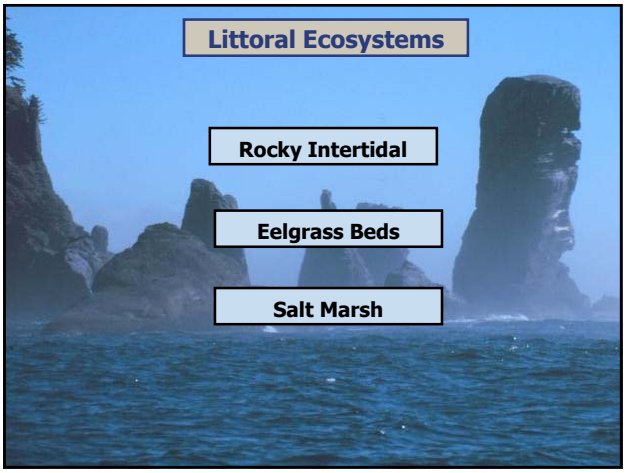
Marine Ecosystems

I. Habitats
1. Habitat Zones
2. PNW Locations
3. Perspectives in Geological Time

II. Ecosystems
1. Oceanic & Neritic Ecosystems
2. **Littoral Ecosystems**

III. Human Interactions
1. Introduced Species
2. Harvesting
3. Mariculture
4. Chemical Pollution
5. Land Conversion

Littoral Ecosystems



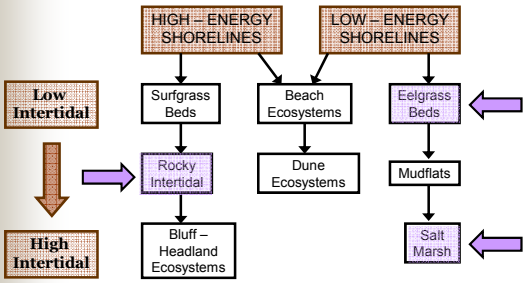
Rocky Intertidal

Eelgrass Beds

Salt Marsh

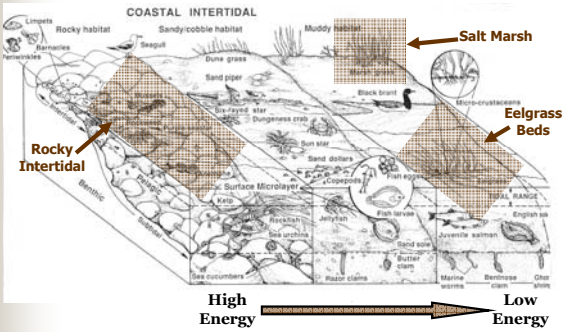
Littoral Ecosystems

Shoreline Habitat Gradients

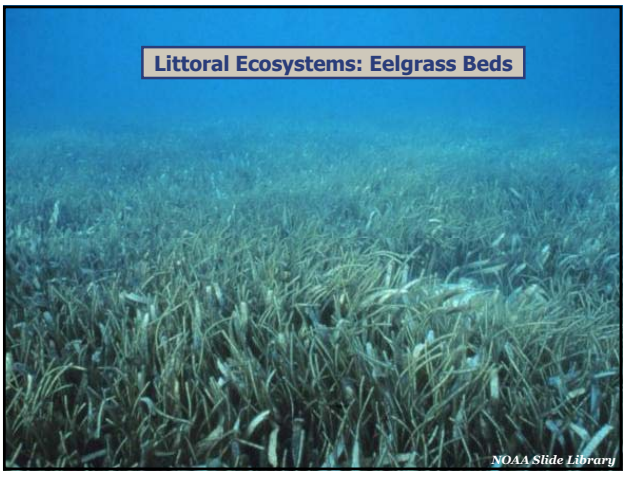


Littoral Ecosystems

Shoreline habitat gradients drawing in your textbook (pg. 78)



