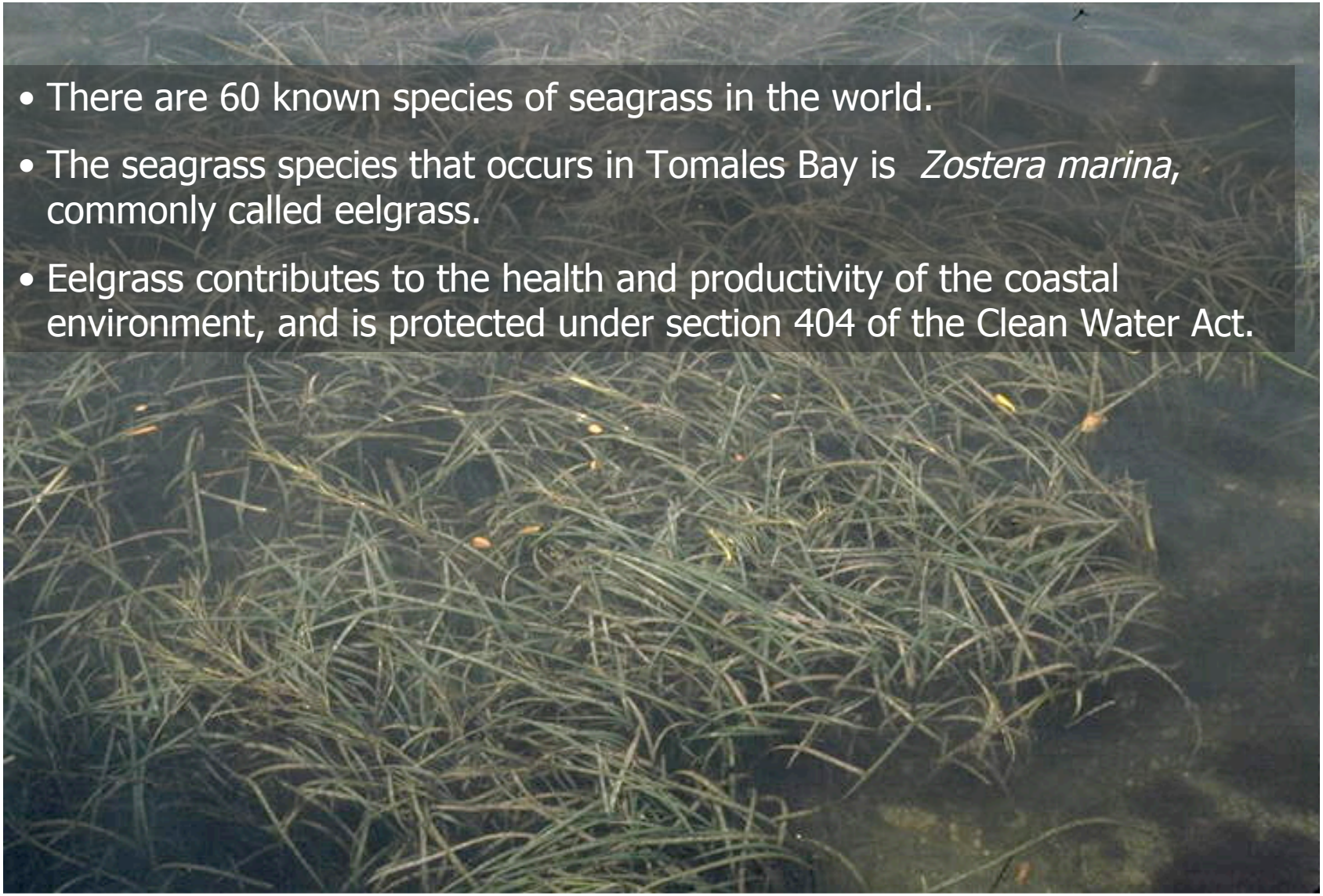
Approximately half the world's human population lives within 62 miles of the coast. On the map below, the coastal areas where seagrasses occur are indicated by the black lines. The "hot" colored areas (pink, red, orange) are the areas where the human population is dense.



Seagrass in Tomales Bay

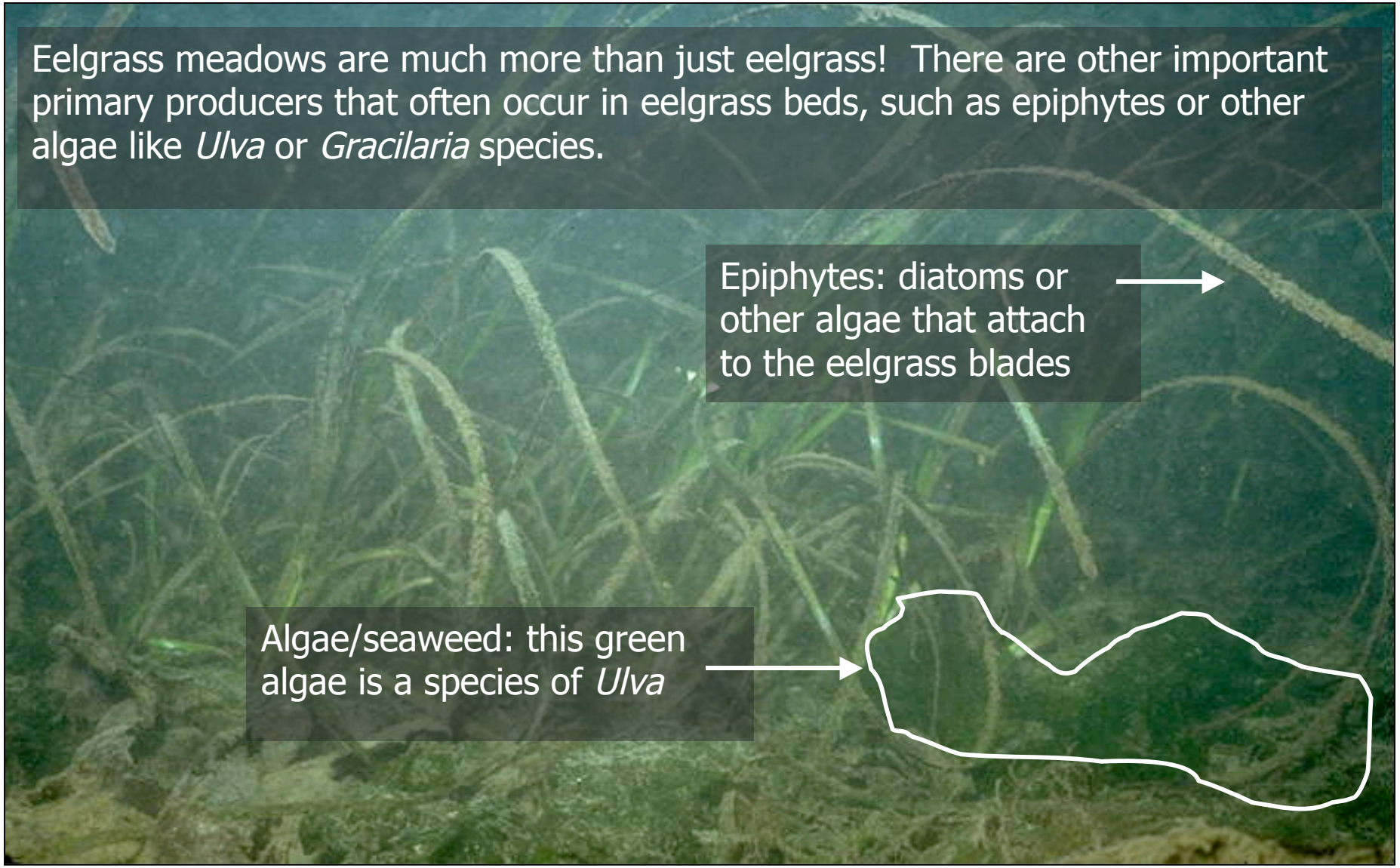


Seagrass in Tomales Bay



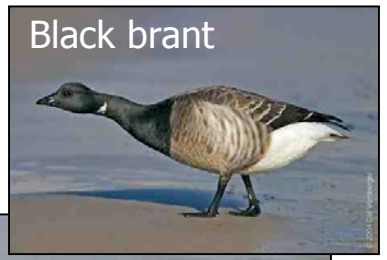
- There are 60 known species of seagrass in the world.
- The seagrass species that occurs in Tomales Bay is *Zostera marina*, commonly called eelgrass.
- Eelgrass contributes to the health and productivity of the coastal environment, and is protected under section 404 of the Clean Water Act.

