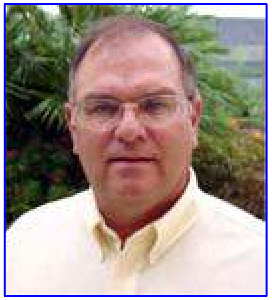
Texas Estuaries



Presented by Dr. Russell J. Miget,
Environmental Quality Specialist, Texas A&M University Corpus Christi.

This presentation was presented as part of the Cradle Of Texas Chapter's *Bonus Advanced Training m*eeting on January 20, 2018 at the Texas AgrLife Extension Service auditorium in Angleton.

It's a Wild, Wild Life on the Mid-Texas Coast

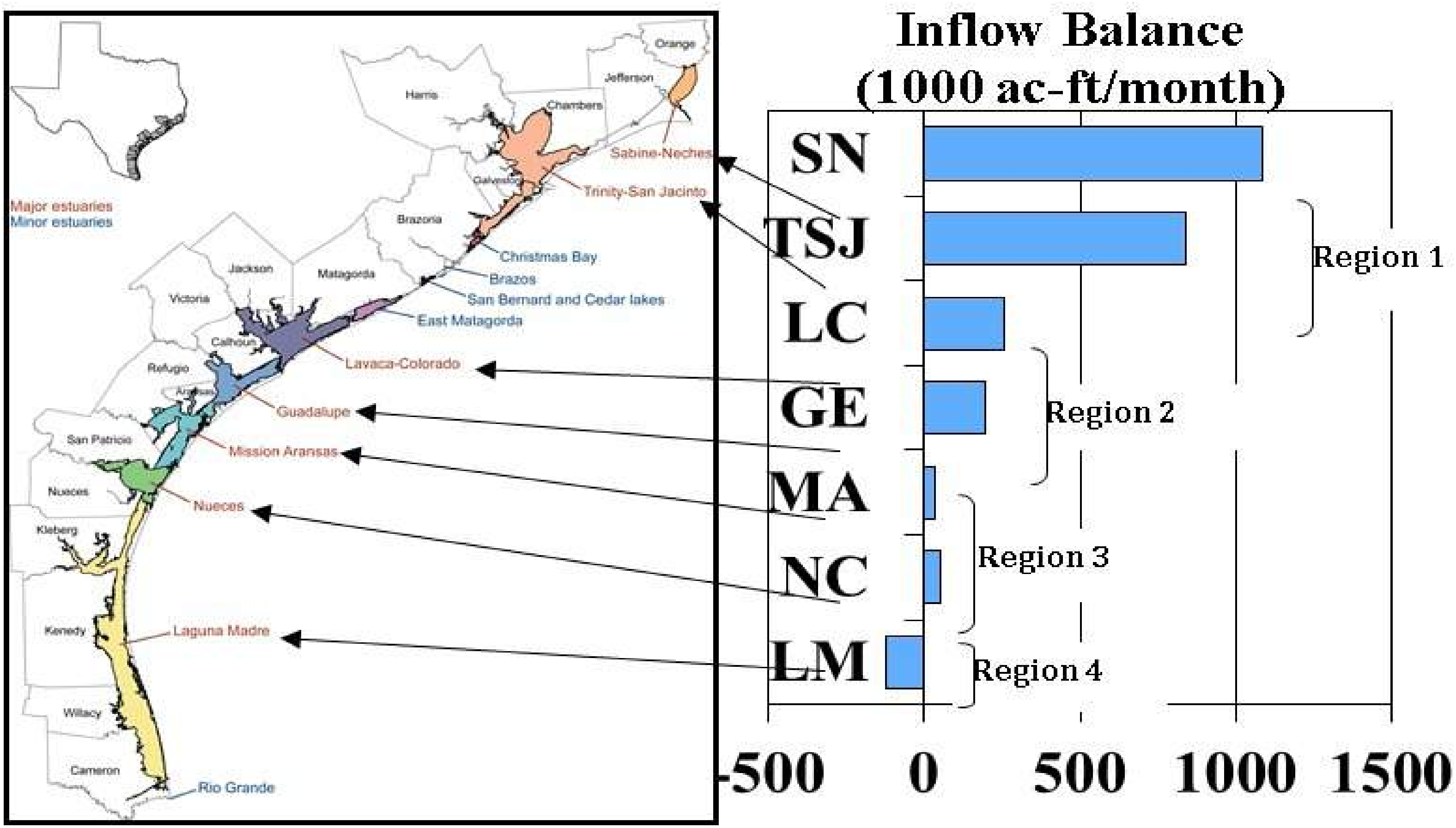
Ecology of the Coastline

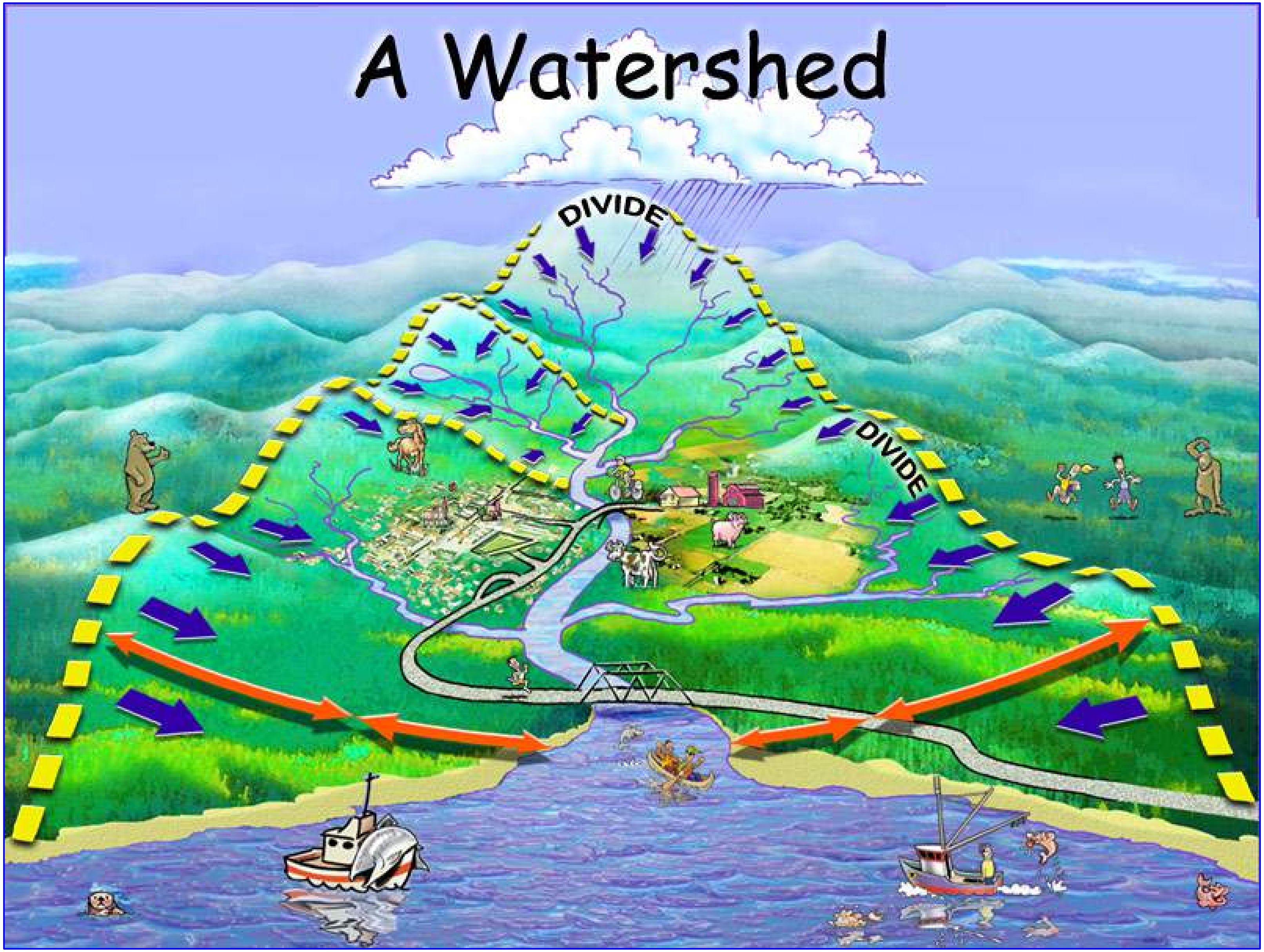
Texas Estuaries

Estuaries cannot function properly without freshwater inflows from rivers, streams, and local runoff. Freshwater provides **low-salinity nurseries (an osmotic gradient), addition of nutrients such as nitrogen and phosphorus as well as detritus and other organic materials**, and **sediment** which flocculates and settles out upon mixing with saline water thereby maintaining proper elevation within an estuary to support fringing emergent vegetation such as *Spartina.*

Spartina alterniflora

Inflow balance of Texas estuaries reflecting average rainfall along the coast 60 inches (Beaumont) to 20 inches (South Padre Island)





A Watershed
DIVIDE
DIVIDE

An estuary (?)

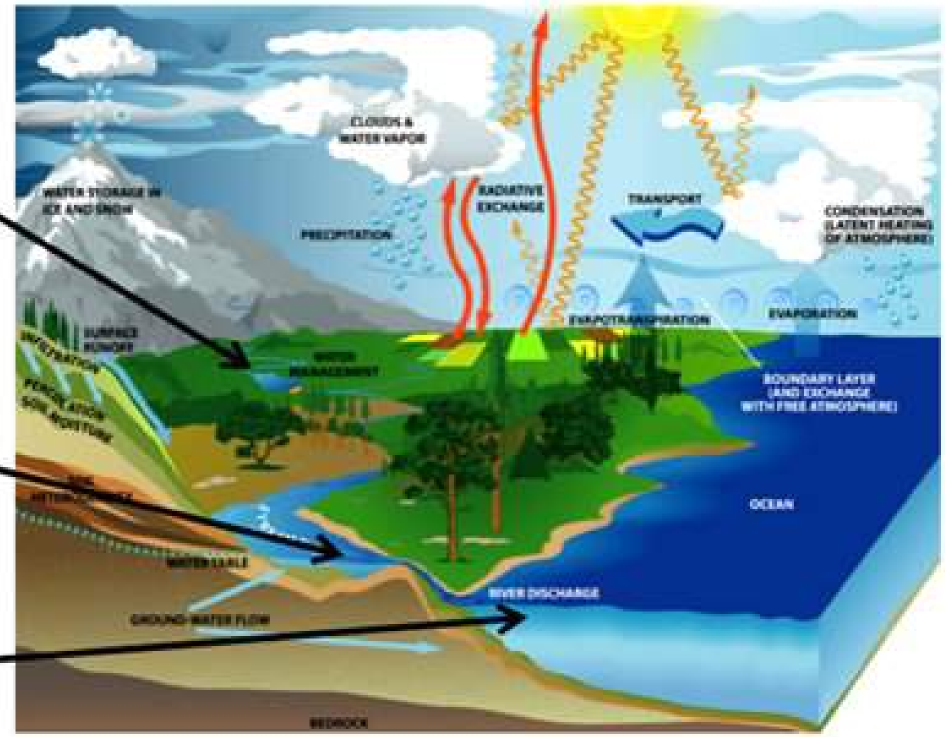
Instream (?)

Outflow (?)

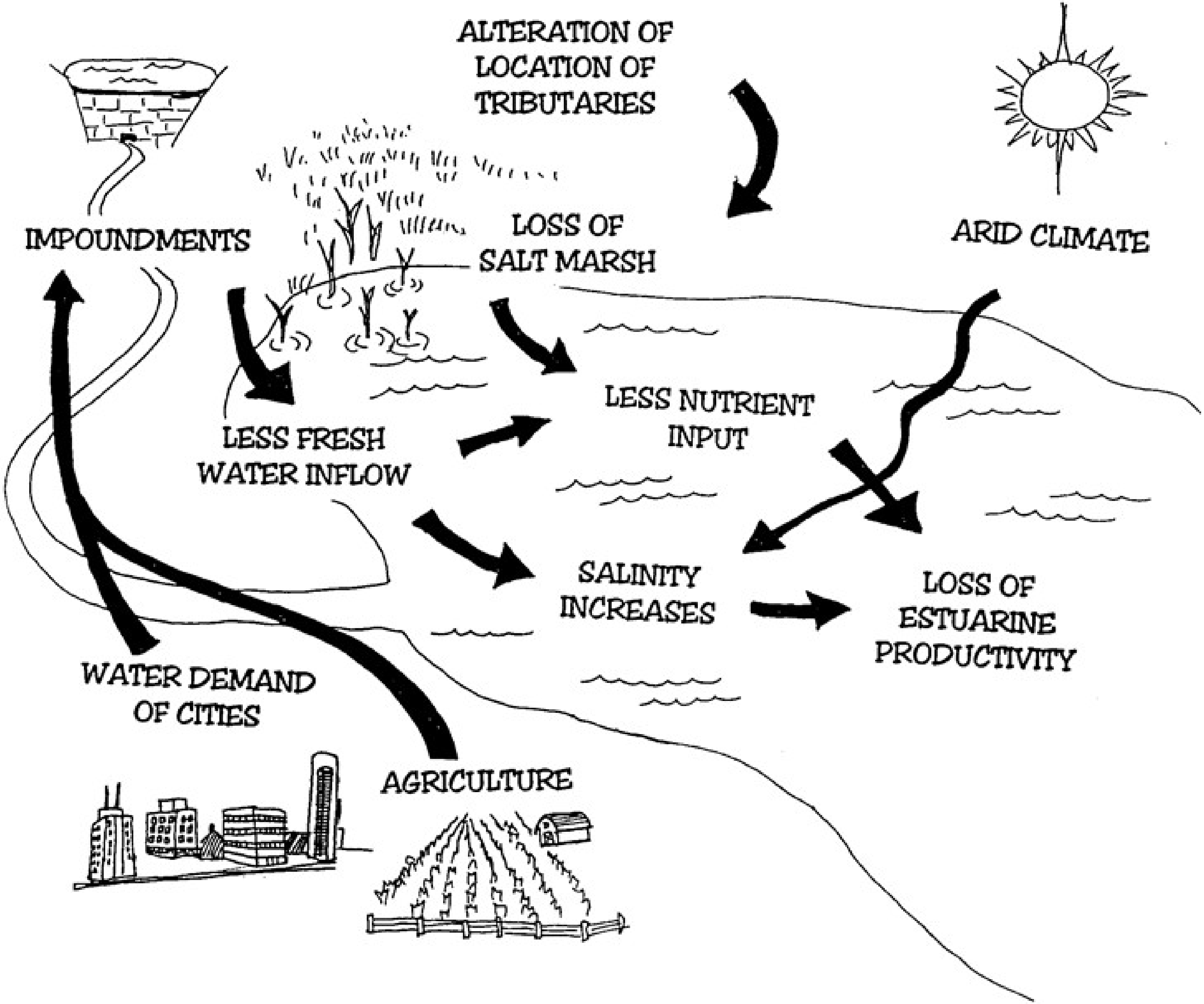
?

