# Towards an Ecosystem Approach for Management of Bristol Bay Estuaries

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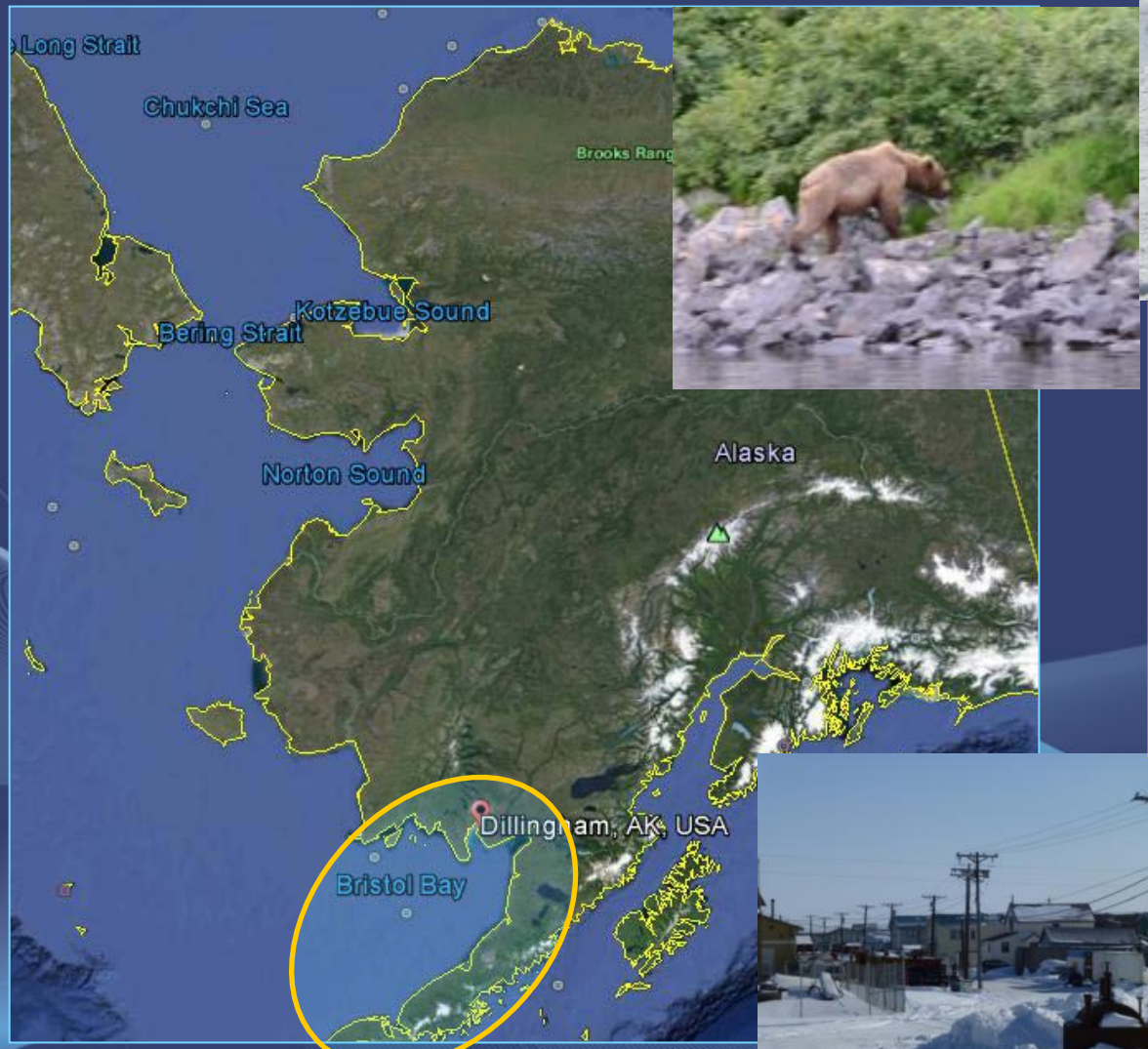
TCUP

# Bristol Bay, Alaska



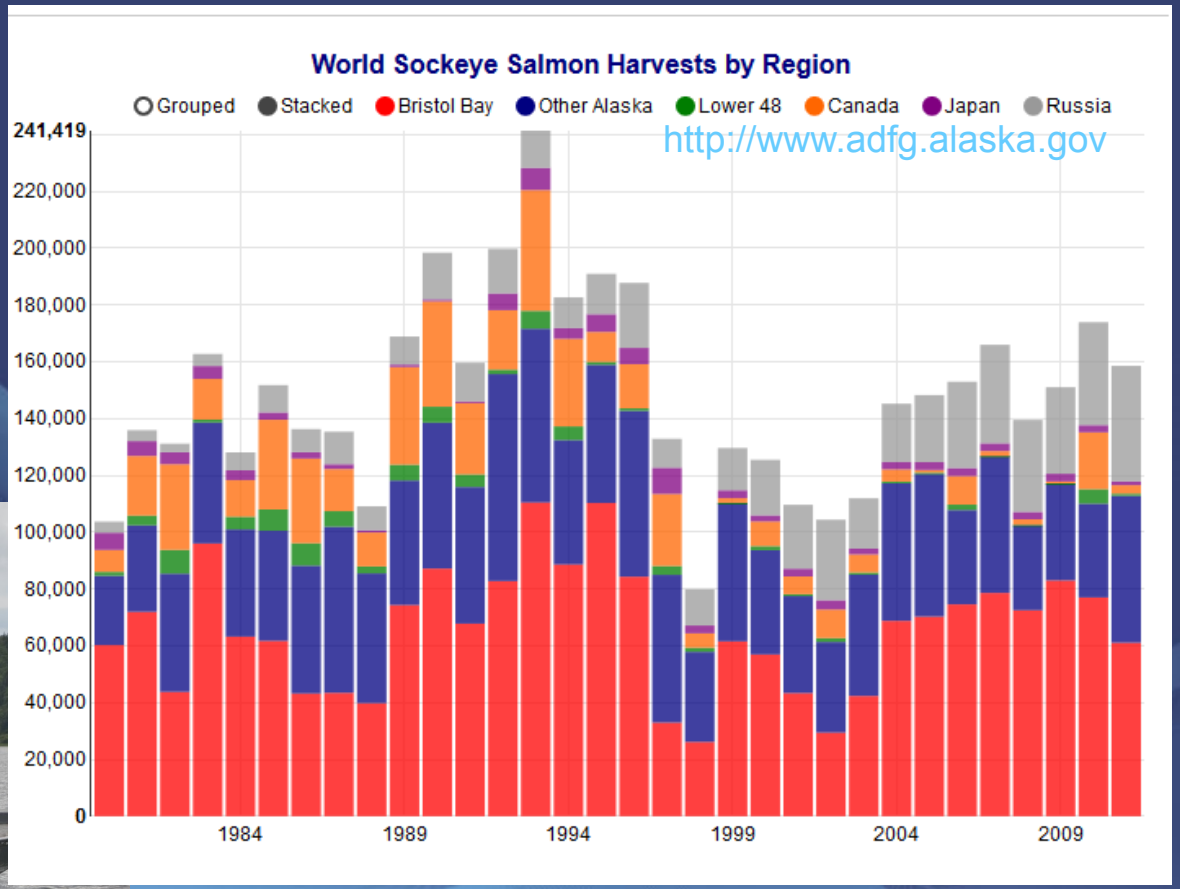




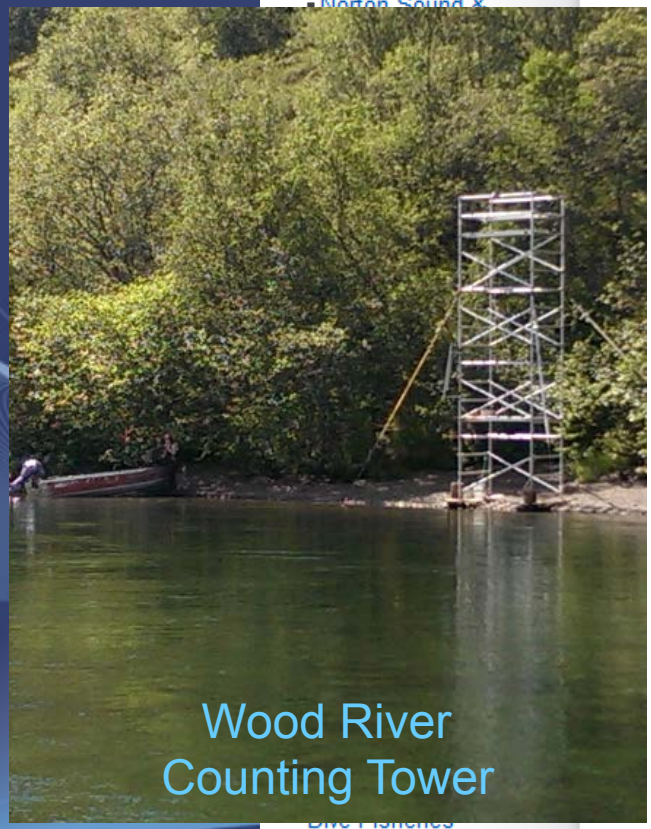

# Known For Salmon

Over 50% of worlds sockeye salmon

But there is so much more…

# Managed Primarily by Estimating Salmon Escapement




- Kuskokwim
- Arctic Area

Fish Counts

Maps

Reporting Resources

Export to PDF

**Alaska Dept. of Fish and Game - Division of Commercial Fisheries**

## - Bristol Bay Daily Run Summary -

* Run Date 07/31/2016

Apply Reset

| | | Catch Daily | Cumulative | Escapement Daily | Cumulative | In-River Estimate | Total Run |
|---|---|---|---|---|---|---|---|
| Bristol Bay East | **Ugashik** | **0** | **6,769,293** | **0** | **1,635,270** | **0** | **8,404,563** |
| | Ugashik River | | | 0 | 1,635,270 | 0 | |
| | **Egegik** | **0** | **8,485,706** | **0** | **1,837,260** | **0** | **10,322,966** |
| | Egegik River | | | 0 | 1,837,260 | 0 | |
| | **Naknek-Kvichak** | **0** | **13,610,820** | **0** | **6,154,638** | **0** | **19,765,458** |
| | Kvichak River | | | 0 | 4,462,728 | 0 | |
| | Naknek River | | | 0 | 1,691,910 | 0 | |
| Bristol Bay West | **Nushagak** | **0** | **7,989,523** | **0** | **2,459,450** | **0** | **10,448,973** |
| | Igushik River | | | 0 | 469,230 | 0 | |
| | Nushagak River | | | 0 | 680,513 | 0 | |
| | Wood River | | | 0 | 1,309,707 | 0 | |
| | **Togiak** | **0** | **544,346** | **8,694** | **158,106** | **0** | **702,452** |
| | Togiak River | | | 8,694 | 158,106 | 0 | |
| **Bristol Bay Totals:** | | **0** | **37,399,688** | **8,694** | **12,244,724** | **0** | **49,644,412** |

Refresh -Export

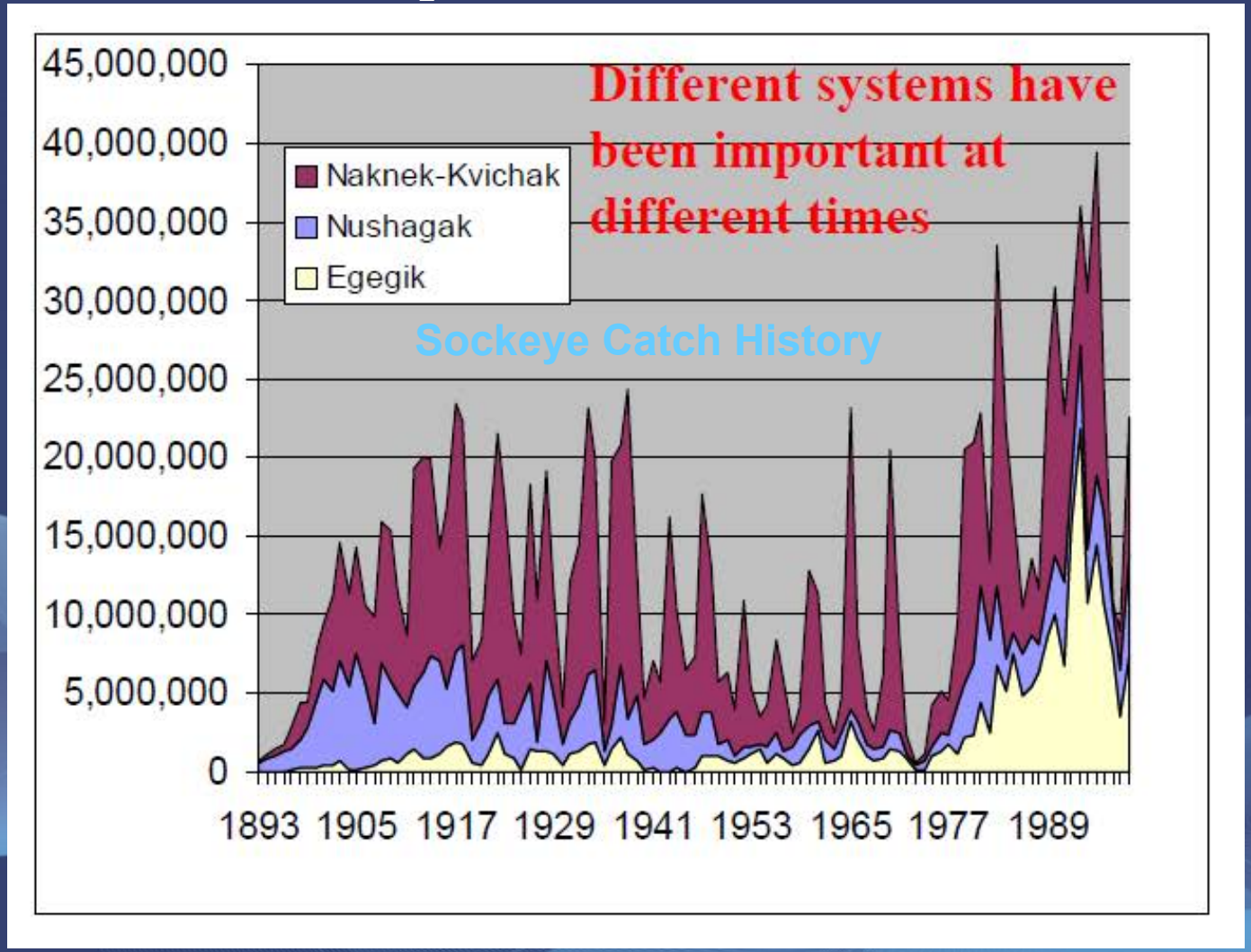
**Sockeye per Drift Delivery for 07/31/2016**

**Test Fishery Port Moller**

No recent results found. Potentially weathered out.

