

Infectious Salmon Anemia

A paradigm shift for understanding risk of ISAV
infection

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US Geological Survey

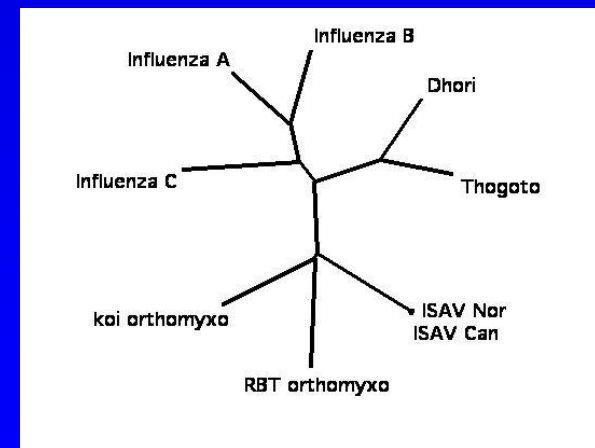
Western Fisheries Research Center

Seattle, Washington



Infectious Salmon Anemia history

- First official outbreak occurred in November 1984 at a smolt farm near Bremnes, Norway but a hemorrhagic syndrome reported as early as 1977
- Affected fish were lethargic with pale gills, fin rot, exophthalmia and hemorrhages of the skin
- Internally, dark pale or yellowish liver, dark swollen spleen, congested intestines, ascites, hemorrhages of swim bladder and muscle
- Spread to other smolt farms and marine net pens in following years
- Major increase in late 1980s and early 1990s in farm-raised Atlantic salmon – losses of 70-90% in some farms (80 outbreaks in Norway in 1990)
- Transmission trials showed ISA was caused by an infectious agent in 1987
- A viral etiology was shown in 1991



Infectious Salmon Anemia - continued

- Management changes in Norway during the early 1990s reduced outbreaks among farms by more than 90% (1 official outbreak in 1994)
- 1996/97 - Hemorrhagic kidney syndrome in farmed Atlantic salmon in Eastern Canada - soon shown to be ISA by molecular methods
- 1998 - ISA occurred in Scotland (eradicated in 1999 – reappeared 2000)
- 1999 - Report of ISAV in coho from Chile
- 2000 - Outbreaks of ISA occur in Faroe Islands
- **2001 - First report of ISA in US (Maine)**
- 2002 - First occurrence of ISA in Ireland
- 2007 - Large scale outbreaks devastated Atlantic salmon farms in Chile
- 2008 - Outbreaks in Shetland Islands
- 2011 - Molecular identification of ISAV in wild Pacific salmon in BC, Canada

ISAV Eradication/Control Program

- USDA ISA Program began Jan. 02
- Bay-wide depopulation
- Complete C & D
- 105 day fallow
- Restock under arbitrary geographic bay management plan
- 6 sites
- Lower stocking density per cage
- Final density stocking
- Strict biosecurity
- Mandatory surveillance
- Mandatory IPM for sea lice

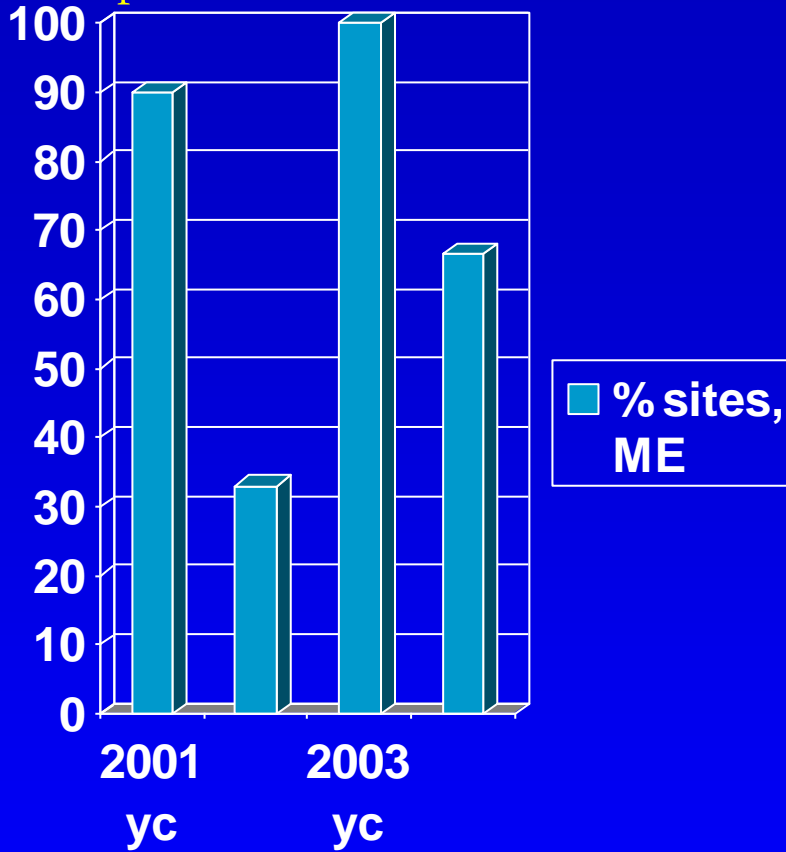


And it worked ...