The Water Cycle

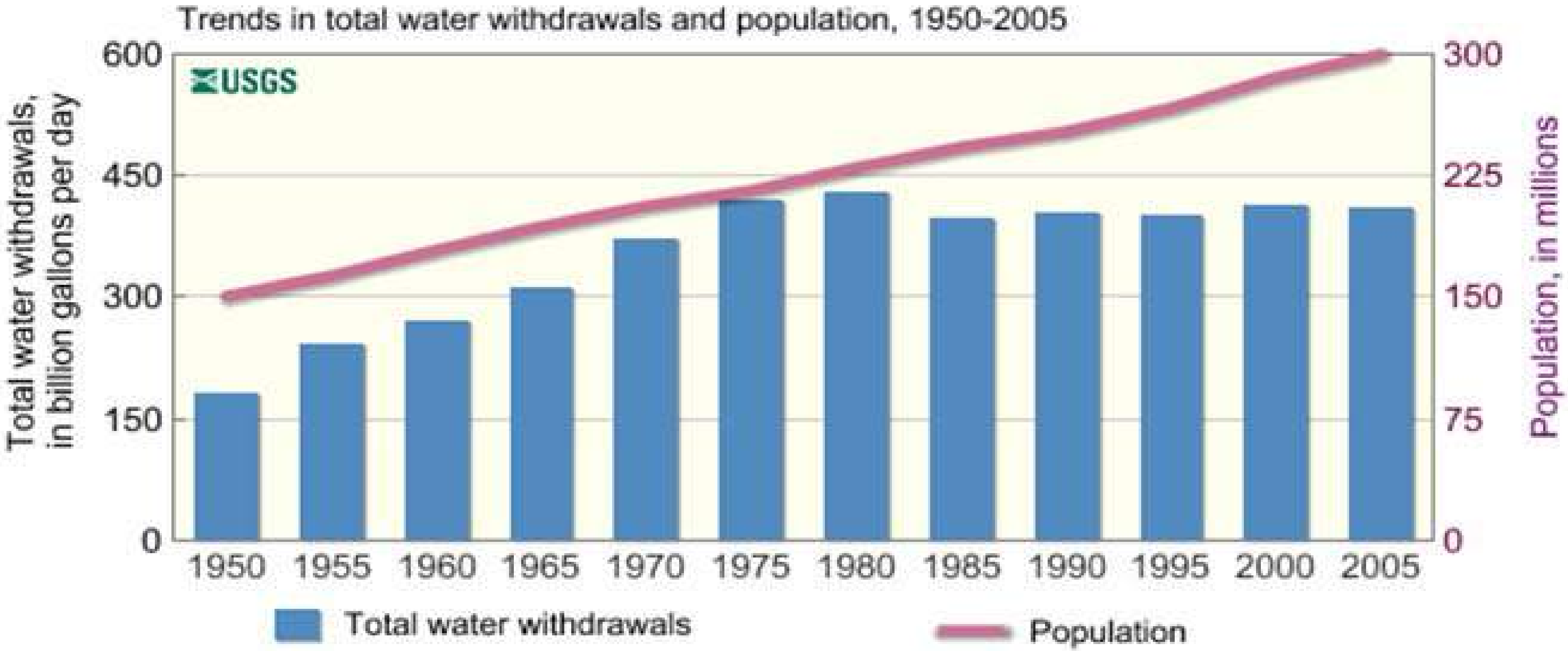
- **Instream:** flow within streams and rivers
- **Inflow:** from rivers to estuaries
- **Outflow:** from estuaries to the coastal ocean



The water cycle


ALTERATION OF LOCATION OF TRIBUTARIES
IMPOUNDMENTS
LOSS OF SALT MARSH
ARID CLIMATE
LESS NUTRIENT INPUT
LESS FRESH WATER INFLOW
SALINITY INCREASES
LOSS OF ESTUARINE PRODUCTIVITY
WATER DEMAND OF CITIES
AGRICULTURE

Freshwater is becoming increasingly limited per household



Total water withdrawals for the United States, 1950-2005
(Data are in billion gallons per day (Bgal/d))

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005
Fresh	140	180	190	210	250	260	280	263	255	261	265	270
Saline	10	18	31	43	53	69	71	59.6	68.2	59.7	61.0	58.0
Total	150	198	221	253	303	329	351	323	323	321	326	328

Estuarine Ecosystems are among the most productive on the planet. All marine habitats combined have been valued at providing 14$ trillion worth of goods and services annually.

Intrinsic value: Something has value in and of itself, and is not necessarily measured monetarily

Example: The Aransas Project lawsuit against the State of Texas for violation of the ESA by honoring **freshwater permits** issued by TCEQ for San Antonio and Guadalupe Rivers thereby reducing freshwater inflow into the coastal estuaries to the extent that the **main food source** of the endangered whooping crane, the blue crab, was reduced sufficiently to result in whooping crane mortality.

Navigation: The Intracoastal Waterway offers protection from heavy Gulf seas moving cargo safely via cost effective barges.   Environmental downside is required periodic maintenance dredging.

Assimilative Capacity: The ability of an estuary to **remove contaminants** in the water by plant absorption and organisms' assimilation into their bodies, thereby reducing the waste load entering the oceans.

However, excessive nutrient loading (nitrogen, phosphorus) can result in **eutrophication** (dense phytoplankton blooms) resulting in low DO, and thereby decreasing the ability of the estuary to effectively filter contaminants.

Recreation and commercial fisheries: 80% recreational harvest and 68% commercial harvest finfish and shellfish is from US estuaries.

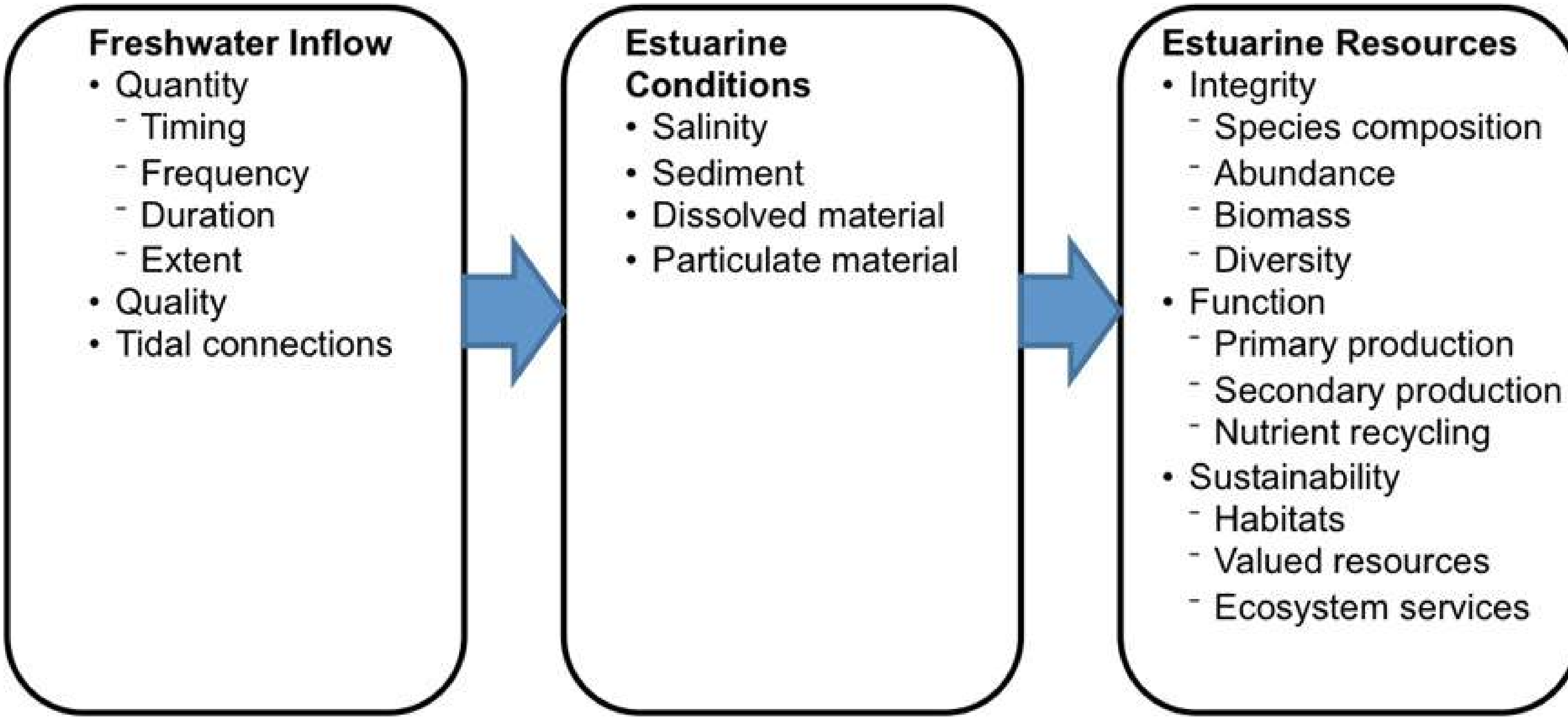
Many offshore species are dependent on estuaries for part of their life cycle- shrimp and menhaden in the Gulf, for example

Recreation

Intertidal wetlands: Estuarine ecosystems between low and high tide. Highly productive ecosystems- 2/3 of worlds' fish catch spend part of their life cycle in intertidal wetlands (most often very early stages) Blue crab larvae move from nearshore ocean to intertidal wetlands as they metamorphoses into the megalopae larval stage

Rare and Endangered species

The **DOMINO THEORY** suggests that freshwater inflow indirectly affects estuarine resources



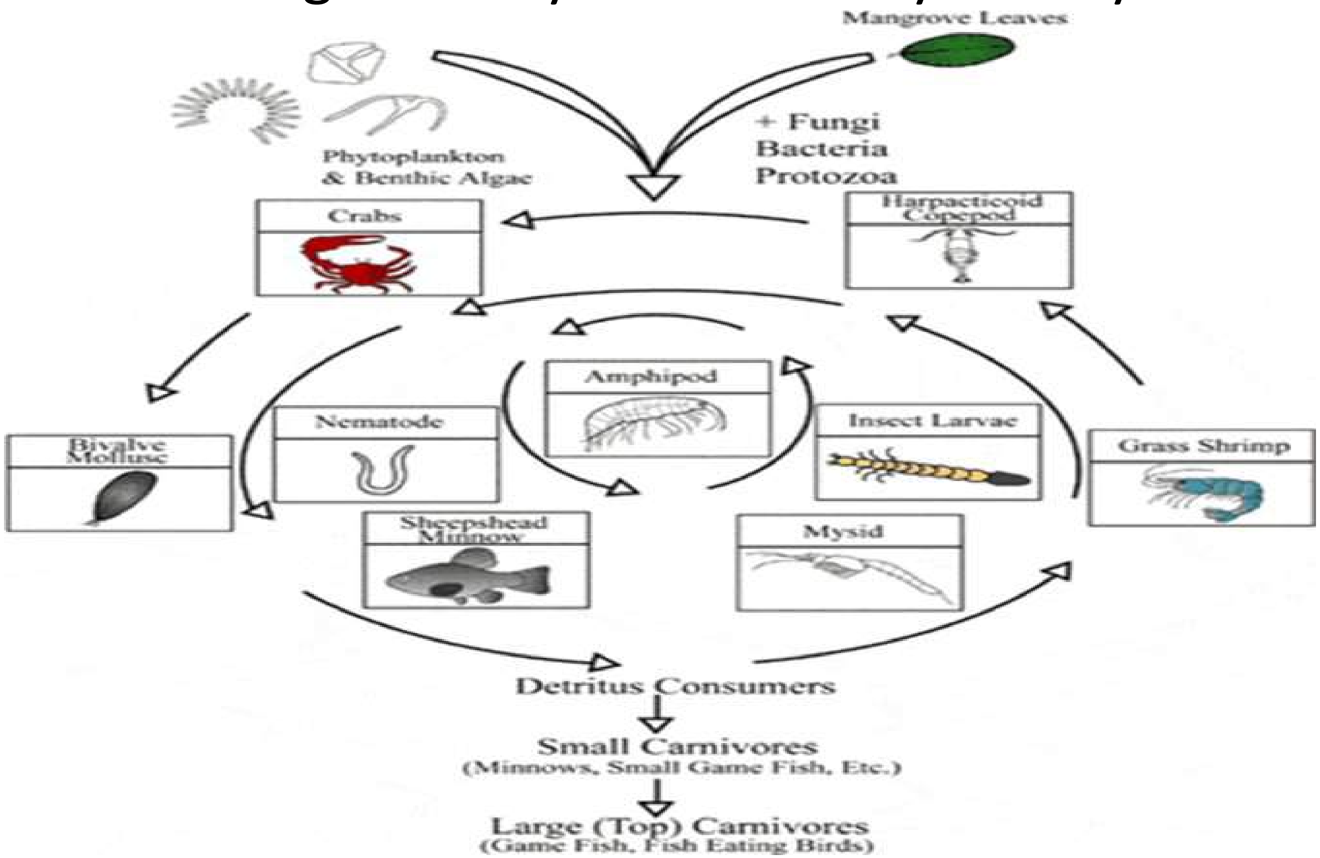
Historically **benthic** biomass, abundance, and species diversity have been used to identify **bioindicators** which in turn signify the health of the ecosystem.

