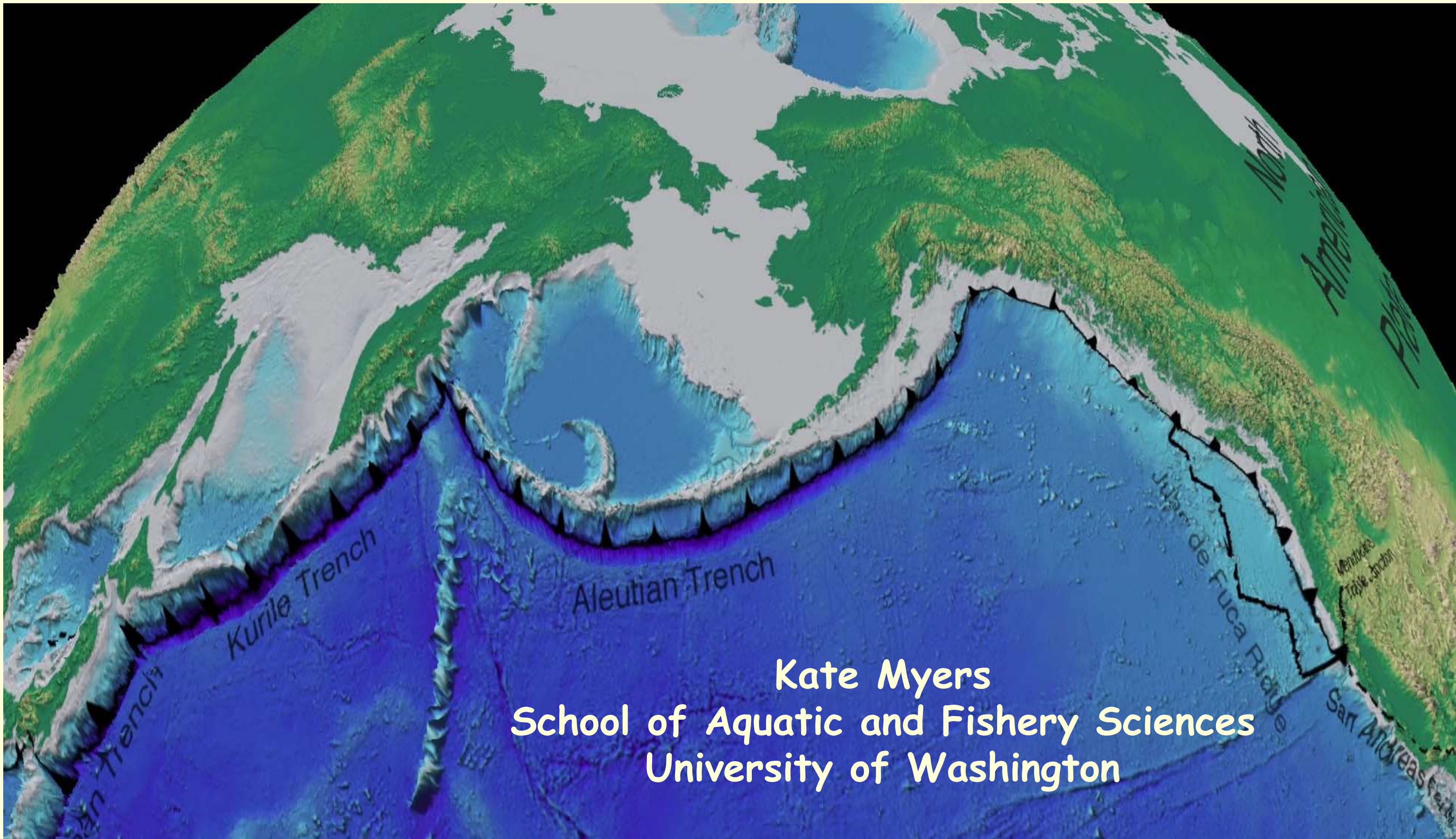
NE Pacific Basin—Tagging Data



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Acknowledgments

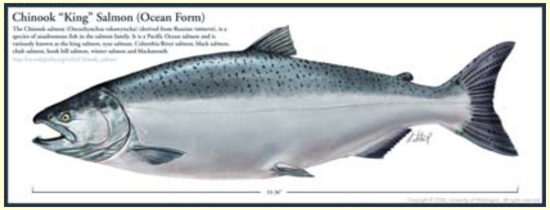
- Ed Casillas, NMFS/NW Fisheries Science Center
- Joe Fisher, Oregon State University
- Nate Mantua, University of Washington
- John Morris, Fisheries & Oceans Canada
- Bill Pearcy, Oregon State University/ISAB
- Marc Trudel, Fisheries & Oceans Canada
- David Welch, POST/Kintama Research Coorp.
- And many more

Main Points

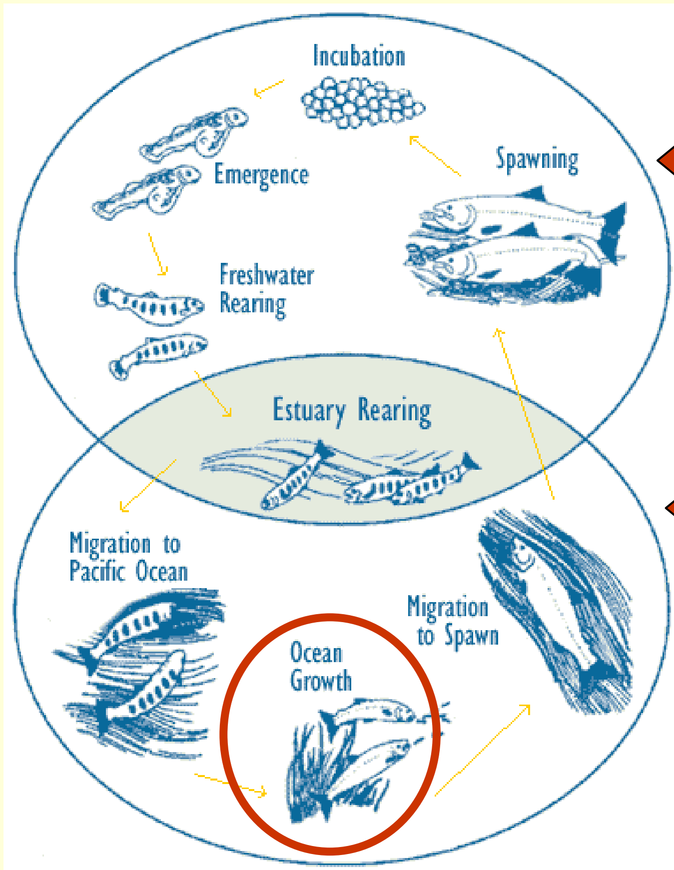
- ✓ **BIODIVERSITY** in freshwater and ocean life histories makes Columbia R. salmon resilient to changes in ocean conditions that affect their survival
- ✓ Tagging Data show that Columbia R. salmon species, life-history types, & ESUs have **DIFFERENT** ocean distribution and migration patterns, which means they experience **DIFFERENT** ocean conditions.
- ✓ We **CANNOT PREDICT THE FUTURE**, but management strategies that ignore the effects of changing ocean conditions on Columbia R. salmon are likely to fail
- ✓ **COMPREHENSIVE TAGGING STRATEGIES** can provide information needed to improve management

Outline

- BIODIVERSITY: Importance and a few ocean life history examples
- OCEAN DISTRIBUTION & MIGRATION: Some historical & recent tagging results for different species, stocks, and ESUs
- POST (Pacific Ocean Shelf Tracking) Project results
- REVIEW of comprehensive tagging strategies (new technologies; technologies appropriate for ocean; and application to management)



BIODIVERSITY in freshwater and ocean life histories makes Columbia R. salmon resilient to changes in ocean conditions that affect their survival



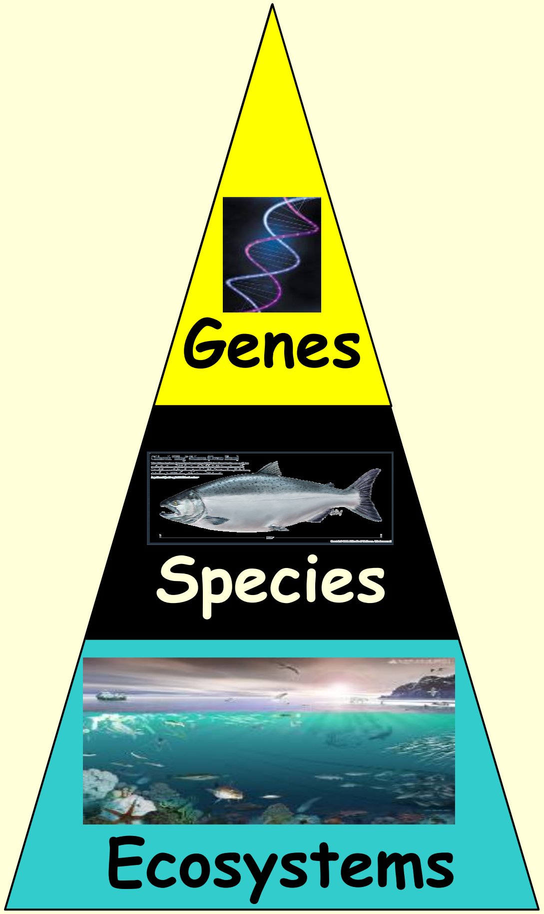
Source: www.wileyslough.org

<u>Freshwater</u>
99% of salmon research

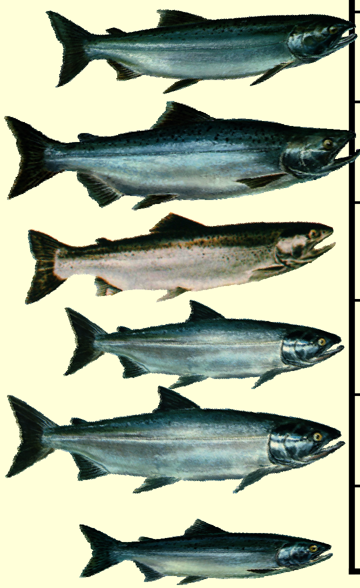
<u>Ocean</u>
99% of salmon growth

Biodiversity can be expressed & measured at many different levels of organization

- Genetic variation within a species
- Variation between species within an ecosystem
- Variation within species between ecosystems



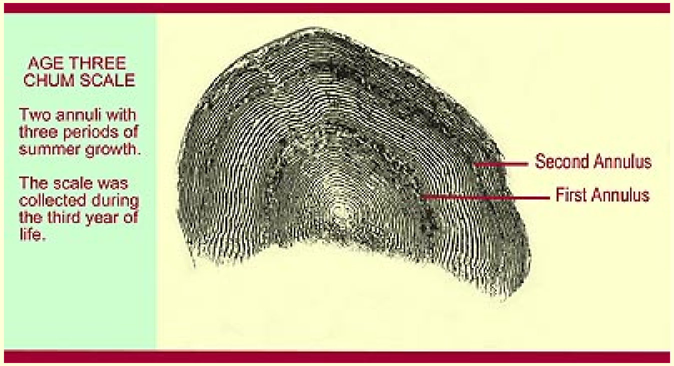
Diversity in Freshwater & Ocean Ages



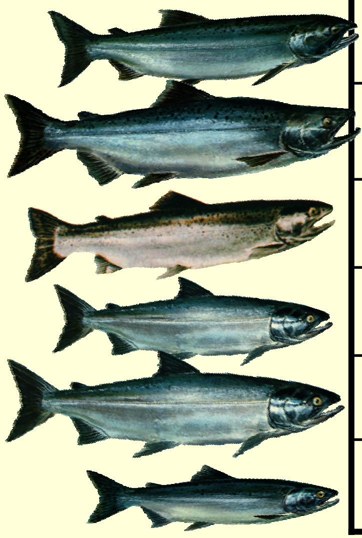
Species	No. years freshwater	No. years in ocean	% of total life in ocean
Coho	1, 2	0, 1	33%-50%
Chinook	0, 1	2-5	67%-97%
Steelhead	1, 2	1-4	33%-80%
Sockeye	1-3	1-3	33%-75%
Chum	0	1-5	89%-97%
Pink	0	1	89%

Otoliths or ear bones

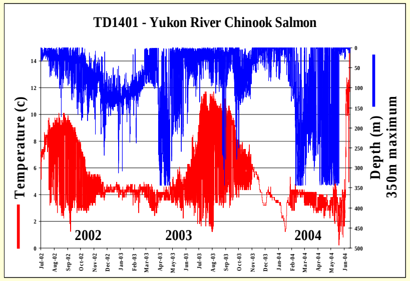
Scales



Diversity in Ocean Habitats



Species	Upper Thermal Limit	Lower Thermal Limit	Upper Salinity Limit (PSUs)
Coho*	15.7°C	3.7°C	34.26
Chinook*	13.4°	?°C	33.95
Steelhead**	15.5°C	?°C	?
Sockeye*	13.3°C	3.3°C	33.46
Chum*	15.6°C	2.7°C	34.45
Pink*	16.6°C	2.8°C	34.37

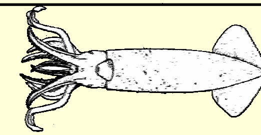
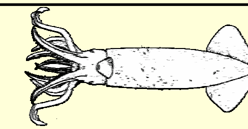
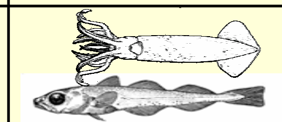
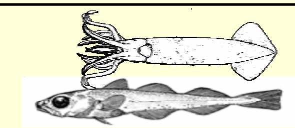
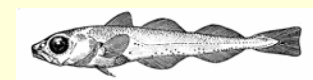
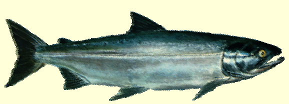
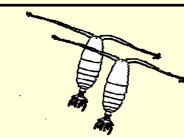
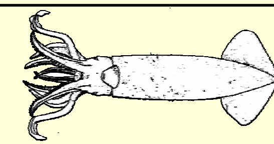
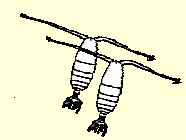
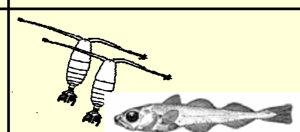
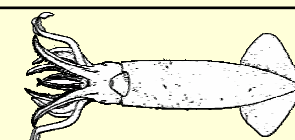


Archival tag data

*Azumaya et al. (2007; surface gillnet data)

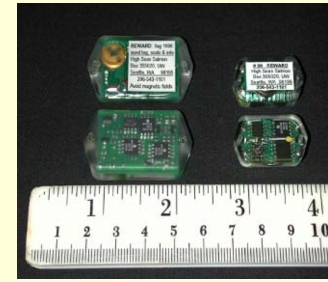
**Welch et al. (1998; surface longline & gillnet data)