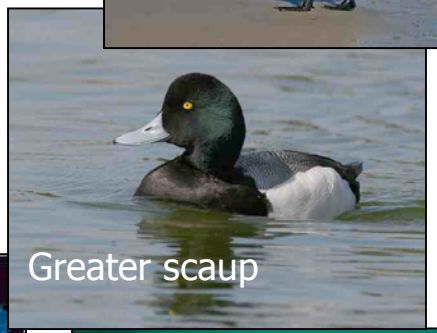
Eelgrass: a rich habitat

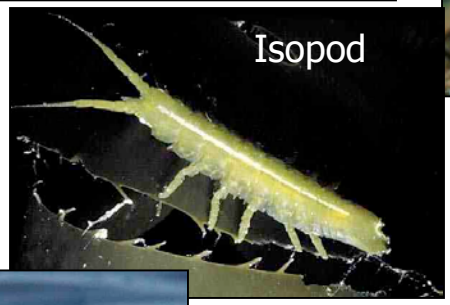


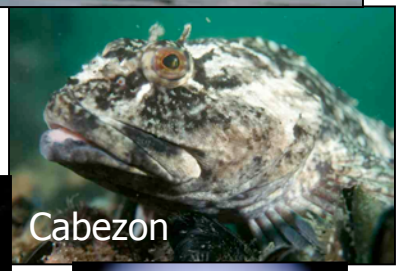
Seagrass is an important habitat provider

There are ten- to 100-times more animals in seagrass beds compared to adjacent sandy or muddy habitats!





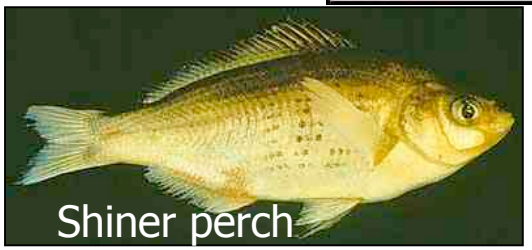


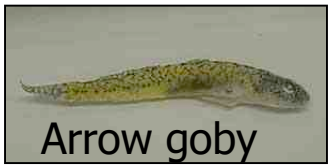


Eelgrass & fish

Eelgrass beds are important for fish:

- Eelgrass provides habitat, a complex, 3-dimensional space to "hang out".
- There is abundant food (plants, algae, invertebrate species, detritus, etc.).
- Eelgrass can provide protection from predation by bigger fish and birds.
- Some species of fish use eelgrass beds for their spawning grounds - a relatively safe place to put their eggs.
- Eelgrass beds also serve as a nursery ground - a safer place for larvae and juvenile fish to feed and grow.
- Eelgrass has been designated as an Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation Management Act.





Eelgrass & salmon

- Estuaries such as Tomales Bay play a vital role in the salmon life cycle by providing a location for returning adults and migrating smolts (juvenile salmon) to adjust to changes in the salinity of the water as they move from saltwater to freshwater and back again.
- Coho salmon and steelhead trout use streams that flow into Tomales Bay for spawning. When they are big enough, juvenile salmon move down into the eelgrass beds of the bay and feed on tiny invertebrates found there.
- To avoid becoming a meal themselves, young salmon hide among the eelgrass leaves.


Juvenile coho salmon

Eelgrass & Pacific herring

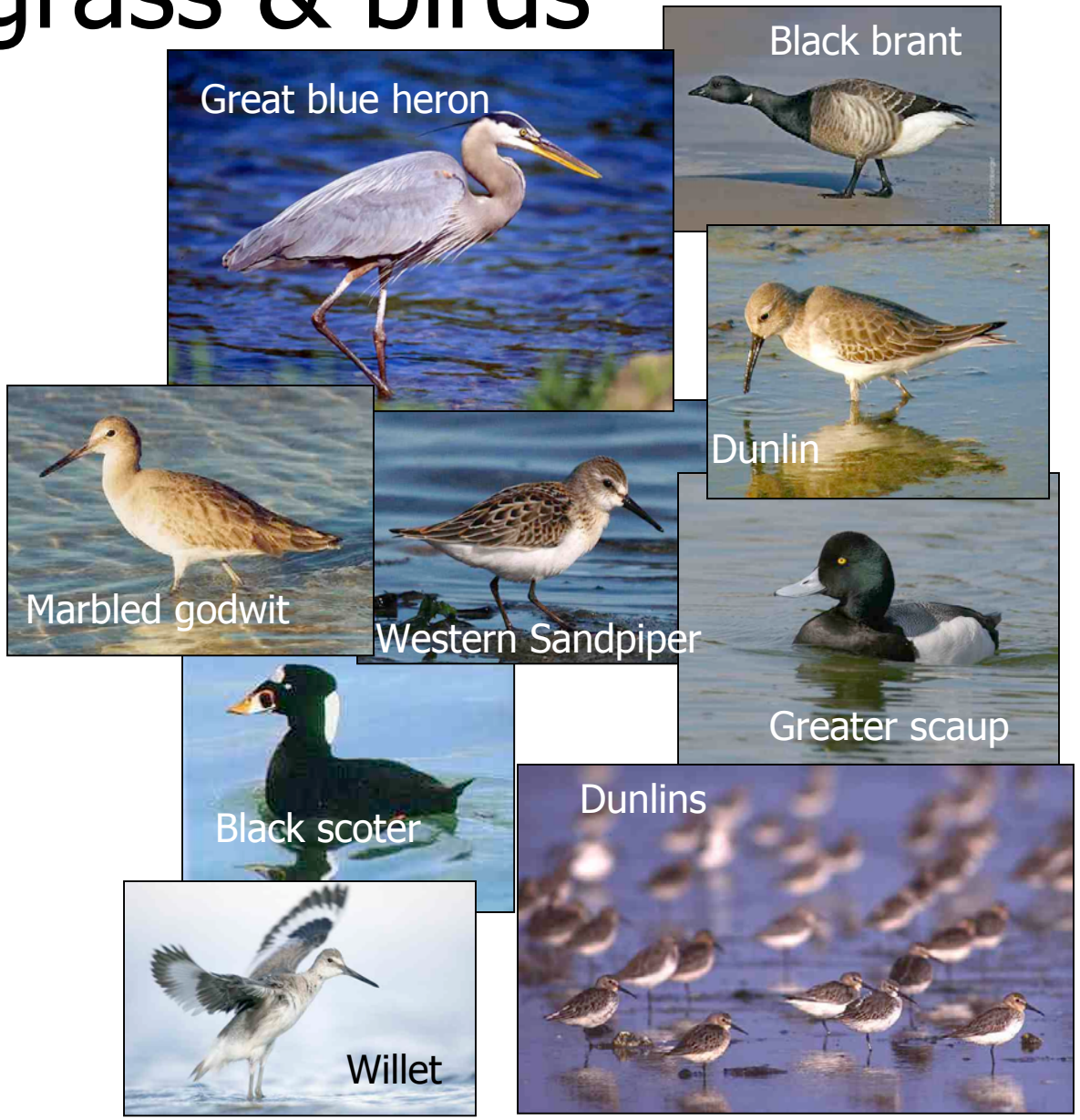
- Eelgrass beds also supply a nursery area for herring, a favorite salmon snack.
- Tomales Bay is a major spawning ground of Pacific herring, second in importance in California only to San Francisco Bay.
- Herring eggs attach themselves to vegetation, mostly eelgrass.
- Herring have been fished commercially in Tomales Bay since the 1930's.

Eelgrass & Pacific herring

- The attached herring eggs are sources of food for diving birds such as surf scoters and greater scaup.
- There are more than 20 species of birds that eat herring eggs!

Eelgrass & birds

- Eelgrass beds help to support a huge population of birds year round.
- During winter, the resources that are found in eelgrass beds are especially important for birds.
- It is estimated that 20,000 shorebirds and 25,000 waterfowl use the eelgrass beds and adjacent areas in Tomales Bay for their winter feeding ground.