Benthos are used as **bioindicators** because they

1. Occur throughout the estuary
2. Can travel only short distances
3. Are generally osmoconformers

(fish, crabs, shrimp can move to avoid stressful conditions, including salinity)

Freshwater inflow and thus salinity gradients (isohalines) within an estuary determine both plant and organism distribution. Although most estuarine organisms **tolerate** a wide range of salinities most have an **optimal** salinity range where they are least stressed and most likely to survive
Estuarine **trophic structures** are some of the most complex in nature and are significantly influenced by salinity.



Estuarine habitats- Emergent vegetation

Estuarine habitats- Seagrass meadow

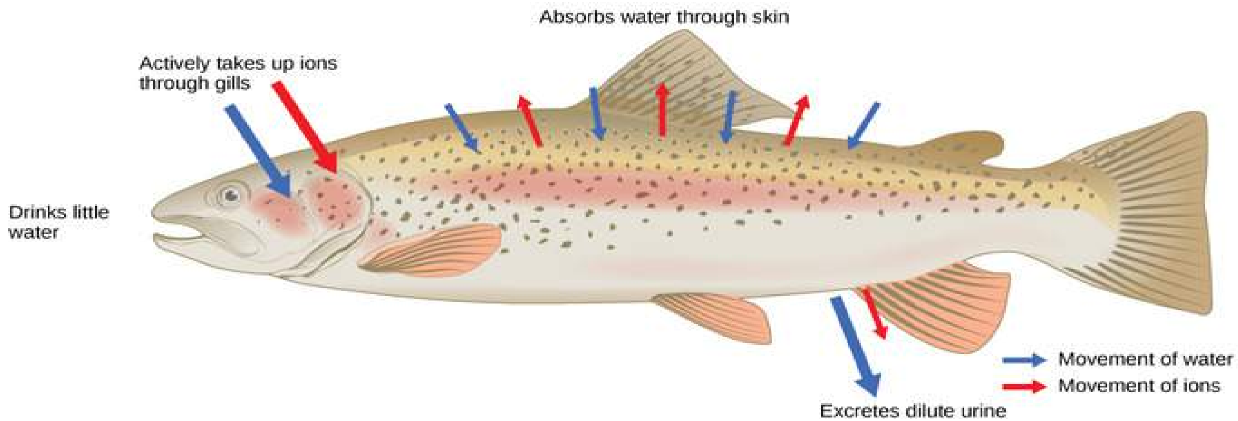
Estuarine habitat- mangroves

Oysters are essential in maintaining an optimal phytoplankton density in Texas bays, which are becoming increasingly **eutrophic** as a result of urbanization which **reduces infiltration** of rainwater as well as **nutrient enriched return flows** from sewage treatment plants.

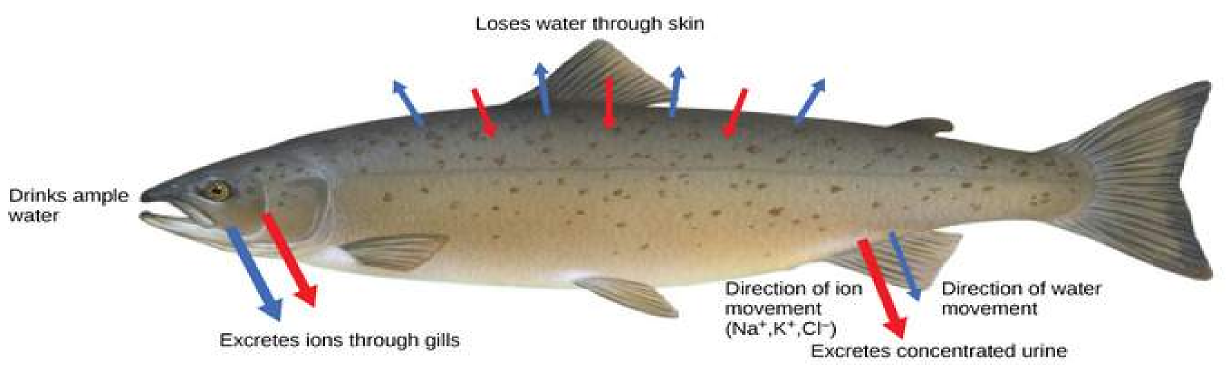
Oysters are stressed at salinities above 15 PPT due to predator infestation (drills) as well as susceptibility to disease (*Perkinsus marinus*)=Dermo

Osmoregulation in fish: **Larval** fish often seek estuaries after hatching in the ocean.

Larval fish often have incompletely developed kidney systems and become physiologically stressed when external salinity varies greatly from their internal salinity. They will seek an optimal salinity in an estuary with salinity gradients.