Refresh

# Healthy due to diverse habitat portfolio




Ray Hilborn et al. 2002

# Is there More to Manage?

**•Local knowledge plays a role in data collection**

- Residents have an intimate knowledge of local resources
  - more scientific training is needed to fully participate in funding processes.

# Traditional Activities

## Yup'ik Subsistance Calendar

by Brett Boyette

| | Ptarmigan | Duck | Geese | Bird Eggs |
|---|---|---|---|---|
| January | Usually | | | |
| Febuary | Usually | | | |
| March | Usually | | | |
| April | Usually | Usually | Usually | |
| May | | Usually | Usually | Usually |
| June | | | | Usually |
| July | | | | |
| August | | Usually | Usually | |
| September | | Usually | Usually | |
| October | | Usually | Usually | |
| November | | | | |
| December | Usually | | | |

| | Beaver | Land Otter | Caribou | Moose | Brown Bear | Red Fox | Ground Squirrel |
|---|---|---|---|---|---|---|---|
| January | Occasionally | Usually | Usually | Occasionally | Usually | Usually | |
| Febuary | Usually | Usually | Usually | Occasionally | Usually | Usually | |
| March | Usually | Usually | Usually | Occasionally | Usually | Usually | |
| April | Usually | Occasionally | | | Usually | Occasionally | |
| May | Occasionally | Occasionally | | | Usually | Usually | |
| June | | Occasionally | | | | Occasionally | |
| July | Occasionally | Occasionally | | | | Occasionally | |
| August | Usually | Occasionally | Usually | Usually | | Occasionally | |
| September | Usually | Occasionally | Usually | Usually | Usually | Occasionally | |
| October | Usually | Occasionally | Usually | Occasionally | Usually | Occasionally | |
| November | | Usually | Usually | Occasionally | Usually | Usually | |
| December | Occasionally | Usually | | Occasionally | Usually | Usually | |

| | Salmon Berries | Crow Berries | Blueberries | Huckleberries | Fiddle Heads | Wild Celery | Sour Dock | Wild Rhubarb | Lamb's Quarter | Fireweed | Labrador Tea |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | | | | | | | | | | | Usually |
| Febuary | | | | | | | | | | | Usually |
| March | | | | | | | | | | | Usually |
| April | | | | | | | | | | | Usually |
| May | | | | | Usually | | | | | | Usually |
| June | | | | | | Usually | Usually | Usually | Usually | Usually | Usually |
| July | Usually | | Usually | | | | | | | Usually | Usually |
| August | Usually | Usually | Usually | Usually | | | | | | | Usually |
| September | | | | Usually | | | | | | | Usually |
| October | | | | Usually | | | | | | | Usually |
| November | | | | | | | | | | | Usually |
| December | | | | | | | | | | | Usually |

| | King Salmon | Sockeye Salmon | Coho Salmon | Chum Salmon | Pink Salmon | Dolly Varden | Alaska Whitefish | Pacific Halibut | Northern Pike | Smelt | Herring | Beluga | Pacific Walrus | Harbor Seal | Razor Clams | Mussels | Sea Anemones |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | | | | | | Occasionally | | | | Usually | Usually | Occasionally | | Usually | Occasionally | Occasionally | Occasionally |
| Febuary | | | | | | Occasionally | | | | Usually | Usually | Occasionally | | Usually | Occasionally | Occasionally | Occasionally |
| March | | | | | | Usually | | | | Usually | Usually | Occasionally | | Usually | Occasionally | Occasionally | Occasionally |
| April | | | | | | Usually | | Usually | Occasionally | Usually | Usually | Occasionally | | Usually | Occasionally | Occasionally | Occasionally |
| May | | | | | | Usually | Usually | Usually | | | Usually | Occasionally | Occasionally | Usually | Occasionally | Occasionally | Occasionally |
| June | Usually | Usually | | | | | Usually | Usually | | | Usually | Occasionally | Occasionally | Usually | Occasionally | Occasionally | Occasionally |
| July | Usually | Usually | | | Occasionally | | | | | | | Occasionally | Occasionally | Usually | Occasionally | Occasionally | Occasionally |
| August | | Usually | Usually | Occasionally | Occasionally | Usually | Usually | | | | | Occasionally | Occasionally | Usually | Occasionally | Occasionally | Occasionally |
| September | | Usually | Usually | Occasionally | | Usually | Usually | | | | | Occasionally | Occasionally | Usually | Occasionally | Occasionally | Occasionally |
| October | | | | | | Usually | Usually | | | | | Occasionally | Occasionally | Usually | Occasionally | Occasionally | Occasionally |
| November | | | | | | Usually | Usually | | | Usually | | Occasionally | | Usually | Occasionally | Occasionally | Occasionally |
| December | | | | | | Occasionally | | | | Usually | Usually | Occasionally | | Usually | Occasionally | Occasionally | Occasionally |

Summer fish camp, Aleknagik, Alaska

Commercial collecting of roe on kelp Togiak, AK.

# Data Collection Courses

# Western Alaska Interdisciplinary Science Conference

Dillingham 2008, 2012, 2016
Nome 2009. 2013
Unalaska 2010, 2017
Bethel 2011. 2015
Kotzebue 2014

http://seagrant.uaf.edu/conferences/waisc/


2008 Western Alaskan
Interdisciplinary Science Conference and Forum
**Weathering Change, Monitoring Uncertainty**
Dillingham, Alaska, April 4-6, 2008

Western Alaska Interdisciplinary Science Conference and Forum

- Current conference
- 2008 home
- Call for papers
- Session information
- Schedule
- Keynote & Plenary info

## Western Alaska Interdisciplinary Science Conference and Forum 2008

**"Weathering Change, Monitoring Uncertainty"**

**April 4–6, 2008**
**Dillingham, Alaska**

The WAISC organization committee wishes to thank everyone who participated in this conference—by most measures it was an outstanding success. WAISC included people from diverse backgrounds including universities, government agencies, industry, and students coming together and discussing science. One major outcome was that it produced lots of synergy and identified misunderstandings between groups. Please check this web site often as we will be adding more information about the


# WAISC: Building Capacity
## Keeping it Local

- local and citizen science - data collection to inventory, monitor and manage

# Big science comes to tiny fishing town

**NSF Award:** Resilience and Vulnerability in a Rapidly Changing North: The Integration of Physical, Biological and Social Processes (University of Alaska Fairbanks Campus)

**State:** Alaska, International

**Congressional Districts:** Alaska At Large

**Research Areas:** Education

The tiny fishing town of Dillingham sits about 250 miles from the road system, however, as host to two major science conferences, Alaska's 20th-largest community welcomed scientists and students from across the nation to highlight research outcomes, and exposed them to the unique cultural and ecological considerations of arctic science.

The American Association for the Advancement of Science (AAAS) held its Arctic Science Conference in Dillingham for the first time in September 2011. Six months later, scientists again flooded the southwest Alaskan town for the 2012 Western Alaska Interdisciplinary Science Conference (WAISC).

Dillingham's newfound popularity as a conference venue stems from efforts by the University of Alaska's Todd Radenbaugh to bring the first WAISC to the town in 2008. Subsequent WAISCs were held in Nome, Unalaska and Bethel before returning to Dillingham in 2012. It was the success of the initial Dillingham conference that led AAAS to propose holding their 2011 meeting there.

The town's proximity to the site of the proposed Pebble Mine has heightened Dillingham's appeal as a meeting site. Pebble, a proposed gold mine, was a key topic at both the 2008 and 2012 WAISCs and at the AAAS meeting; the latter two conferences both had special sessions entirely devoted to the controversial project.

The AAAS and WAISC conferences are highly interdisciplinary, covering a huge range of fields and topics--from salmon fisheries to sustainable rural energy to education and traditional ecological knowledge. A number of local residents participated in the 2012 WAISC meeting, including students and Alaskan Native elders who attended sessions and who served as presenters.

Funding from the Alaska Experimental Program to Stimulate Competitive Research (EPSCoR) enabled researchers and students to attend the WAISC and AAAS conferences.

## Image

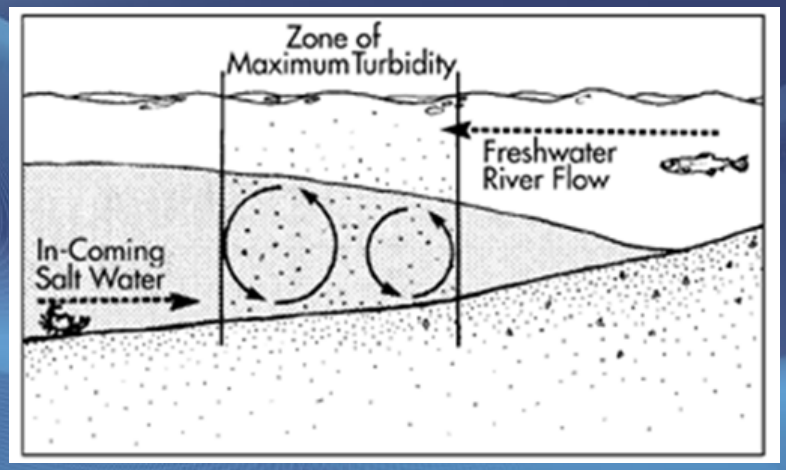
# Managment Data Gaps

## What are we missing

- ✓ Lakes – FRI, Univ Wash
- ✓ Streams – ADFG
- ✓ Marine– NOAA NMFS
- **?** – Coasts and Estuaries

# Estuaries

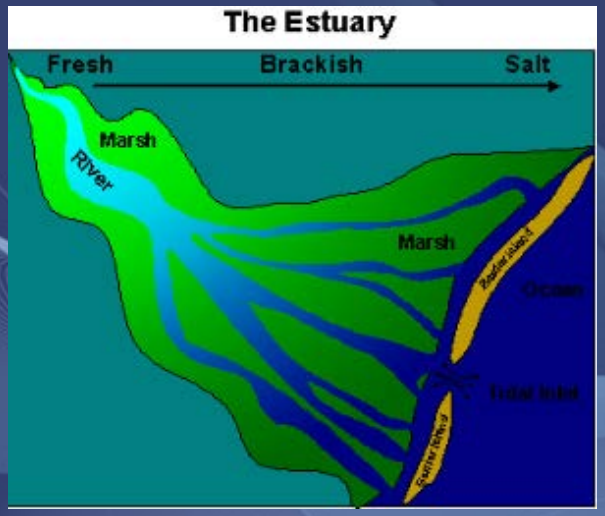
- Semi-enclosed bodies of coastal water
  Mouth of rivers where fresh meet saltwater
- Influenced by tides and coastal currents
- Generally large human pop lives there
- Knowledge of their dynamics and roles is limited, especially in Alaska



# Convectional Estuarine Wisdom

The foundation of high production of estuary ecosystems are dependent on”

- Primary producers – (highest)
- Trophic cascade




Sun

Primary Productivity

Photosynthesis

Consumers – Primary to Tertiary

Respiration

Detritus – Decomposers/deposit feeders

Respiration/fermentation

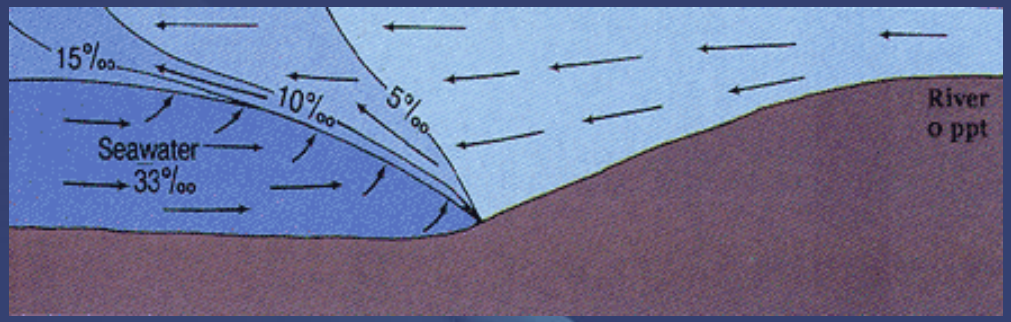
Nutrients

# Fresh Meets Salt

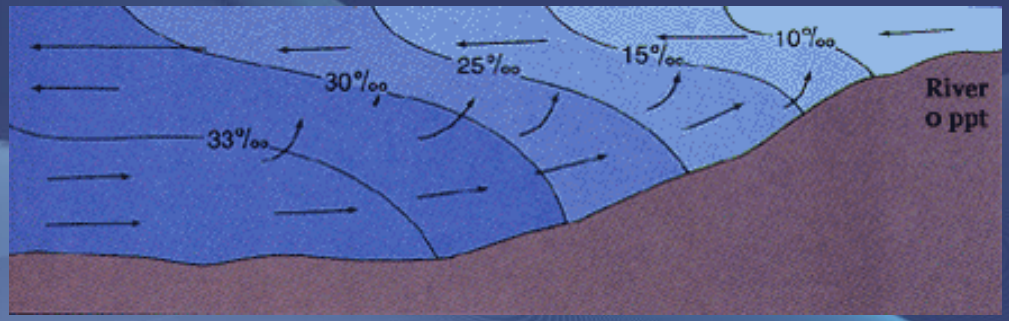
- Estuaries are among the most important coastal features
- Ecological functions provide services
  - Human settlement and use
    - Transportation
    - Safe harbors and ports
    - Commercial and subsistence harvest