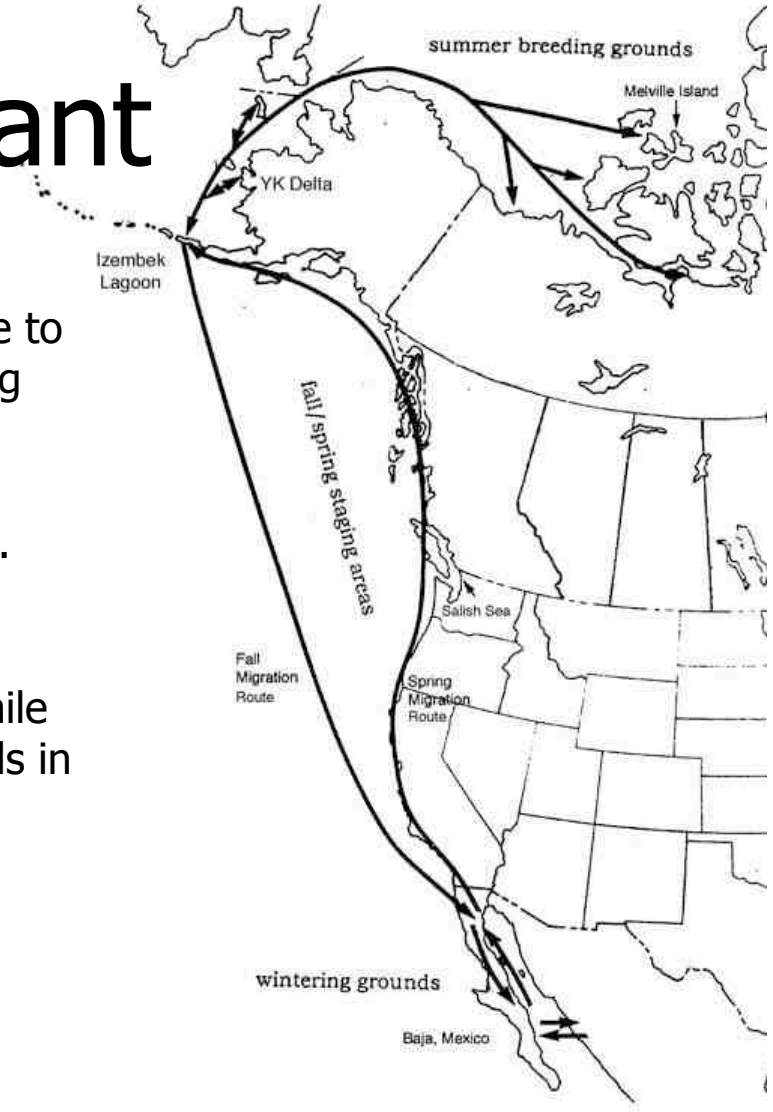


Eelgrass & black brant

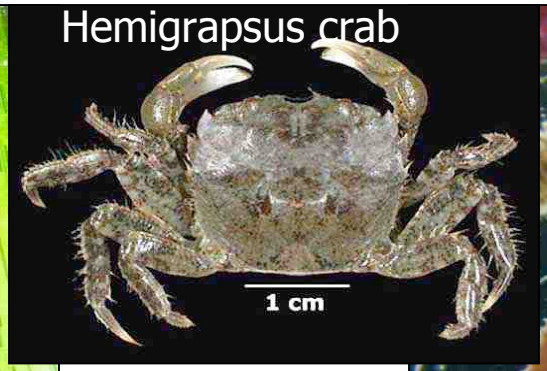
- Black brant are highly dependent on eelgrass for food.
- They use California eelgrass beds - including those in Tomales Bay - during their extensive migration.
- These migratory stops are important refueling stations that help them to survive their migration and to produce next year's offspring.
- Because brant depend highly upon eelgrass which is only available at key sites, the entire population of brant is vulnerable to pressures at only one location. Pressures include loss of eelgrass habitat, recreational hunting, subsistence hunting and egg gathering.

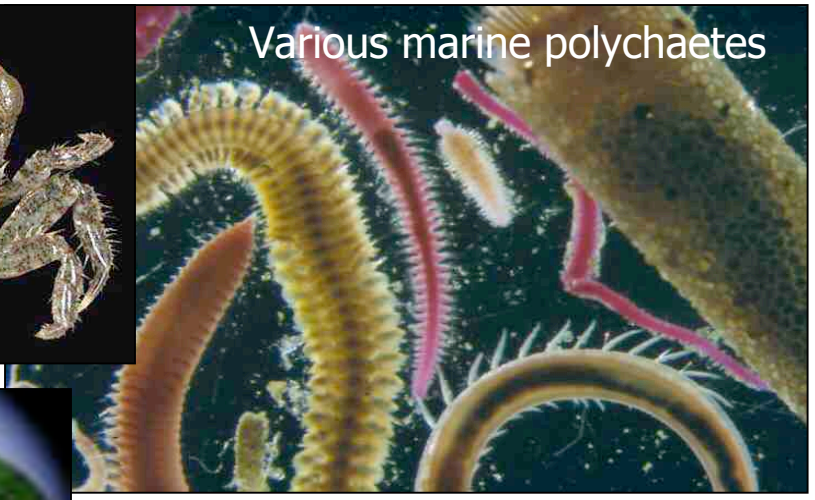
Eelgrass & black brant

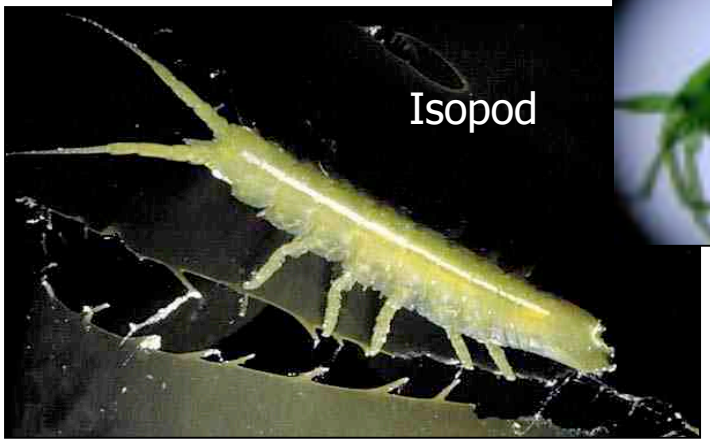
- Brant build nests and lay eggs in the high Arctic tundra of Alaska, Russia, and Canada. In late June to early July, young brant hatch out and begin feeding on insects to gain strength for their first migration.
- By September, the young brant join thousands of others at Izembek Lagoon on the Alaska Peninsula. Here they fatten up on eelgrass in preparation for their non-stop migration south.
- In November, they leave all together on a 3,000-mile journey over the Pacific Ocean to wintering grounds in the estuaries and lagoons of southern British Columbia, the United States, and Mexico.
- This migration takes between 60-95 hours and the brant lose nearly one-third of their body weight on this trip.
- The flight back begins in mid-February. The brant stop at estuaries along the way to once again feed and rest as they travel north.

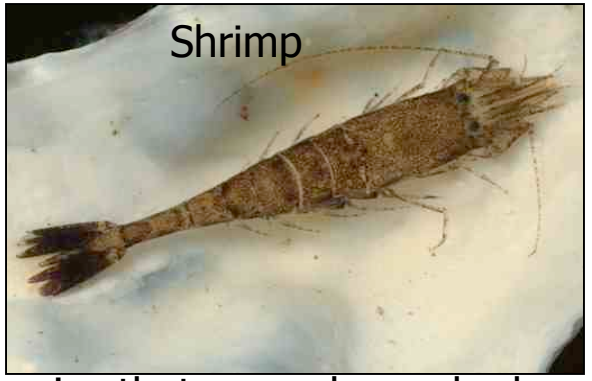


Eelgrass & other species









In addition to fish & birds, there are many other, less obvious species that use eelgrass beds. These animals actually eat very little of the eelgrass. Instead, they eat associated algae, and filter detritus and phytoplankton from the water. In turn, these animals are provide food for many other animals that live and/or feed in eelgrass beds. It is estimated that approximately 20 species of commercially valuable fish species feed in eelgrass beds at some point in their lives!

Simplified food web





bigger predators

predators

herbivores

eelgrass

algae

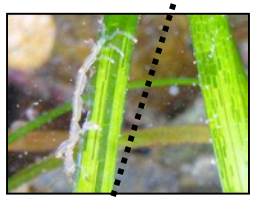
nutrients

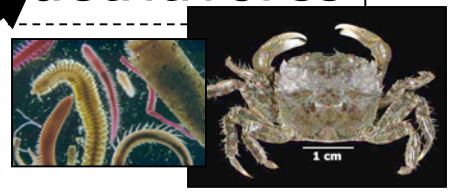
epiphytes

detrital "soup"