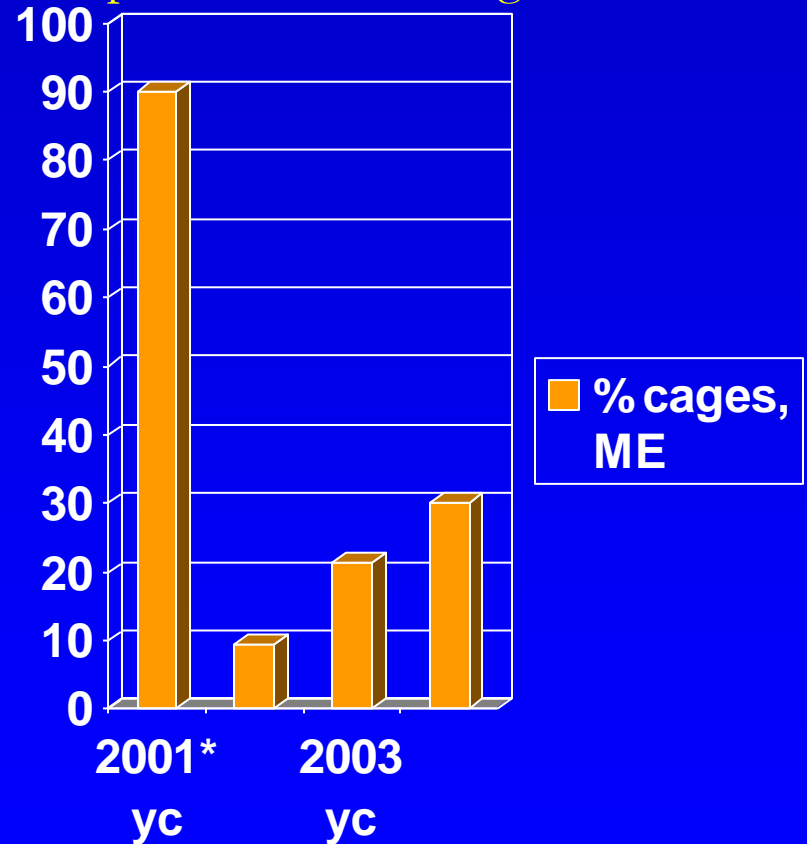


... in part

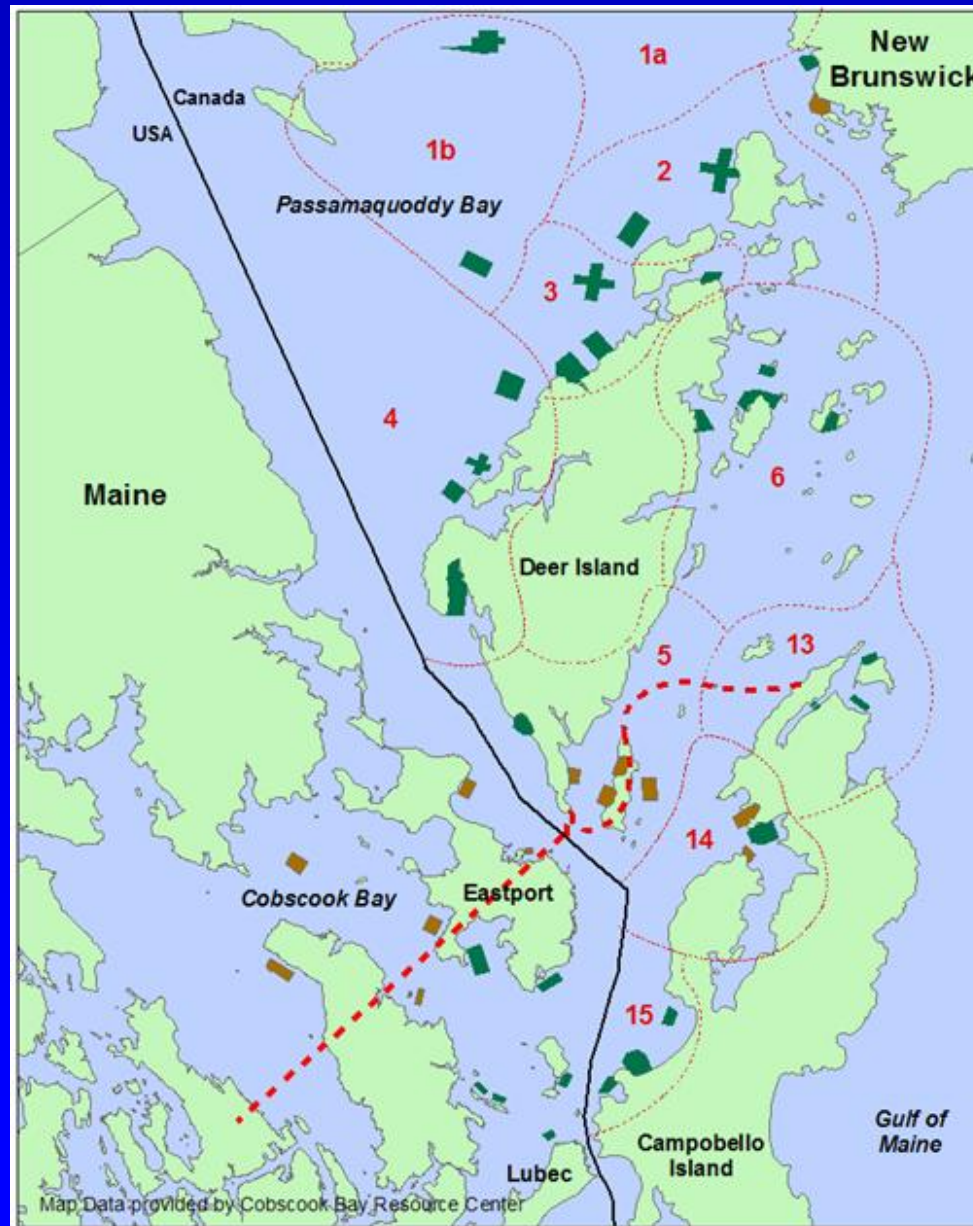
US Quoddy region:
percent infected sites