# Different Types of Estuaries

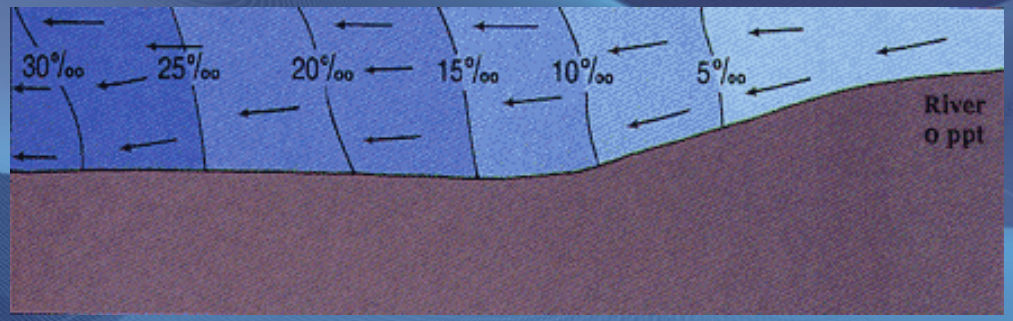
## Circulation Patterns of Estuaries




Salt Wedge




Partially Mixed

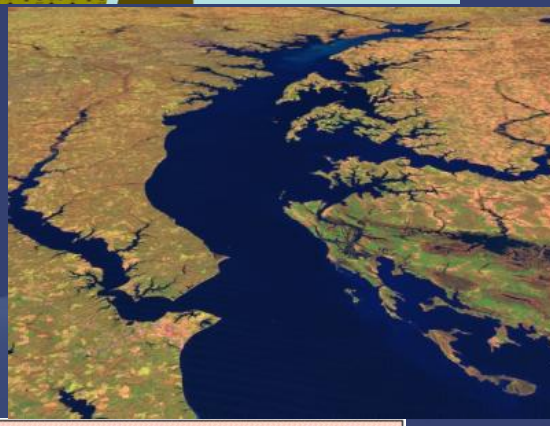


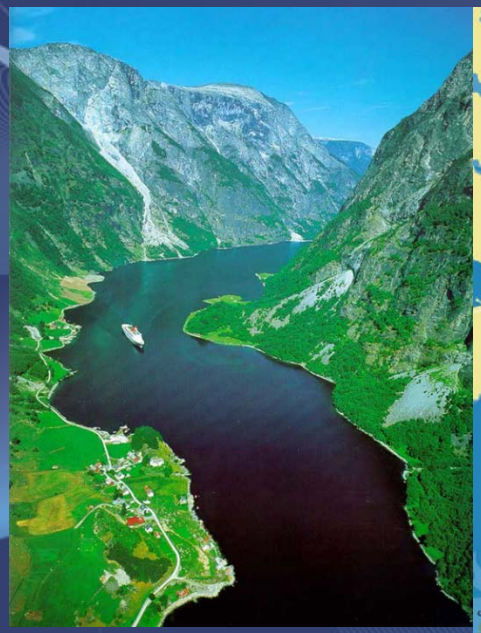

Mixed

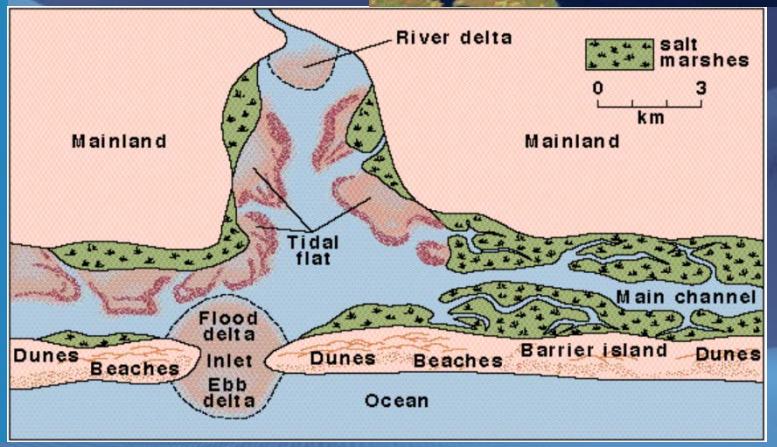
# Classical Types of Estuaries

- Drowned Shoreline - Coastal Plain
- Bar Built - Barrier Island
- Tectonic
- Fjord



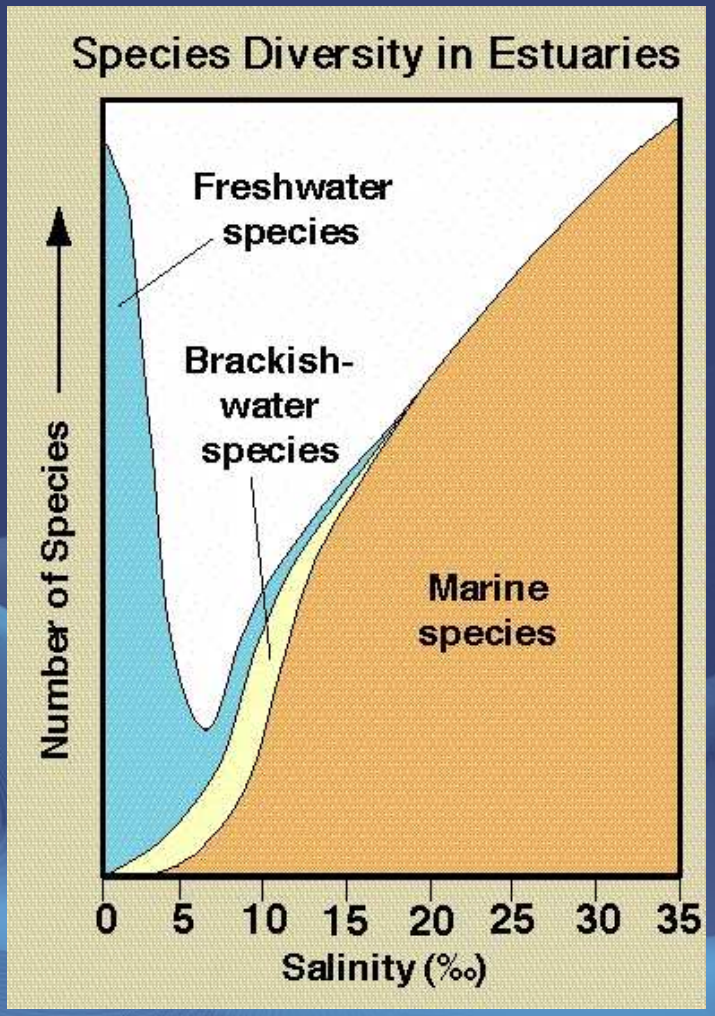




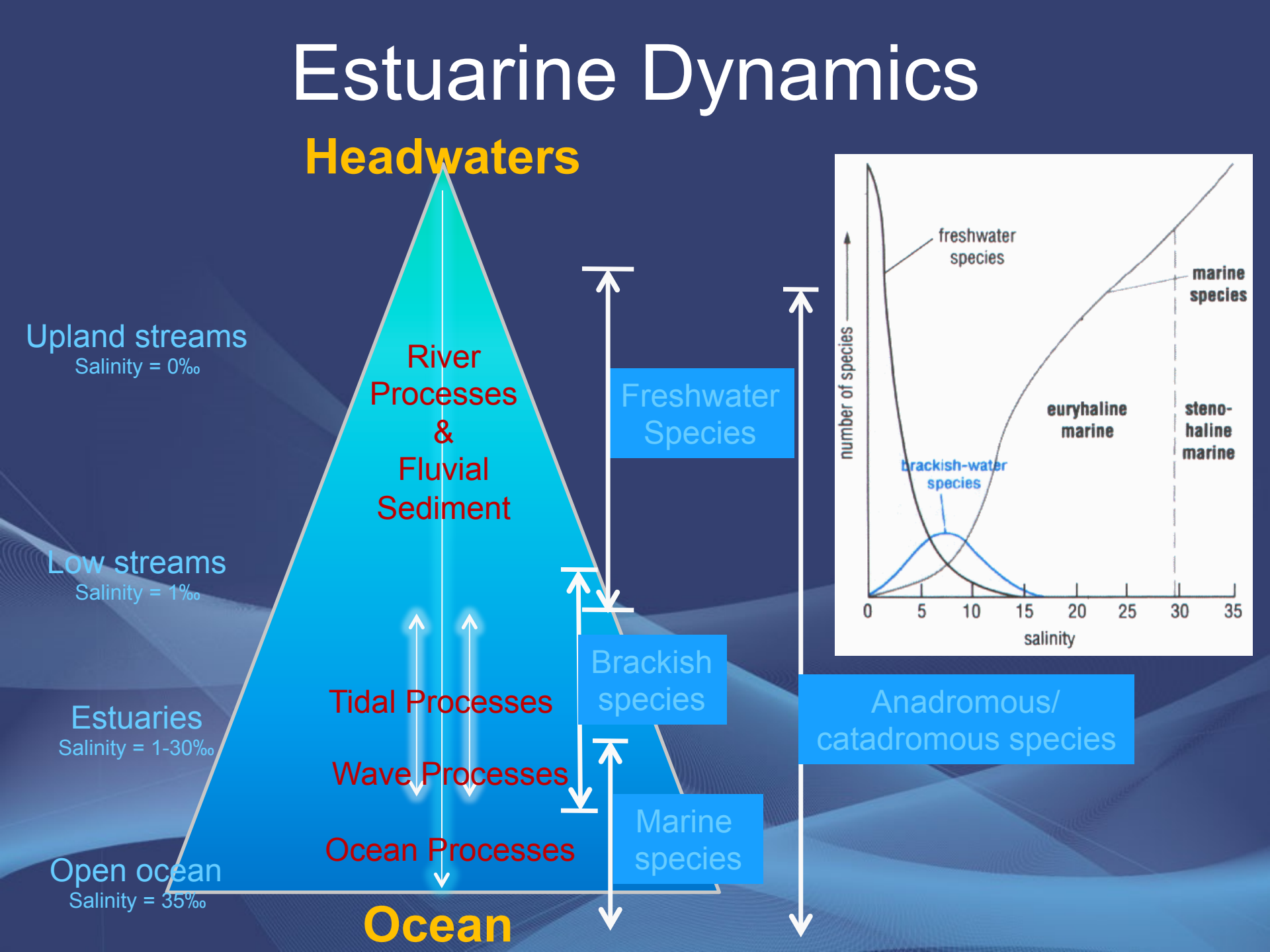



# Physical Features of Estuaries

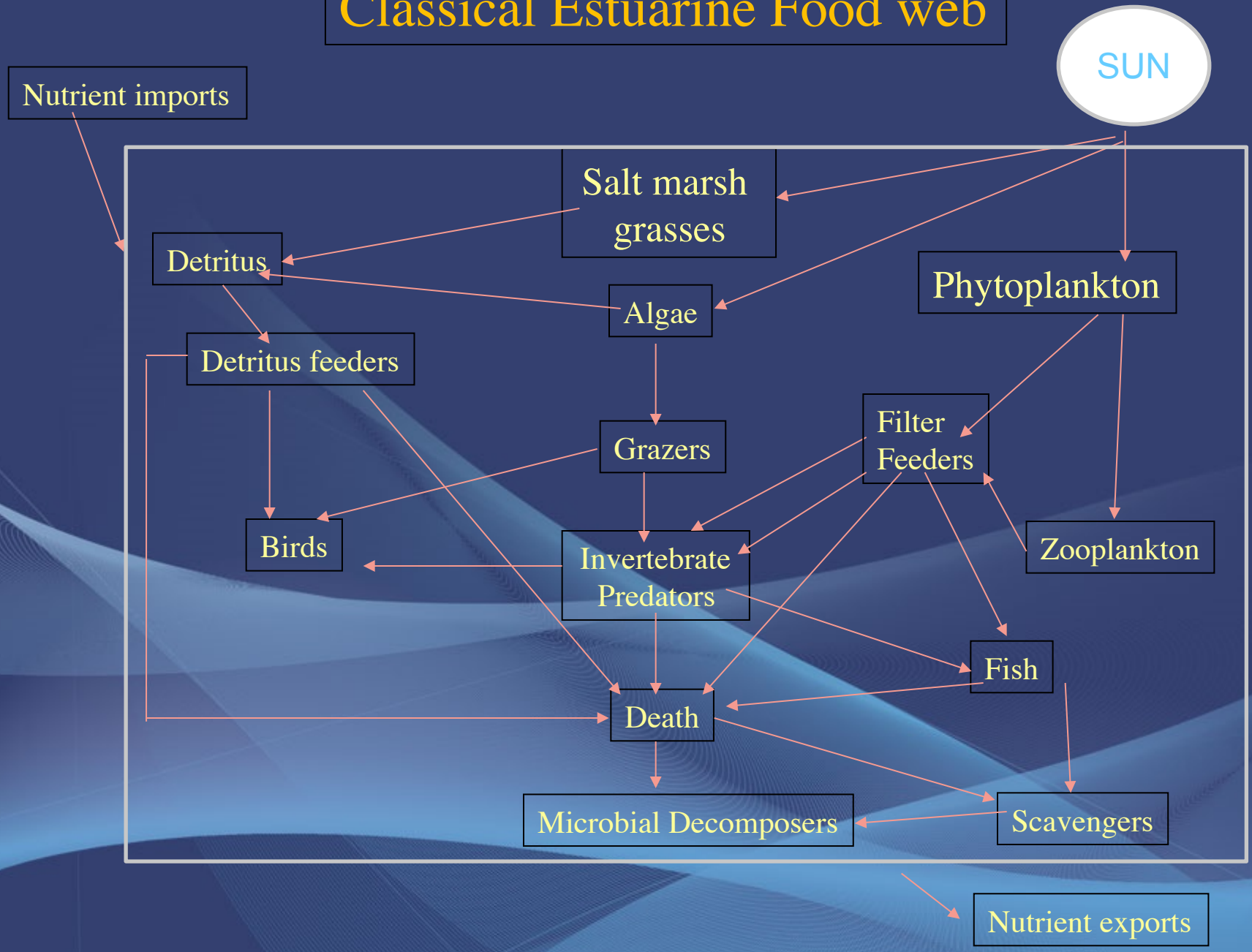
- Substrate - Movement by Current
- Temperature
- Waves and Currents
- Turbidity
- Oxygen