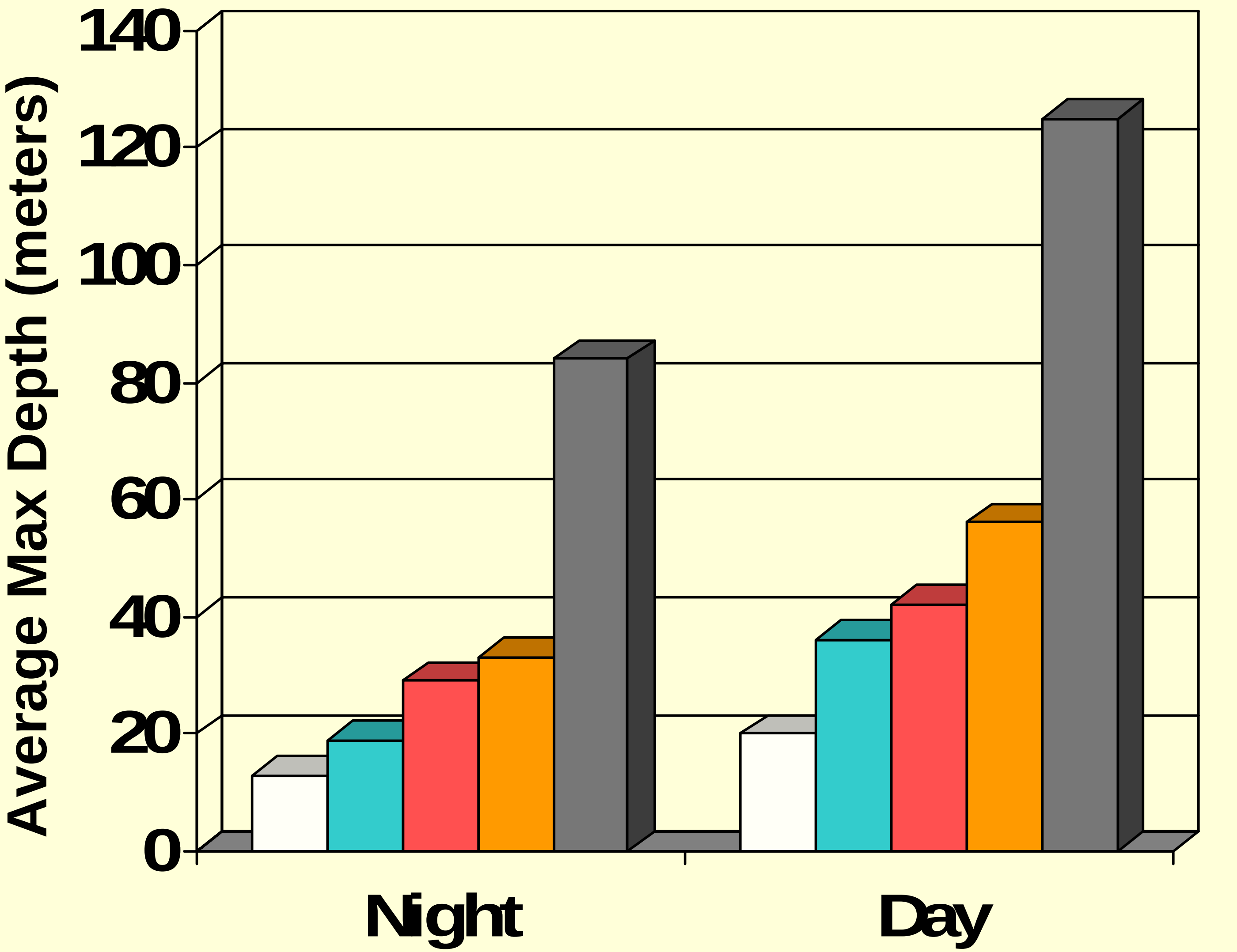
Diversity in Salmon Diets in NE Pacific Basin in Summer

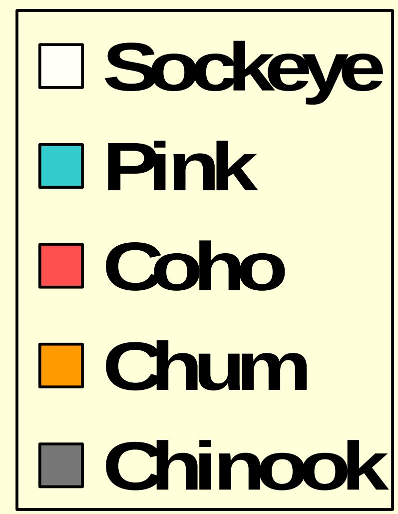
Species	Open Ocean Diet	Small body size	Large body size
 Coho	squid		
 Chinook	Squid, fish		
 Steelhead	fish		
 Sockeye	Zooplankton, squid		
 Chum	Zooplankton, jellyfish		
 Pink	Zooplankton, fish, squid		

Diversity in Vertical Distribution in the Open Ocean (Source: Walker et al. 2007)

Archival tags

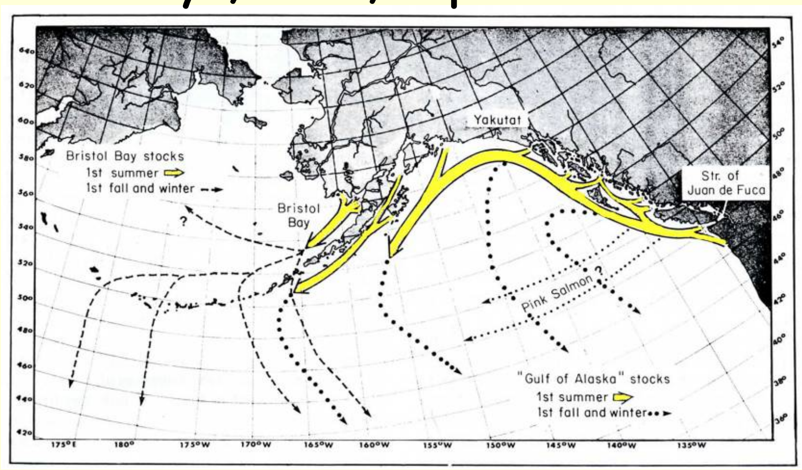




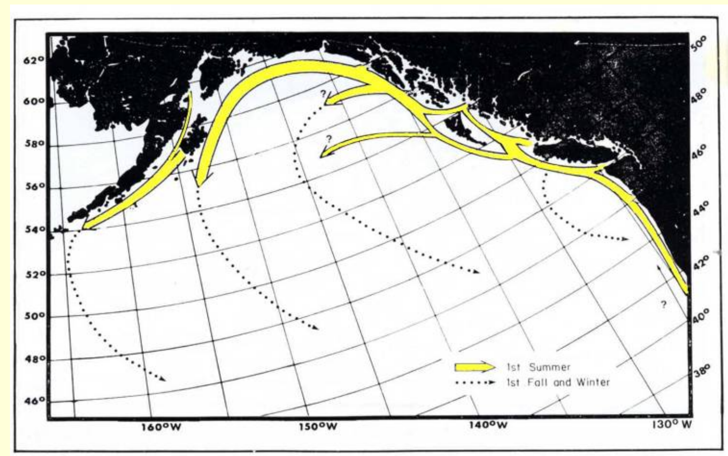


Tagging Data show that salmon species, life-history types, ESUs, etc.,have DIFFERENT ocean migration patterns

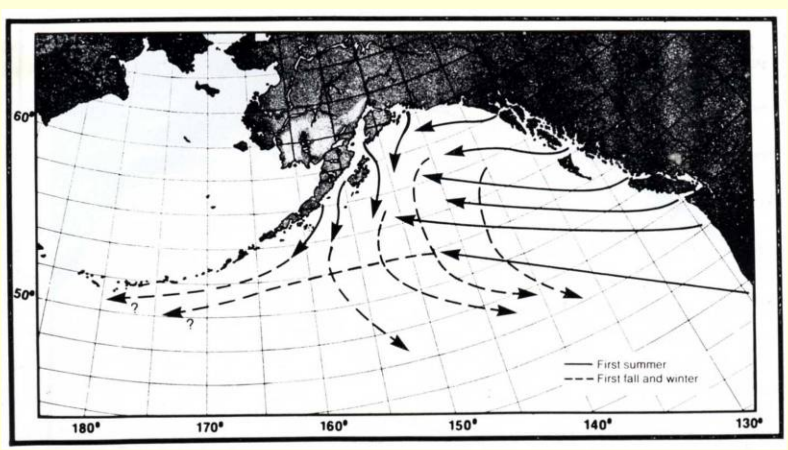
Sockeye, chum, & pink salmon



Chinook and Coho salmon

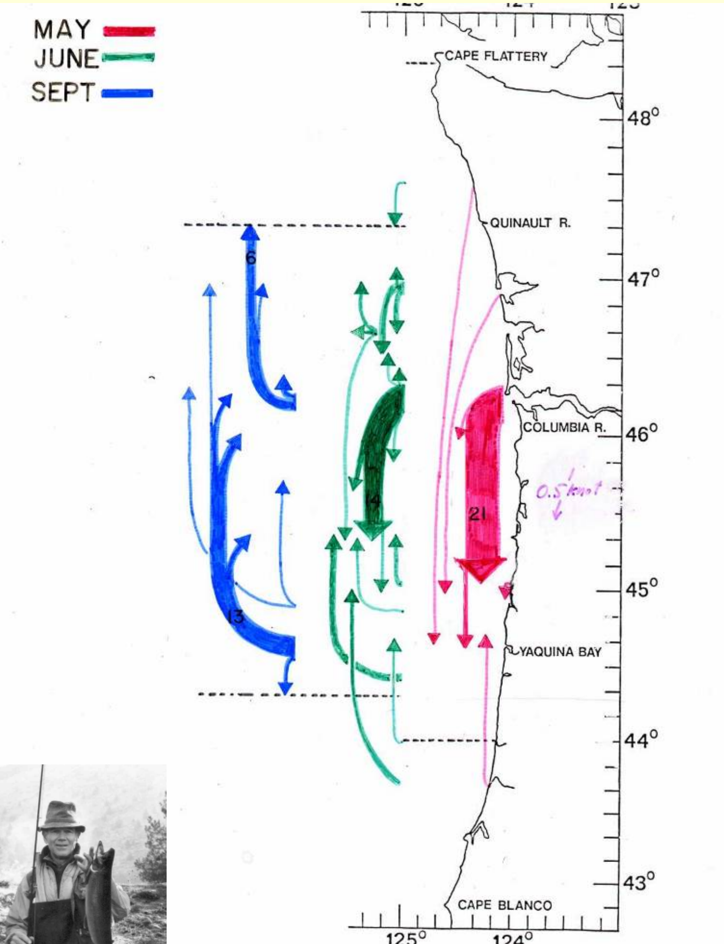


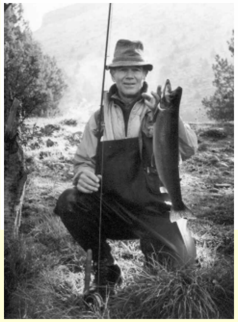
Steelhead



Ocean Migration Patterns of Juvenile Salmon in 1960s (Hartt & Dell 1986)

Southward Migrations of Columbia R. Juvenile Coho Salmon Related to Ocean Conditions (Pearcy and Fisher 1988)

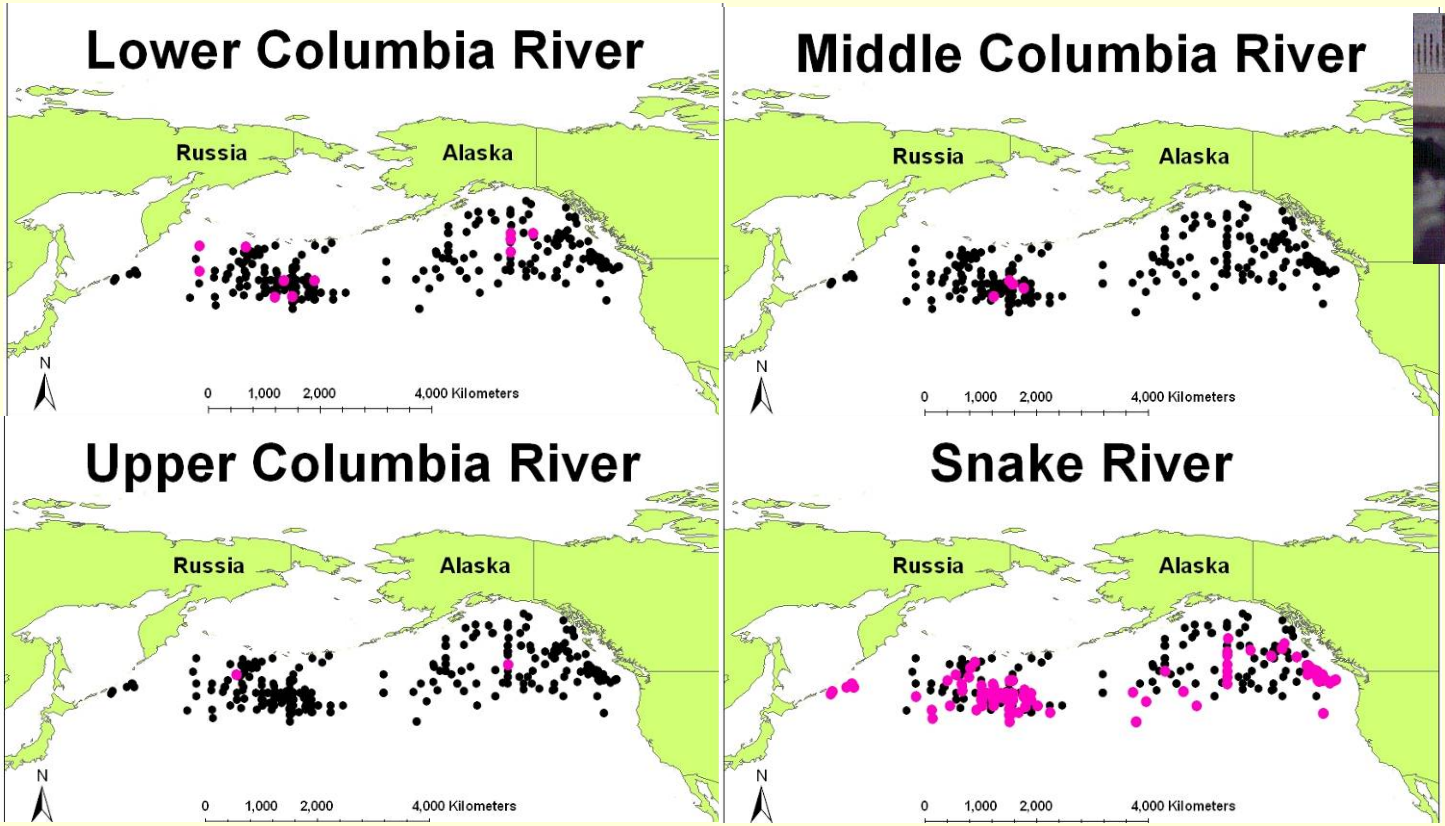


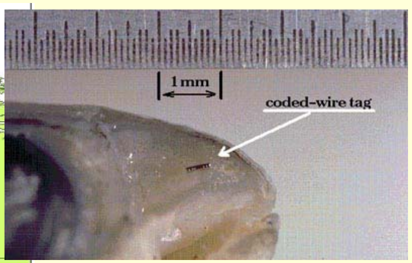


Bill Pearcy. Photo by Jeffrey Dambacher

- Initial southward movements of juveniles, likely the result of advection by southward flowing coastal currents
- Most did not make distant water migrations into the Gulf of Alaska
- Ocean conditions in the 1980s (weak upwelling and Ekman transport) might have modified migratory patterns