detritivores



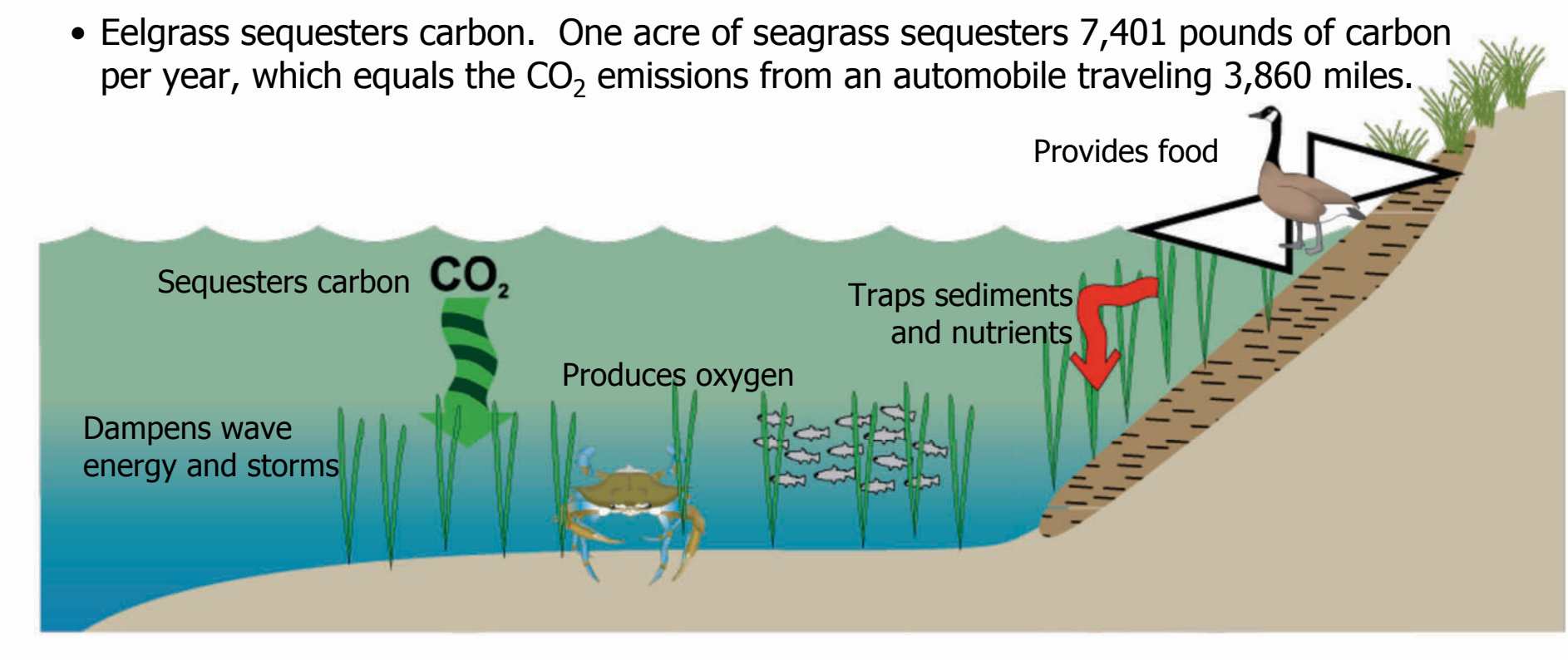



But it’s not just about the food…

Besides food and shelter, eelgrass provides many other important services:

- Eelgrass improves water quality by trapping sediments and nutrients. One acre of seagrass absorbs 6.4 pounds of nutrients per year, the equivalent of treated effluent from 490 people. With less nutrients available, phytoplankton are less likely to multiply rapidly and create blooms that shade out eelgrass.
- Eelgrass guards against shoreline erosion by dampening wave energy and storms.
- Eelgrass produces oxygen, which is used by marine animals.
- Eelgrass sequesters carbon. One acre of seagrass sequesters 7,401 pounds of carbon per year, which equals the CO_2 emissions from an automobile traveling 3,860 miles.



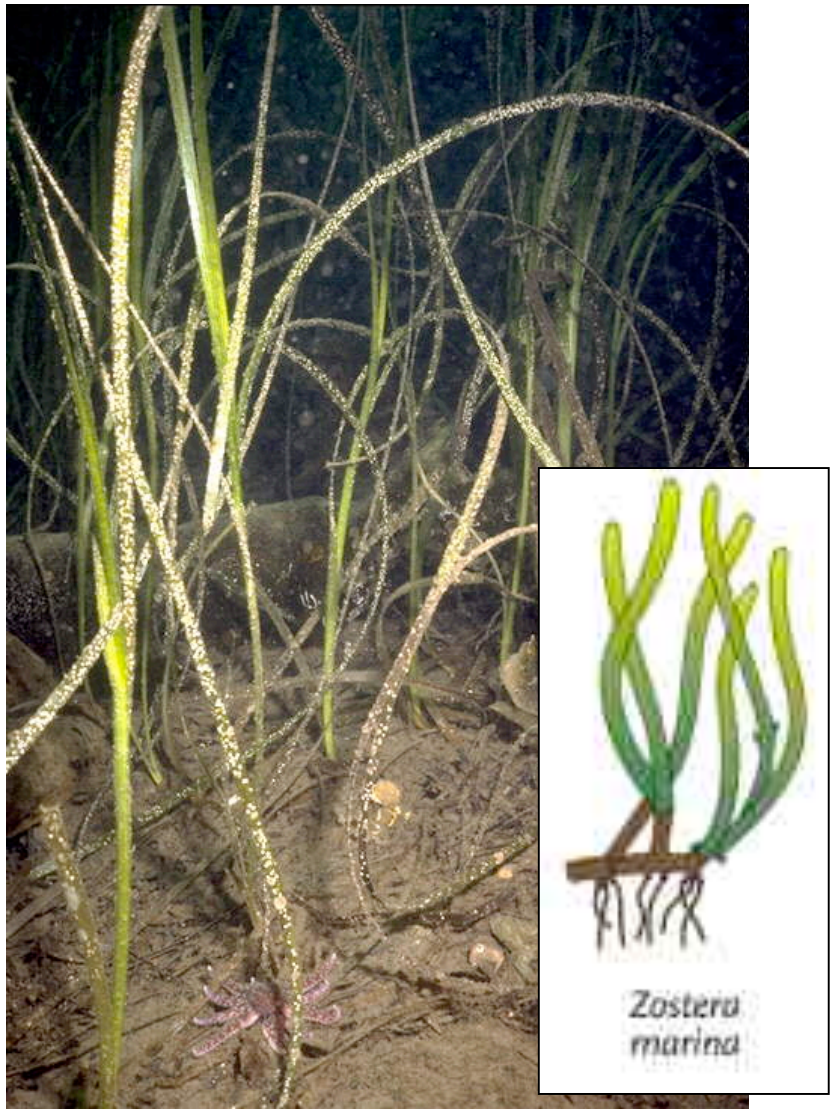
The importance of seagrass was dramatically revealed in the 1930's when over 90% of the North Atlantic eelgrass meadows died off

- The die-off was caused by the deadly combination of abnormally warm ocean currents and a fungal disease.
- Many species of duck and geese vanished
- Crabs, clams, scallops, lobsters suffered steep declines
- Coastal erosion became a problem

Okay, so it's important…
But what *is* eelgrass, anyway??

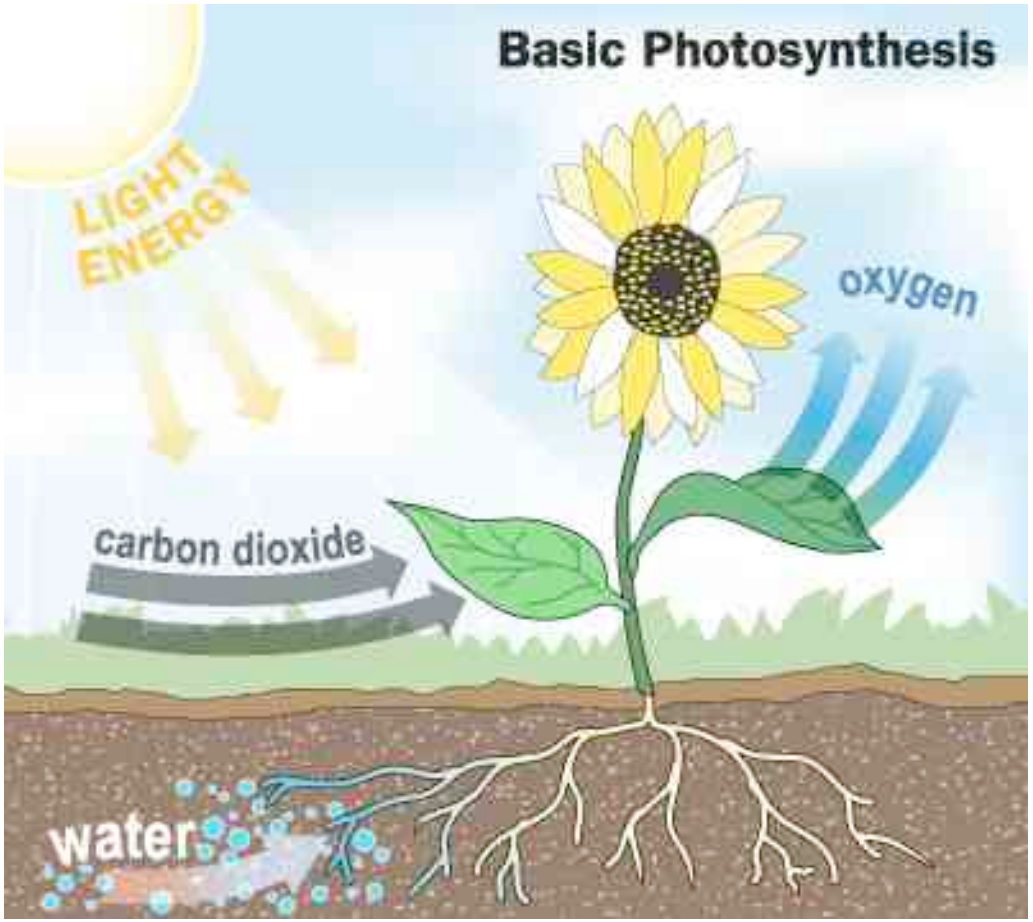
What *is* eelgrass?