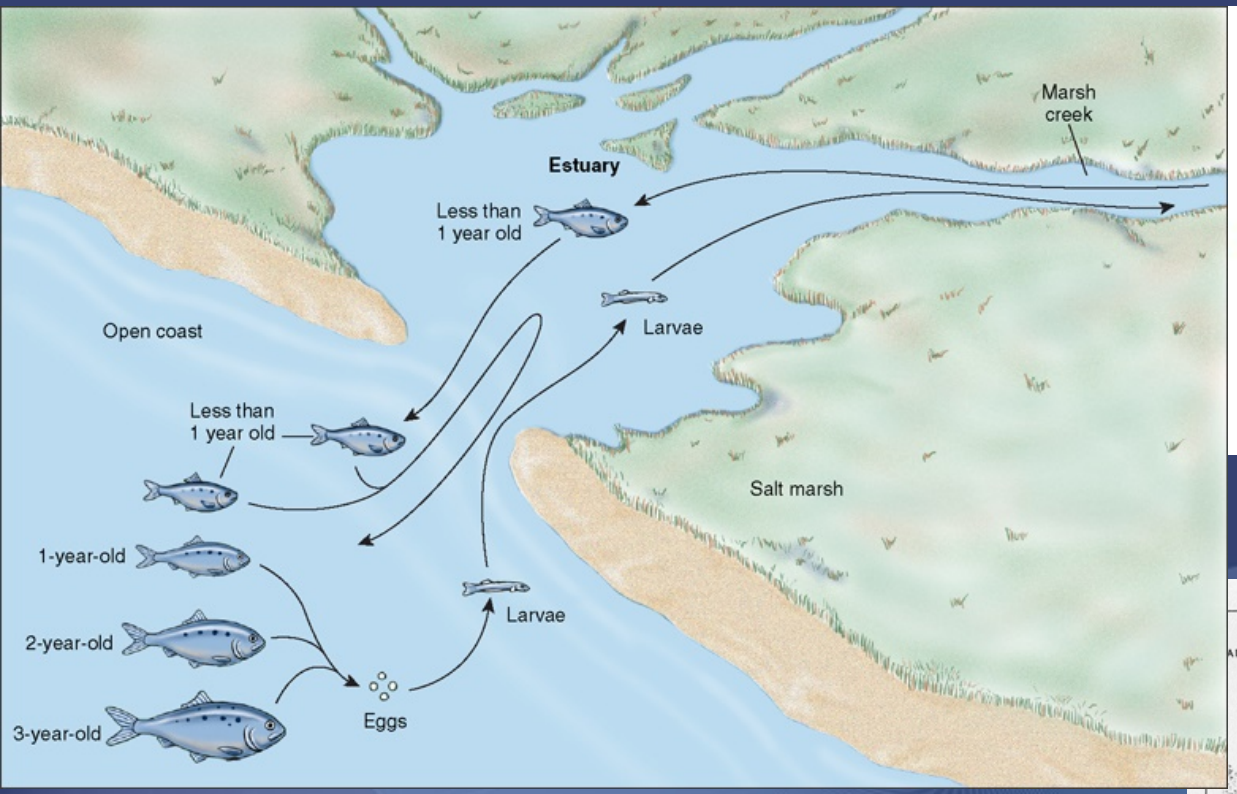
# Estuarine Dynamics

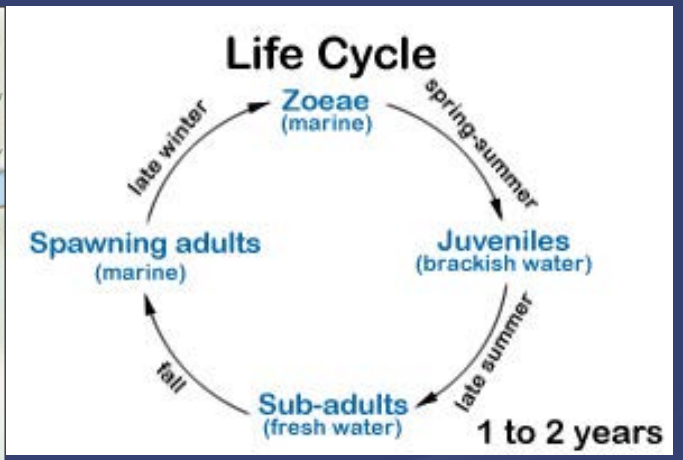


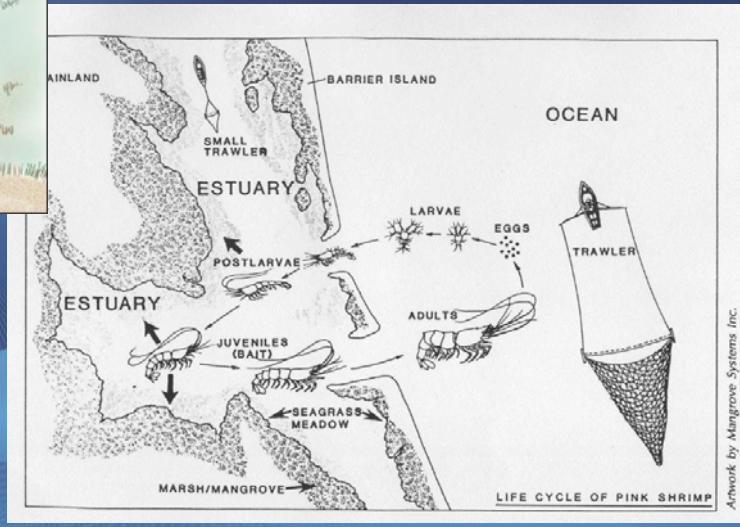
# Classical Estuarine Food web



# Life Cycles of Biota Span Rivers and Oceans

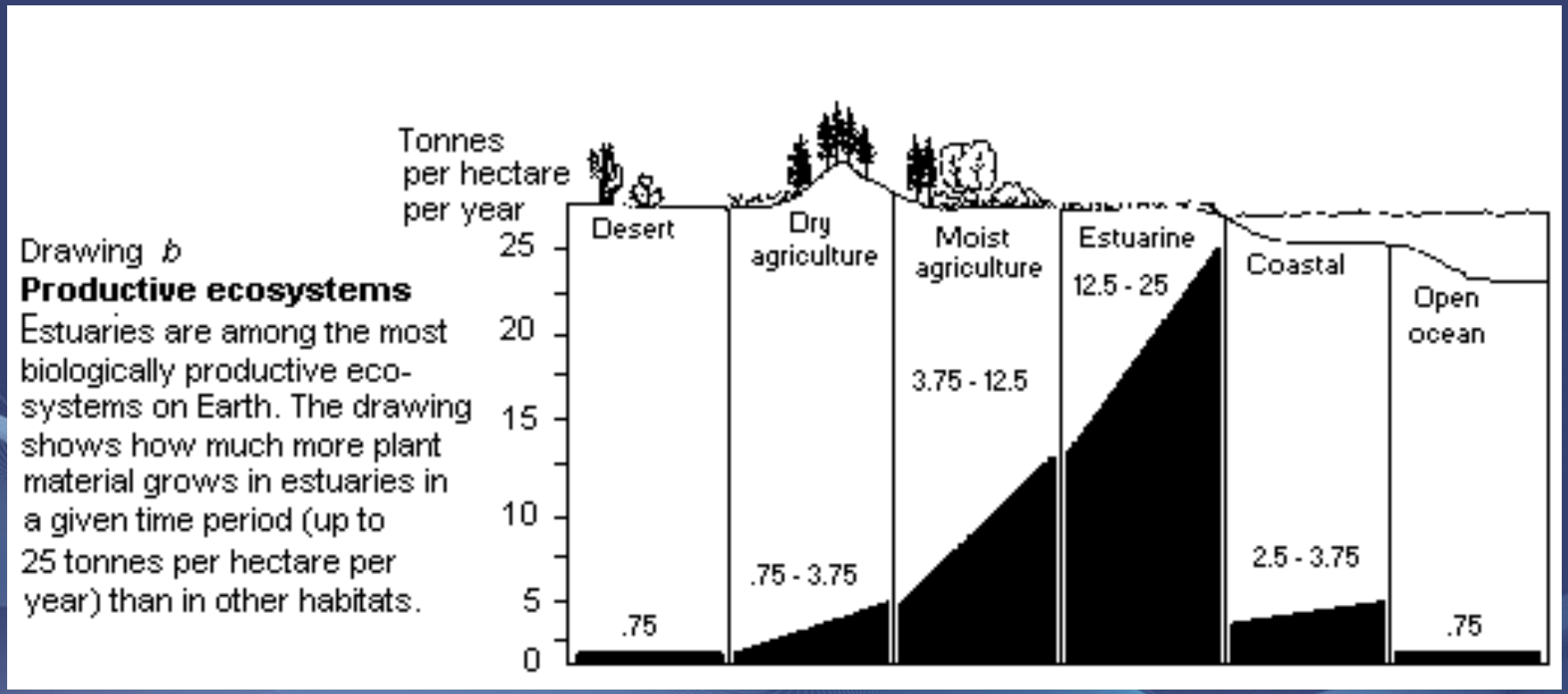



Catadromous: Sea to fresh
Anadromous: Fresh to sea

# Convectional Estuary Productivity




Drawing *b*

**Productive ecosystems**

Estuaries are among the most biologically productive ecosystems on Earth. The drawing shows how much more plant material grows in estuaries in a given time period (up to 25 tonnes per hectare per year) than in other habitats.

# Ecological Roles of Estuaries

- Important habitat
  - wetlands, seagrass beds, mudflats, sandbars, shoreline grasslands
- Breeding and nursery grounds
  - Important for spawning and growth
- Mixing zone
  - major ecotone and conduit between land ad sea
- Dynamic
  - location of active process in sedimentology and geomorphology

# Estuaries as Havens

- Abundant food sources
- Safety from predators – Turbidity
- Physiological transition for smolts

# Estuaries as Highways

- Species must pass through *en route* to the river and sea


# What Do We Really Know about Bristol Bay Estuaries?

# Alaska – Ecosystem Management for Estuaries

I DON'T KNOW!

e drivers of the food web?

rocessing influence
tion, abundance and

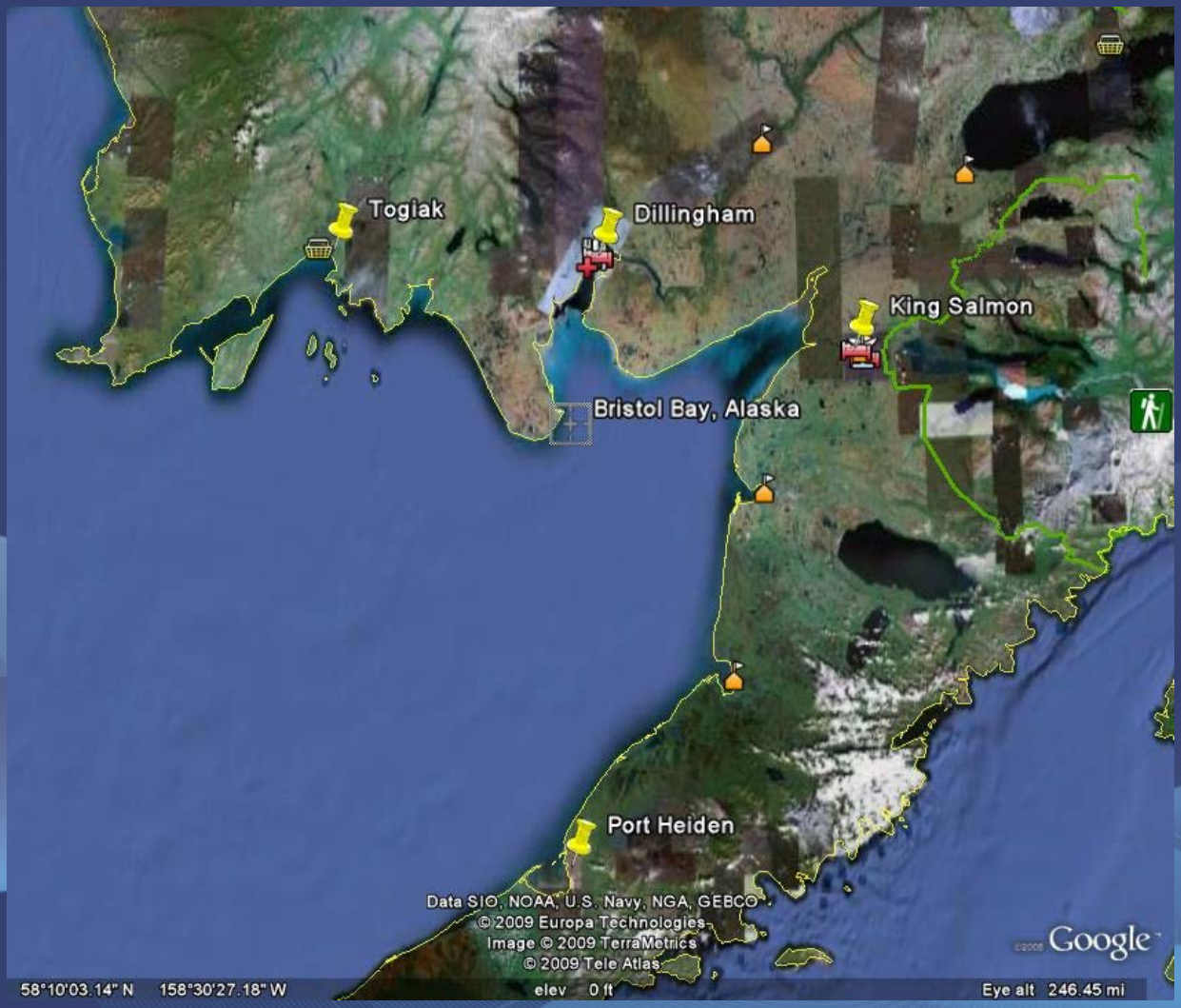
easonal species migrations?