(a) Osmoregulation in a freshwater environment



(b) Osmoregulation in a saltwater environment

TWDB/TPWD approach to determining freshwater inflow needs

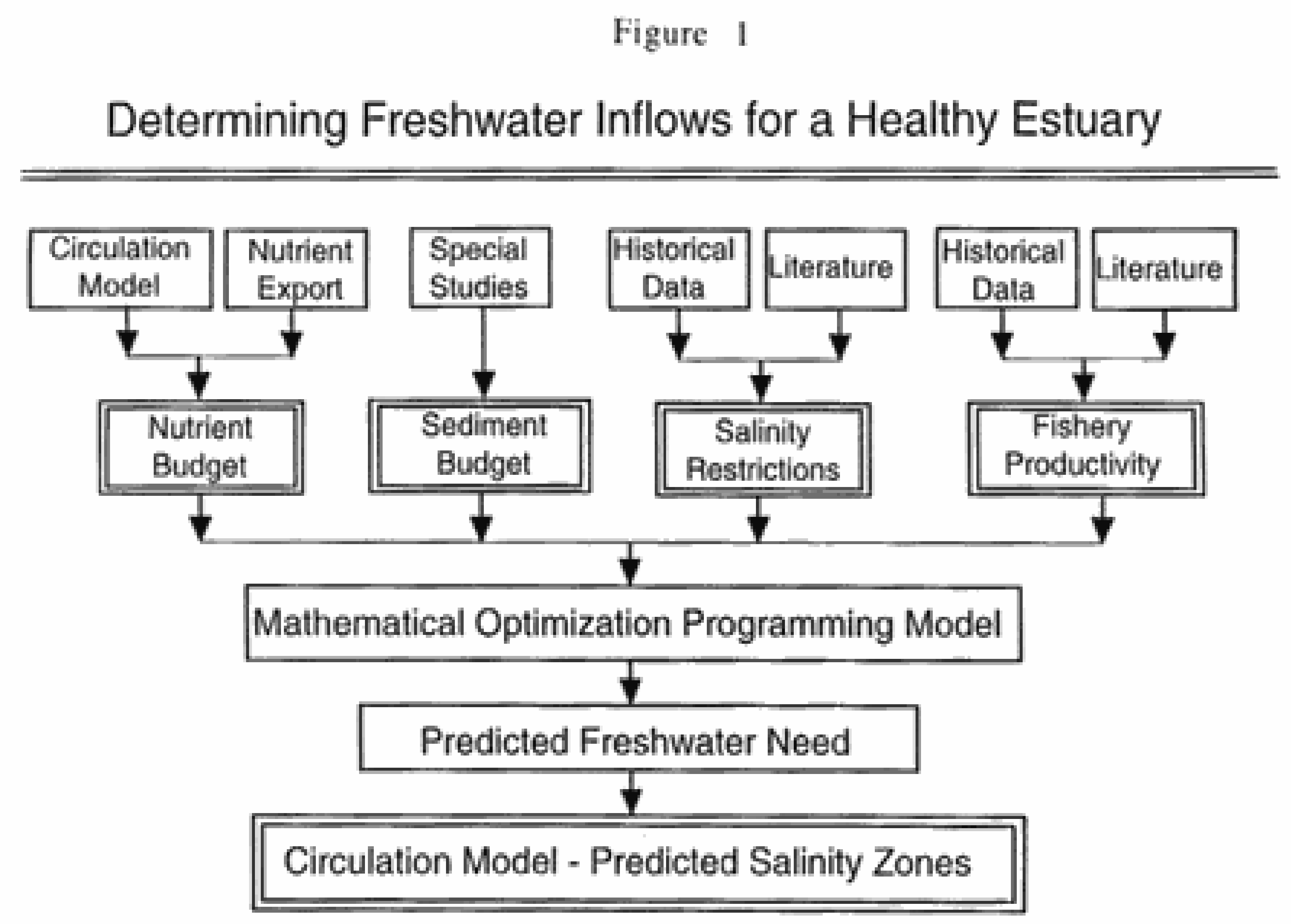


Table 1

TxEMP MODEL SOLUTIONS FOR GUADALUPE ESTUARY

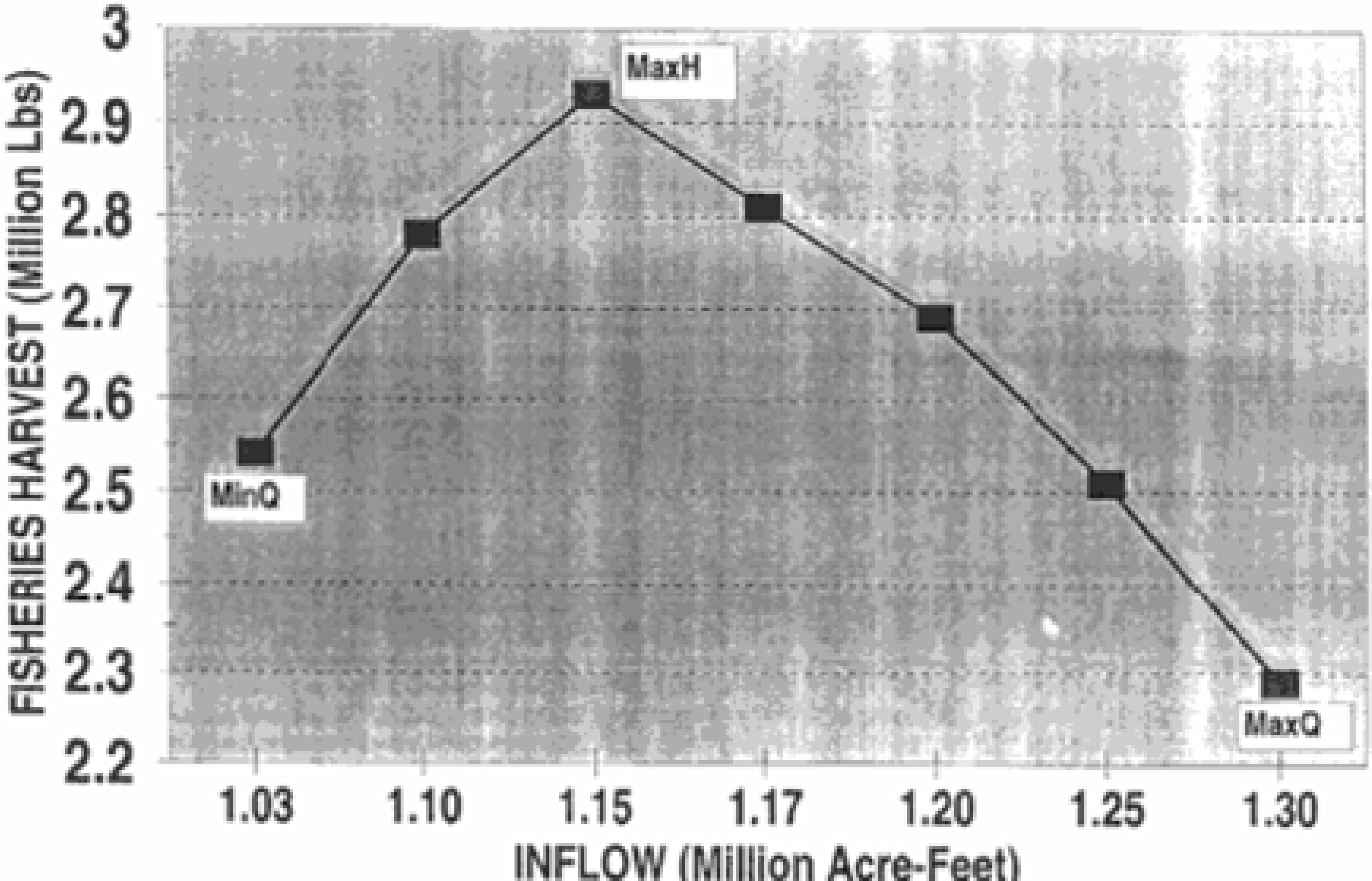
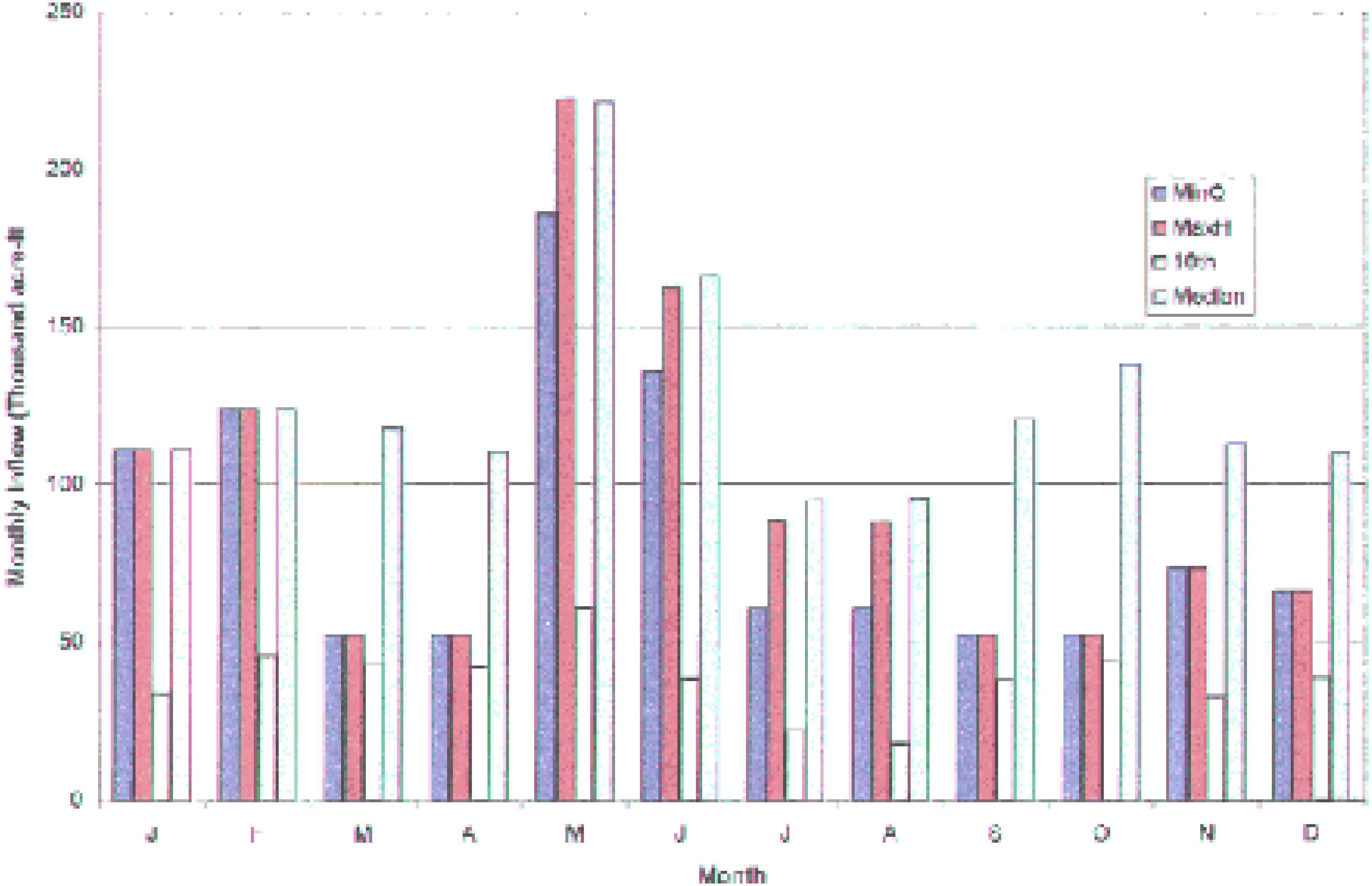


Table 2. Monthly Inflow Needs (in thousands of acre-feet) of Guadalupe Estuary for Two Simulations.

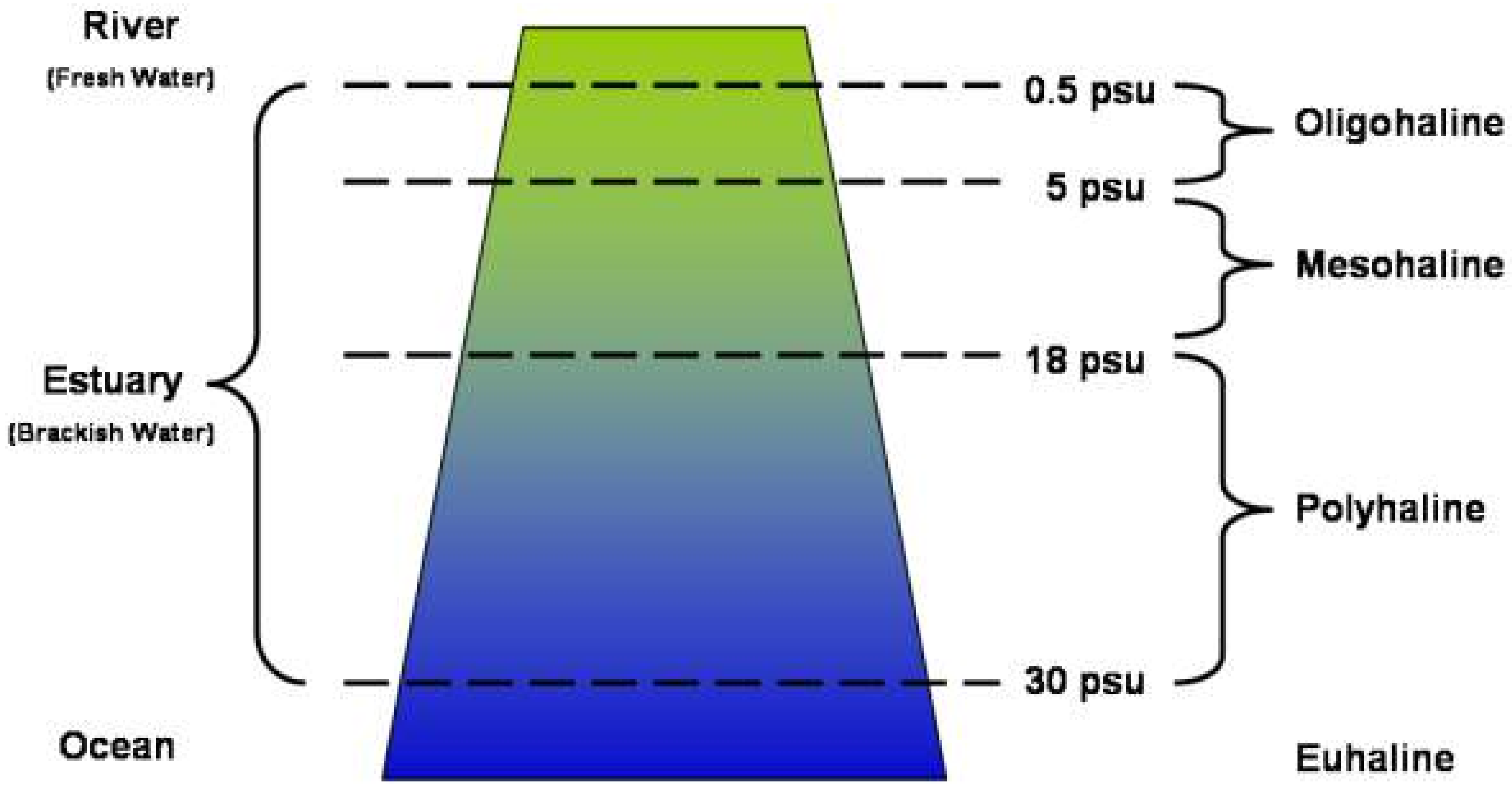
Species	MinQ	MaxH
Blue Crab	255.5	379.9
Oyster	609.7	702.7
Red Drum	63.8	84.0
Black Drum	32.4	32.4
Spotted Seatrout	113.0	114.8
Brown Shrimp	547.8	704.0
White Shrimp	918.2	910.3
Total Harvest	2540.4	2928.0

END

Figure 4. TxEMP Monthly Inflow Distribution - Guadalupe Estuary



Title?


River
(Fresh Water)
Estuary
(Brackish Water)
Ocean
0.5 psu
5 psu
18 psu
30 psu
Oligohaline
Mesohaline
Polyhaline
Euhaline

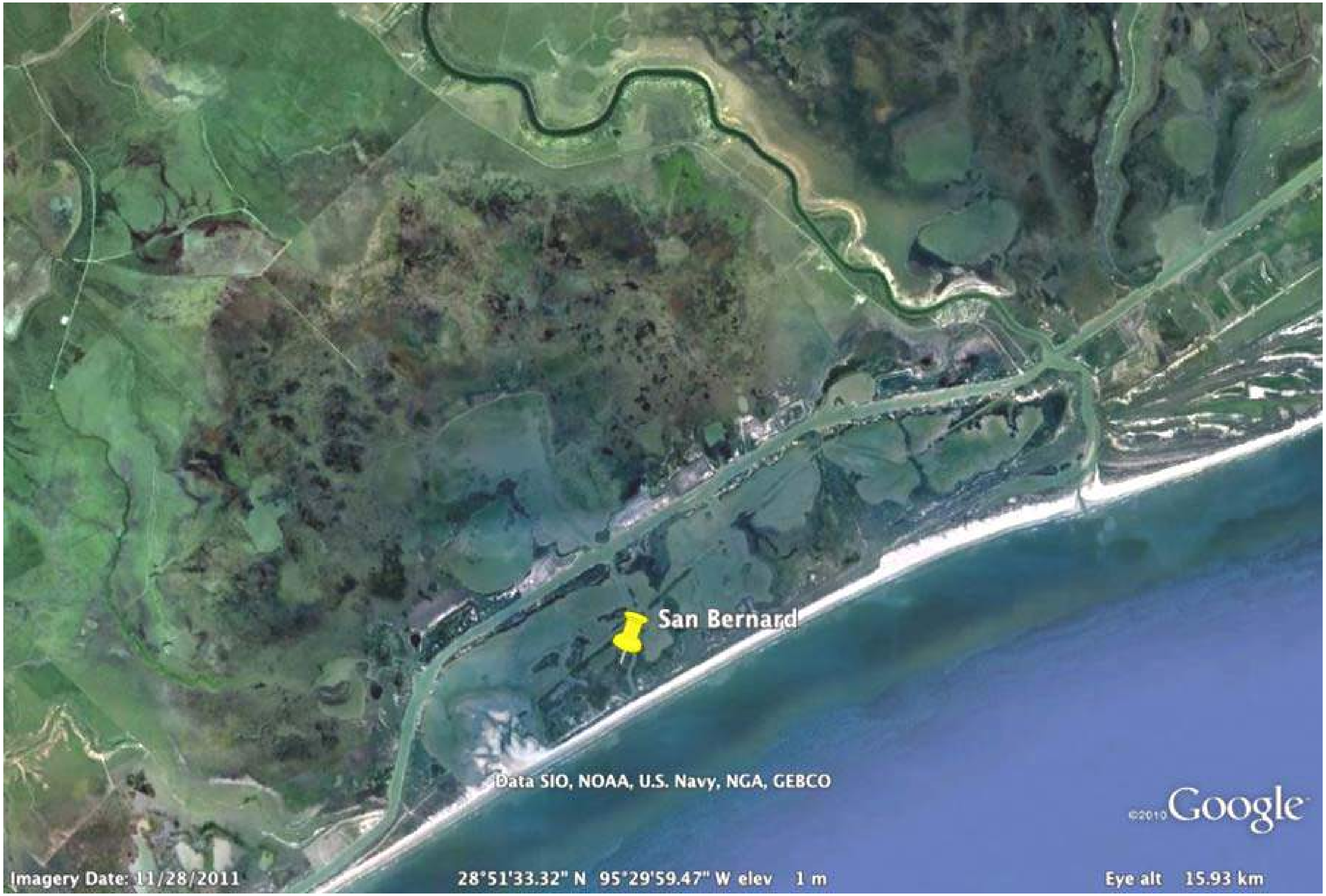
Title?


Matagorda Bay, Texas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2012 TerraMetrics
Google
28°34'47.08" N 96°15'21.69" W elev -1 m
Eye alt 63.76 km

Title?