- Although it lives in seawater, it is *not* a seaweed or algae!
- It is a true plant, which means it has roots, leaves, and flowers on stems.
- Primarily found in the subtidal zone, eelgrass spends its entire life cycle underwater -- including flowering, pollination and seed germination.
- Eelgrass has ribbon-like leaves, which can grow to 4 feet in length.
- It has a root & rhizome system, which anchors it in the sediment and allows the plant to take up nutrients from the sediment.
- Seagrass originated on land, then moved into the marine coastal habitat 65 million years ago.



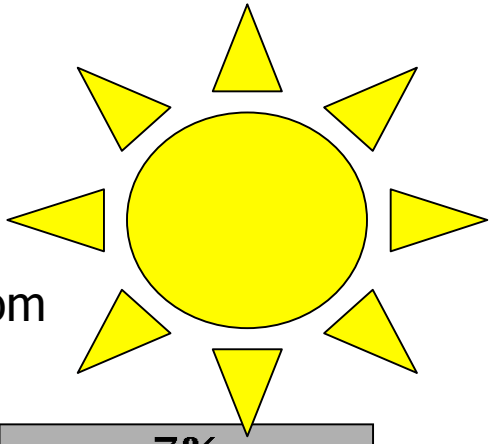
Eelgrass is a plant

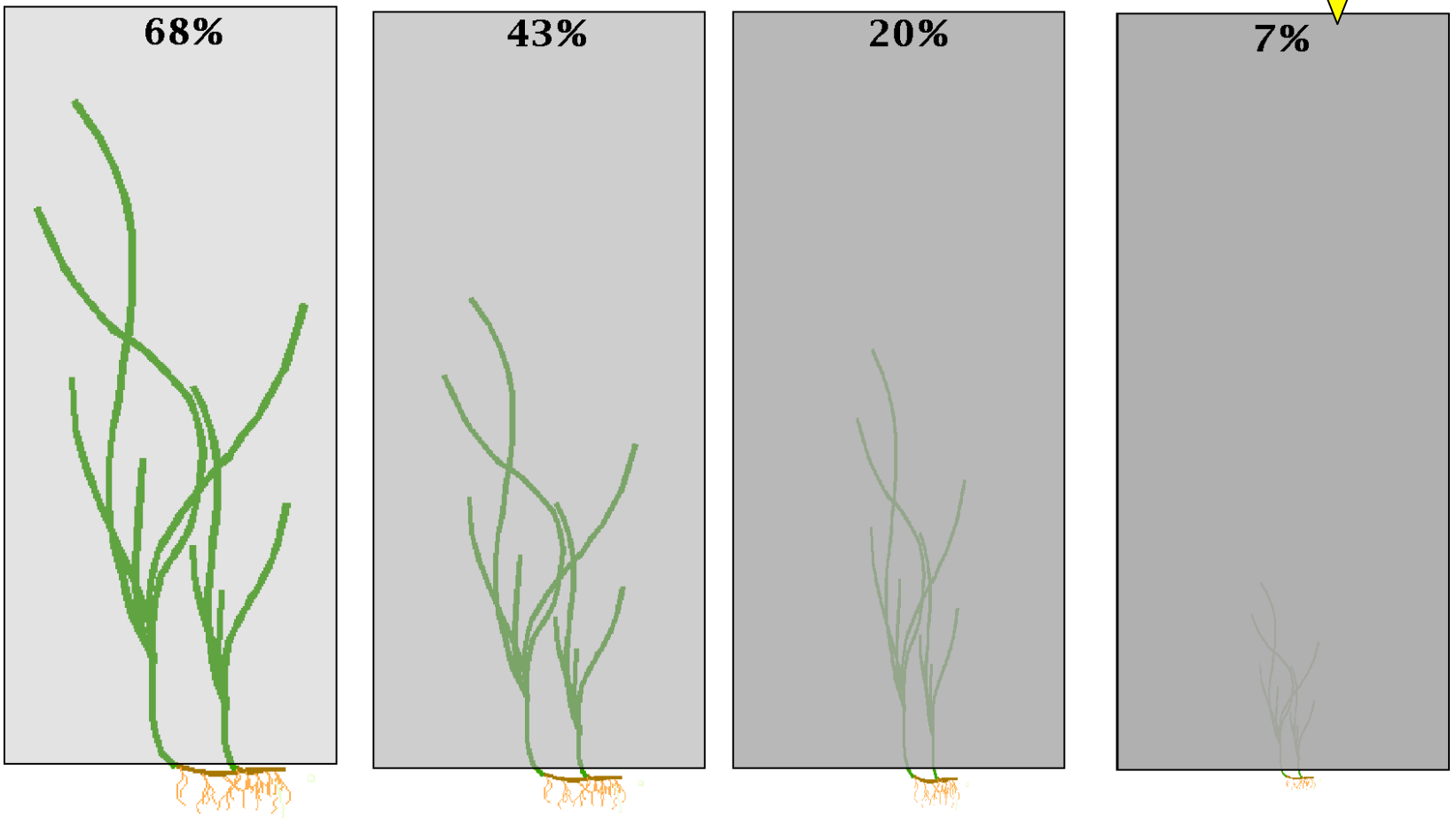
- Like other plants, eelgrass uses energy from the sun to convert water, carbon dioxide ($CO_{2)}$ and minerals into food.
- Because it needs sunlight to grow, this restricts where it can survive. And although it grows in water, it has to remain in shallow water so that it can still get sunlight.
- *Seagrass is highly productive -- more productive than a fertilized corn field!*



Water clarity & eelgrass

Because eelgrass needs sunlight, water clarity is important. This cartoon shows what happens to eelgrass when water clarity is decreased (for example, by increased nutrients from land runoff, or from sedimentation due to development).





Eelgrass Life Cycle

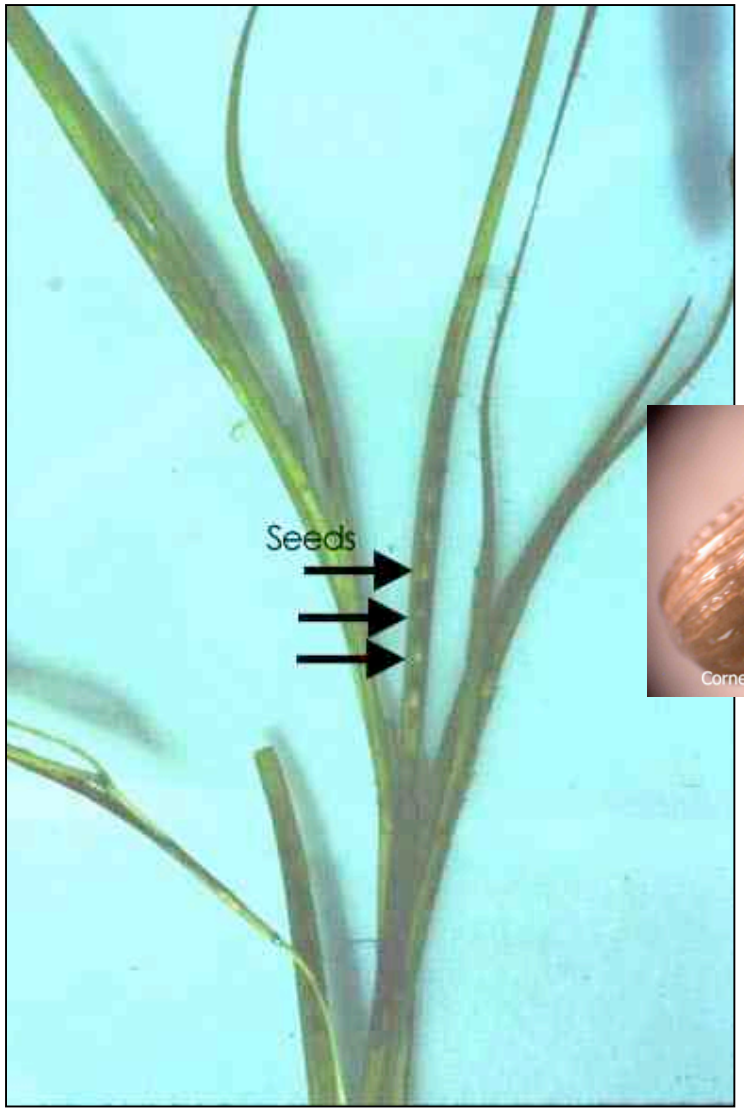
Eelgrass can reproduce two different ways:

1. Sexual reproduction:

- In Spring, pollen grains are released and come into contact with the female flowers.
- Male and female flowers mature at different times on the same plant to prevent self-fertilization.