How do the salmon smelt influence the food web?

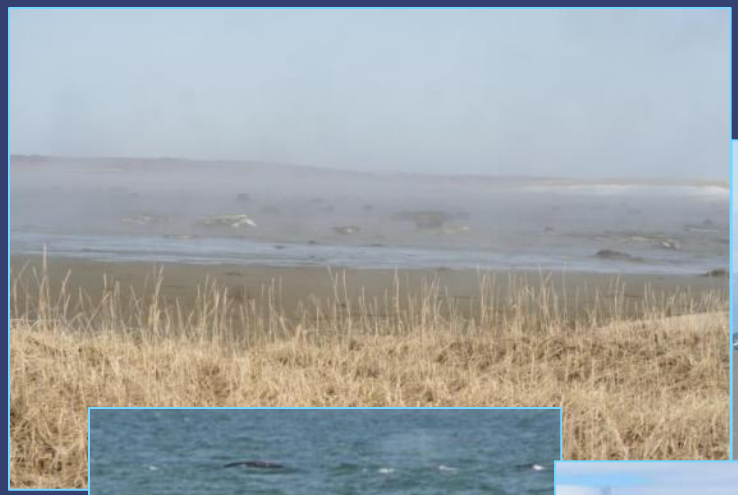
Winter ecology?

# Estuary Research

## A look at the Nushagak Estuary



# Nushagak Estuary, Alaska





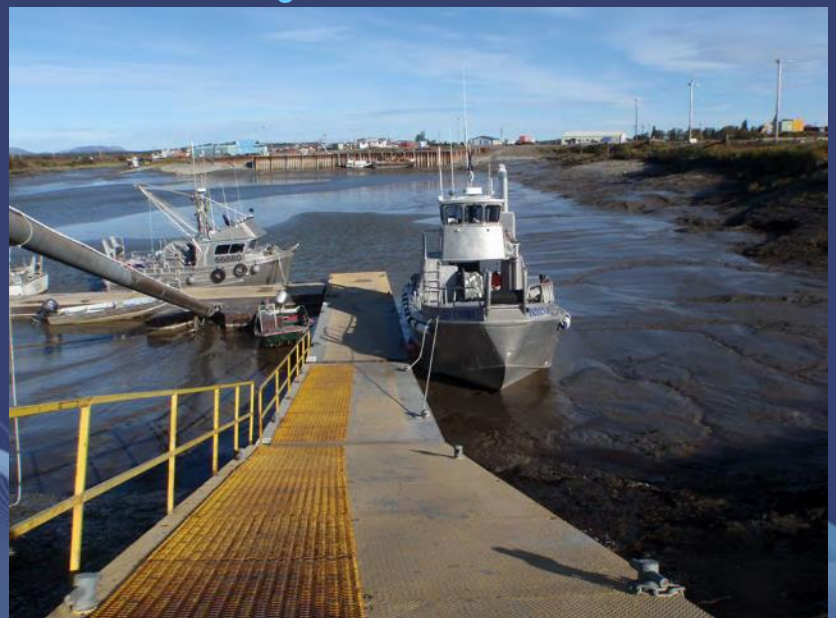


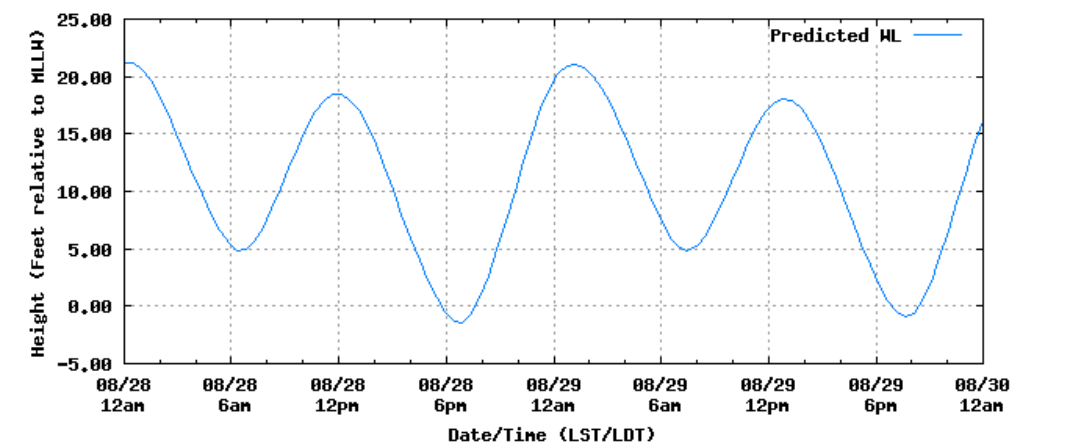


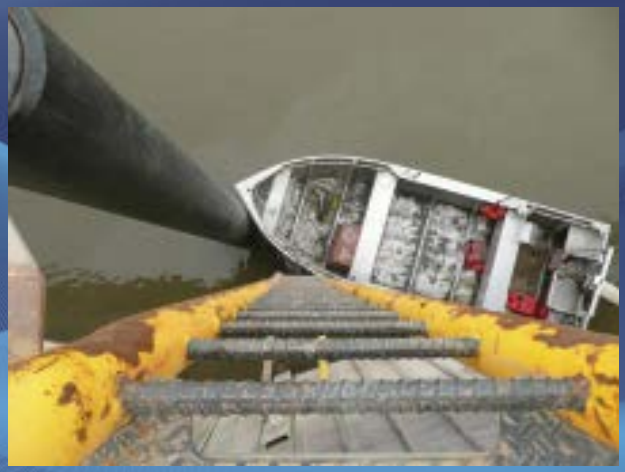
# Large Tides

## Range between -1 to 7 m (-2 to 23 ft)

Same boat images taken a few apart.
Dramatic tidal range.





# **Straty 1969**: The Migratory Pattern of Adult Sockeye Salmon in Bristol Bay as Related to the Distribution of Their Home-River Waters (UAF Dissertation).

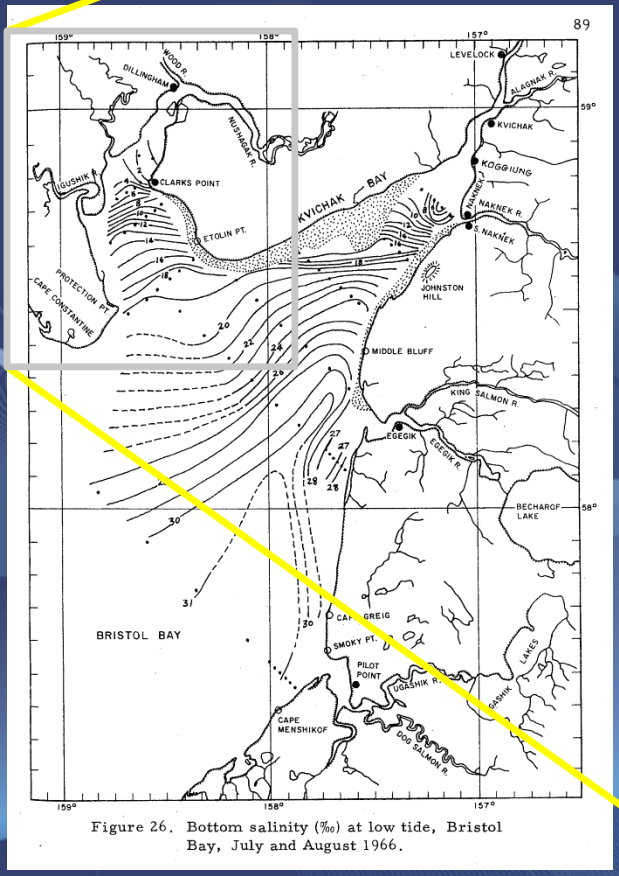
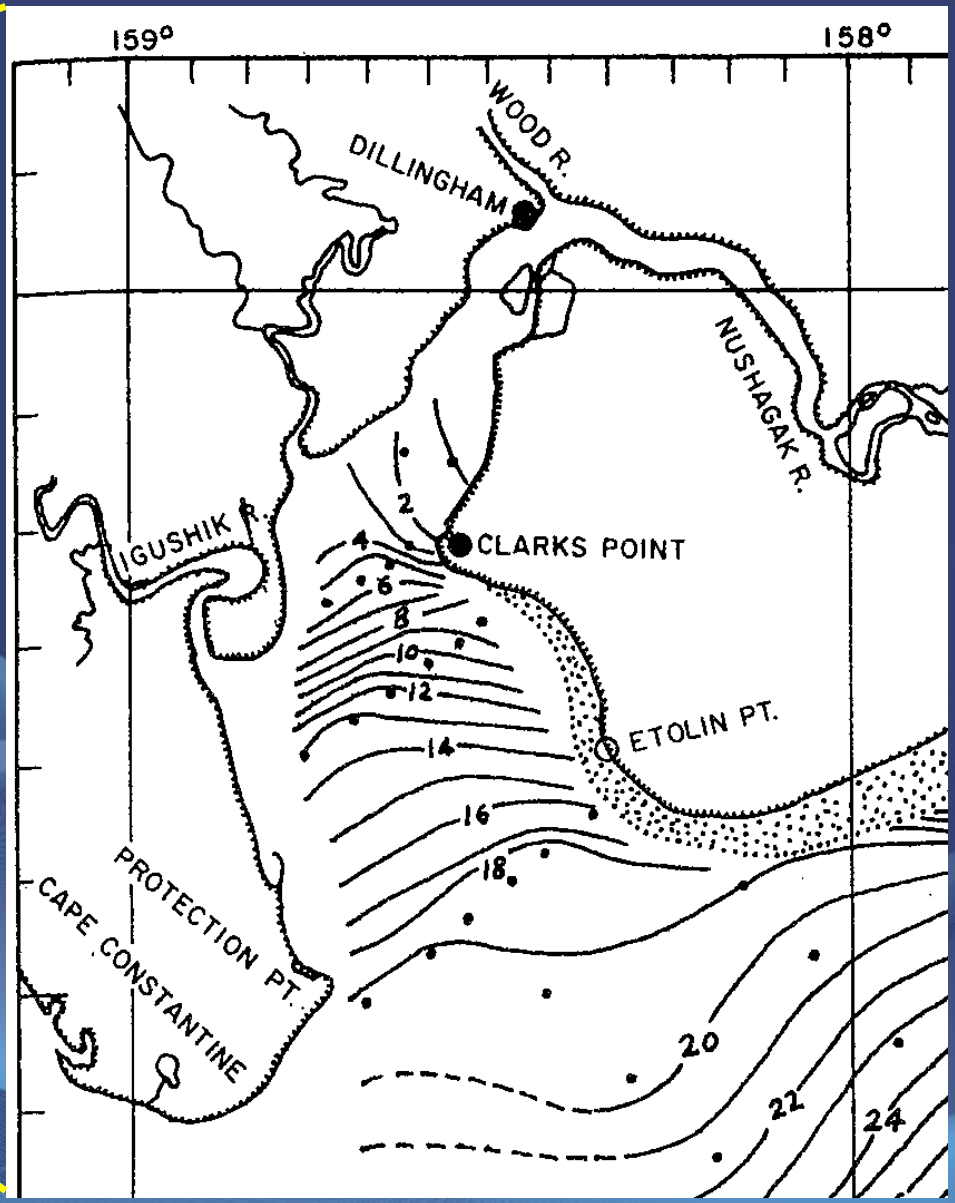



Figure 26. Bottom salinity (‰) at low tide, Bristol Bay, July and August 1966.



# Nushagak Estuary River Inflows


**Surface Area:** ~ 50 km$^2$
**Average Depth:** 15 - 20 m
**Average Tidal Flow:** 3-5 knots
**Tidal Range:** 5.5 m

**Large Cumulative Freshwater Input**

- Nushagak River
- Wood River
- Snake River
- Igushik River

# Sampled Nushagak Bay Over The Summers Of 2007-2013


32 Foot Vessel &
3 Meter Otter Trawl

# Methods

- 3 meter Otter Trawl for fish and macroinvertebrates
- Ponar Grab for sediment samples

Deploying the Otter trawl

Itemizing the samples

Bottom grab taking sediment samples

# Dominate Invertebrates


Crangon shrimps, and *Saduria* isopods, were abundant.

Other species included amphipods *Ampelisca* sp and *Gammarus* sp, jelly fish, *Macoma* clams, and Blanus barnacles.