East Matagorda Bay, Texas
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
©2010 Google
Imagery Date: 11/28/2011
28°41'36.86" N 95°50'55.90" W elev 0 m
Eye alt 35.00 km

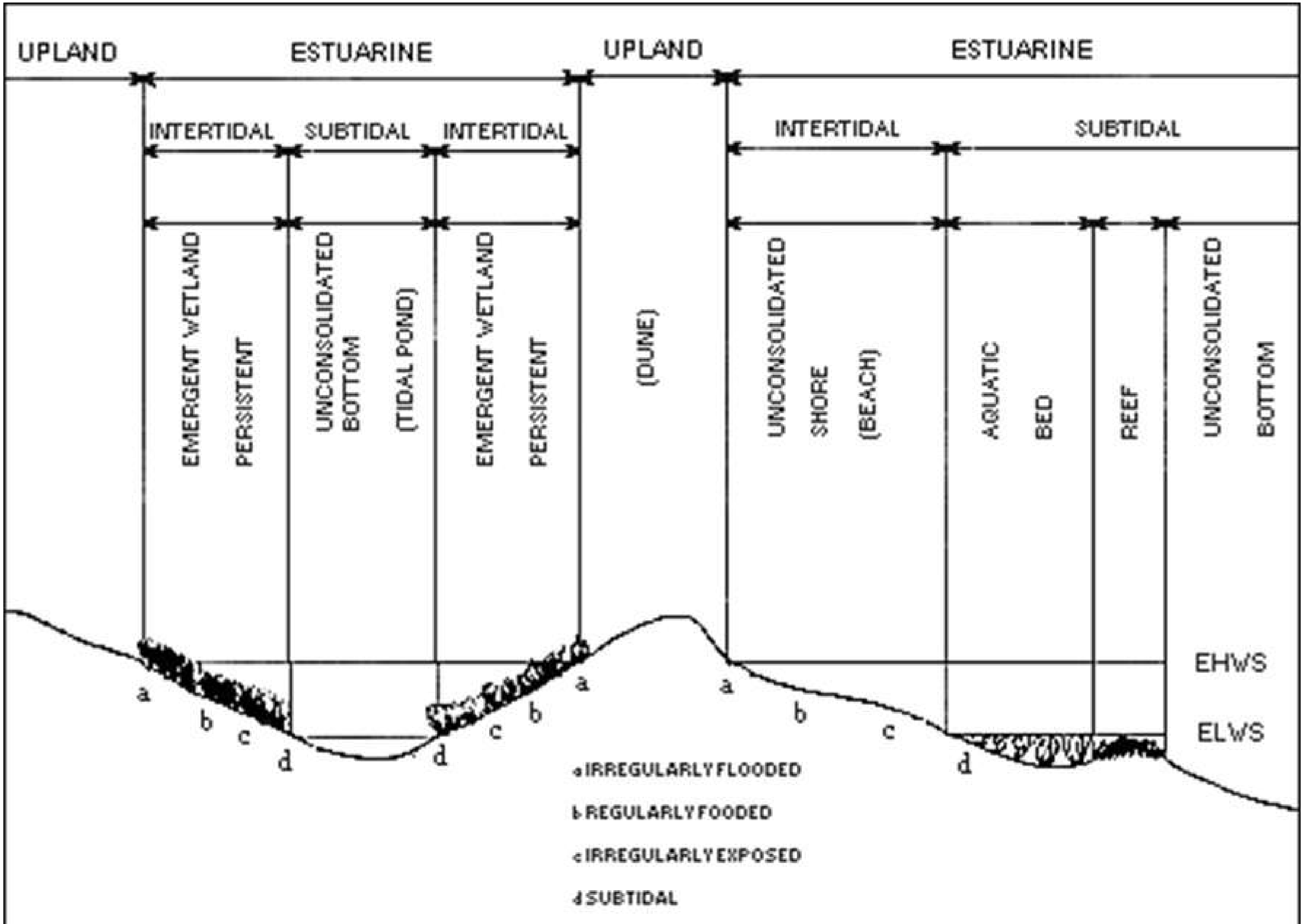
Title ?



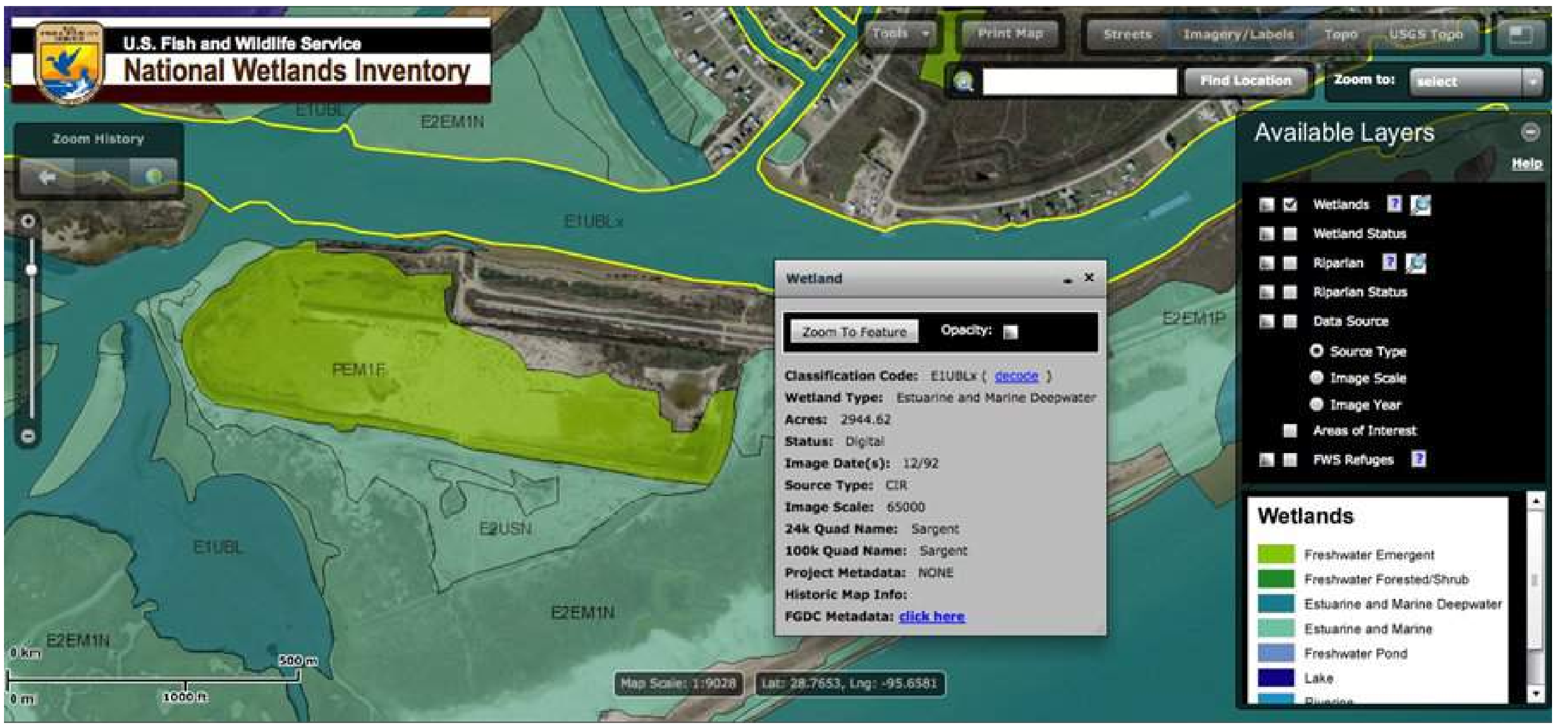
San Bernard
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
©2010 Google
Imagery Date: 11/28/2011
28°51'33.32" N 95°29'59.47" W elev 1 m
Eye alt 15.93 km

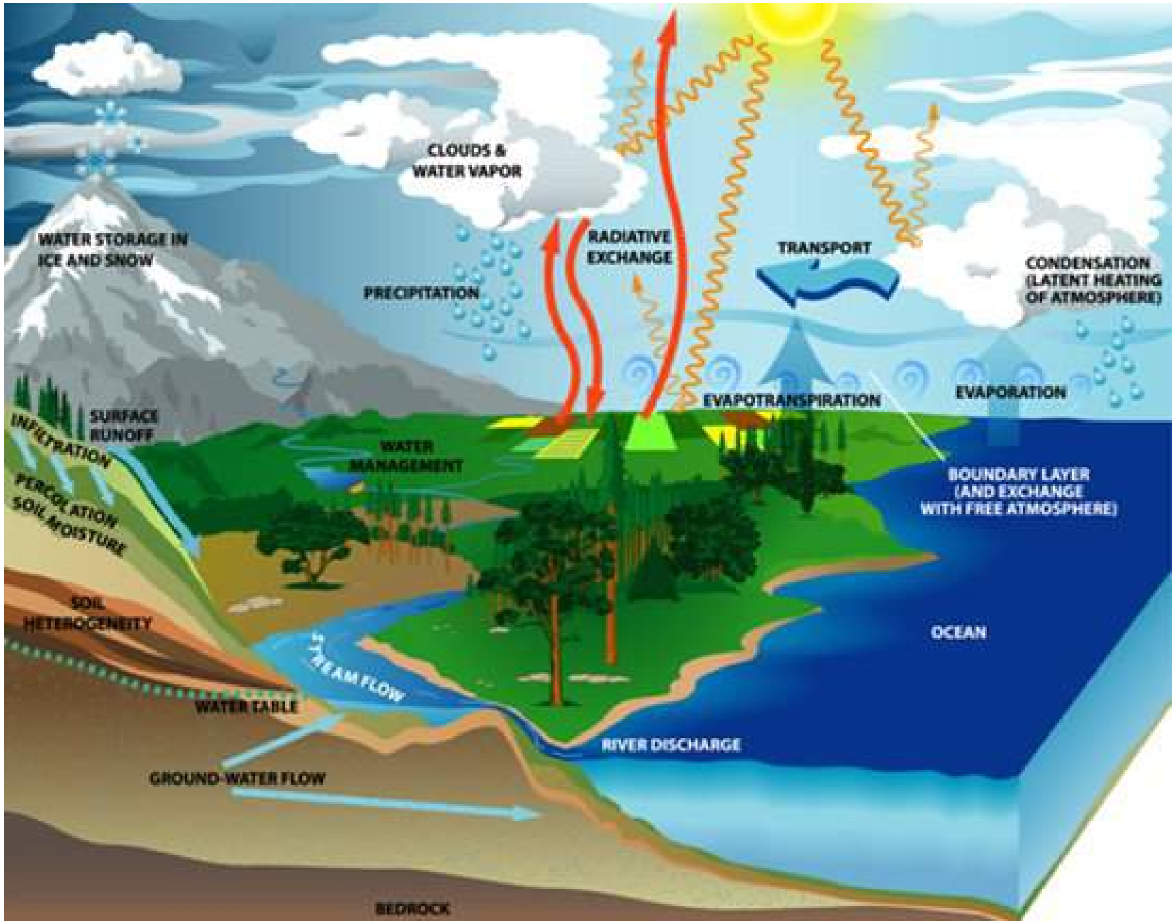
Title?

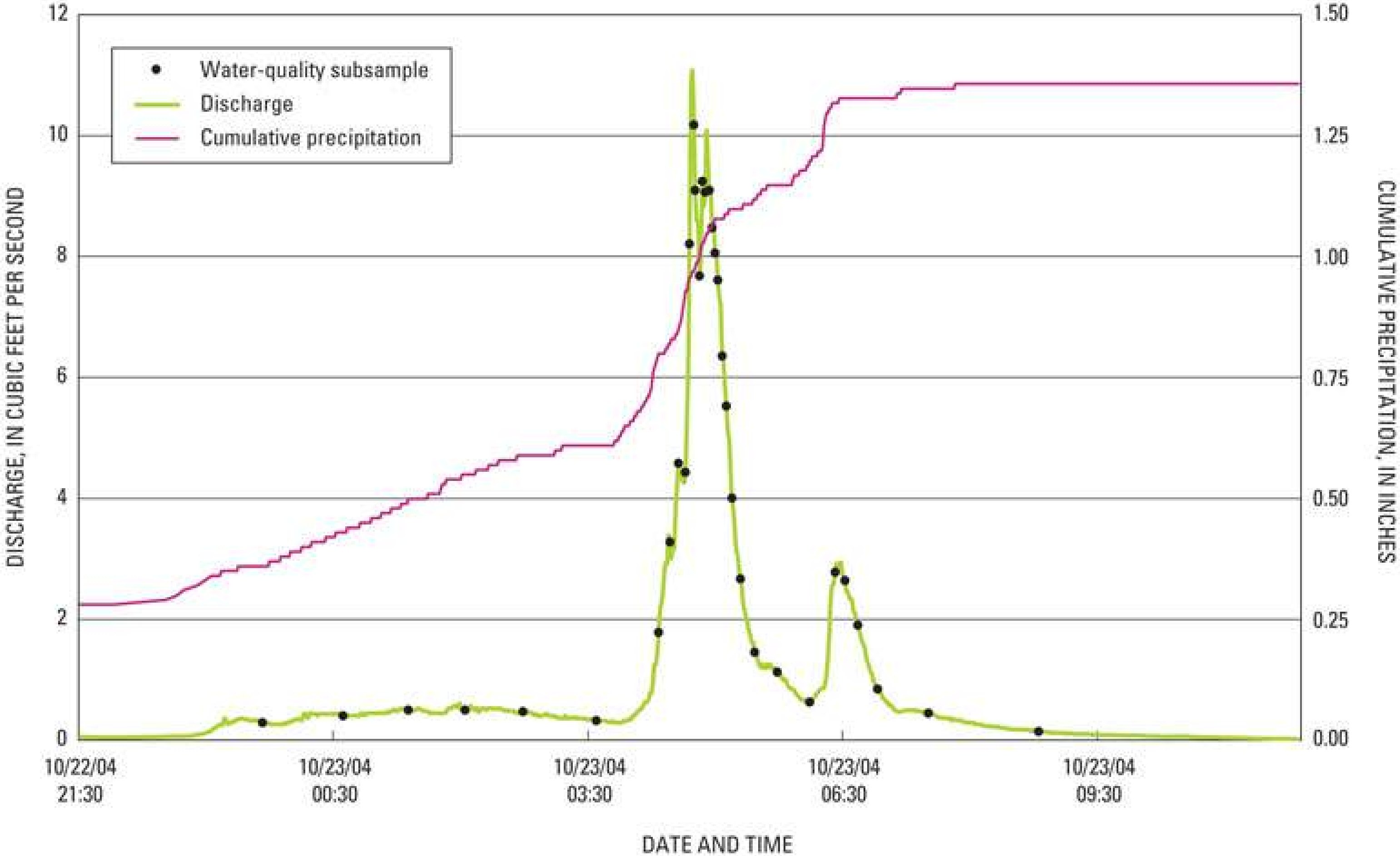
Title?