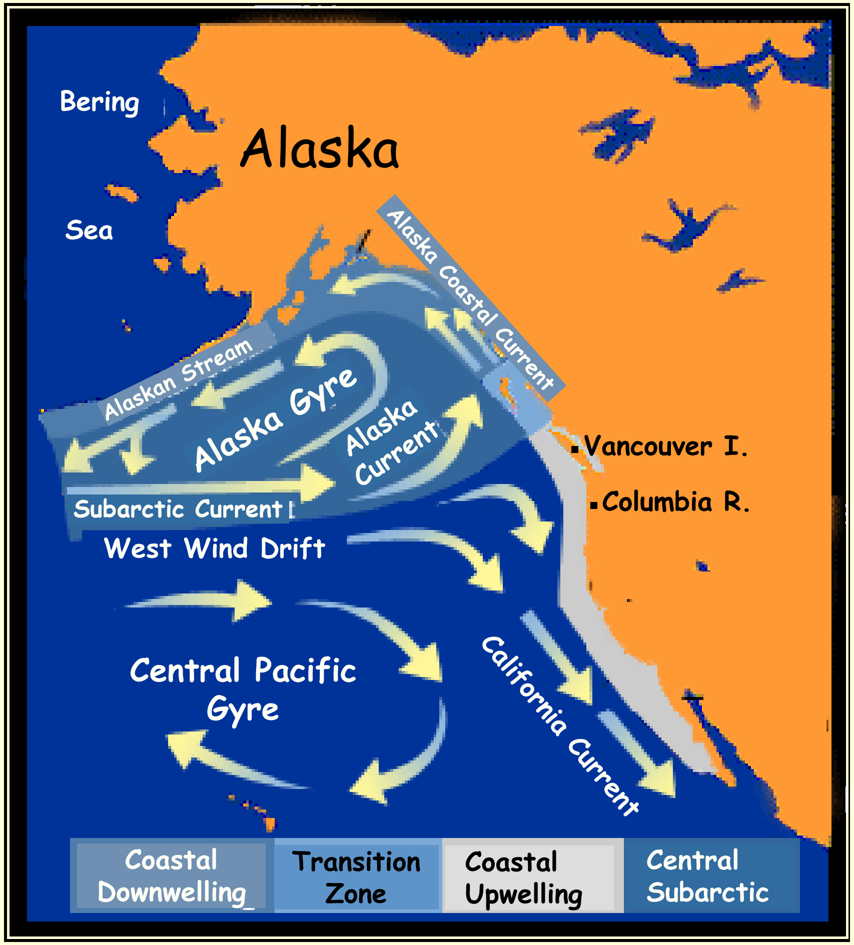
Coded-wire Tag Data Show Columbia R. Steelhead are Distributed Across the Entire North Pacific Ocean (research pioneered by Pearcy and Masuda 1982)





Black Dots = All North American steelhead from coded-wire tag and high seas disk tag recoveries (1956-2005); Pink dots = Columbia R. Stocks

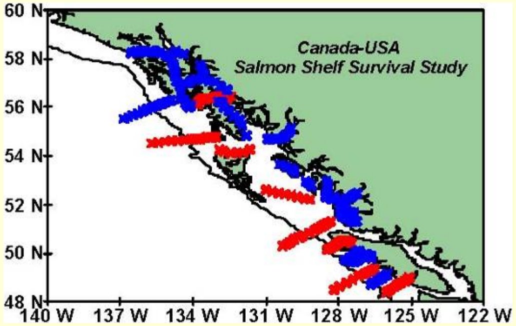
BPA-funded tagging research focuses on juvenile salmon in NE Pacific Continental Shelf habitats

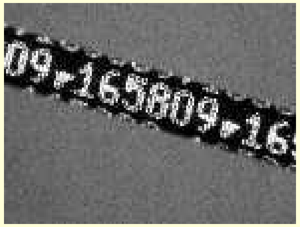


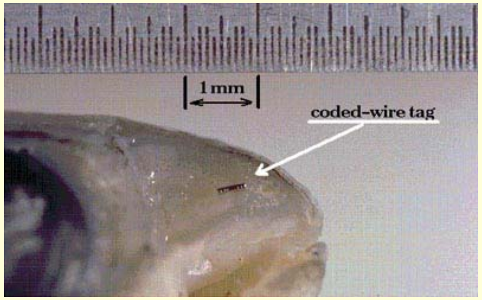
- Canada-USA Shelf Survival Study (Marc Trudel, Fisheries & Oceans Canada)
- Ocean Survival Study (Ed Casillas, NW Fisheries Science Center)
- Pacific Ocean Shelf Tracking (POST) Project (David Welch, Kintama Research Coorporation)

Canada-USA Shelf Salmon Survival Study (1998-present)

Summary of recent results from coded-wire tag recoveries







Columbia River fall Chinook salmon:

- Juveniles remain within a few 100 km of the Columbia River, and stay there at least until their first winter at sea

Columbia River spring Chinook salmon:

- Exhibit far more complex migration behavior than fall Chinook salmon, with different regional groups (i.e., LOCR, UPCR, and Snake) migrating at different rates, both fast and slow migrants, and some stocks migrating south of the Columbia River (primarily Cowlitz River)

Columbia River coho salmon:

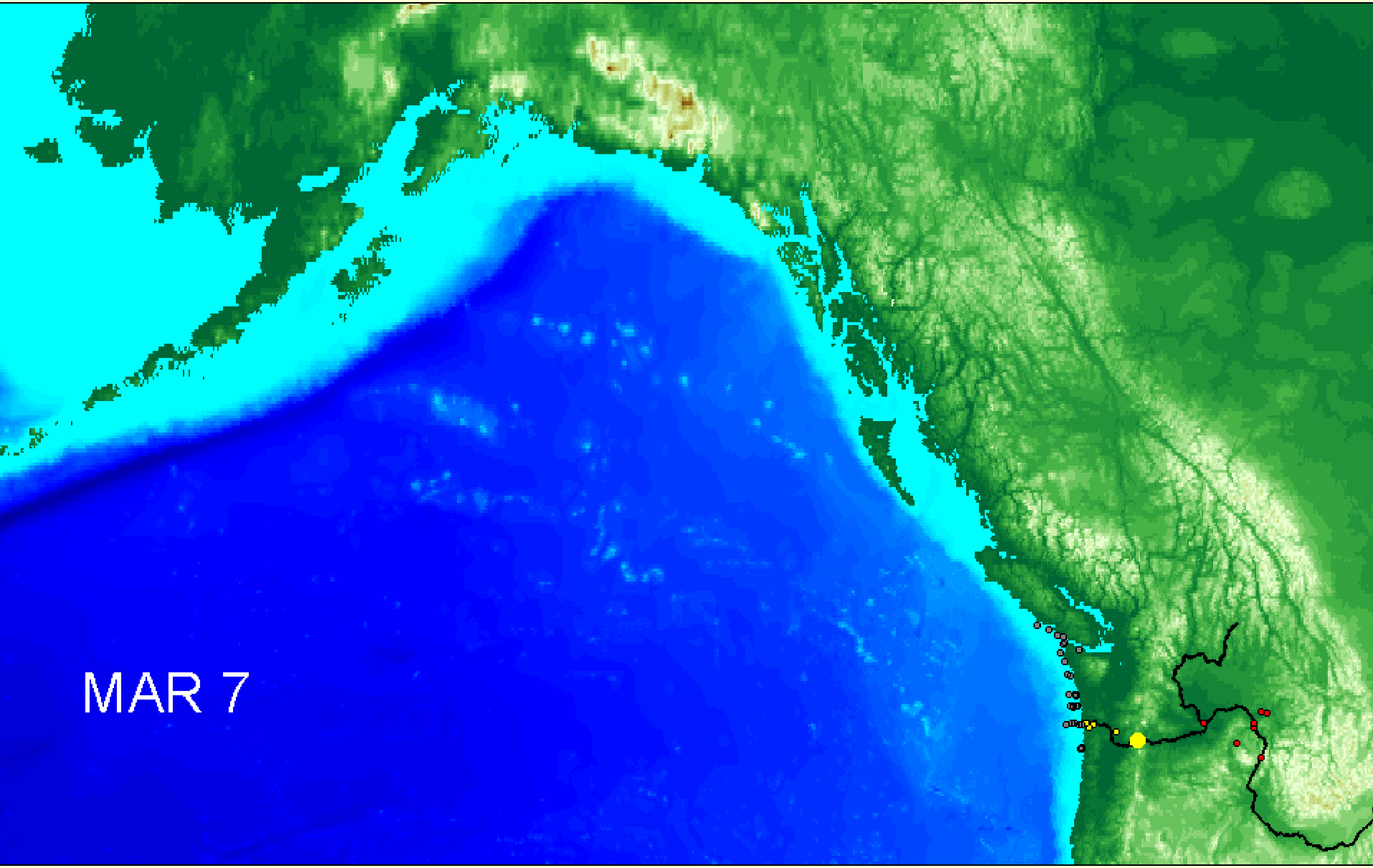
- Migration pattern similar to spring chinook salmon with both fast and slow migrants

Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

CWT Fall Chinook Salmon Annimation

Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

CWT Fall Chinook Released as Subyearlings
LOWER = Yellow   UPPER = Red

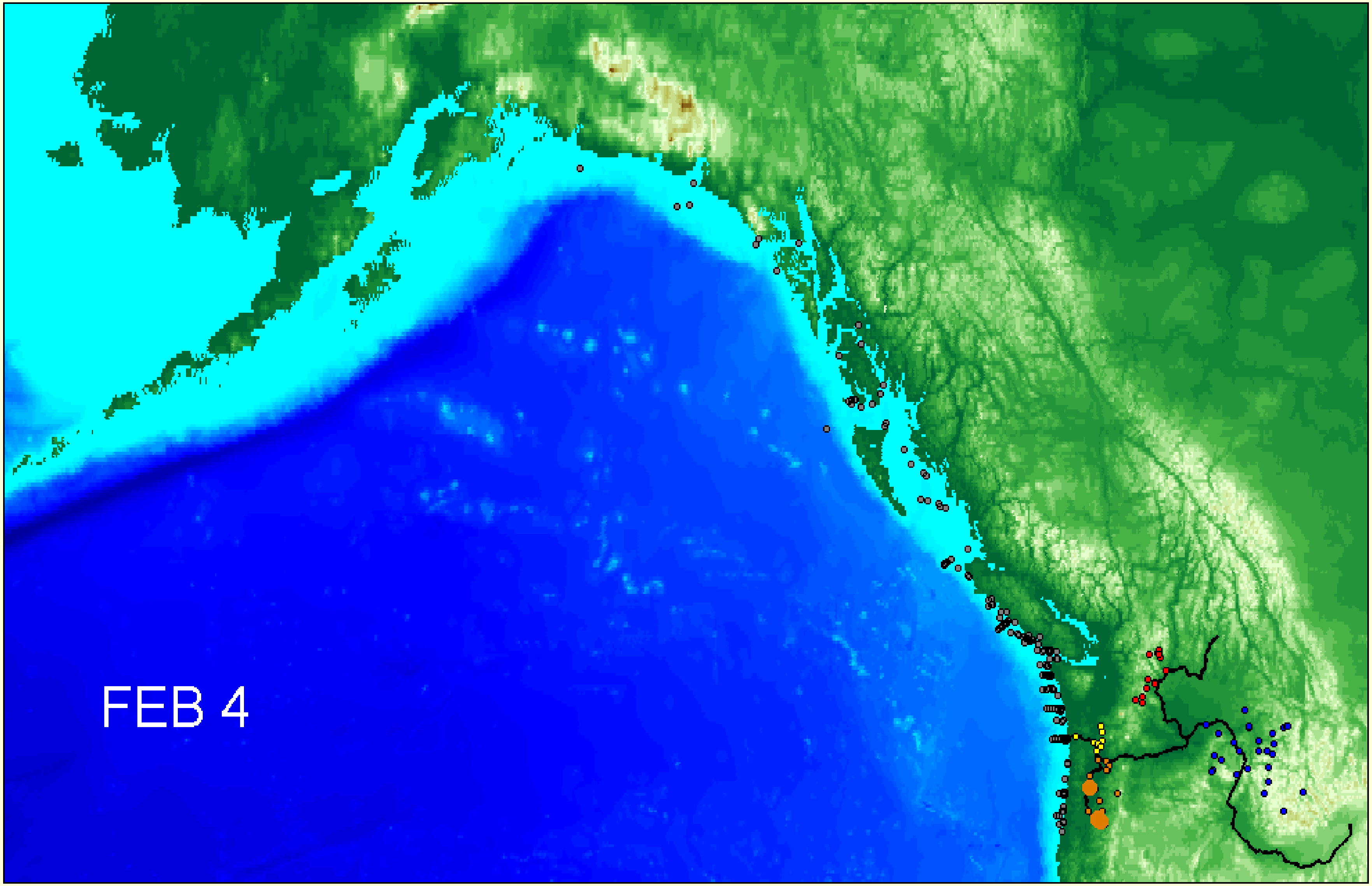


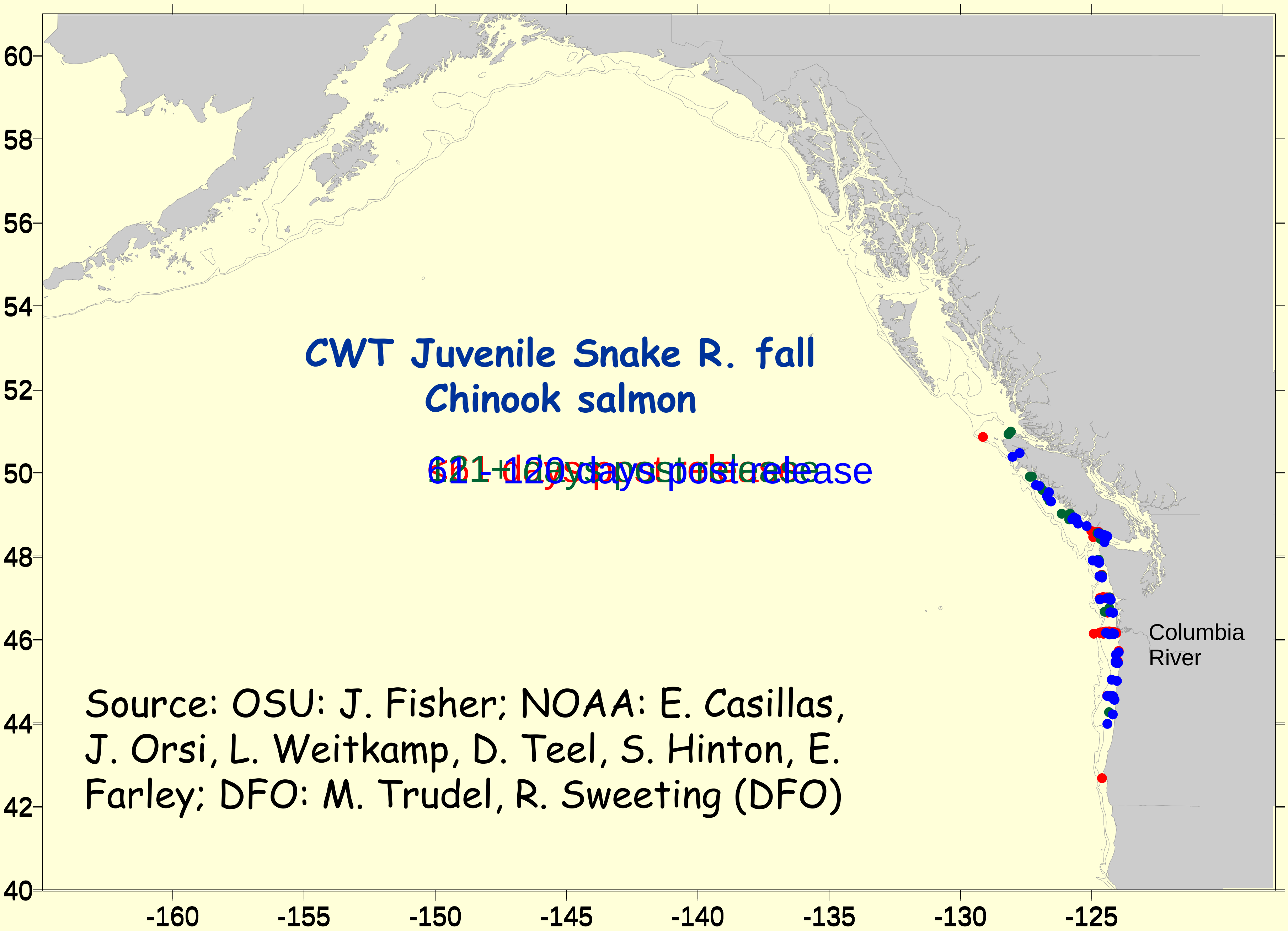
CWT Fall Chinook Salmon Annimation

Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

CWT Spring Chinook Released as Yearlings

LOCR=Yellow, Will=Orange, UPCR=red, Snake=blue




CWT Juvenile Snake R. fall
Chinook salmon
61-120 days post release
Columbia
River
Source: OSU: J. Fisher; NOAA: E. Casillas,
J. Orsi, L. Weitkamp, D. Teel, S. Hinton, E.
Farley; DFO: M. Trudel, R. Sweeting (DFO)
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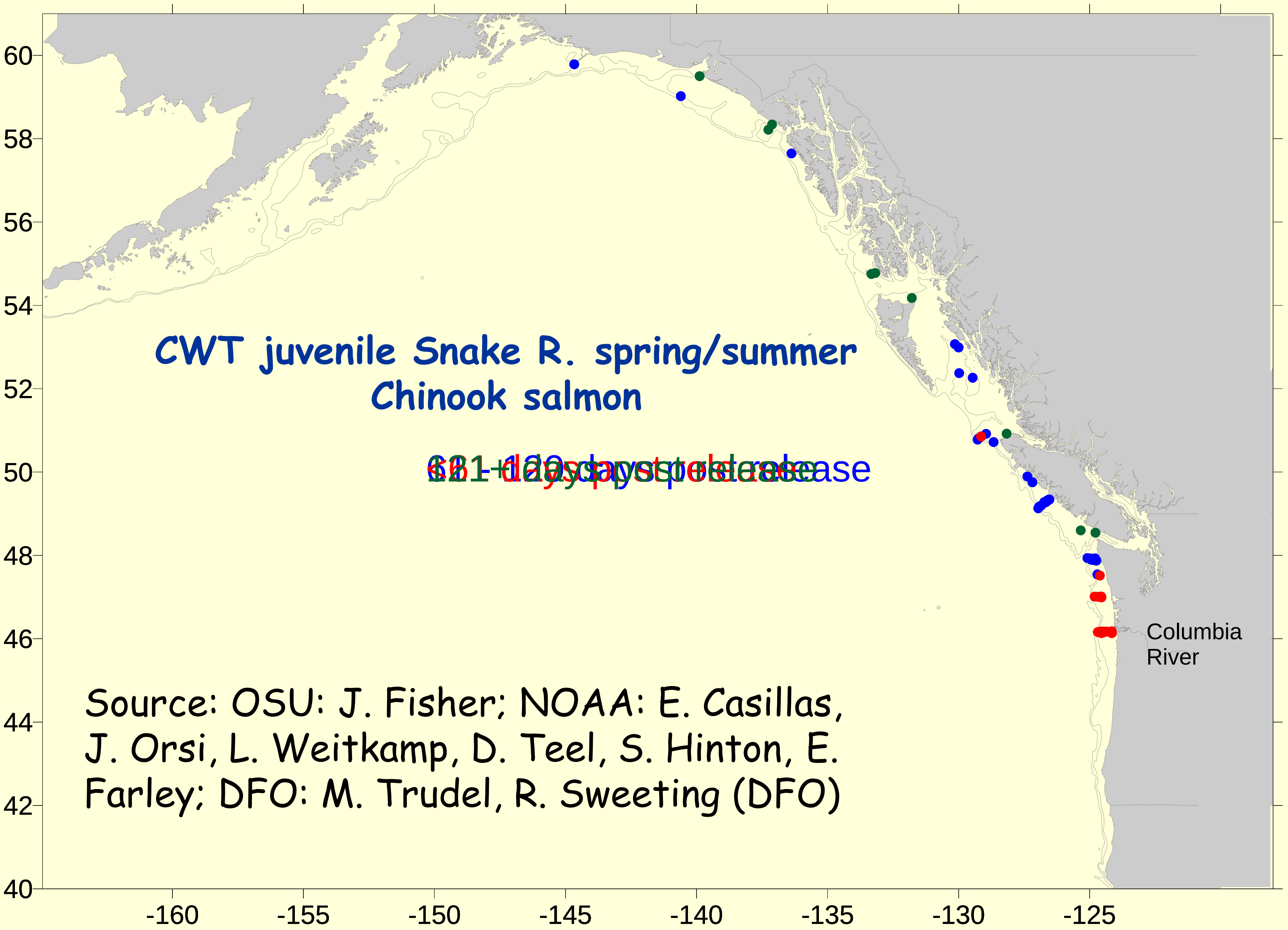

CWT juvenile Snake R. spring/summer
Chinook salmon
Columbia
River
Source: OSU: J. Fisher; NOAA: E. Casillas,
J. Orsi, L. Weitkamp, D. Teel, S. Hinton, E.
Farley; DFO: M. Trudel, R. Sweeting (DFO)
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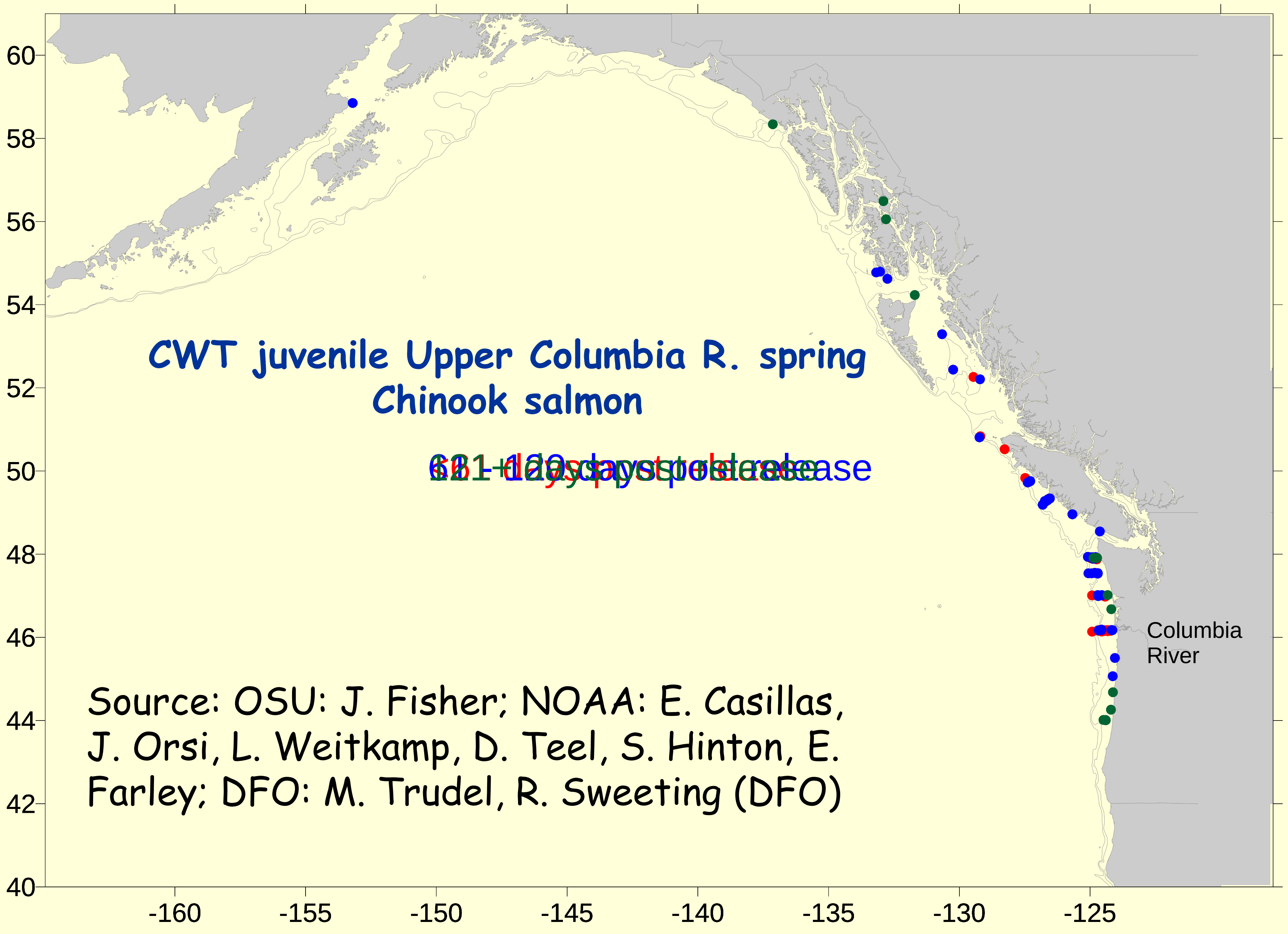
CWT juvenile Upper Columbia R. spring Chinook salmon
<61 days post release
61-120 days post release
121+ days post release
Columbia River
Source: OSU: J. Fisher; NOAA: E. Casillas, J. Orsi, L. Weitkamp, D. Teel, S. Hinton, E. Farley; DFO: M. Trudel, R. Sweeting (DFO)
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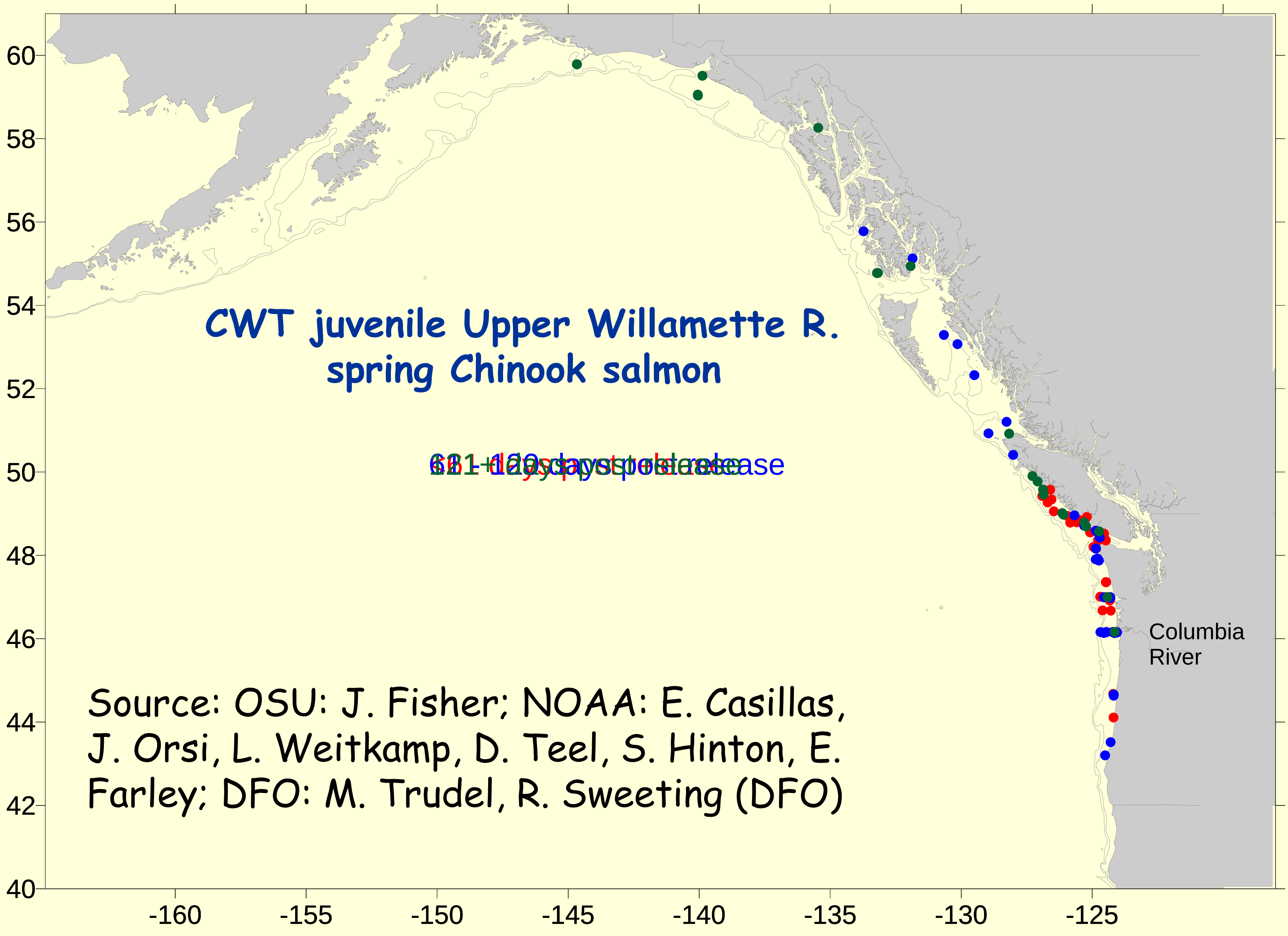