# Common Species

| | Scientific Name | Common Name |
|---|---|---|
| MACRO INVERTEBRATES | Scyphozoa | Jellyfish |
| | *Modiolus modiolus* | Horse Mussel |
| | *Macoma balthica* | Macoma Clam |
| | *Balanus glandula* | Common Barnacle |
| | *Mesidotea entomon* | Isopod |
| | *Crangon sp.* | Bay Shrimp |
| | *Gammarus sp.* | Amphipod (sm) |
| | *Gammaridae* | Amphipod (rg) |
| FIN FISH | *Osmerus mordax* | Rainbow Smelt |
| | *Platichthys stellatus* | Starry Flounder |
| | Cottidae | Sculpin |
| | *Pungitius pungitius* | 9-spine Stickleback |
| | *Gasterosteus aculeatus* | 3-spine Stickleback |
| | Acantholumpenus mackayi | Blackstripe Prickleback |
| | Liparidae | Snailfish |
| | *Lampetra tridentata* | Pacific Lamprey |
| | *Onchorhynchus sp.* | Salmonid fingerlings |

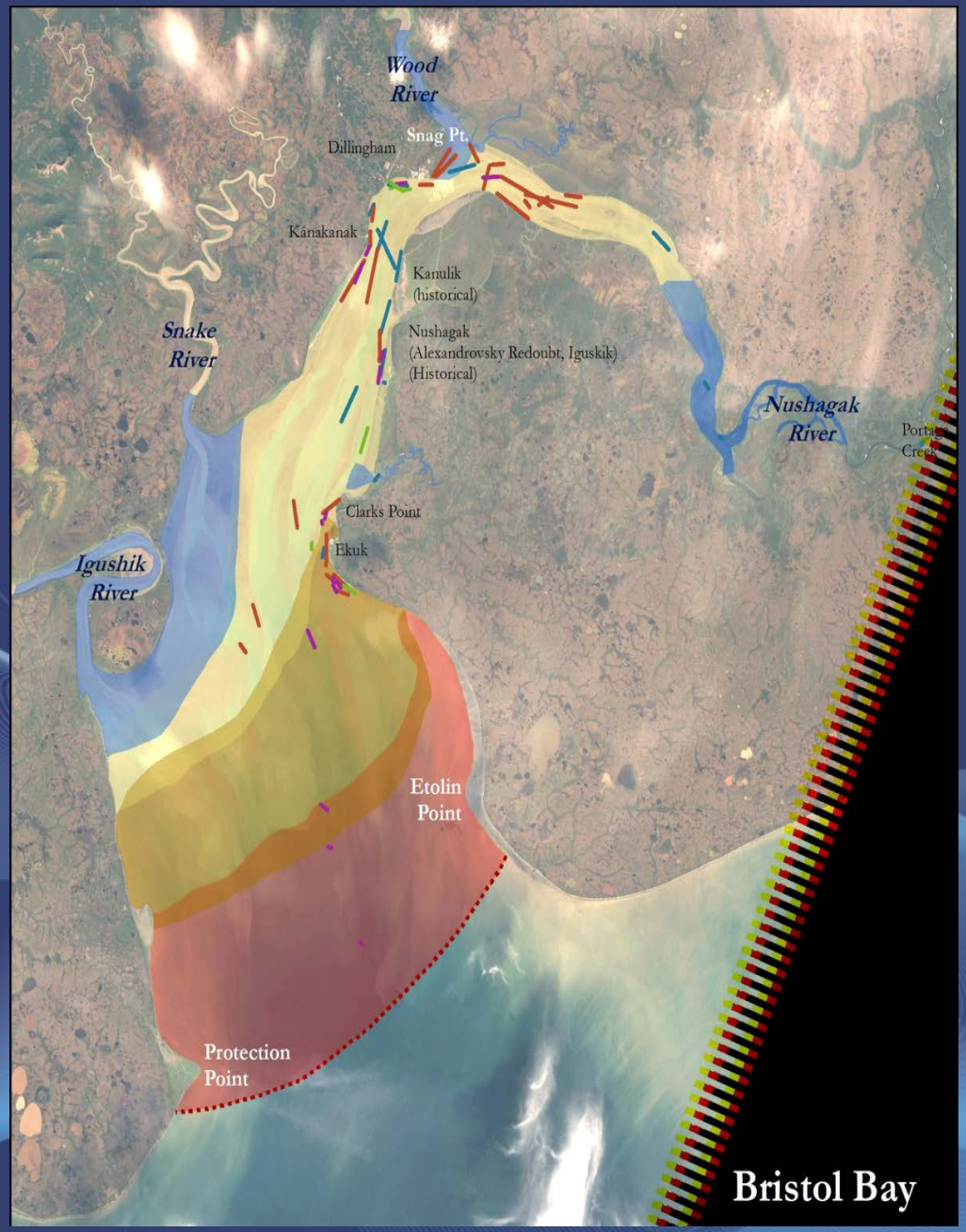
# Species Diversity

Nushagak Estuary

Shannon Diversity (H')

| INDEX | UPPER | LOWER |
|---|---|---|
| Richness (n) | 15 | 12 |
| Diversity (H') | 1.656 | 1.011 |
| Evenness (J) | 0.424 | 0.282 |

- These values rank below similar subarctic estuaries such as Lower Herring Bay in Price William Sound (60°30'N, 147°13'W) (Dean and Jewett 2001) H'=2.5.
- This difference is most likely due to low salinity and high turbidly




**Riverine**

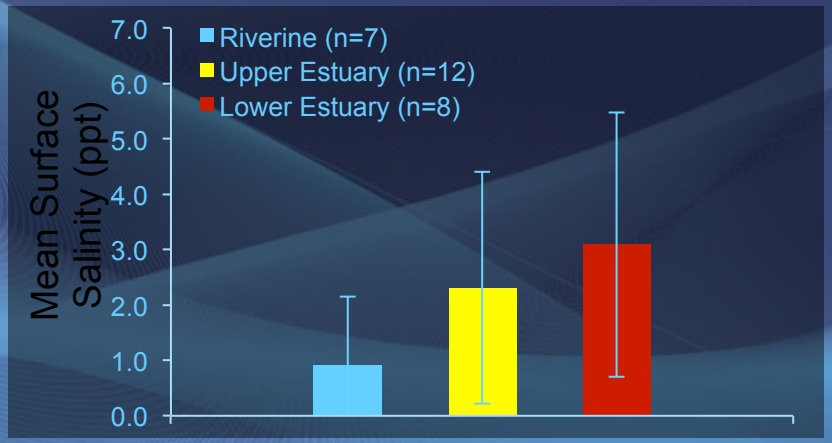
Gravel / Cobble Sediment
All freshwater organisms
Lowest Diversity

**Upper Estuary**

Mostly course or fine sand
Estuarine species present
High Biomass (shrimp/ amphipods)

**Lower Estuary**

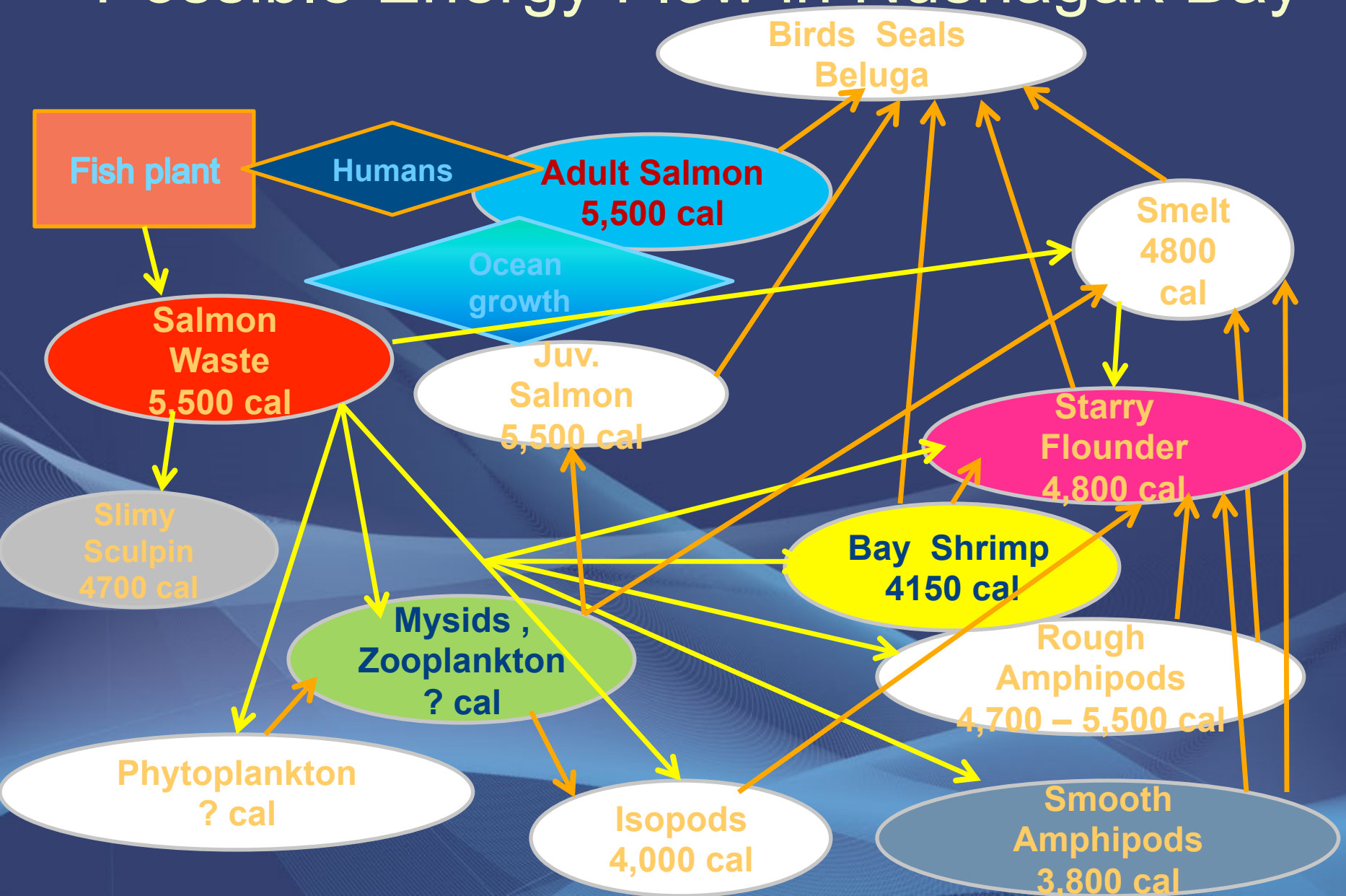
Mostly fine sediment (mud)
Marine species present
Highest Diversity



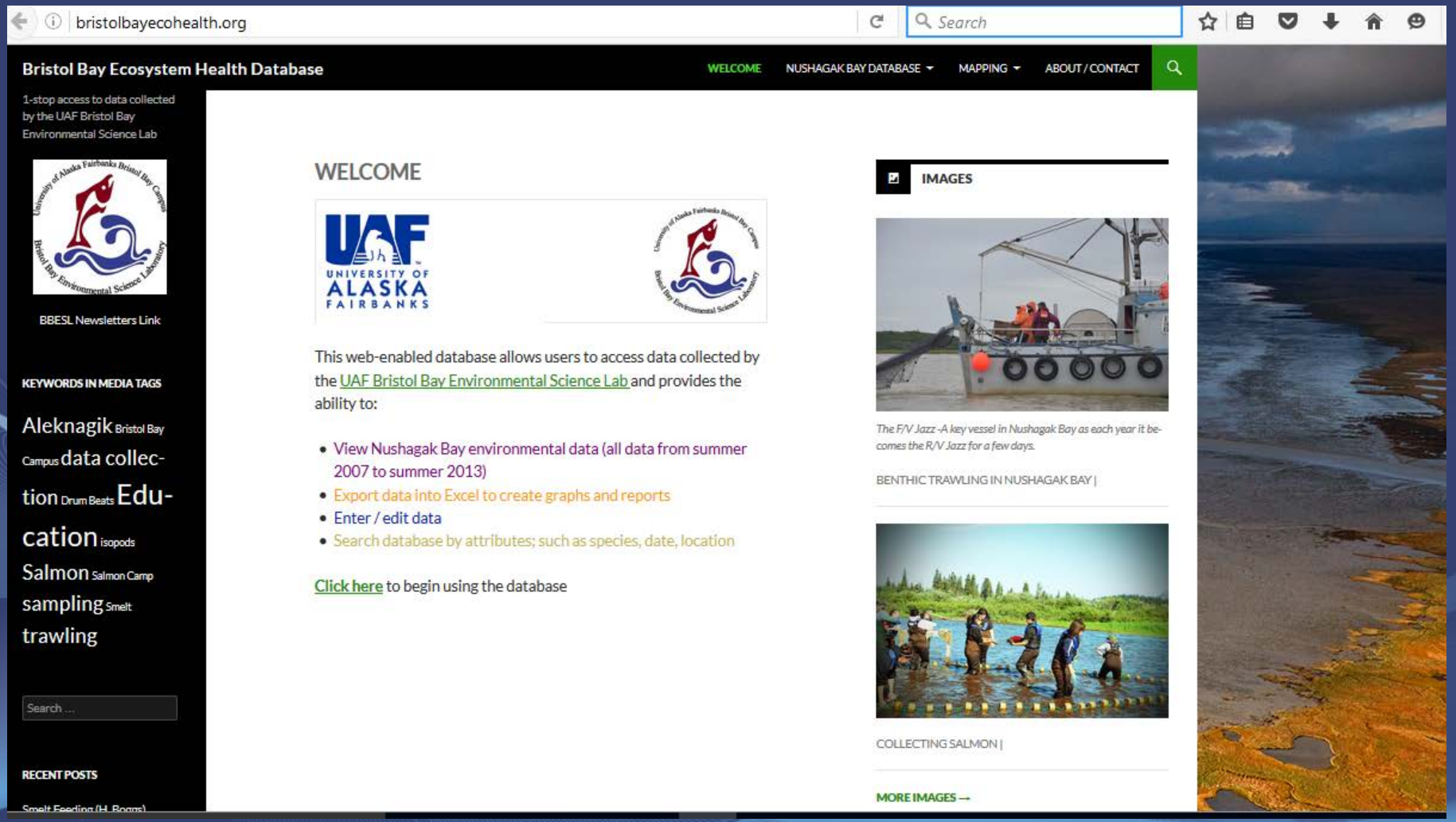
# Caloric Content?