UPLAND
ESTUARINE
UPLAND
ESTUARINE
INTERTIDAL
SUBTIDAL
INTERTIDAL
INTERTIDAL
SUBTIDAL
EMERGENT WETLAND
PERSISTENT
UNCONSOLIDATED BOTTOM
(TIDAL POND)
EMERGENT WETLAND
PERSISTENT
(DUNE)
UNCONSOLIDATED
SHORE
(BEACH)
AQUATIC
BED
REEF
UNCONSOLIDATED
BOTTOM
EHWS
ELWS
a IRREGULARLY FLOODED
b REGULARLY FOODED
c IRREGULARLY EXPOSED
d SUBTIDAL

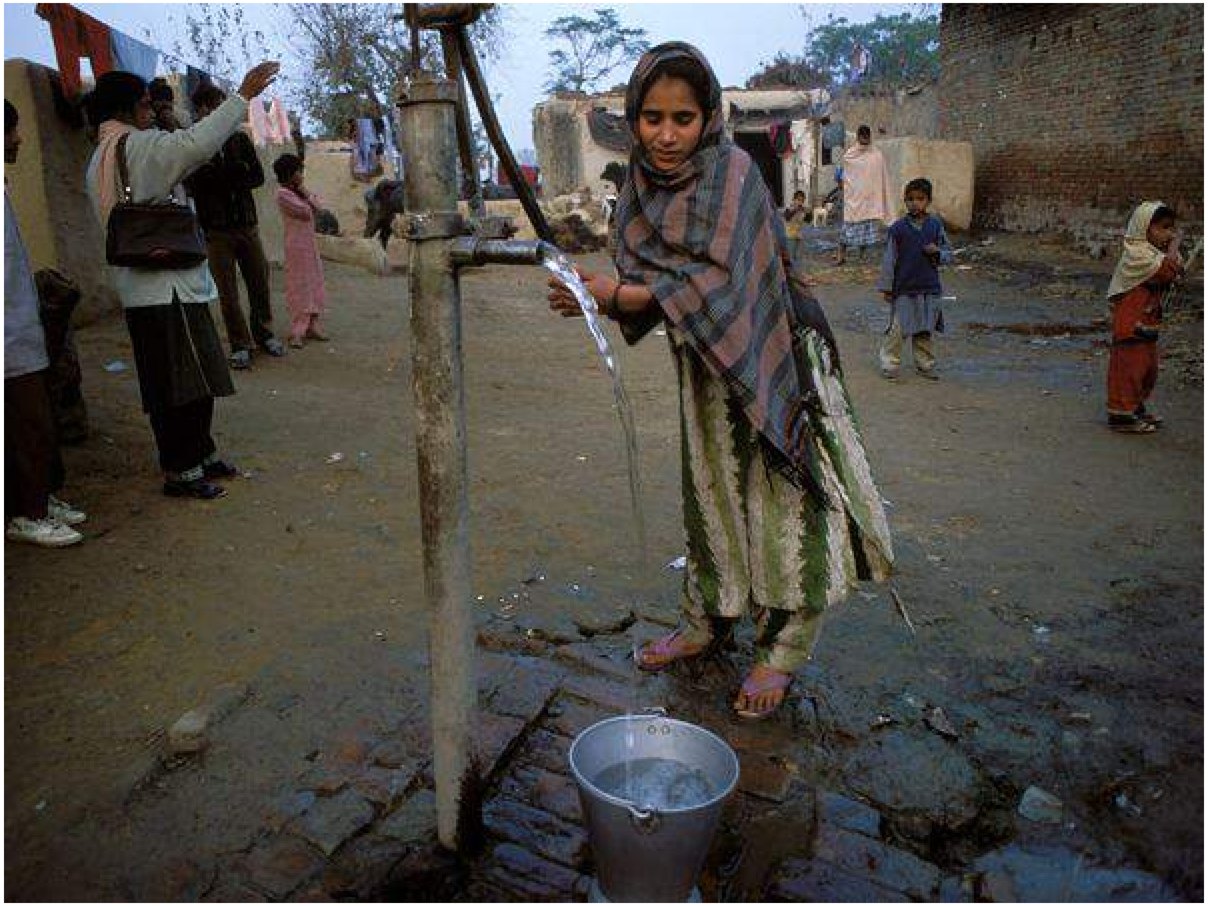

U.S. Fish and Wildlife Service
National Wetlands Inventory
Tools
Print Map
Streets
Imagery/Labels
Topo
USGS Topo
Find Location
Zoom to:
select
Zoom History
E1UBL
E2EM1N
E1UBLx
PEM1F
E2USN
E1UBL
E2EM1N
E2EM1N
E2EM1P
Wetland
Zoom To Feature
Opacity:
Classification Code: E1UBLx (decode)
Wetland Type: Estuarine and Marine Deepwater
Acres: 2944.62
Status: Digital
Image Date(s): 12/92
Source Type: CIR
Image Scale: 65000
24k Quad Name: Sargent
100k Quad Name: Sargent
Project Metadata: NONE
Historic Map Info:
FGDC Metadata: click here
Available Layers
Help
Wetlands
Wetland Status
Riparian
Riparian Status
Data Source
Source Type
Image Scale
Image Year
Areas of Interest
FWS Refuges
Wetlands
Freshwater Emergent
Freshwater Forested/Shrub
Estuarine and Marine Deepwater
Estuarine and Marine
Freshwater Pond
Lake
0 km
500 m
0 m
1000 ft
Map Scale: 1:9028
Lat: 28.7653, Lng: -95.6581


CLOUDS &
WATER VAPOR
WATER STORAGE IN
ICE AND SNOW
RADIATIVE
EXCHANGE
TRANSPORT
CONDENSATION
(LATENT HEATING
OF ATMOSPHERE)
PRECIPITATION
EVAPOTRANSPIRATION
EVAPORATION
SURFACE
RUNOFF
INFILTRATION
WATER
MANAGEMENT
BOUNDARY LAYER
(AND EXCHANGE
WITH FREE ATMOSPHERE)
PERCOLATION
SOIL MOISTURE
SOIL
HETEROGENEITY
OCEAN
STREAM FLOW
WATER TABLE
RIVER DISCHARGE
GROUND-WATER FLOW
BEDROCK



Water-quality subsample
Discharge
Cumulative precipitation
DISCHARGE, IN CUBIC FEET PER SECOND
CUMULATIVE PRECIPITATION, IN INCHES
DATE AND TIME
0
2
4
6
8
10
12
0.00
0.25
0.50
0.75
1.00
1.25
1.50
10/22/04
21:30
10/23/04
00:30
10/23/04
03:30
10/23/04
06:30
10/23/04
09:30


ROAD
FLOODED



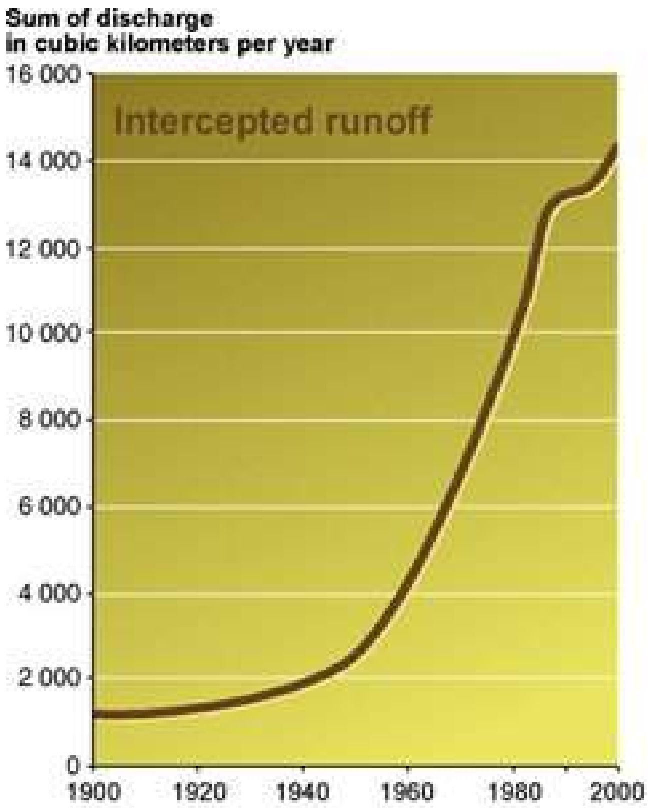


Figure 1. Intercepted continental runoff entrains 3-6 times more water in reservoirs than exists in natural rivers (MEA 2005).

Thus, total surface inflow reaching the estuary consists of:

Surface Inflow = (1) Sum over all gaged watersheds(USGS Gaged Flow)

+ (2) Sum over all ungaged watersheds(Modeled Flow)

- (3) Sum over all ungaged watersheds(Diverted Flow)

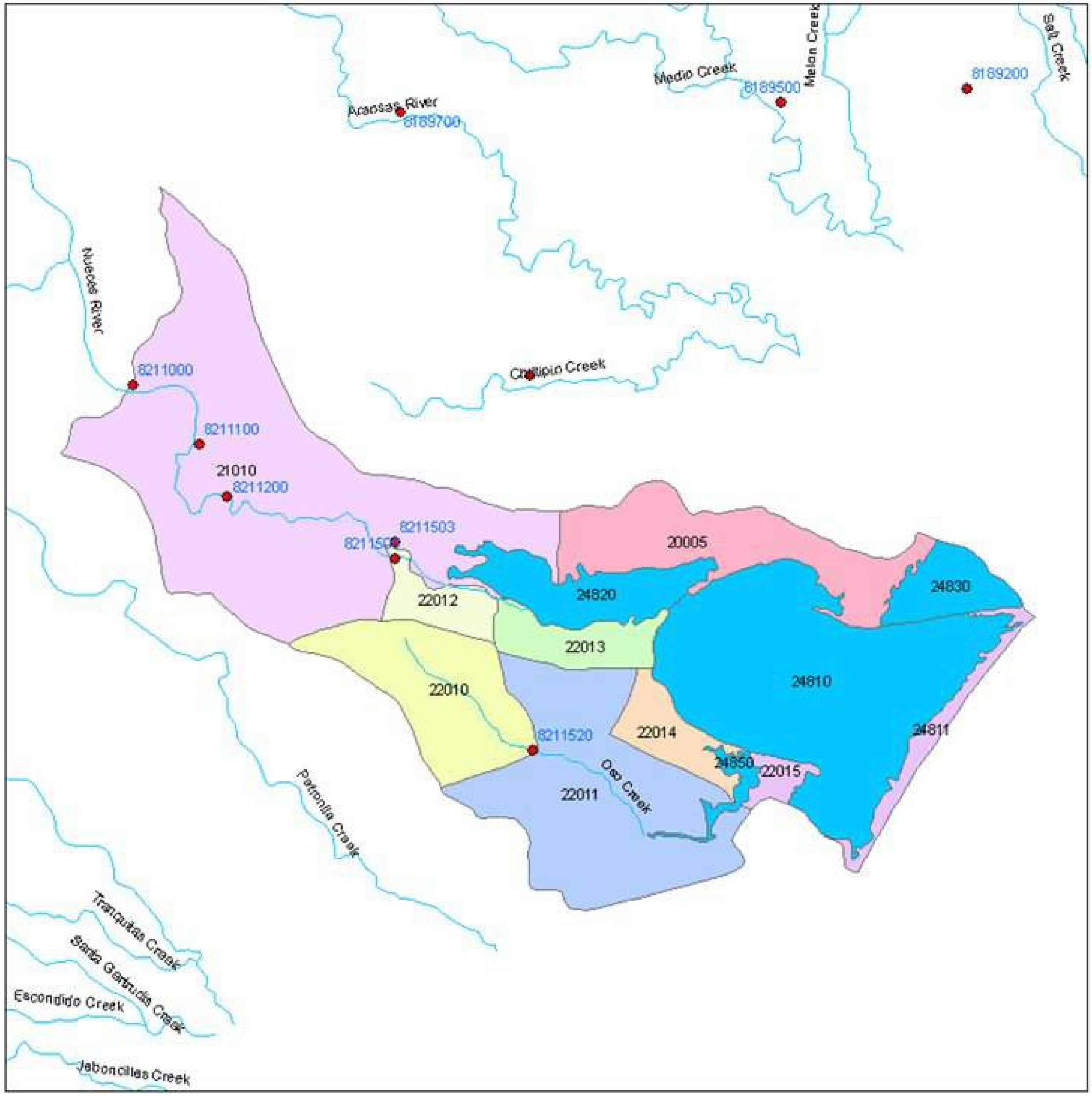
+ (4) Sum over all ungaged watersheds(Returned Flow)