Eelgrass Life Cycle:

Sexual Reproduction (cont'd)



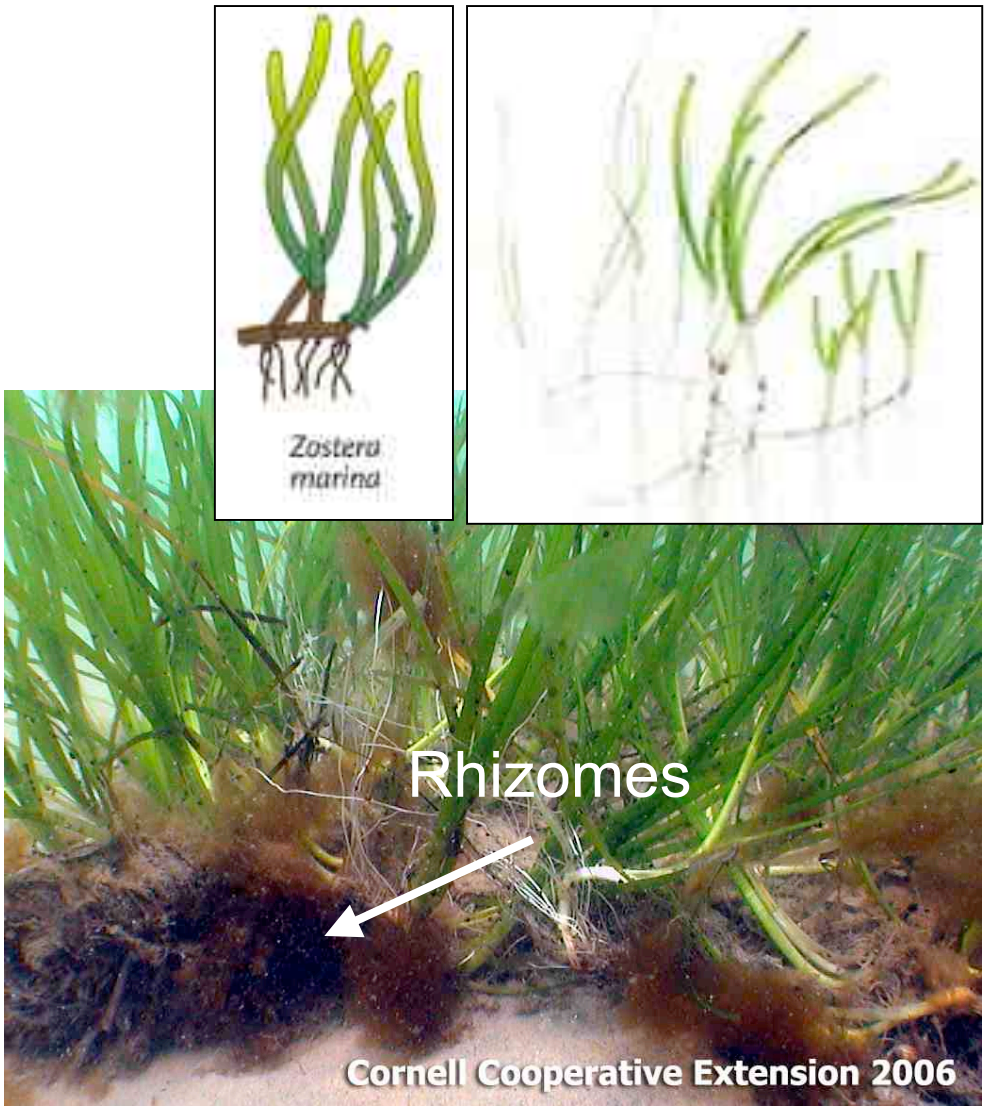
Eelgrass Life Cycle:

Sexual reproduction (cont'd)

Eelgrass Life Cycle:

2. Asexual reproduction

- The other way eelgrass can reproduce is by vegetative growth, or "asexual" reproduction.
- By extending its rhizome it produces new "ramets"; these are essentially clones of the original plant.
- The rhizomes provide structure and help maintain beds.
- Rhizomes are subject to physical damage from boat anchors and propellers, digging, etc.
- Eelgrass can live for many years (perennial). Annual forms (those that live for only one year) also exist.



Seagrasses are "Coastal Canaries"

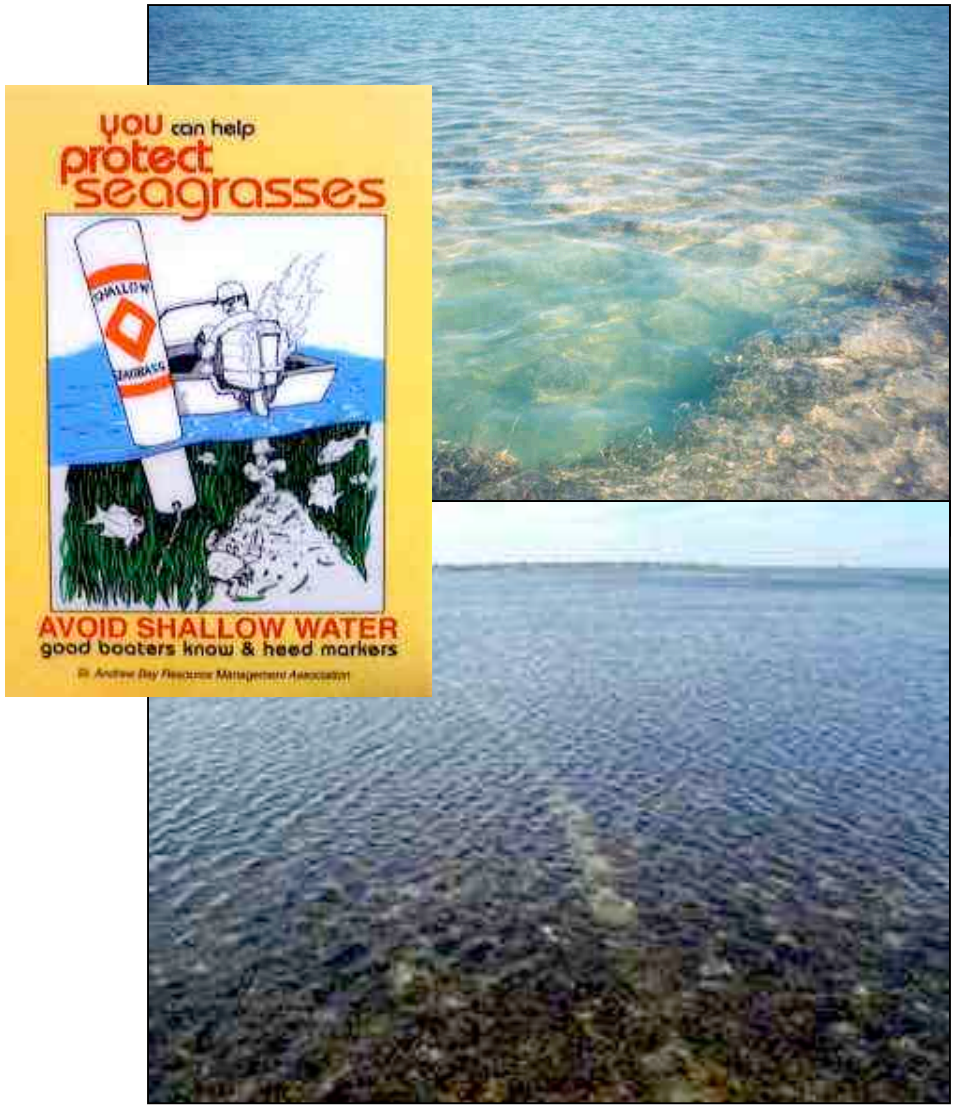
- Because they occur in coastal areas, seagrasses accumulate effects from both land and sea.
- Seagrass can alert us to greater problems in the coastal habitat - if seagrass declines, we know there is a problem that needs to be addressed.
- Seagrass is under increasing amounts of stress from:
  - Sediment and nutrient runoff
  - Physical disturbances (dredging, damage from boating activities)
  - Invasive species
  - Disease
  - Algal blooms

Boat impacts from areas outside of Tomales Bay

- Propeller and anchor scarring is common in shallow waters where boating occurs.
- This type of scarring damages the rhizome system, which can have long-term impacts on the health of the seagrass bed.
- Studies in other parts of the world have found this type of damage causes impacts on the animals living in and using seagrass beds.