Catching
Drying
Grinding
Bombing

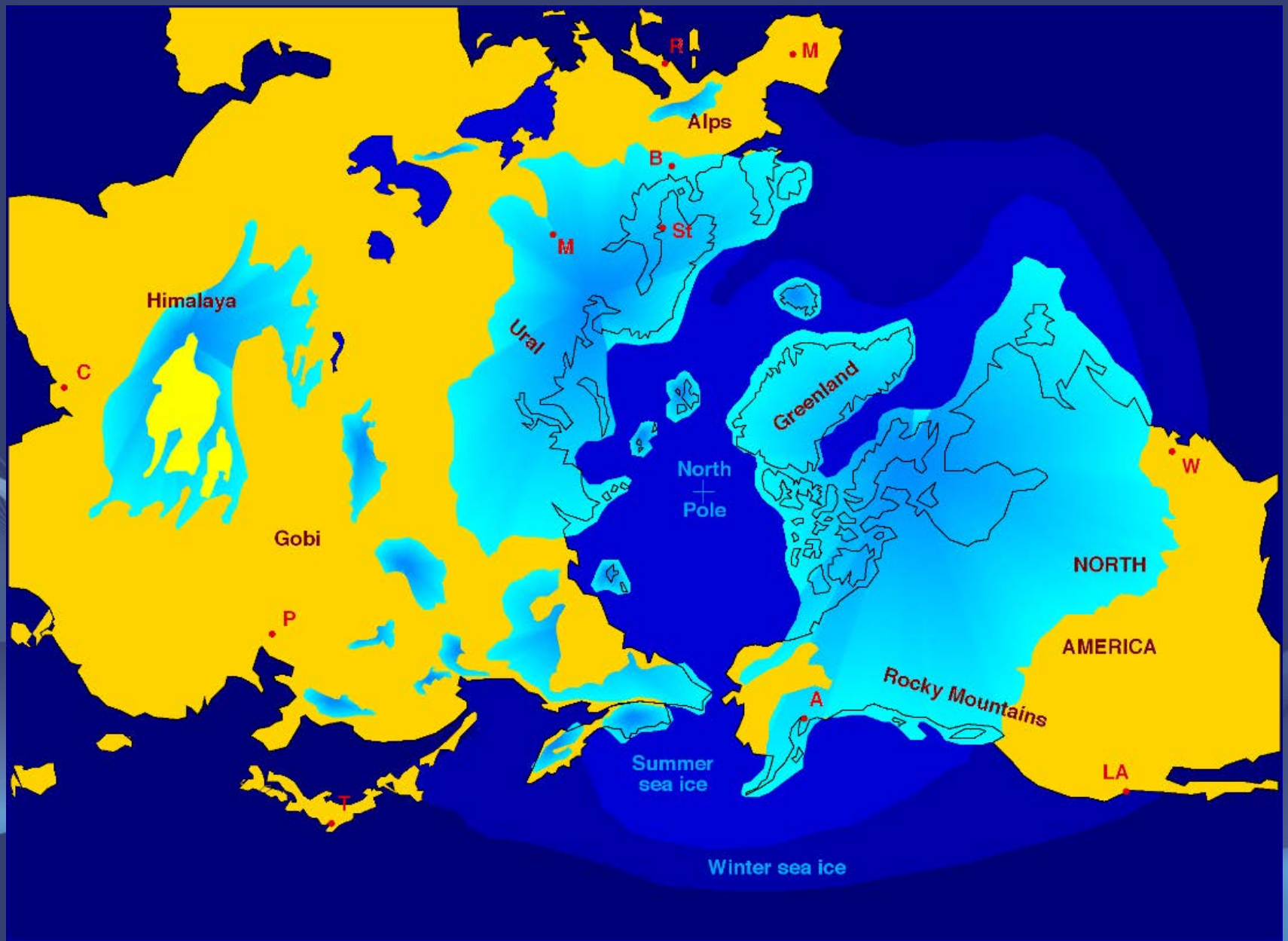
# Possible Energy Flow in Nushagak Bay



# Online Database

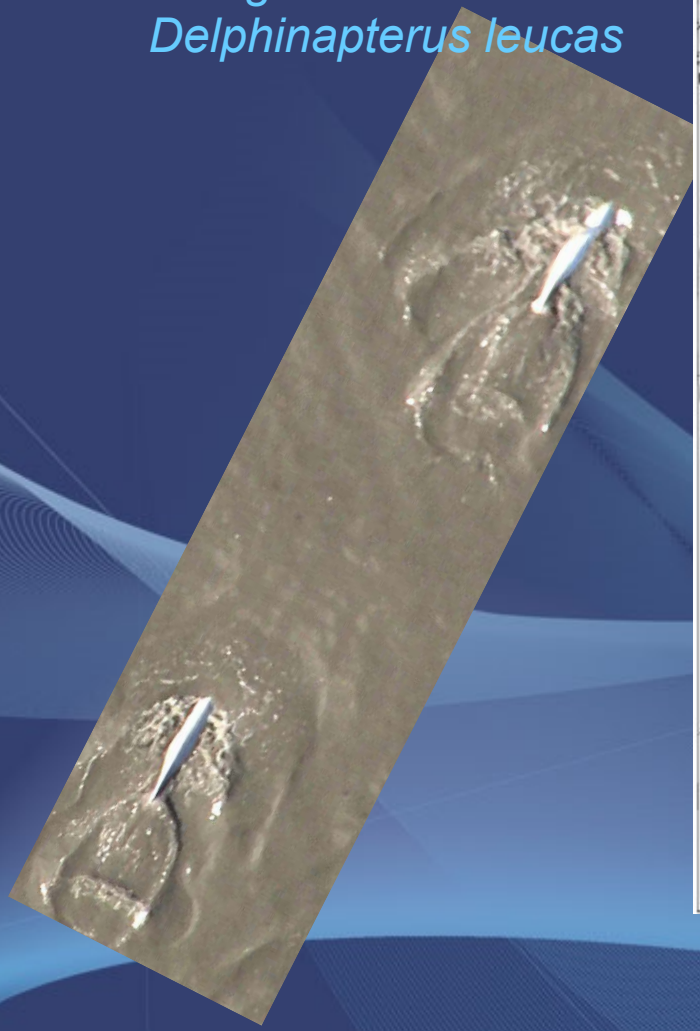


# Modern Biota – Ice Age Relics



# Ice Age Relics

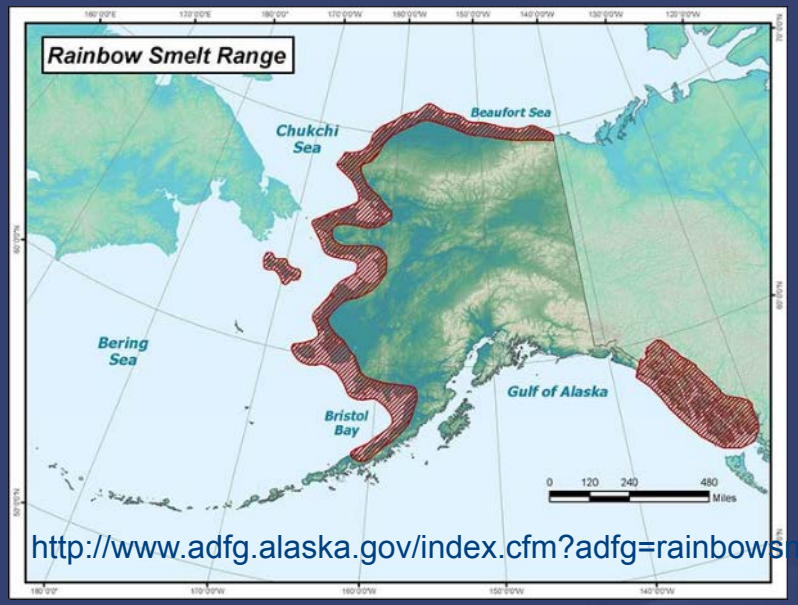
Beluga Whale
*Delphinapterus leucas*



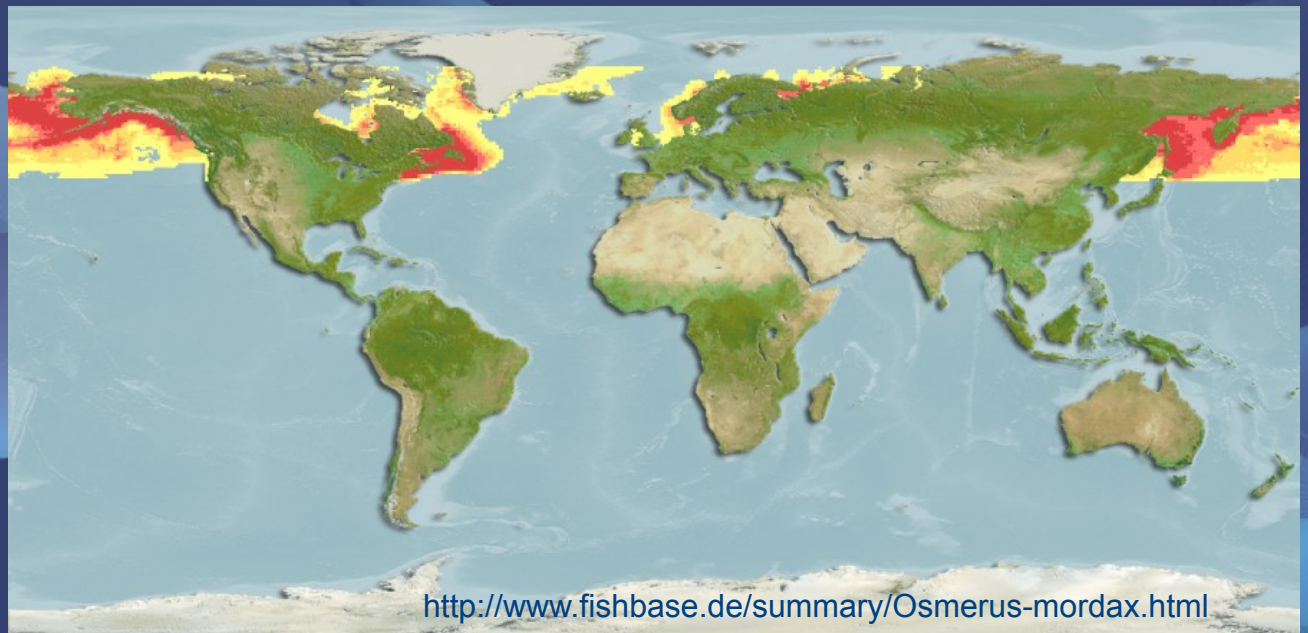

https://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=361B61FA-1&offset=2

# Ice Age Relics

Rainbow Smelt
*Osmerus mordax*




http://www.adfg.alaska.gov/index.cfm?adfg=rainbowsmelt



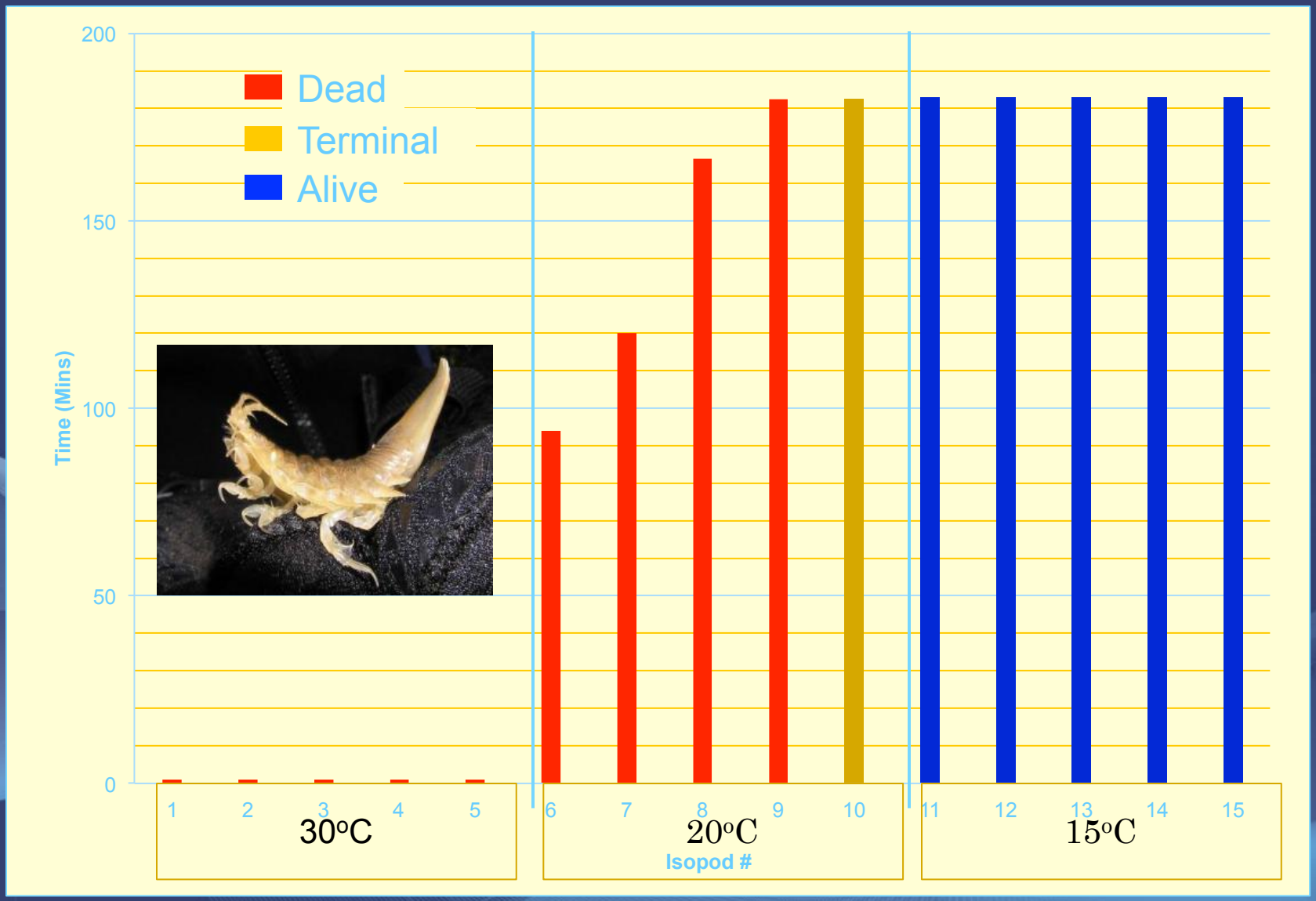
http://www.fishbase.de/summary/Osmerus-mordax.html