Finally, when considering total fresh water balance, evaporation from and precipition onto the water surface of the estuary must be considered:

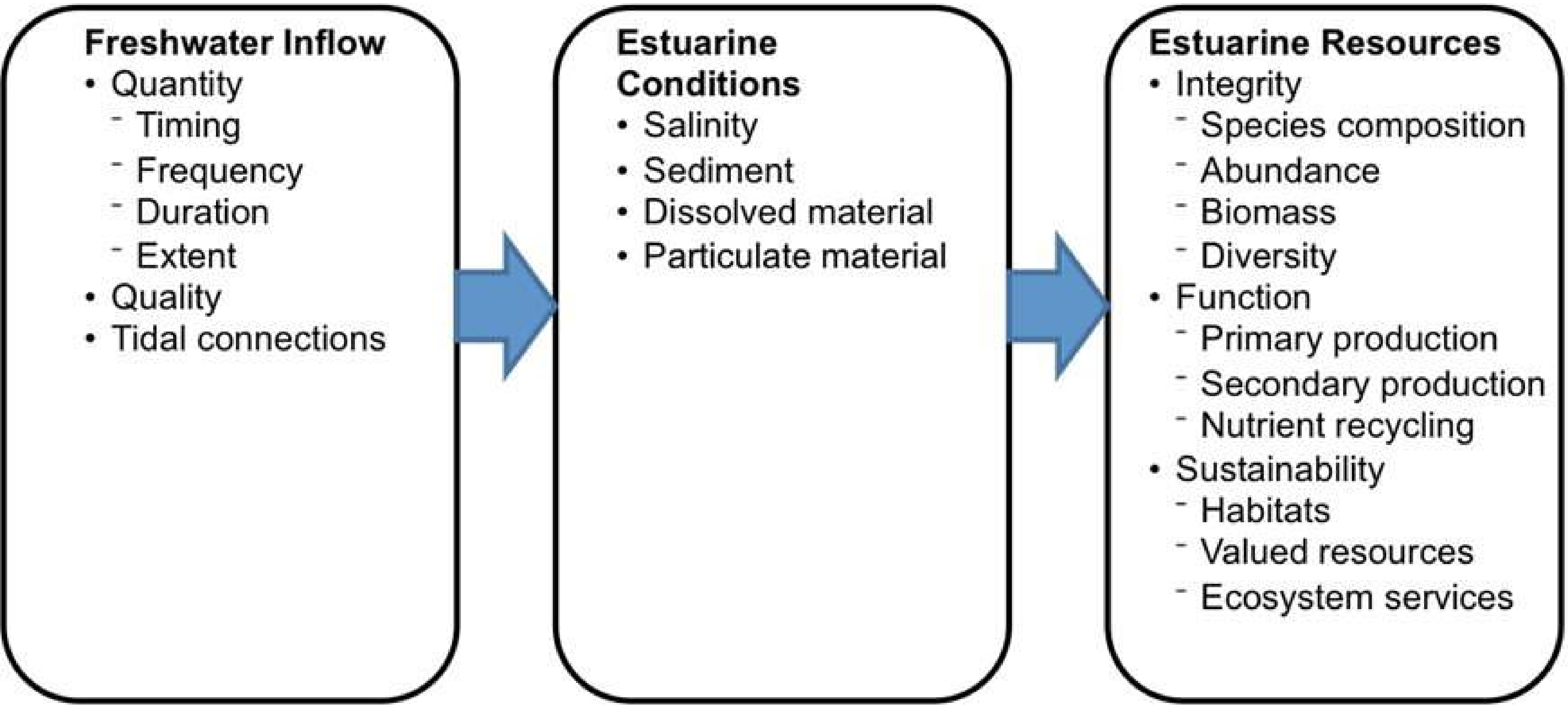
Fresh Water Balance = Surface Inflow

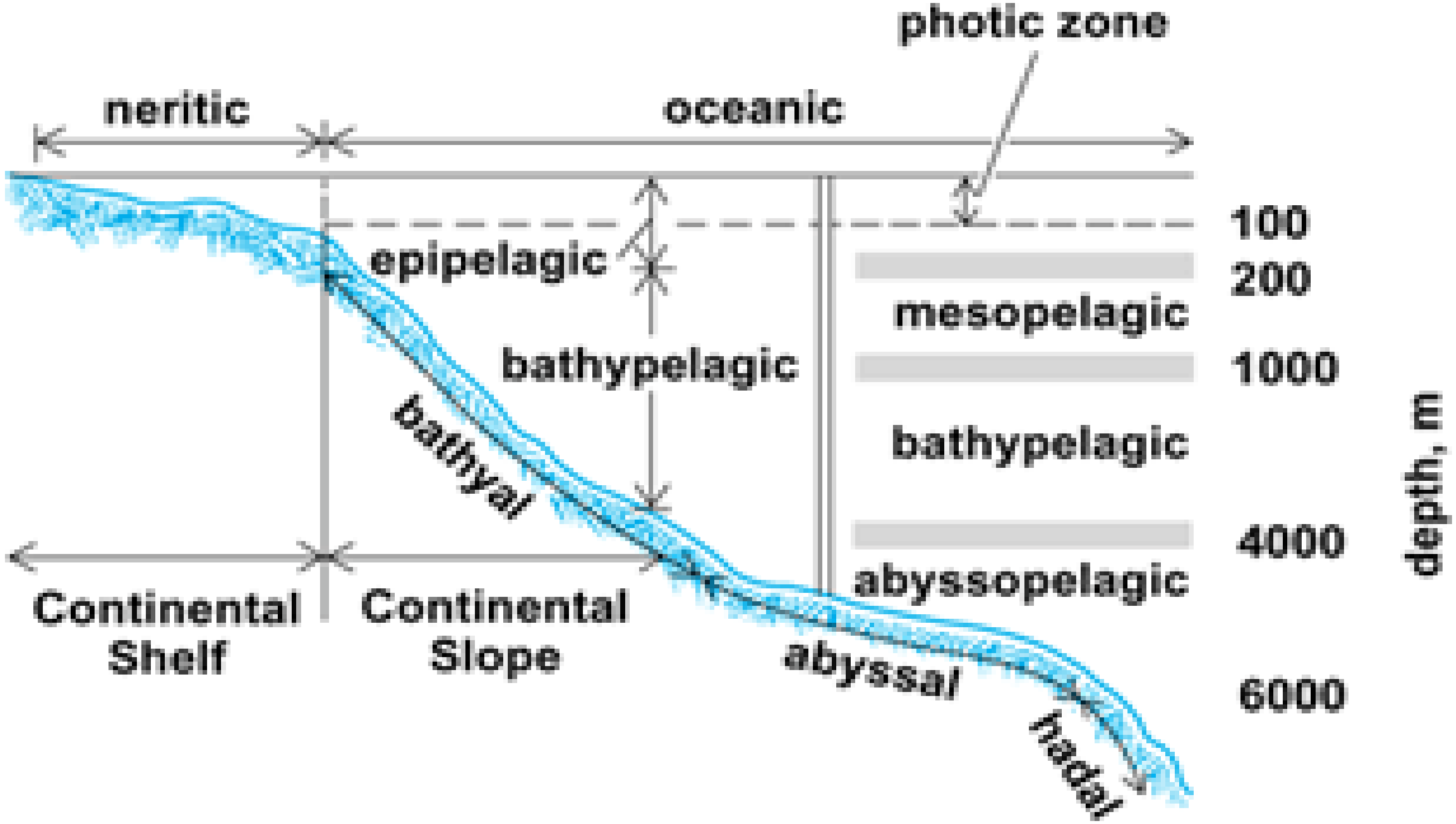
- (5) Evaporation from the estuary surface

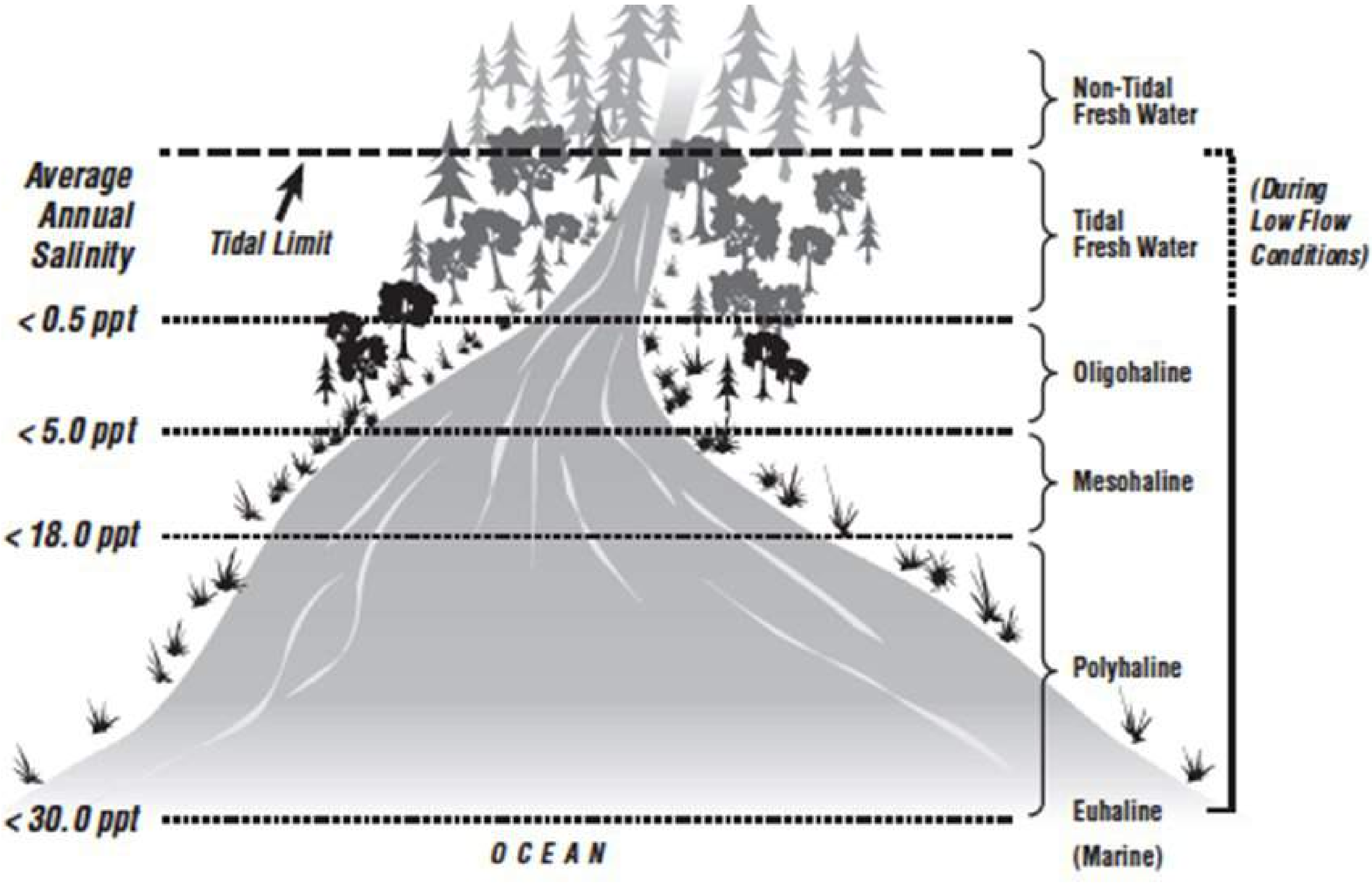
+ (6) Precipitation on the estuary surface