Littoral Ecosystems: Eelgrass Beds

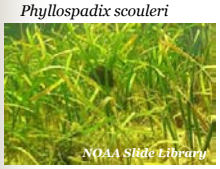


Seagrass Beds: a note on nomenclature

Seagrass Beds

Surfgrass Beds

Phyllospadix scouleri



Exposed outer coast & straits
high energy environments

Eelgrass Beds

Zostera marina

Puget Sound; Estuaries
low energy environments

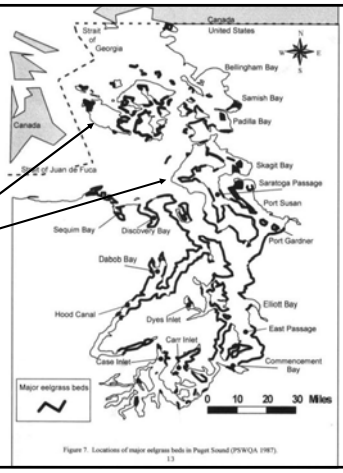
Eelgrass Beds

1. Environment

- Protected, low-energy systems
- Mostly upper subtidal to lower intertidal (exposed only at low tides)
- Shallow gradient, sandy substrate (usually estuarine)

Eelgrass Bed Distribution in Puget Sound & San Juan Islands

Note the **lower** abundance on more exposed shorelines



Eelgrass Beds

2. Primary Productivity

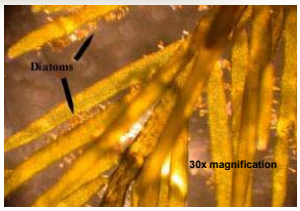
A) Primary Producers

Eelgrass (*Zostera marina*)

Flowering, vascular plant

Eelgrass as an ecological engineer

Crustose algae & diatoms



Eelgrass Beds

2. Primary Productivity

B) The Nature of Primary Productivity – why so productive?

1) **Abundant nutrients**: terrestrial, riverine, and tidal inputs
2) **High light**: shallow position
3) **Moderate temperatures**: year round growing season
4) **Buoyancy**: Minimal need for eelgrass structural investments
5) **Eelgrass as an ecological engineer**: Epiphytes provide nearly 50% of NPP
6) **Eelgrass organic exudates**: Supports bacterial growth that traps dissolved nutrients, reducing nutrient loss from system

Eelgrass Beds

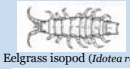
3. Secondary Productivity - Consumers

A) Herbivores & Detritivores

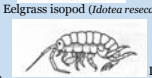
Invertebrates feeding on eelgrass & epiphytes:

Snails, isopods, amphipods, crabs, etc.

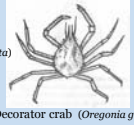
Eelgrass snail (*Lacuna varigata*)



Eelgrass isopod (*Idotea resecata*)



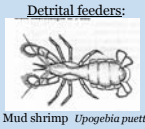
Amphipods



Decorator crab (*Oregonia gracilis*)

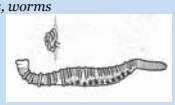
Mud snail (*Batallaria attramentaria*)

Detrital feeders: *Ghost shrimp, amphipods, worms*



Mud shrimp *Upogebia puettensis*)

Polychaete worms



Lug worm (*Abarenicola pacificum*)

Drawings from Padilla Bay NERR Estuary Guide (1992)

Eelgrass Beds

3. Secondary Productivity - Consumers

A) Herbivores & Detritivores

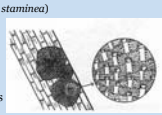
Filter feeders – omnivores (*sponges, bryozoans, bivalves, tunicates, marine worms, mussels, etc.)*

Mud clam (*Mya arenaria*)

Littleneck clam (*Protothaca staminea*)

Polychaete worms

Lug worm (*Abarenicola pacificum*)



Bryozoans

Few epifaunal feeders; mostly infaunal filter feeders – why?