CWT juvenile Upper Willamette R.
spring Chinook salmon
Columbia
River
Source: OSU: J. Fisher; NOAA: E. Casillas,
J. Orsi, L. Weitkamp, D. Teel, S. Hinton, E.
Farley; DFO: M. Trudel, R. Sweeting (DFO)
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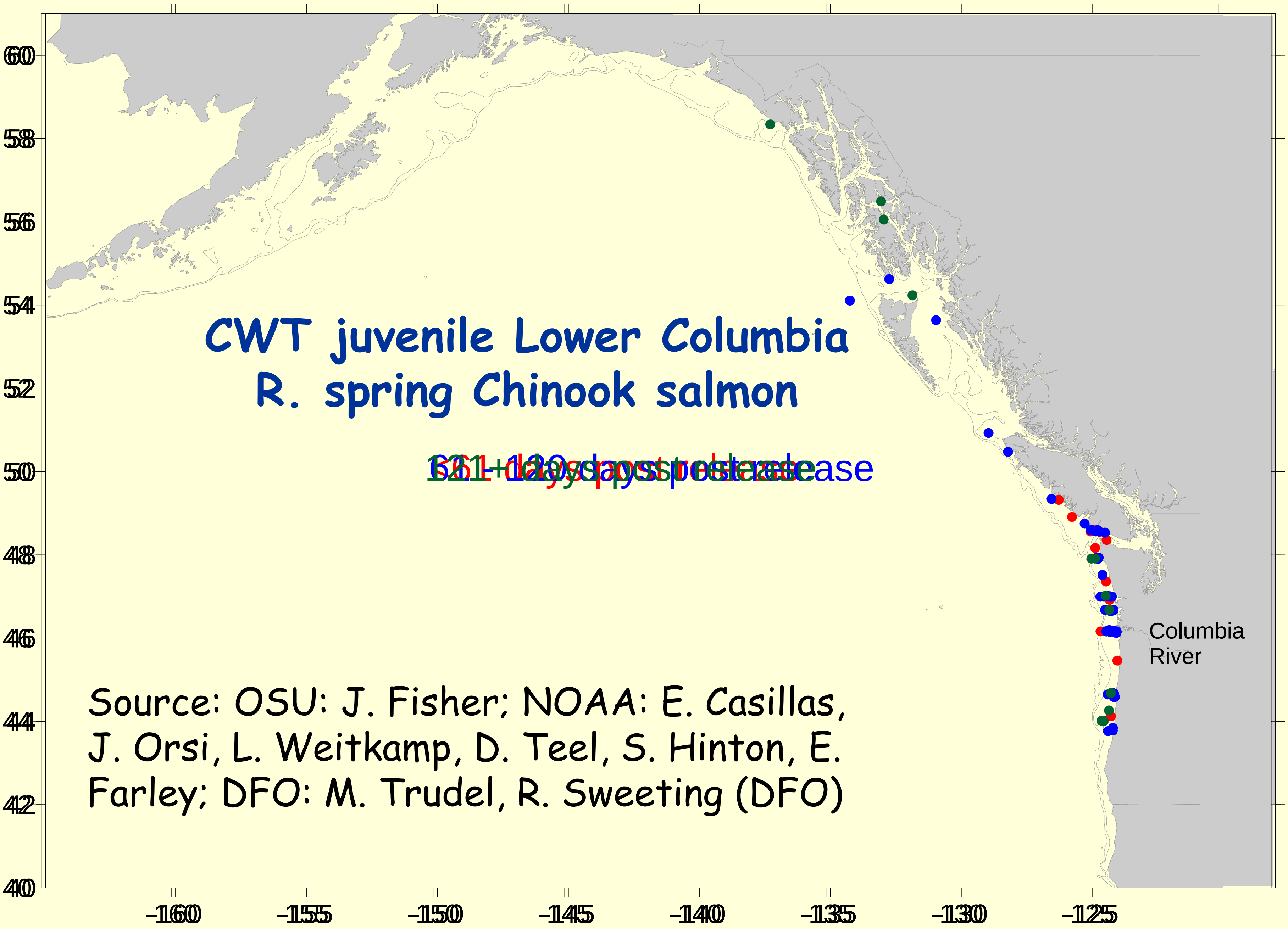
CWT juvenile Lower Columbia
R. spring Chinook salmon
Columbia
River
Source: OSU: J. Fisher; NOAA: E. Casillas,
J. Orsi, L. Weitkamp, D. Teel, S. Hinton, E.
Farley; DFO: M. Trudel, R. Sweeting (DFO)
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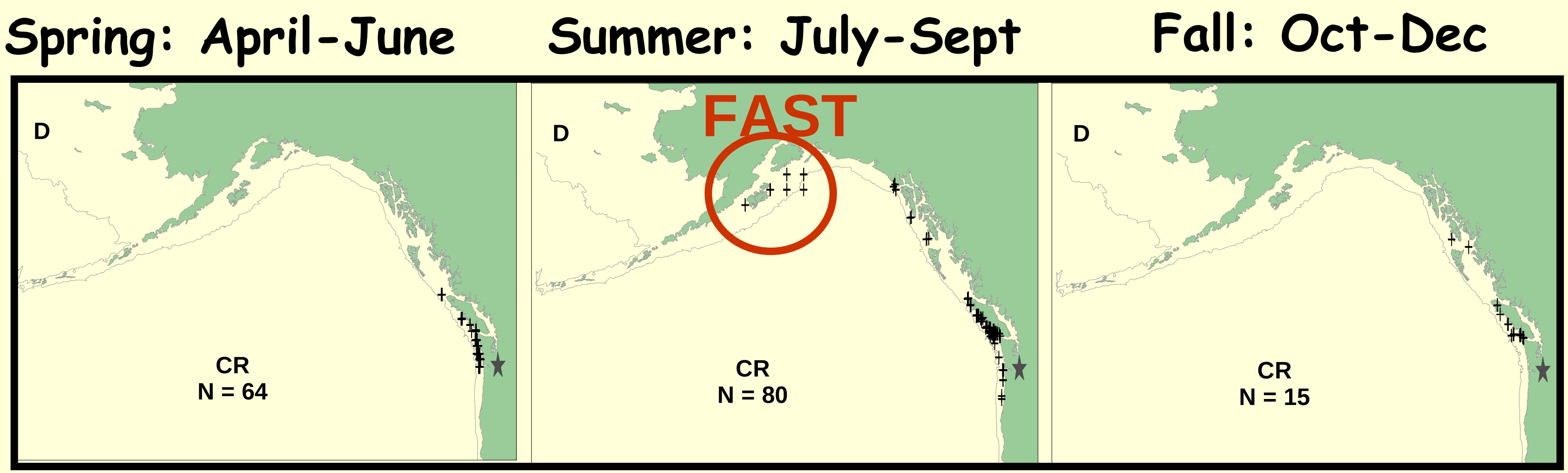
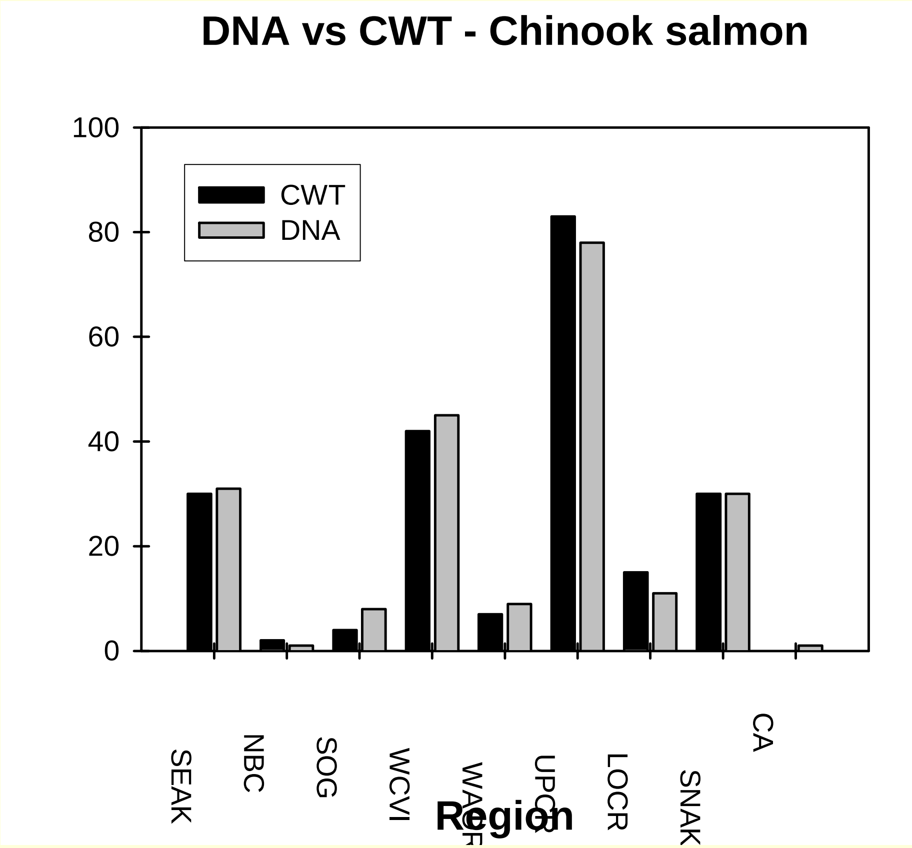
Coho Salmon: CWT Recoveries of juveniles released in the Columbia R. Basin in 1995-2004 indicate "slow" and "fast" northward migrating fish



Source: J.F.T. Morris, M. Trudel, M.E. Thiess, R.M. Sweeting, J. Fisher, S.A. Hinton, J.A. Orsi, E.V. Farley, Jr., D.W. Welch, and E. A. Fergusson (in press; American Fisheries Society Special Publication)

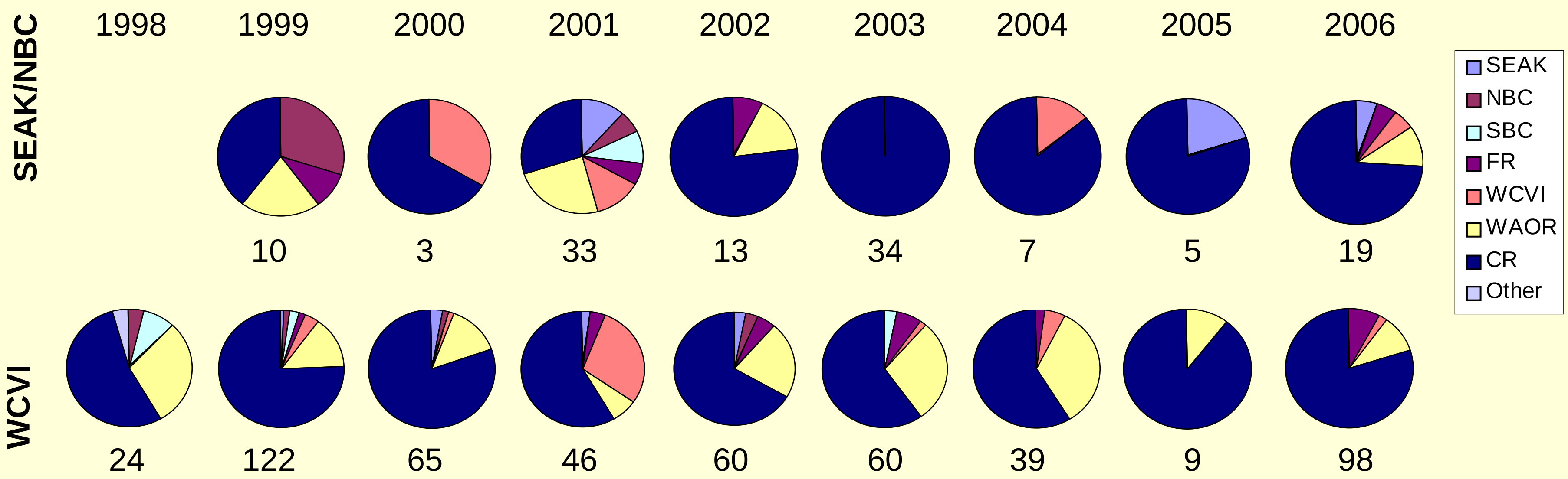
Comparison of CWTs and Genetics:



microsatellite DNA Markers are 90-95% Accurate

Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

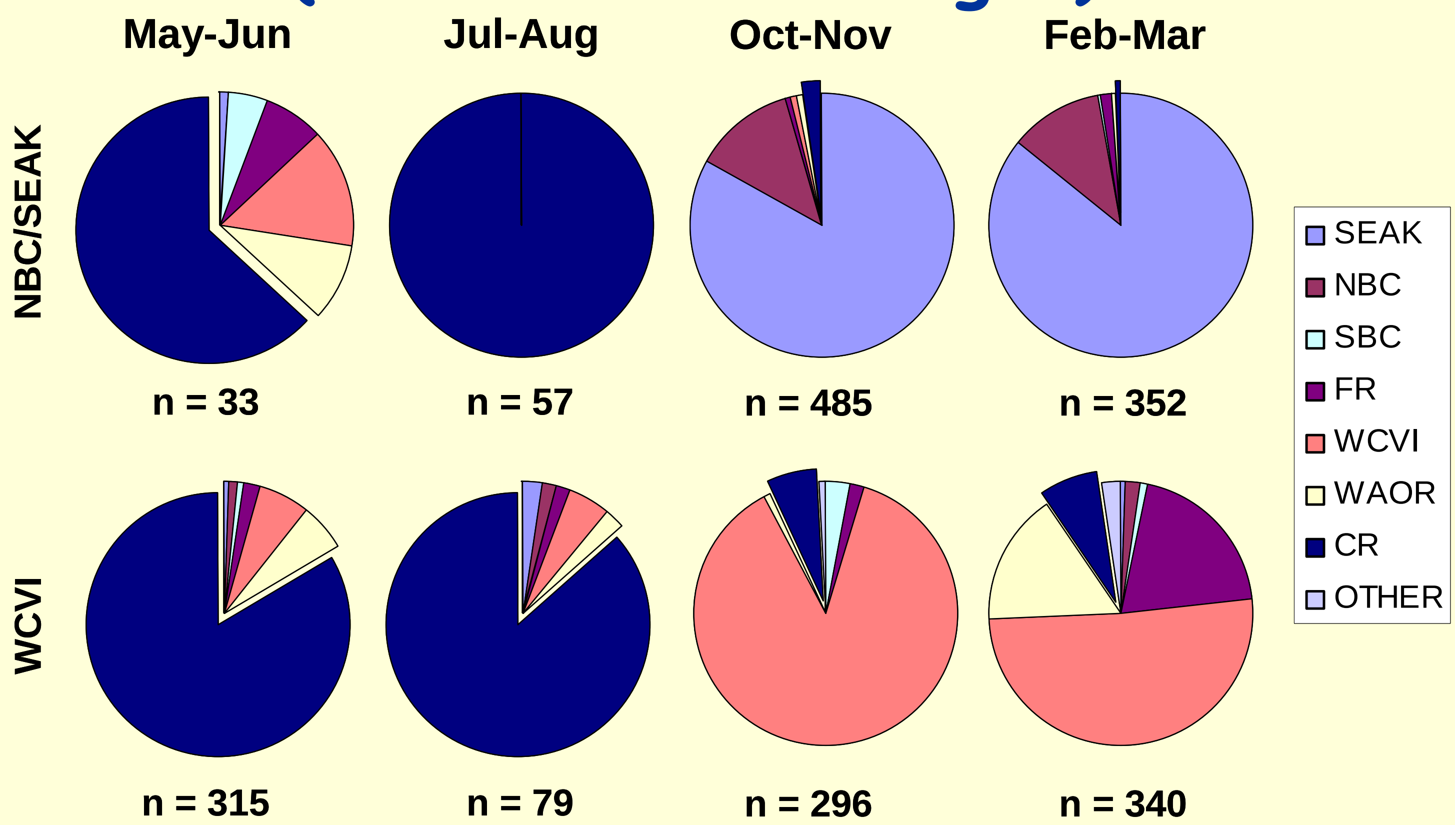
Annual and Spatial Variation in Genetic Stock Composition of Juvenile Chinook Salmon



Columbia R. is the dominant regional stock in spring/summer (about 70%), few caught in 1st fall/winter.