# Ice Age Relics

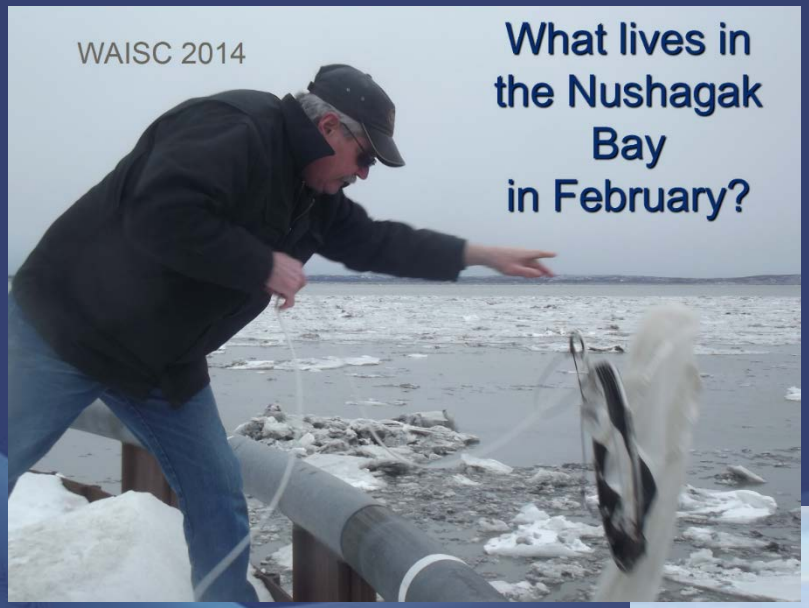
Arctic Isopod
*Saduria entomon*


# Isopod Temperature Tolerances

## Example: 183 hours (8.5 days)



# Primary vs. Secondary Production?

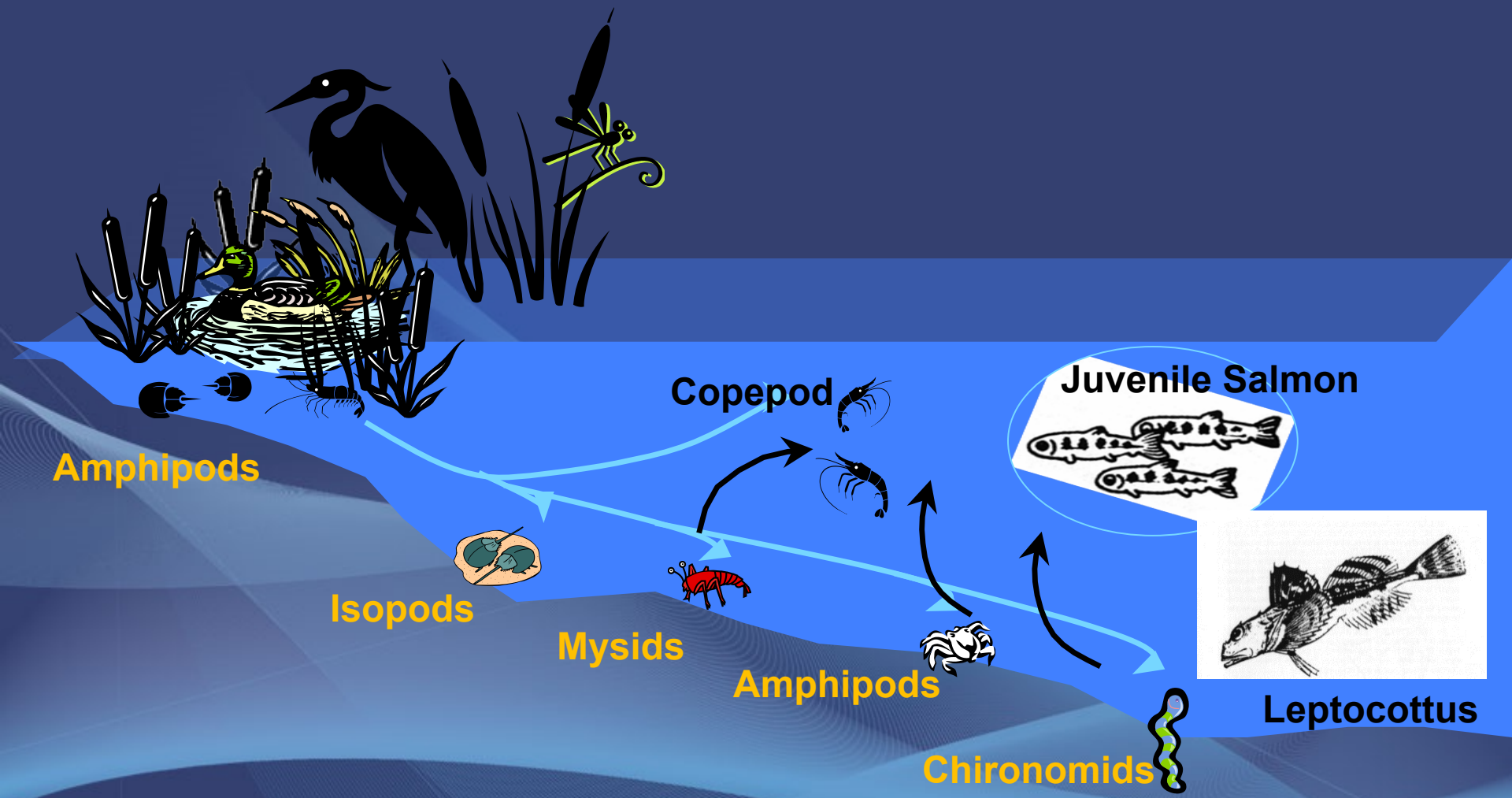




- High turbidly
- Strong currents
- Few  phytoplankton
- Abundant Mysids

# Fish Processing Waste

What are the influences of processing waste?


# Detritus-based food web in estuary marshes




Adapted from Dorcey et al. 1978. Westwater Res. Rept. UBC.

# Ecosystem Management Attributes

Few essile benthic species – most mobile

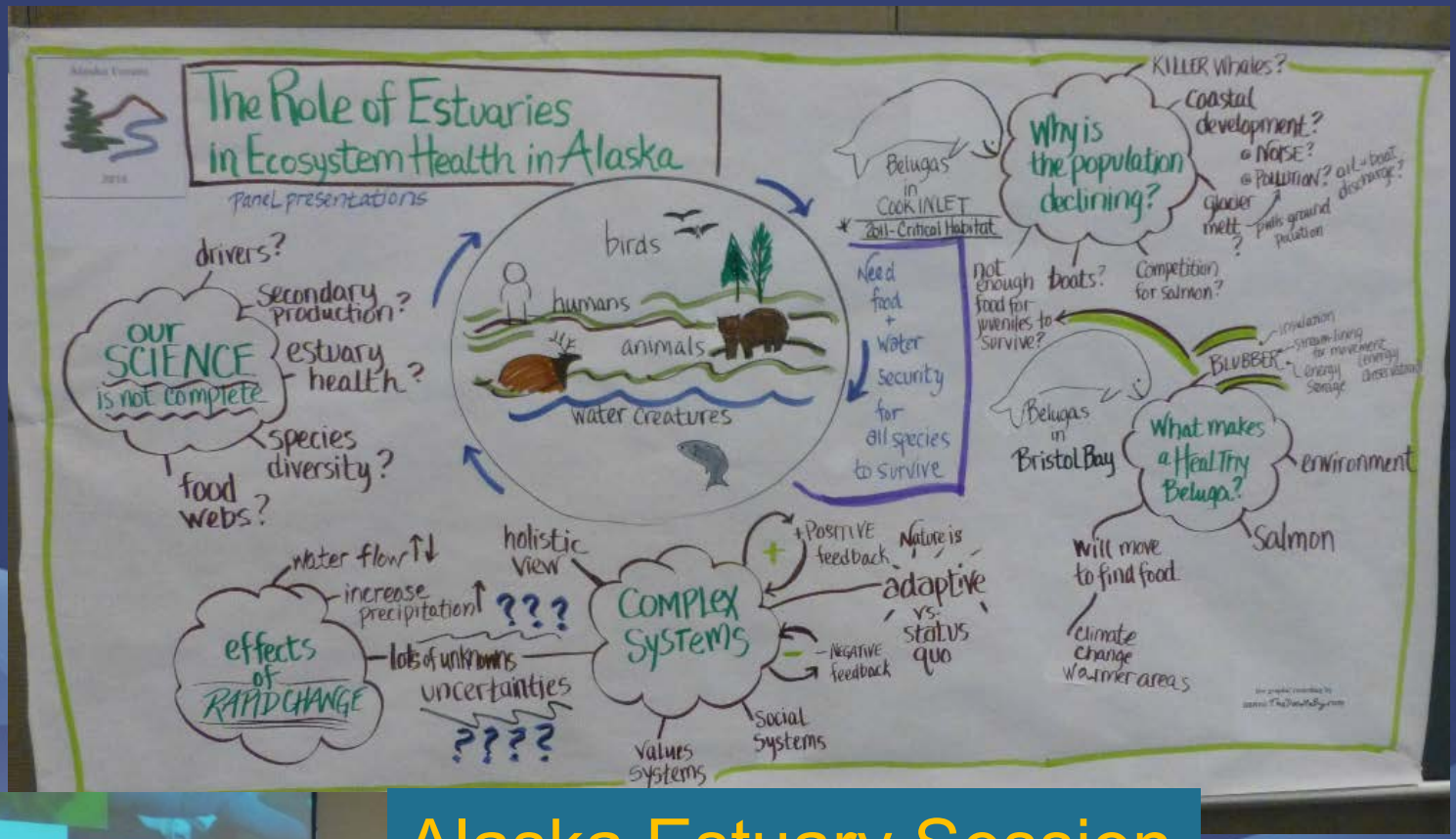
Cold water adapted species. Fauna dominated by ice age relics

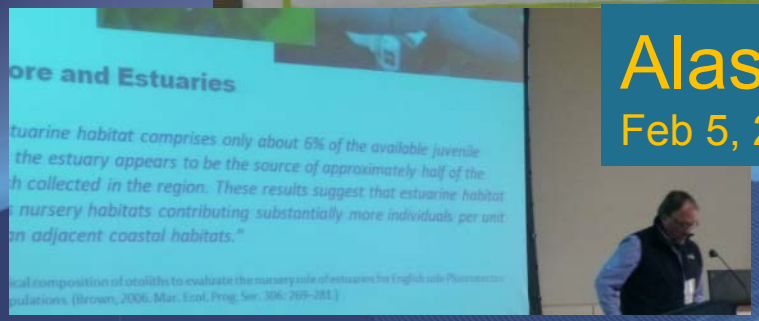
Low species diversity estuary wide (compared to lower latitude estuaries). Species diversity increases towards Bristol Bay

Low primary productivity - Salmon based detritus may drive system

Most trawls dominated by Crangon shrimp and Gammarus amphipods

# Alaska Forum on the Environment




## Alaska Estuary Session

Feb 5, 2015 Anchorage, AK

ALASKA FORUM

# AAAS Arctic Division Meeting

Theme:

***Healthy Estuaries: Sustainability and Resilience***

in Anchorage , October 1-3, 2015


## Arctic Estuaries Threatened by Climate Change

The 2015 AAAS Arctic Science Conference focused on the health and sustainability of estuaries, as well as other climate-driven changes to the region's environment.

6 October 2015 Gavin Stern

Email Print

AAAS NEWS | ASSOCIATION AFFAIRS | NEWS

AN ESTUARY ON COOK INLET NEAR ANCHORAGE, ALASKA. | AAAS/GAVIN STERN

Not many species call the brackish, murky waters of Alaska's estuaries home. But a great diversity of life transits through and spawns in them. Erosion, increasing water temperature, and rising sea levels threaten those estuaries today — not 50 years from now.

"Estuaries are the heart of reproduction and food systems. That's where the fish and the algae and food systems start out," said Larry Duffy, executive director of the AAAS Arctic Division.

# More to Learn

- Few strictly estuarine species
  - Which species migrate in out
  - Which population are permanent residents but interact with others in adjacent habitats.
- More studies will reveal even more!
  - Unknown roles
  - Human influences
  - Influences of continued and accelerated climate change

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# Thank you

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# Coastal Erosion?