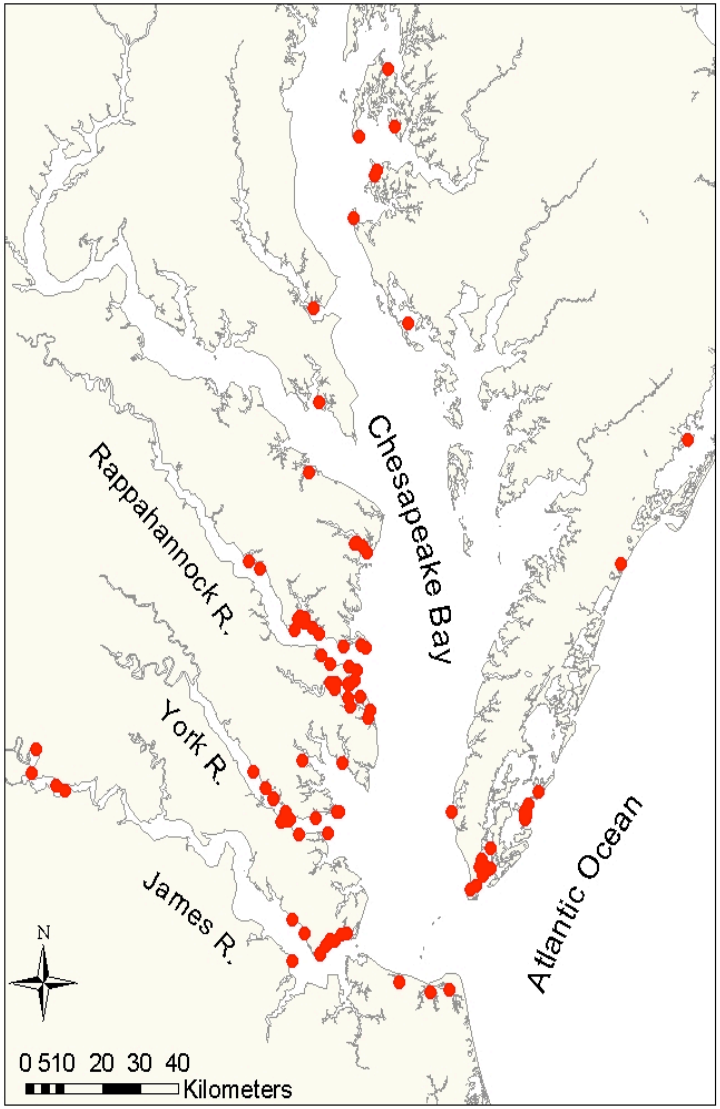
Can seagrass recover from this damage?

- Unfortunately, there are not many studies out there that have examined the recovery from this type of damage, and there are a lack of studies for Tomales Bay in particular.
- One study in Massachusetts found there were negative effects on eelgrass 7 years after the disturbance occurred.
- Many management agencies are working to educate people about the ways we can avoid damaging this important resource.



Another reason to proceed with caution and avoid damaging seagrass

- We don't have foolproof ways of successfully restoring seagrass once it's been damaged.
- Researchers have been working on restoring seagrass beds in the Chesapeake Bay for several decades.
- This map shows the transplant sites from 1979-2006 (~90 sites).

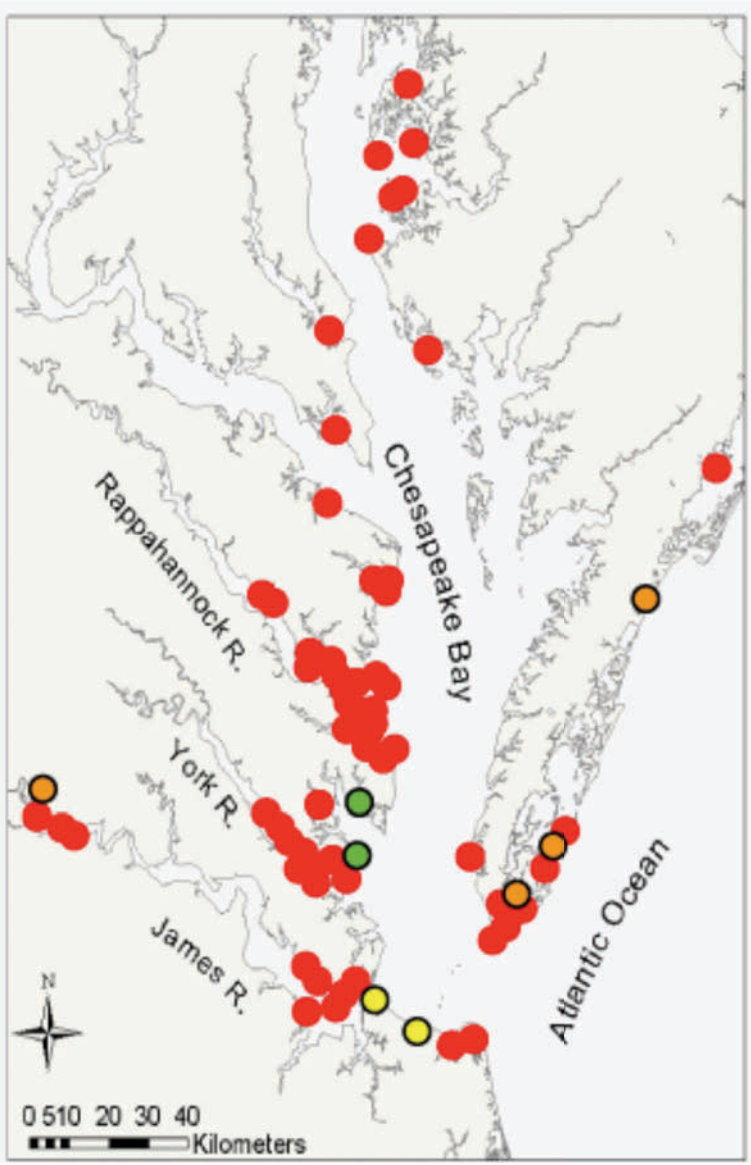


Seagrass Restoration Efforts

The green circles (there are only 2!) represent the sites where seagrass had long-term survival (over 10 years).

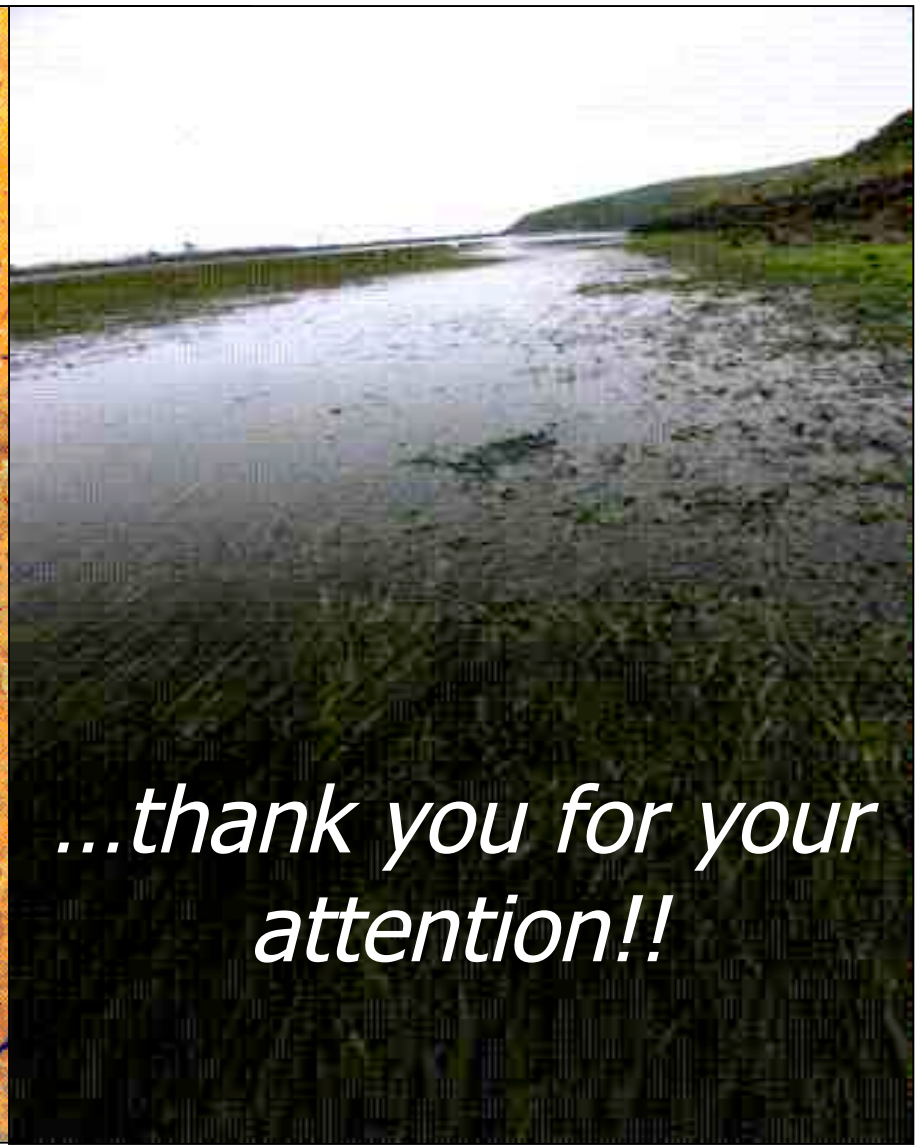
- Transplants died
- Survival 1-5 years
- Survival 5-10 years
- Survival >10 years

Less than 10% of transplant sites have long-term survival. Preventing damage to seagrass may be the best strategy.