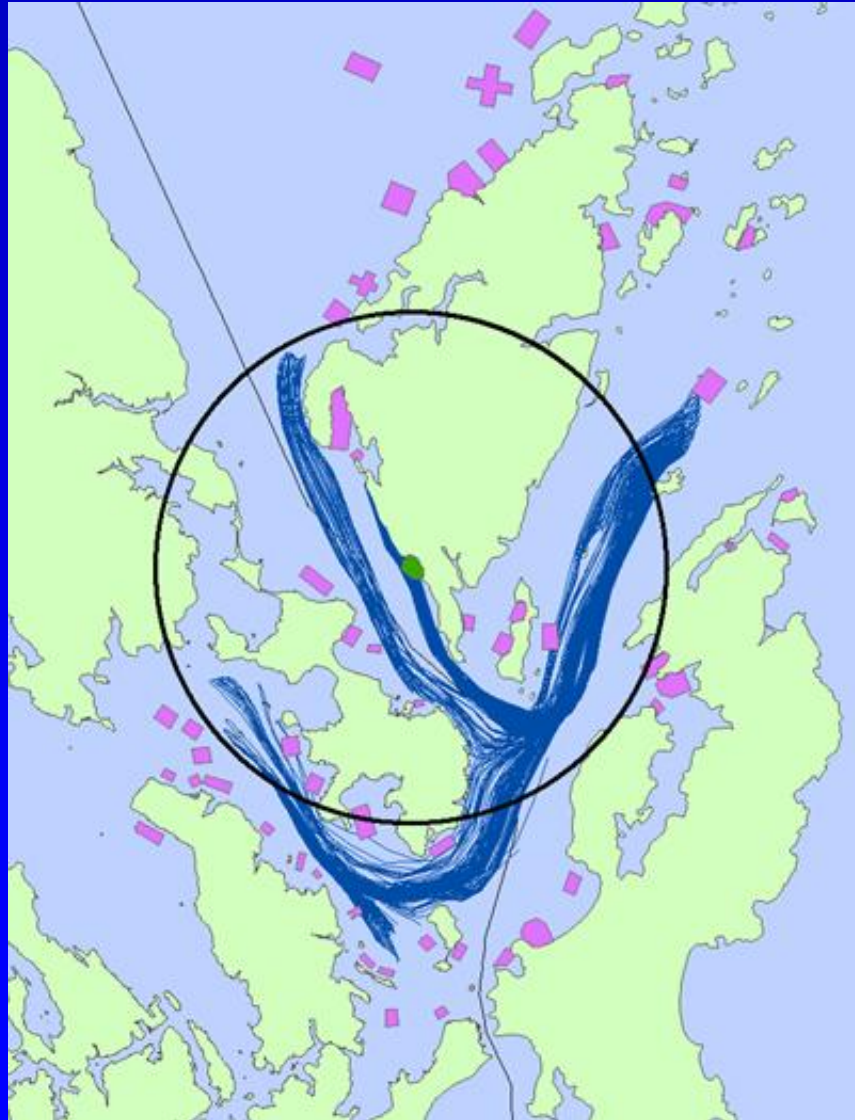
US Quoddy region:
percent infected cages