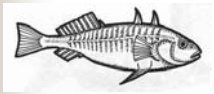
Drawings from Padilla Bay NERR Estuary Guide (1992)

Eelgrass Beds

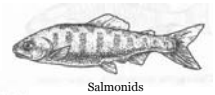
3. Secondary Productivity - Consumers

B) Carnivores

Filter feeders – omnivores *(sponges, bryozoans, tunicates, marine worms, etc.)*
Mobile Invertebrates: *crabs, shrimp, etc.*
Marine mammals: *sea otters, river otters, grey whales*
Fish: *variety of small fishes eating epiphytic animals*
Birds: *black brant, ducks, shorebirds, gulls, terns, jaegers, etc.*



Threespinbe stickleback (*Gastrosteus aculeatus*)



Salmonids

Dungeness crab (*Cancer magister*)

Drawings from Padilla Bay NERR Estuary Guide (1992)

Littoral Ecosystems: Salt Marsh

Salt Marshes

1. Abiotic Environment

Factors influencing species' presence & distribution

- Salinity
- Frequency & duration of tidal coverage
- Soil porosity (O_2)
- Soil organic content & nutrient availability
- Dissolved oxygen
- Tidal forcing & freshwater flooding (physical impacts)

Salt Marshes

2. Salt Marsh Organisms

A) Primary Producers: some examples

Low Marsh	
Salicornia virginica	Pickleweed
Distichlis spicata	Saltgrass
Jaumea carnosa	Fleshy Jaumea
Spergularia canadensis	Sandspurry
Triglochin maritima	Seaside Arrowgrass
Green algae & cyanobacteria	Free-living & epiphytic

High Marsh	
Carex lyngbyii	Lyngby's Sedge
Distichlis spicata	Saltgrass
Jaumea carnosa	Fleshy Jaumea
Deschamsia caespitosa	Tufted hairgrass
Triglochin maratima	Seaside Arrowgrass
Potentilla anserina	Pacific Silverweed
Grindelia integrifolia	Gumweed
Atriplex patula	Fat-hen Saltbush

Dominated by grasses, sedges & herbs – all herbaceous plants

Why such a lack of woody primary producers?

Salt Marshes

2. Salt Marsh Organisms

B) Herbivores & Detritivores: some examples

Invertebrates:
Isopods (*Limnoria* spp.) & shipworms (*Bankia* spp.)
Other insects, annelid worms (nematodes), Crustaceans, Mollusks

Vertebrates:
Birds (esp. migratory waterfowl)
Occasional grazing mammals
Fish

C) Carnivores: some examples

Birds, mammals (marine, terrestrial), fish, insects, etc.

Coho salmon (and other anadromous fish) feed on insects and smaller fish in the water associated with sloughs and salt marshes & acclimate physiologically to different salinities

Salt Marshes

3. Communities in the Marsh Landscape

Habitat factors blend into a continuum in gentle topography

Low Marsh **High Marsh**

Jaumea carnosa

- Broad ecotones in marsh
- Sharp ecotones along tidal channel banks

Scirpus acutus

Salicornia virginica

Carex lyngbyei

3. Communities in the Marsh Landscape

- Sharp ecotones along tidal channel banks

4. Communities Diversity & Dynamics

A) The Role of Topography

Subtle changes in elevation result in rapid changes in communities

△ Topography → △ inundation frequency
→ △ inundation duration
→ △ salinity
→ △ drought patterns & intensity
→ △ sediment dynamics (see part C below)

4. Communities Diversity & Dynamics

B) The Role of Woody Debris in Topography & Disturbance

Large organic material

Provides topographic heterogeneity

Acts as elements of disturbance

↑ Biodiversity & community dynamics

4. Communities Diversity & Dynamics

An example of large woody debris & critical topography in Snohomish estuarine salt marshes

Black Lily (*Fritillaria camchatkensis*)

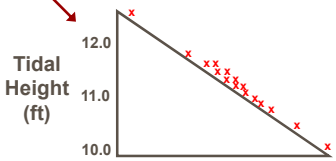
4. Communities Diversity & Dynamics

Large woody debris & critical topography in Snohomish estuarine salt marshes

Black Lily (*Fritillaria camschatcensis*)

Black lily only exists on logs of a certain decomposition state

at a certain tidal height in the estuary



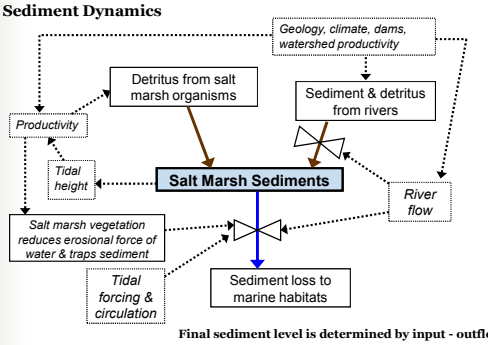
4. Communities Diversity & Dynamics

C) Sediment Dynamics

Accreting or eroding sediments alter topography (and hence habitats) and can either increase or decrease the extent of a salt marsh

4. Communities Diversity & Dynamics

C) Sediment Dynamics



Final sediment level is determined by input - outflow

5. Salt Marsh Productivity

Tremendously productive ecosystem – why?