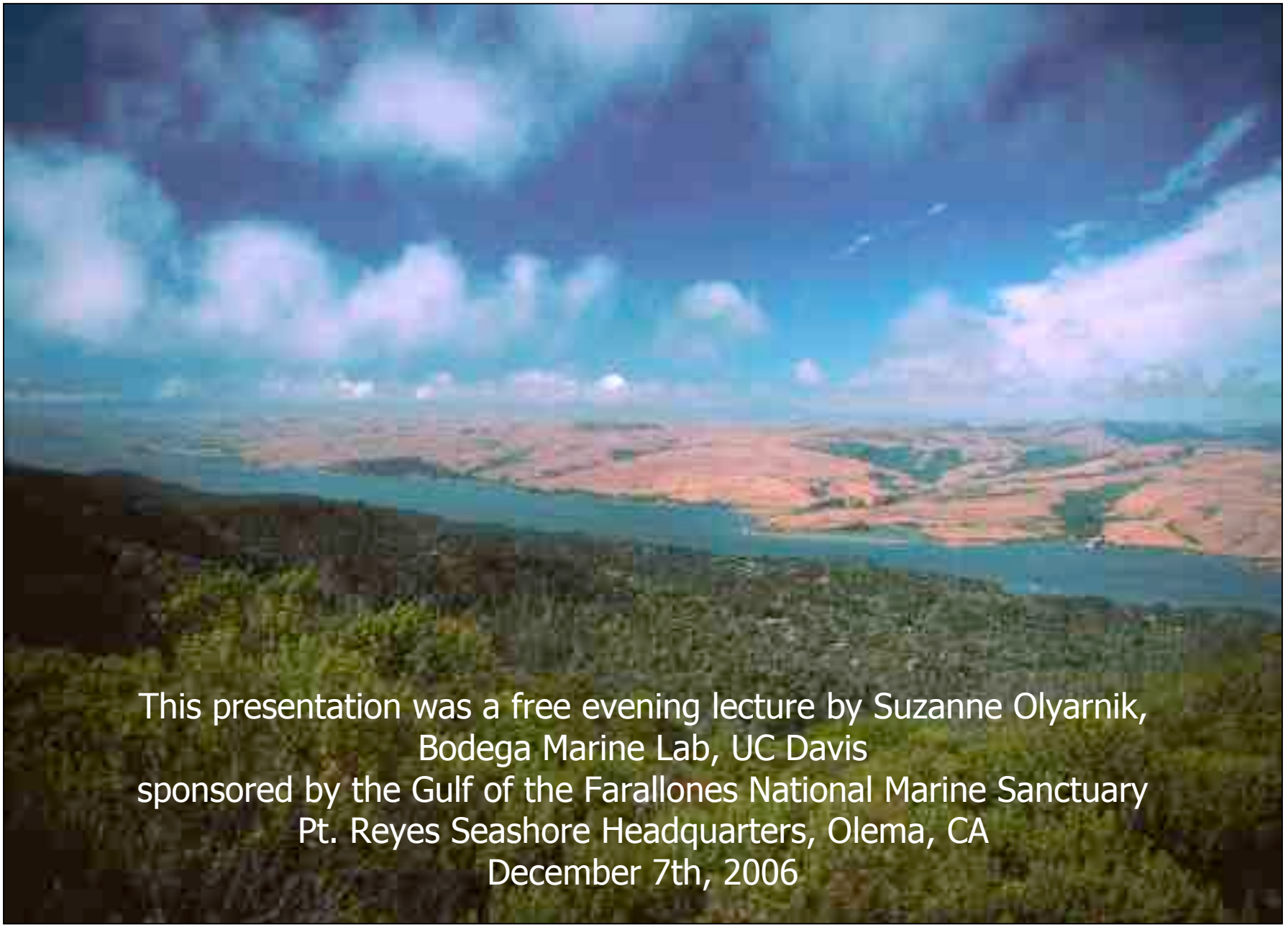


Seagrass in Tomales Bay

Seagrass is an important resource that provides many ecosystem services and helps to make Tomales Bay the special place that it is.



…thank you for your attention!!

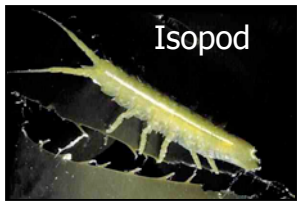


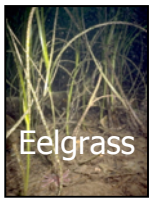
This presentation was a free evening lecture by Suzanne Olyarnik,
Bodega Marine Lab, UC Davis
sponsored by the Gulf of the Farallones National Marine Sanctuary
Pt. Reyes Seashore Headquarters, Olema, CA
December 7th, 2006

Scientific names of animals in this presentation

Common name	Scientific name
Arrow goby	*Clevelandia ios*
Bay pipefish	*Syngnathus leptorhynchus*
Black bellied plover	*Plutalis squatarola*
Black brant	*Branta bernicia nigricans*
Black scoter	*Melanita nigra*
Cabezon	*Scorpaenichthys marmoratus*
California halibut	*Paralichthys californicus*
Clam	*Macoma nasuta*
Coho salmon	*Oncorhynchus kisutch*
Dunlin	*Calidris alpina*
Eelgrass	*Zostera marina*
Great blue heron	*Ardea herodius*
Greater scaup	*Aythya marila*
Hemigrapsus crab	*Hemigrapsus oregonensis*
Isopod	*Idotea* sp.

Common name	Scientific name
Leopard shark	*Triakis semifasciata*
Lingcod	*Ophiodon elongatus*
Marbled godwit	*Limosa fedoa*
Northern anchovy	*Engraulis mordax*
Pacific herring	*Clupea pallasii*
Pacific staghorn sculpin	*Leptocottus armatus*
Rockfish	*Sebastes caurina*
Sea hare	*Phyllaplysia taylori*
Shiner perch	*Cymatogaster aggregata*
Shrimp	*Crangon* sp.
Skeleton shrimp	*Caprellid* sp.
Ulva	*Ulva lactuca*
Western sandpiper	*Calidris mauri*
Willet	*Catoptrophorus semipalmatus*





Sources

Dennison, William. *Seagrasses: Prairies of the Sea* fact sheet. In press.

Kelly, John P. 2001. *Distribution and abundance of winter shorebirds on Tomales Bay, California: Implications for conservation*. Western Birds 32(3): 145-160.

Kelly, John P. and Sarah L. Tappen. 1998. *Distribution, abundance, and implications for conservation of winter waterbirds on Tomales Bay, California*. Western Birds 29: 103-120.

Neckles HA, FT Short, S Barker, and BS Kopp. 2005. *Disturbance of eelgrass* Zostera marina *by commercial mussel* Mytilus edulis *harvesting in Maine: dragging impacts and habitat recovery*. Marine Ecology Progress Series 285: 57-73.

Orth, Robert J., Tim J.B. Carruthers, William C. Dennison, Carlos M. Duarte, James W. Fourqurean, Kenneth L. Heck, Jr., A. Randall Hughes, Gary A. Kendrick, W. Judson Kenworthy, Suzanne Olyarnik, Fred T. Short, Michelle Waycott, Susan L. Williams. 2006. *A Global Crisis for Seagrass Ecosystems*. BioScience 56(12): 987-996.

Pettigrew, Jim. 2004. *Summer habitat association of nearshore fishes in Tomales Bay, California:* A report to Pt. Reyes National Seashore Association and the All Taxa Biodiversity Inventory of Tomales Bay.

Short, FT. *What is eelgrass?* http://marine.unh.edu/jel/faculty/fred2/eelgrass.html

Stout, Prentice K. *Rhode Island Sea Grant Fact Sheet*. http://seagrant.gso.uri.edu/factsheets/eelgrass.html

Uhrin, AV and JG Holmquist. 2003. *Effects of propeller scarring on macrofaunal use of the seagrass* Thalassia testudinum. Marine Ecology Progress Series 250: 61-70.

Watanabe, Ryan. 2006. *Summary of the 2005-06 Tomales Bay herring fishery season*. California Department of Fish & Game.