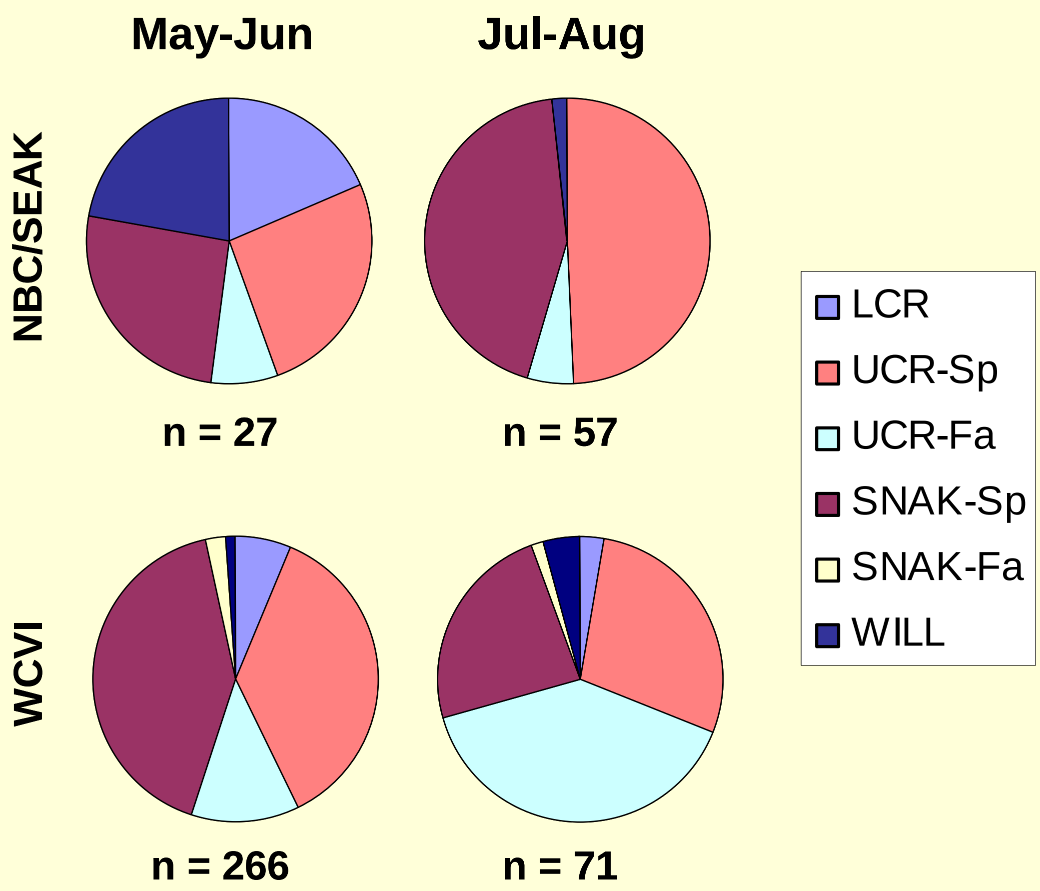
Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

Seasonal and Spatial Variation in Genetic Stock Composition of Juvenile Chinook Salmon (1998-2006 averages)



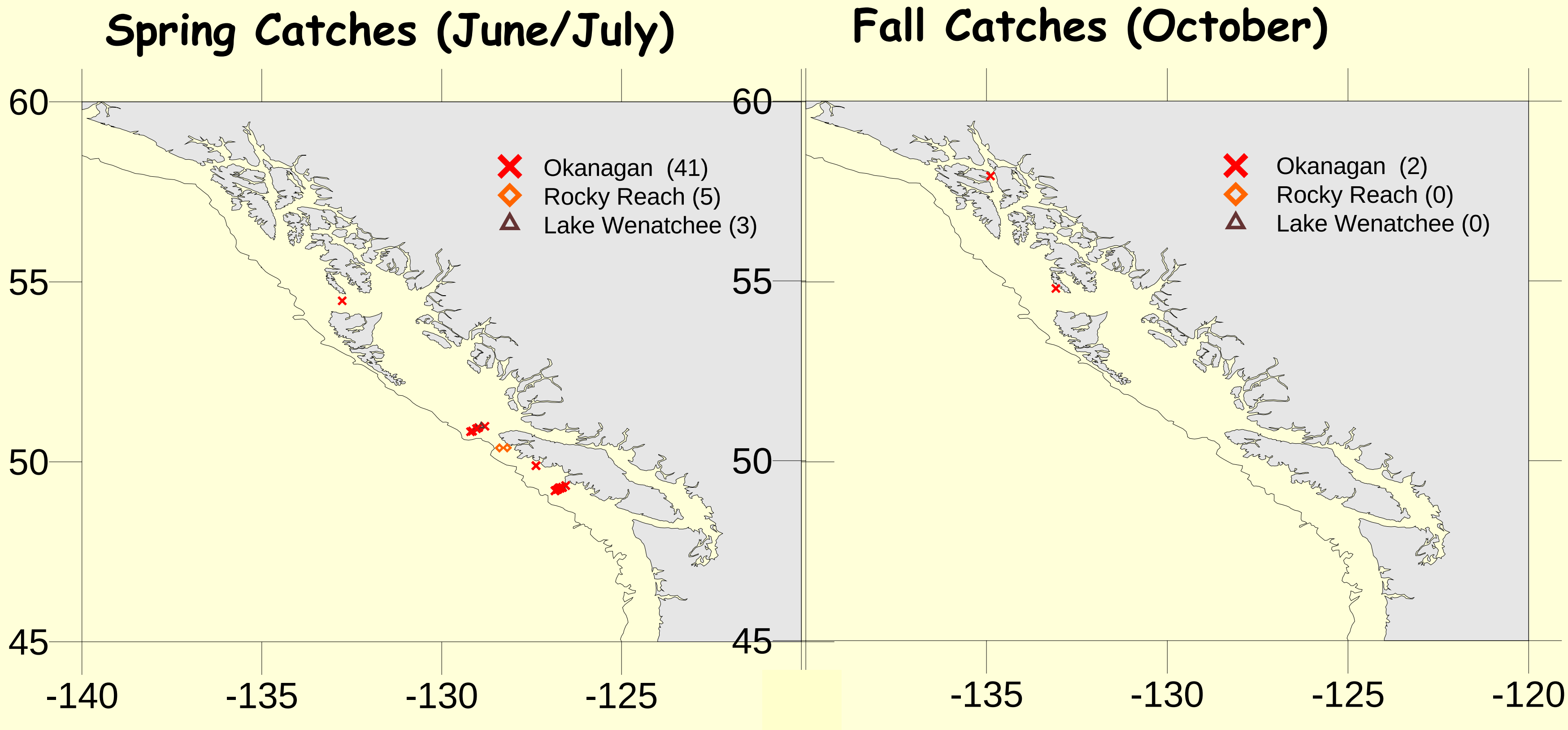
Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

Seasonal and Spatial Variation in Genetic Stock Composition of Columbia R. ESUs of Juvenile Chinook Salmon (1998-2006)



Data Source: Marc Trudel, Jointly funded by Fisheries & Oceans Canada & BPA Contract 200300900

Sockeye Salmon: Genetic data indicate that most Col. R. juveniles migrate rapidly northward out of study area



Data Source: Marc Trudel, Funded by Department of Fisheries & Oceans Canada & Canadian Space Agency

The Pacific Ocean Shelf Tracking Project (POST)

POST monitors movements of acoustic-tagged juvenile salmon from release sites in the Columbia River to locations over the continental shelf.

Tags implanted in the fish send out unique signals, which are picked up by receivers placed on the ocean floor.

Location of the POST acoustic tracking array in 2006. Array locations are overlaid in yellow.

Source: D. Welch, Kintama Research Coorp.

POST Preliminary Results

- ✓ Barged smolts had higher survival than run of river smolts (2X higher to Willapa Bay; 5X higher to Lippy Pt.), but spent more time in the higher mortality ocean environment than ROR smolts
- ✓ No evidence of delayed stress mortality. Freshwater and ocean survival & ocean migration rates of Snake & Yakima stocks comparable.

Summary of releases of acoustic tagged Chinook smolts and detections on POST ocean array in 2006

Stock	Study Group	No. Rel.	Willapa Bay	Lippy Pt.
Snake	Barge1	102	48	8
	Barge2	101	30	3
	ROR1	198	39	1
	ROR2	198	42	3
Yakima	ROR1	199	19	2
	ROR2	199	61	0

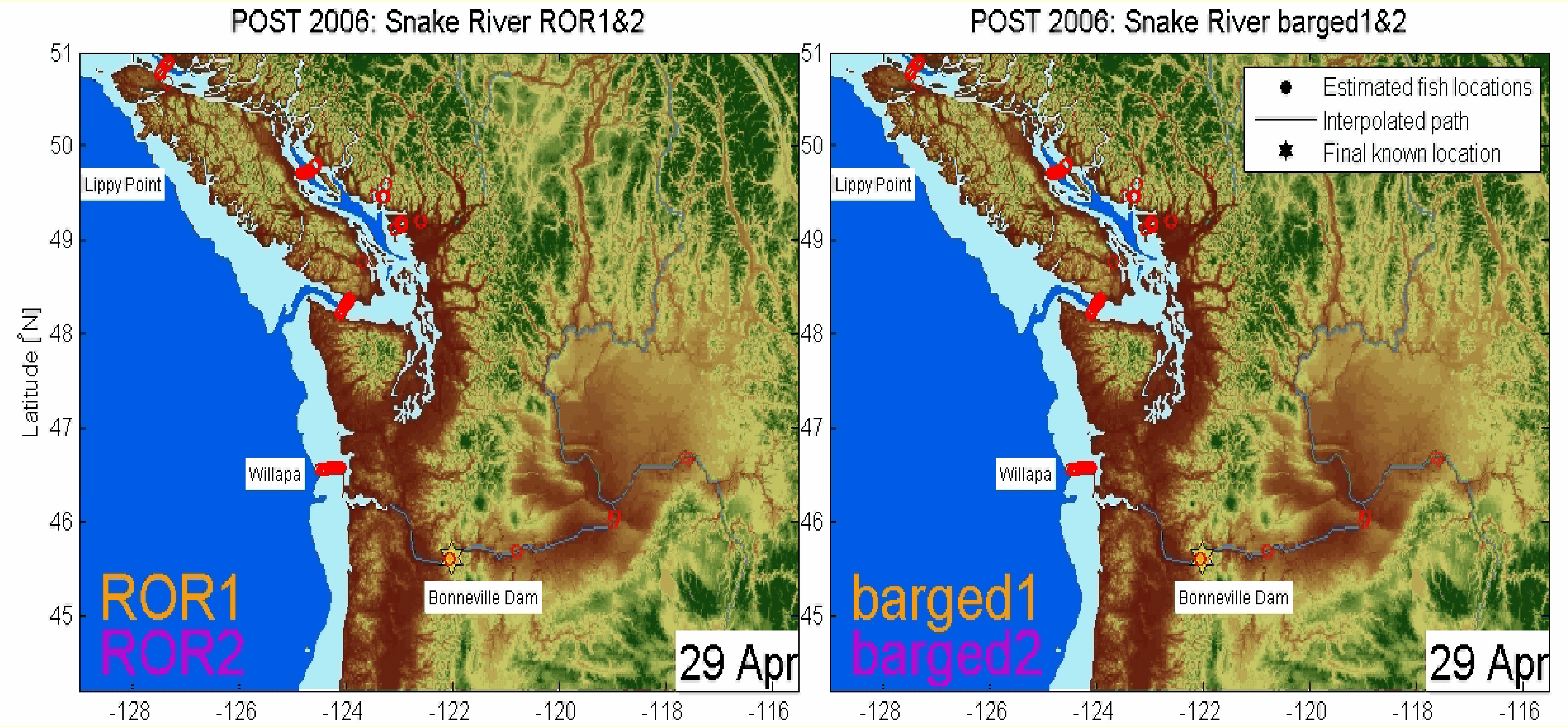
Source: Welch et al. 2007; BPA Contract No. 2003-114-00

POST Snake R. & Yakima R. Spring Chinook Salmon Annimations

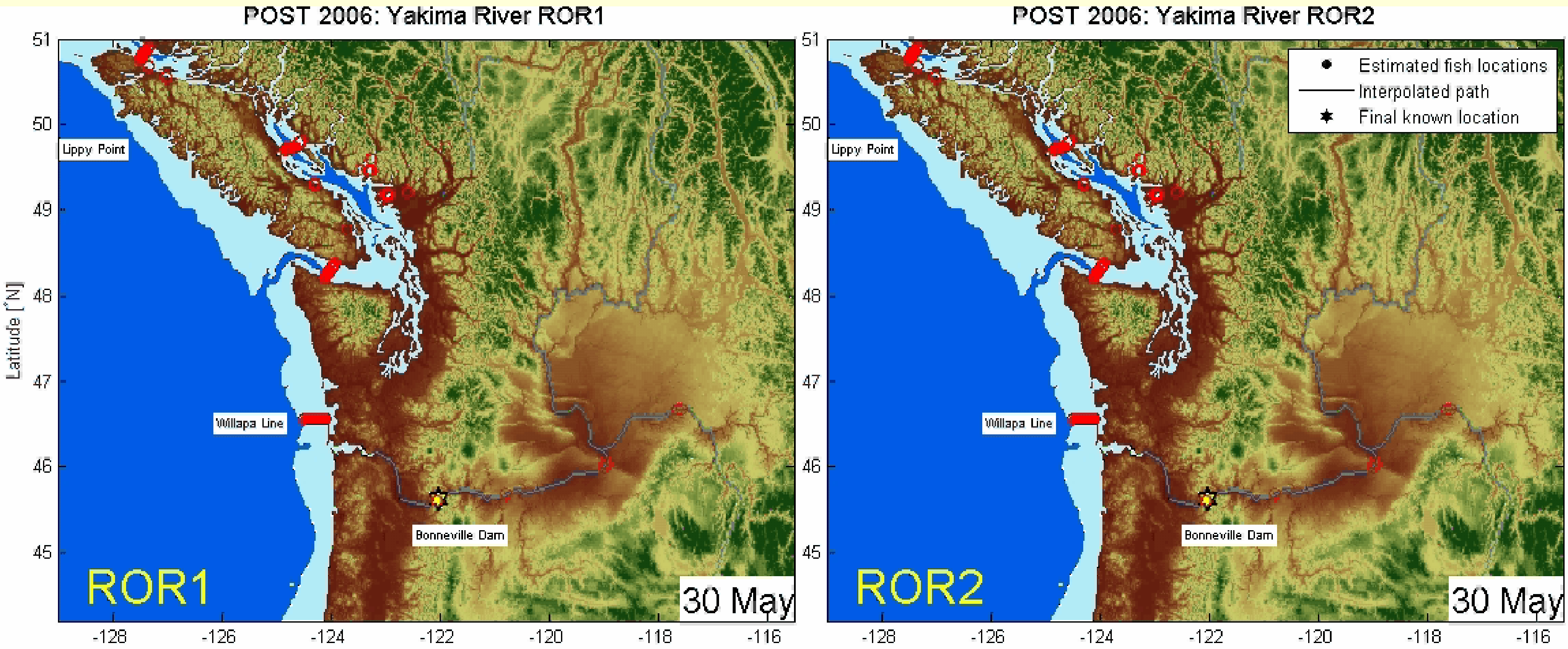
- Does transporting or barging of Snake R. Spring Chinook smolts improve early marine survival rates?
- Do Snake R. Chinook smolts (pass 8 dams) have higher mortality below Bonneville Dam than Yakima R. Chinook smolts (pass 4 dams)?