1) Abundant nutrients

Terrestrial, riverine, and tidal inputs

~80% Aboveground NPP and ~100% Belowground NPP go to detrital pathway (decomposers rather than herbivores) – this is a "detrital ecosystem" – **RAPID nutrient cycling**

2) High light

Shallow position

3) Moderate temperatures

Coastal, shoreline position

5. Salt Marsh Productivity

What are the primary limitations for productivity?

1) Drought

Salinity & dry summers

2) Salinity

Toxicity & other direct effects

3) Disturbances

Physical & biotic disturbances

6. The State of WA Salt Marshes

A) Decline in salt marsh habitat area

1800 – 1979: 70% loss in area

Particularly high in urban locations

WA Dept of Natural Resources (1998)

6. The State of WA Salt Marshes

B) Current Human Threats

1) Draining & filling (agriculture)

6. The State of WA Salt Marshes

B) Current Human Threats

2) Development

Ocean Shores, Grays Harbor County

WA DNR 1998

Salt Marshes

6. The State of WA Salt Marshes

B) Current Human Threats

3) Shoreline physical alteration (jetties, levees, etc.)

- Removal of tidal influence
- Altering sediment dynamics
  - ✓ Jetties & levees at river mouths for navigation alter sediment outfall patterns

4) Diversion of freshwater input

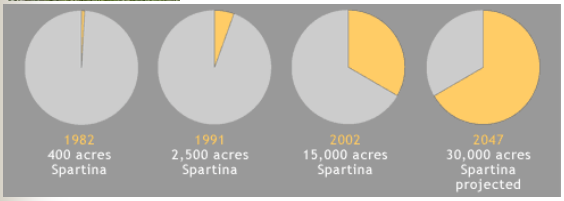
5) Pollution of freshwater input

- Nutrient enrichment
- Heavy metals & toxic organics

6. The State of WA Salt Marshes

B) Current Human Threats 6) Introduction of exotic species: an example

Spartina alterniflora invasion of Willapa Bay



Photos & graphics: WA Dept. of Ecology

6. The State of WA Salt Marshes

B) Current Human Threats

6) Introduction of exotic species: an example

***Spartina* invasion of Willapa Bay**

Spartina invasion colonizing tidal mudflats in Willapa Bay

Spartina invasion altering sediment transport at the mouth of a stream

Photos: WA Dept. of Ecology

Spartina alterniflora invasion of Willapa Bay

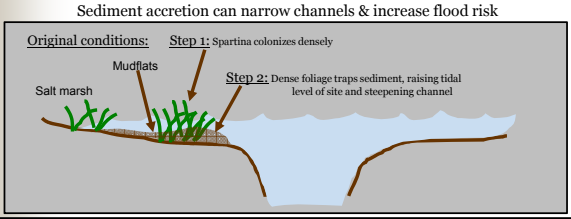
Some problems:

Converts mudflats to marshes

- Crowd out native plant species and associates
- Loss of habitat for some fish & shellfish
- Loss of habitat for some wintering & breeding birds (↓ 16-20%)

Alters sediment transport

- Sediment accretion further accelerates conversion to marsh
- Sediment accretion can narrow channels & increase flood risk



6. The State of WA Salt Marshes

B) Current Human Threats 6) Introduction of exotic species: an example

Spartina alterniflora invasion of Willapa Bay

Some possible "solutions":

- Hand pulling (tons of people!)
- Burning
- Cutting / Mowing
- Herbicide
- Biocontrol

Leafhopper that feeds on Spartina extensively in its native range (East coast & S. CA).

Prokelisia marginata

Photo: Seagrant Oregon State Univ.