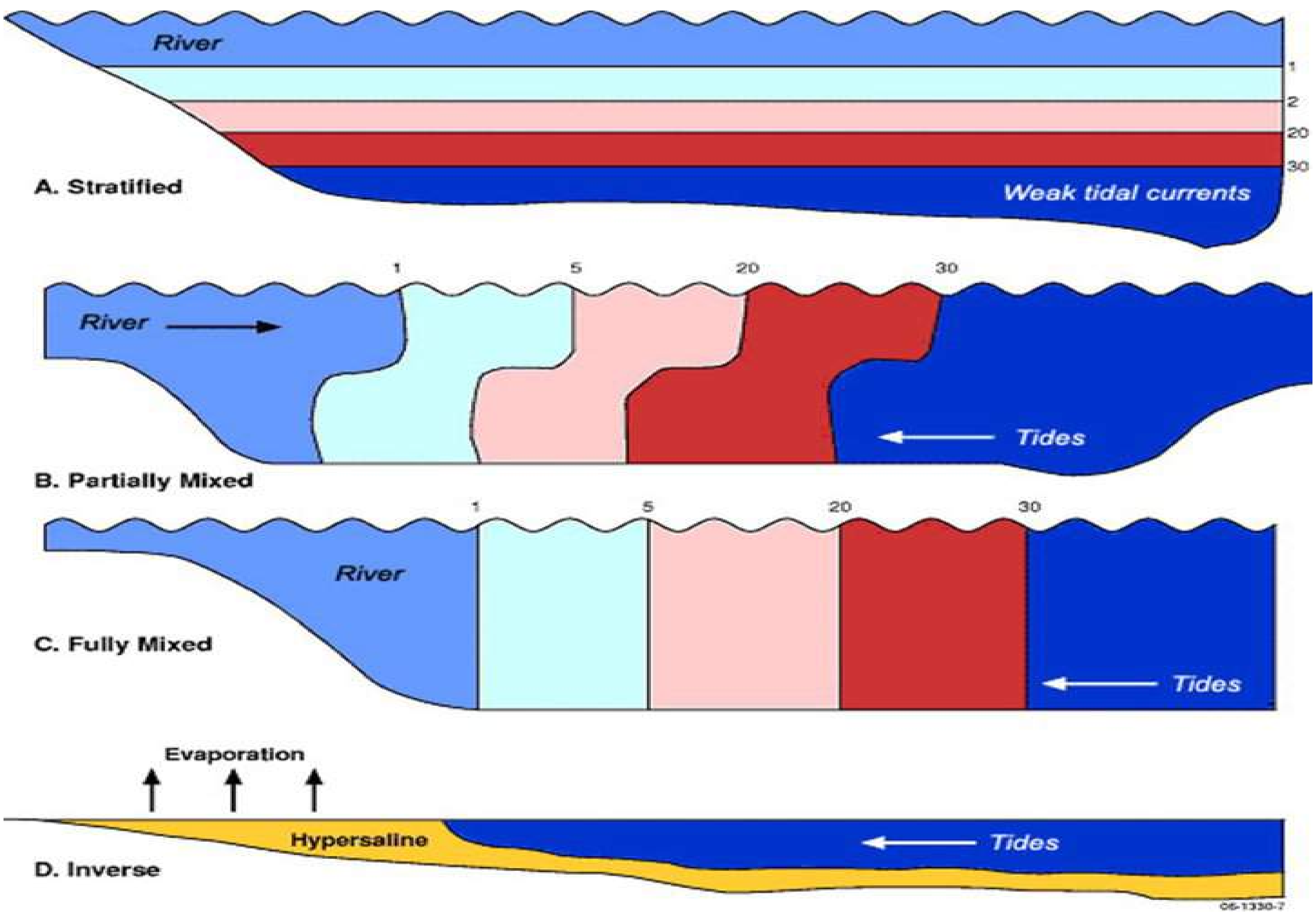

Aransas River
8189700
Medio Creek
8189500
Melon Creek
8189200
Salt Creek
Nueces River
8211000
8211100
21010
8211200
8211503
20005
24820
24830
22012
22013
24810
22010
8211520
22014
24811
24850
22015
22011
Oso Creek
Petronila Creek
Tranquitas Creek
Santa Gertrudis Creek
Escondido Creek
Jaboncillas Creek

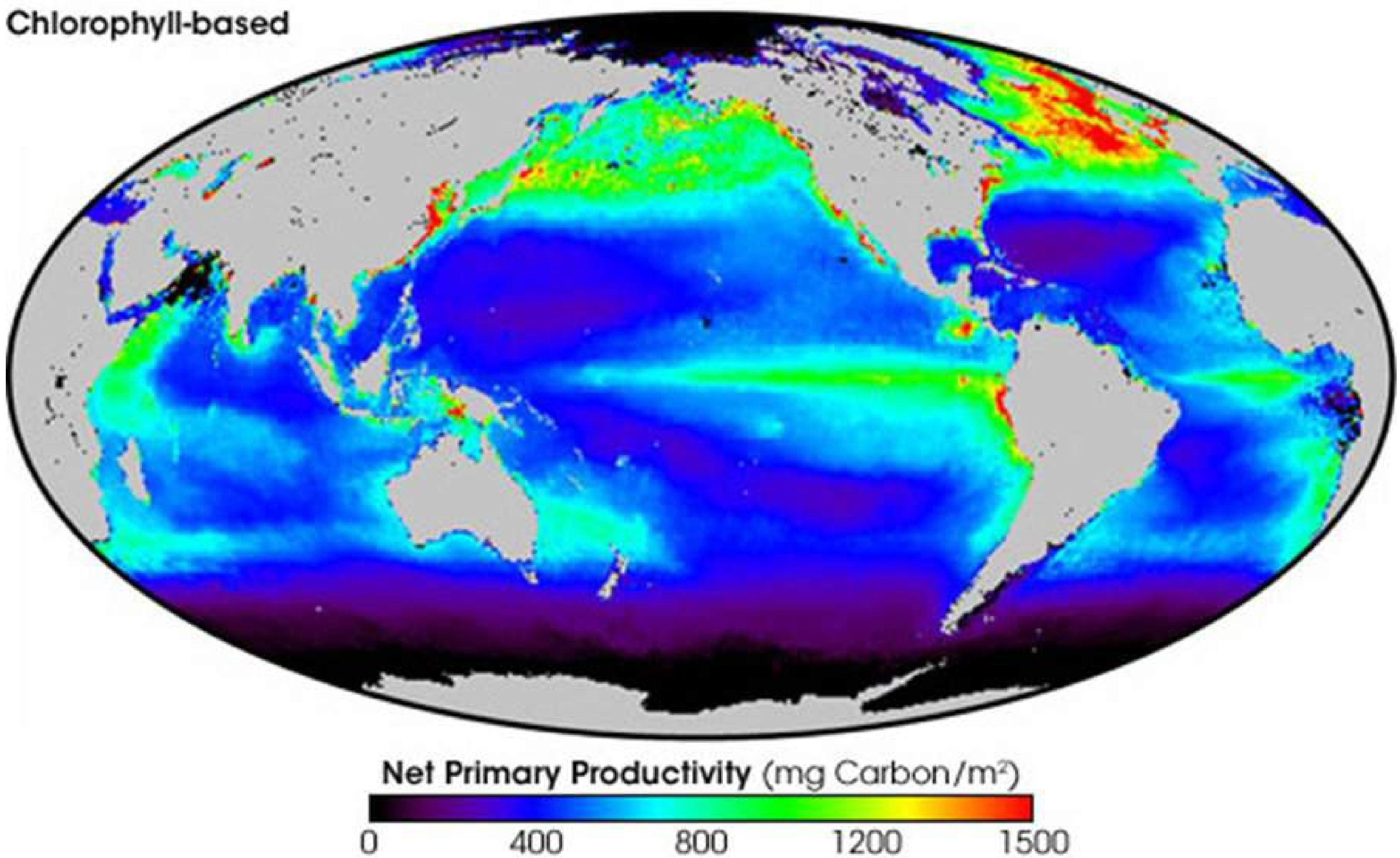
Intertidal Zone
Organisms
Sculpin
Tidepool
Periwinkle
snail
Barnacles
Barnacles
Isopods
Chitons
Isopods
Limpets
Sea star
Sea star
Sea anemone
Mussels
Limpets
Mussels
Isopods
Hermit crab
Crab
©EnchantedLearning.com
Spray Zone
(Usually dry)
High Tide Zone
(Wet during high tide)
Middle Tide Zone
(Wet and dry)
Low Tide Zone
(Usually wet)

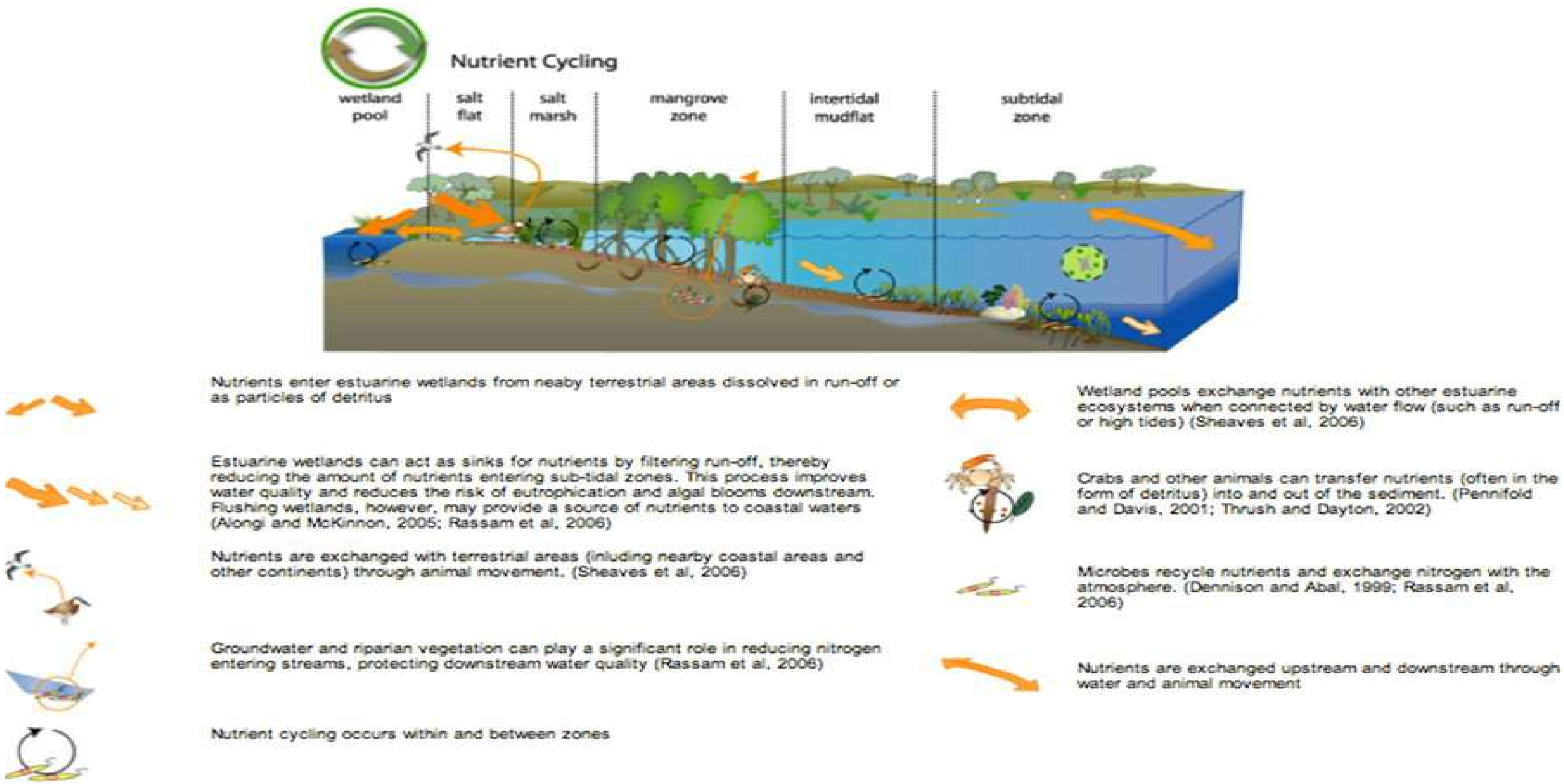

Freshwater Inflow
• Quantity
- Timing
- Frequency
- Duration
- Extent
• Quality
• Tidal connections
Estuarine Conditions
• Salinity
• Sediment
• Dissolved material
• Particulate material
Estuarine Resources
• Integrity
- Species composition
- Abundance
- Biomass
- Diversity
• Function
- Primary production
- Secondary production
- Nutrient recycling
• Sustainability
- Habitats
- Valued resources
- Ecosystem services


photic zone
neritic
oceanic
100
epipelagic
200
mesopelagic
bathypelagic
1000
bathyal
bathypelagic
depth, m
4000
abyssopelagic
Continental
Shelf
Continental
Slope
abyssal
6000
hadal


Average Annual Salinity
Tidal Limit
< 0.5 ppt
< 5.0 ppt
< 18.0 ppt
< 30.0 ppt
OCEAN
Non-Tidal Fresh Water
Tidal Fresh Water
Oligohaline
Mesohaline
Polyhaline
Euhaline
(Marine)
(During Low Flow Conditions)


River
1
2
20
30
A. Stratified
Weak tidal currents
1
5
20
30
River
Tides
B. Partially Mixed
1
5
20
30
River
C. Fully Mixed
Tides
Evaporation
Hypersaline
Tides
D. Inverse
05-1330-7


Chlorophyll-based
Net Primary Productivity (mg Carbon/m²)
0
400
800
1200
1500


Nutrient Cycling
wetland pool
salt flat
salt marsh
mangrove zone
intertidal mudflat
subtidal zone
Nutrients enter estuarine wetlands from neaby terrestrial areas dissolved in run-off or as particles of detritus
Estuarine wetlands can act as sinks for nutrients by filtering run-off, thereby reducing the amount of nutrients entering sub-tidal zones. This process improves water quality and reduces the risk of eutrophication and algal blooms downstream. Flushing wetlands, however, may provide a source of nutrients to coastal waters (Alongi and McKinnon, 2005; Rassam et al, 2006)
Nutrients are exchanged with terrestrial areas (inluding nearby coastal areas and other continents) through animal movement. (Sheaves et al, 2006)
Groundwater and riparian vegetation can play a significant role in reducing nitrogen entering streams, protecting downstream water quality (Rassam et al, 2006)
Nutrient cycling occurs within and between zones
Wetland pools exchange nutrients with other estuarine ecosystems when connected by water flow (such as run-off or high tides) (Sheaves et al, 2006)
Crabs and other animals can transfer nutrients (often in the form of detritus) into and out of the sediment. (Pennifold and Davis, 2001; Thrush and Dayton, 2002)
Microbes recycle nutrients and exchange nitrogen with the atmosphere. (Dennison and Abal, 1999; Rassam et al, 2006)
Nutrients are exchanged upstream and downstream through water and animal movement