Source: D. Welch, Kintama Research Coop. 2007; BPA Contract No. 2003-114-00

Acoustic Tagged Snake R. Spring Chinook
ROR=Run of River & Barged



Acoustic Tagged Yakima R. Spring Chinook Pass 4 mainstem dams



We CANNOT PREDICT THE FUTURE, but management strategies that ignore the effects of changing ocean conditions on Columbia R. salmon are likely to fail

Mystery of the missing salmon

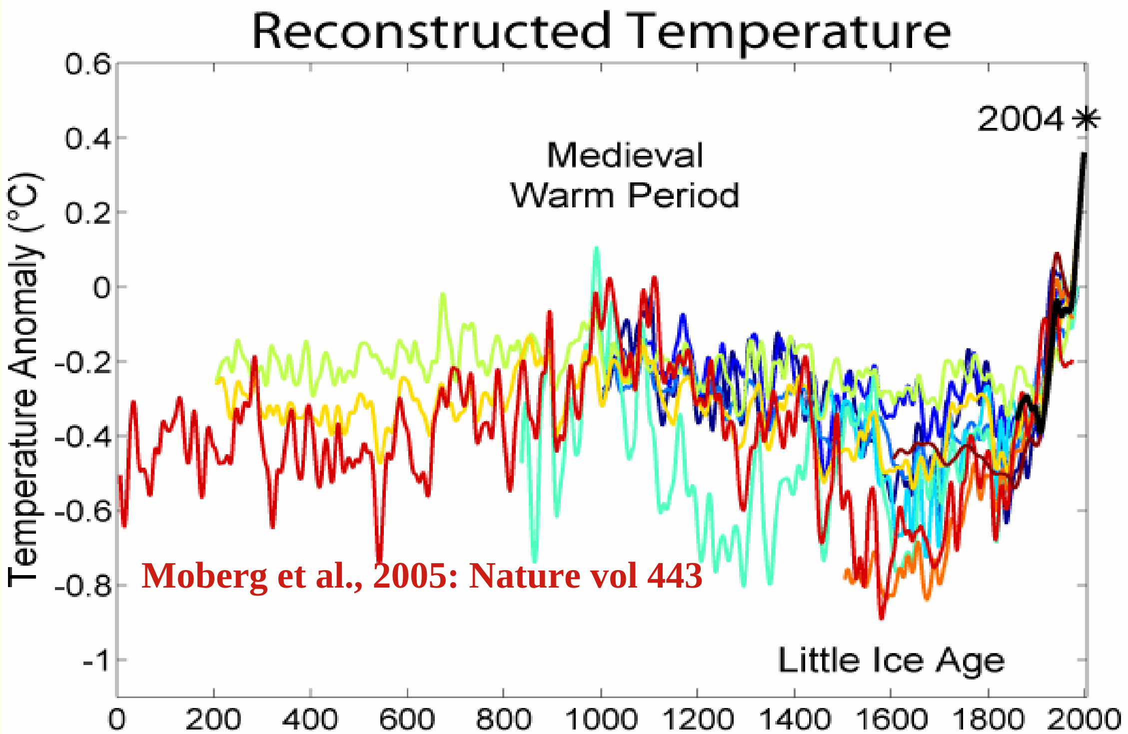
Dramatic drop in annual run in Northwest

By K.C. Johnston, Reporter, NBC News, Updated: 4:54 p.m. PT May 5, 2005

"We've got a big mystery on our hands, a run of salmon that seems to have disappeared," said a harvest management biologist with the Columbia River Inter-Tribal Fish Commission.

Don Ryan / AP file - Salmon pass through the Bonneville Dam fish ladder on the Columbia River, during a salmon run in North Bonneville, Washington

Why can't we predict the future? The rate of warming over the past 100 years is exceptional



Year

Source: http://www.realclimate.org

Measured and reconstructed Northern Hemisphere Growing Season Temperatures

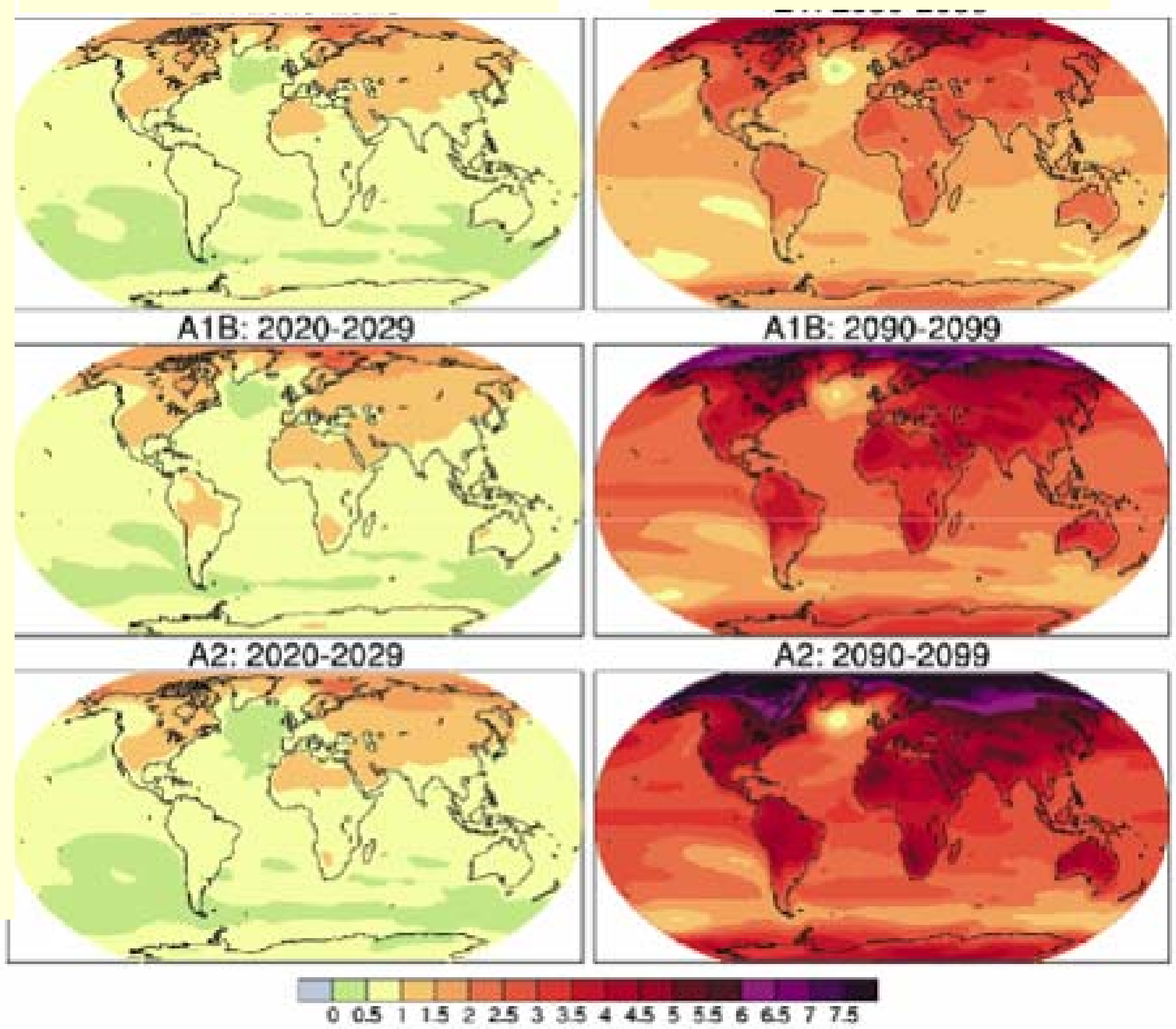
Scenarios of future temperature change at low, medium, and high greenhouse gas emissions

Years 2020-2029 | Years 2090-2099

Low emissions

Medium emissions

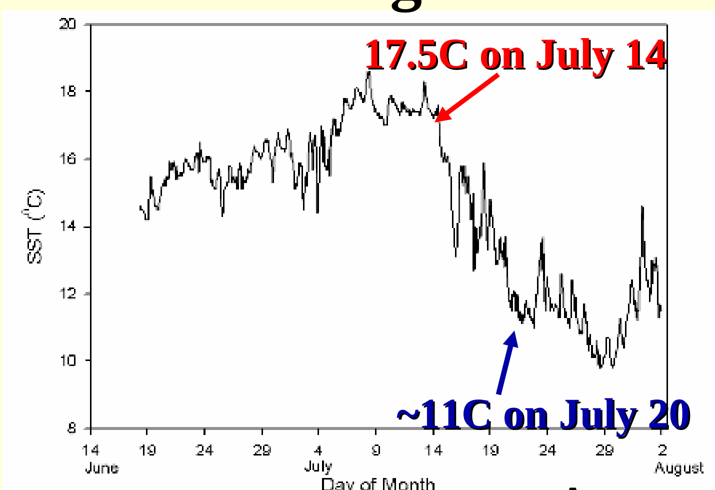
High emissions



Source: International Panel on Climate Change http://www.ipcc.ch

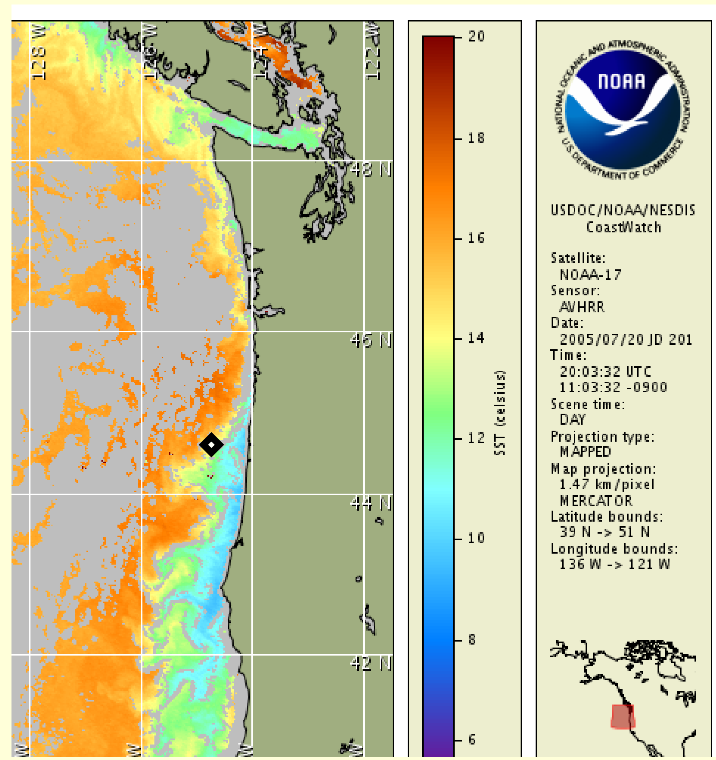
Fickle winds can cause large changes in upwelling habitat on short time-space scales

Stonewall Banks Buoy SST
June 18 - August 2 2005



June July August

Buoy SST plot courtesy of Pete Lawson

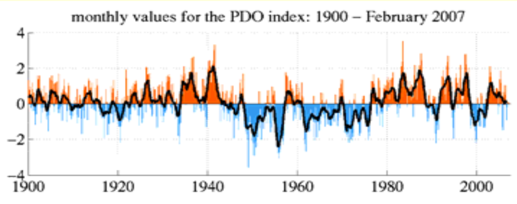


20 July 2005 SST
NOAA CoastWatch image

Slide Source: N. Mantua, UW SAFS

"We cannot predict the future …but that's okay" – N.Mantua, UW Climatologist

What do we do & how do we do it?



- Scientific knowledge from comprehensive research programs in combination with new and improved technologies & management tools can lead to sustainable fisheries and salmon returns to the Columbia R.
- Use of informed "what if?" scenarios for future ocean conditions, climate, habitat, harvest, and hatchery production offers a means for testing different long-term planning strategies for resilience in the face of uncertainty
- Seek new innovative & comprehensive approaches

COMPREHENSIVE TAGGING STRATEGIES can provide information needed to improve management

Comprehensive review of tagging technologies recommended by ISRP in 2007

Objectives:

- Recommend specific types of tags for use in the Fish and Wildlife Program project review process
- Facilitate coordination of fish tagging projects and programs
- Encourage the development and use of innovative tagging technologies relevant to program needs

Source: Fuller & Henne, USFWS; http://www.fws.gov/fisheries/nfhs/ftc/FTCwhatsnew.htm

Examples of Tools Appropriate for Ocean Research: otolith marking of hatchery fish

Otolith marking has proven to be an effective tool to determine the hatchery origin of individual salmon in high seas and in coastal waters. Because of this the North Pacific Rim countries (Canada, Japan, Korea, Russia and United States) are using this technique to mass mark anadromous salmon for both research and fishery management. http://npafc.taglab.org/

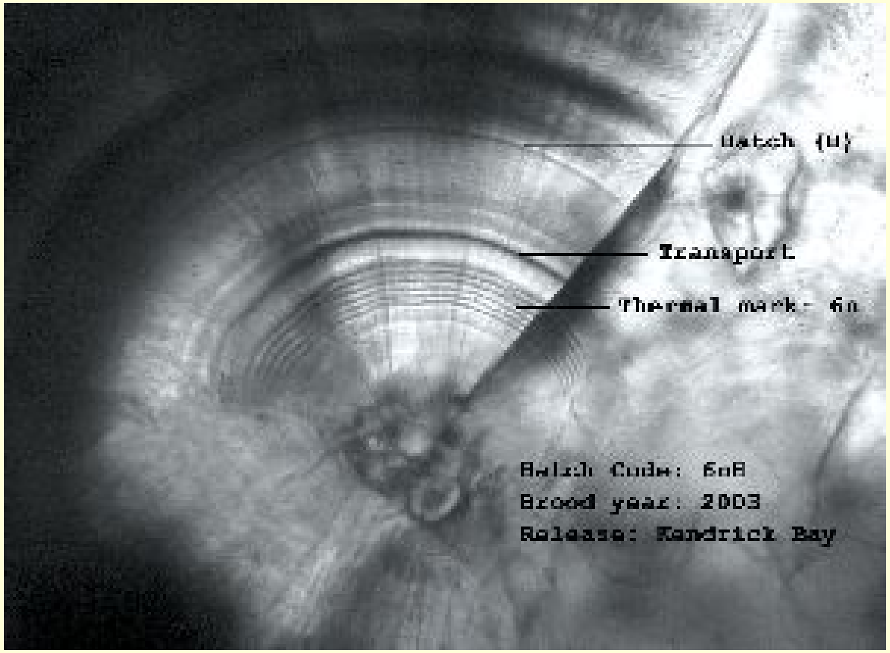
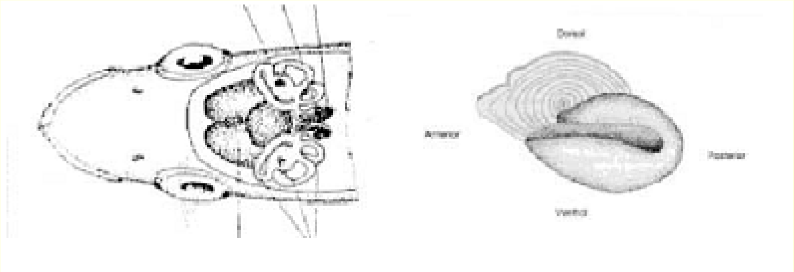
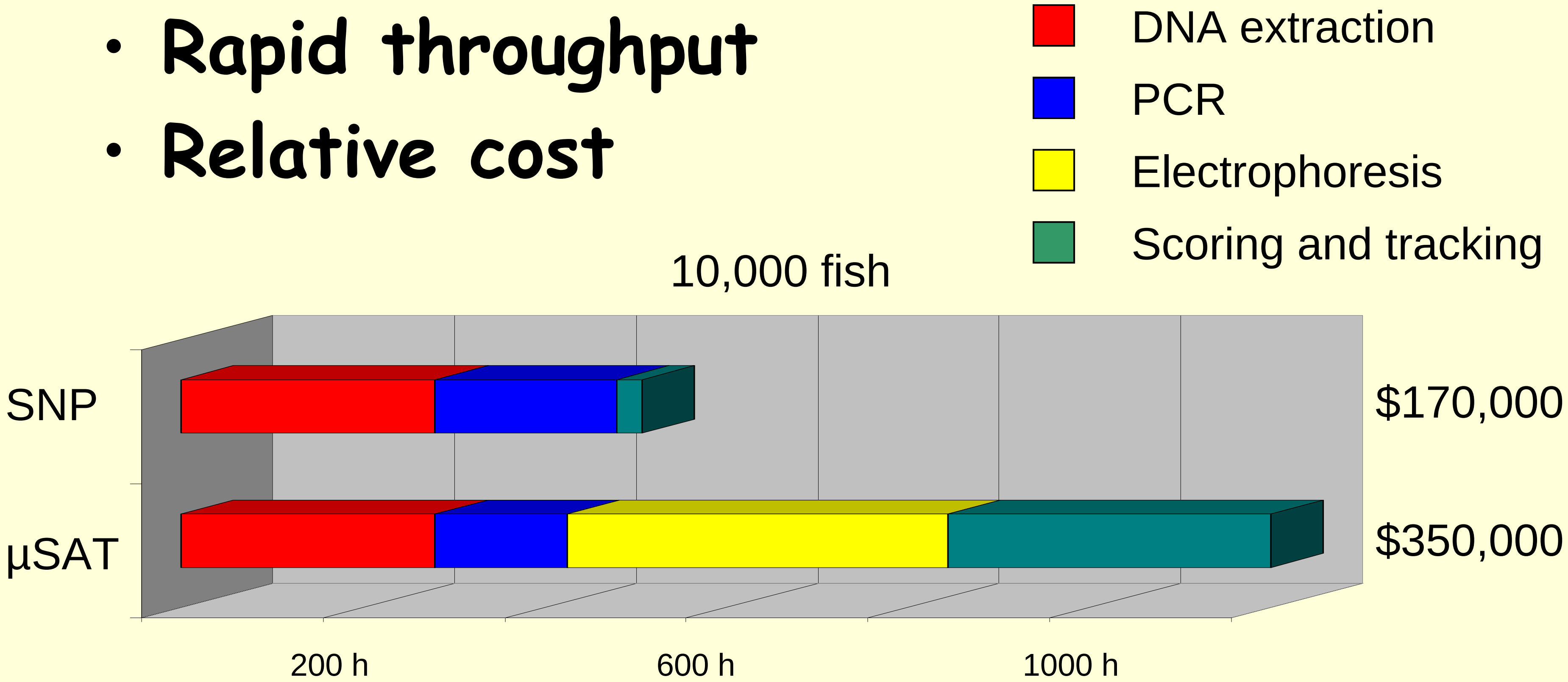


Photo courtesy of the Southern Southeast Regional Aquaculture Association



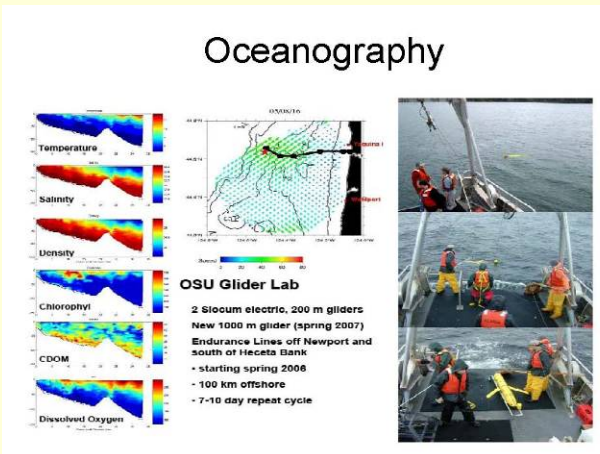
Example of New Tools Appropriate to Ocean Research: SNPS - Single Nucleotide Polymorphisms vs. Microsatellite (µSAT) DNA

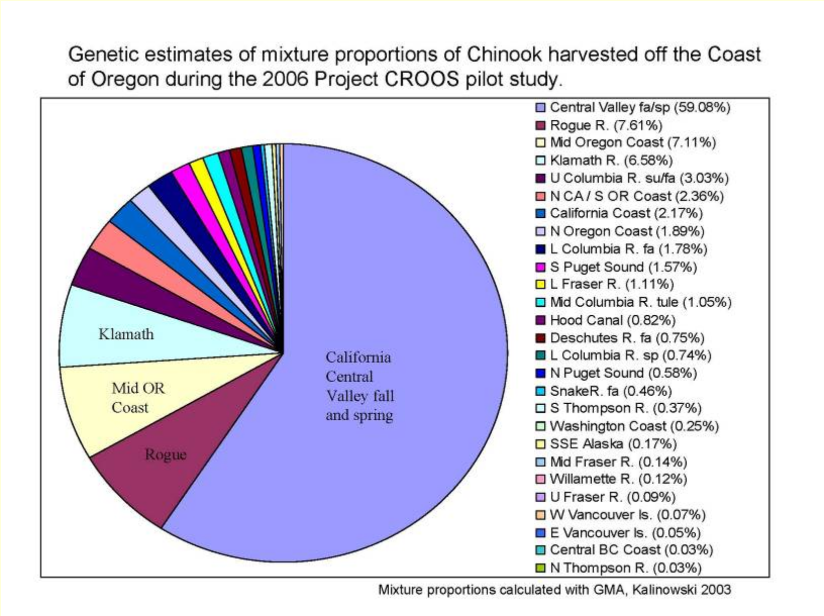
- **Automatic standardization**
- **Rapid throughput**
- **Relative cost**

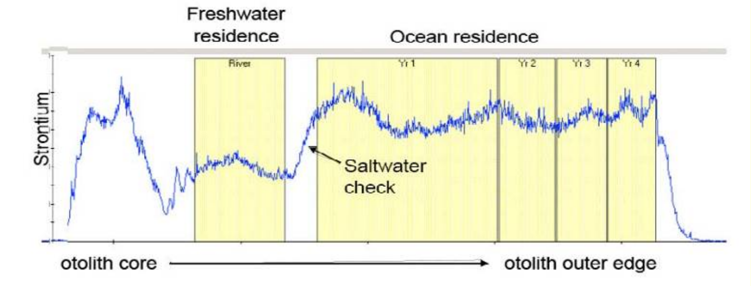


Source: Jim Seeb, SAFS/UW

Example of Local Comprehensive Research Strategy: Collaborative Research on Oregon Ocean Salmon (CROOS)



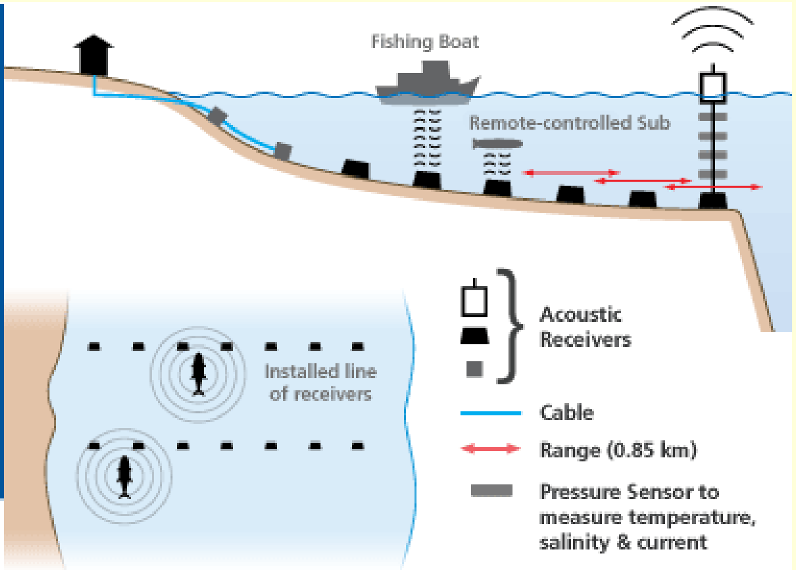




Source: Banks et al. 2007 (www.ProjectCROOS.com)

Example of Global Comprehensive Strategy: Ocean Tracking Network

Dalhousie University, Halifax, Nova Scotia, Canada



- International collaboration—14 ocean regions
- Develop next generation of technology — archival + acoustic tags/OTN curtain to replace research vessel surveys

Source: www.oceantracking network.org

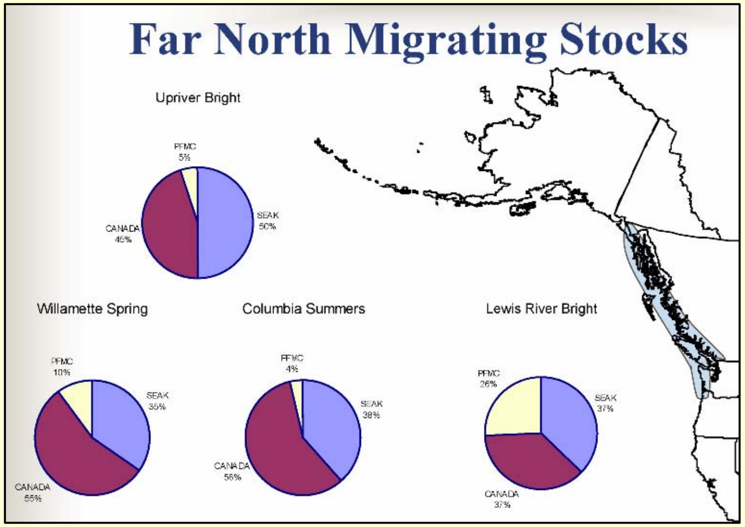
OCEAN TRACKING NETWORK

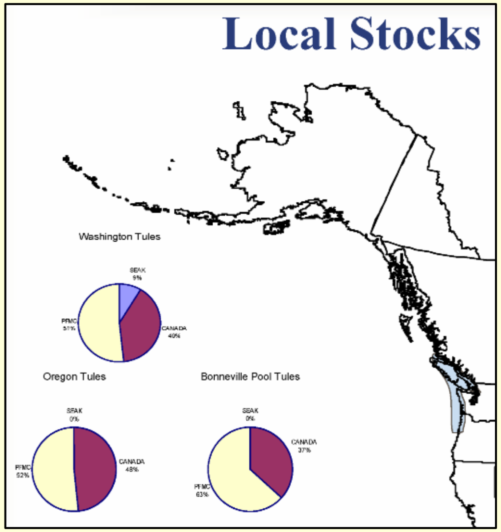
Management applications: Tagging data from different coastal fishery jurisdictions can provide a strong foundation for informed fishery policy and management decisions (e.g. Pacific Salmon Commission)

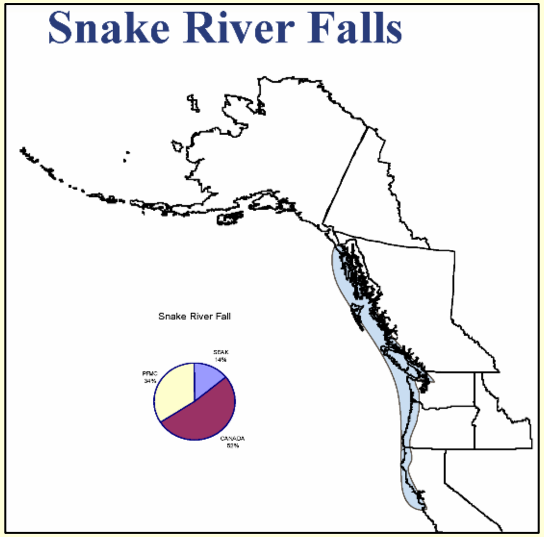
SE Alaska

Canada

WA/OR /CA



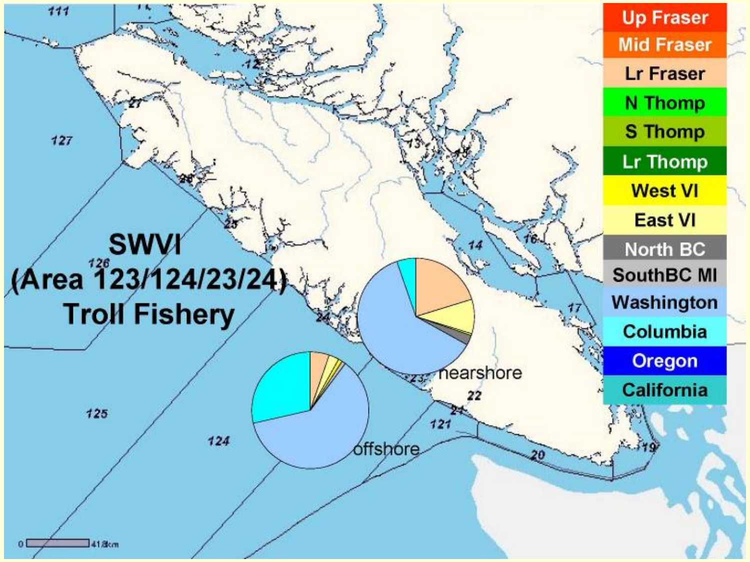


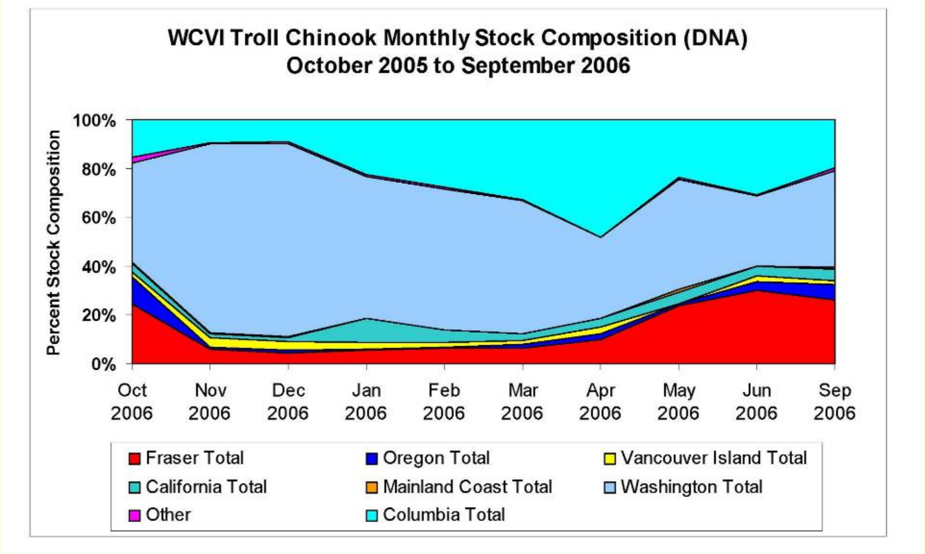


Source: G. Norman, WDFW (2006)

CWT recoveries Upper Col. Spring Chinook, Snake R. Spring & Summer Chinook, and steelhead are low in these regions

Management applications: Department of Fisheries & Oceans Canada is using Genetic (DNA) Analysis to Manage WCVI Troll Fishery





Source: Beacham & Candy 2007 Pacific Salmon Commission GSI Workshop May 15-17, 2007

More Examples of Possible Management Applications of NE Pacific Basin Tag Data

- Habitat: Identify critical ocean habitats & plan for future effects of climate change
- Hydrosystem: Improve transportation and spill operations to maximize early ocean survival of salmon
- Harvest: Plan strategies to meet escapement goals using stock-specific estimates of early ocean survival and abundance
- Hatcheries: Adjust hatchery production to match salmon carrying capacity/ocean conditions

Summary

- ✓ BIODIVERSITY in freshwater and ocean life histories makes Columbia R. salmon resilient to changes in ocean conditions that affect their survival
- ✓ Columbia R. salmon species, life-history types, & ESUs have DIFFERENT ocean distribution and migration patterns, which means they experience DIFFERENT ocean conditions.
- ✓ We CANNOT PREDICT THE FUTURE, but management strategies that ignore the effects of changing ocean conditions on Columbia R. salmon are likely to fail
- ✓ COMPREHENSIVE TAGGING STRATEGIES can provide information needed to improve management

Council Member Questions About NE Pacific Tagging Data

- What have we learned about the effectiveness of actions above Bonneville dam from tagging data?
- Does this information suggest different actions?
- What does tagging data tell us about wild fish?