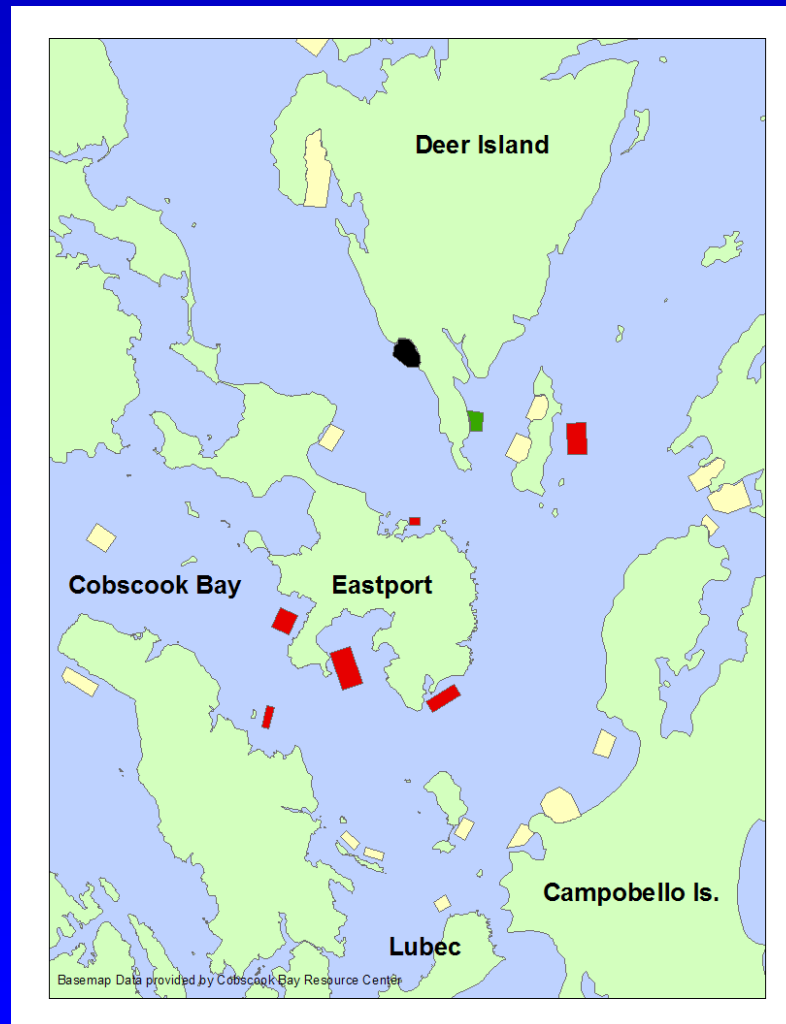
Too many Bay Management Areas?



Tides are strong in this region



A single tidal excursion links this example site to 7 other sites



An initial study found ISAV material throughout the environment

- Microtechnologies, Inc., NBDAFA and APHIS VS
- Visited an infected site in NB
- 9 visits in 6 months
- Sampled fish, cages, vessel hulls and work surfaces, invertebrates, shellfish, water



But changes in zoning are not easy



New Bay Management Strategy

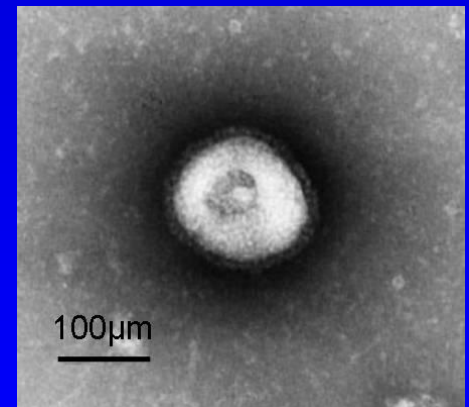
- Needed industry buy-in
- Needed cooperation from Canadian neighbors
- Needed to convince skeptics (different approach from Norway)
- Ultimately led to success – No cases of infectious disease since February 2006

ISA – the disease

- ISA is one of nine diseases of fish reportable to the World Organization for Animal Health (OIE)
- Etiological agent is an orthomyxovirus, distantly related to influenza
- Atlantic salmon suffer high mortality in both freshwater and seawater
- Asymptomatic infections also found in wild Atlantic salmon , sea trout and brown trout in freshwater and marine environments – serve as long-term carriers and transmit wild-type virus while spawning in freshwater
- Pacific salmon species suffer limited mortality, but may serve as carriers
Virus shown to be vertically transmitted with high efficiency
- Sea lice shown to be mechanical vector but not infected
- Atlantic herring and Atlantic cod can be infected experimentally, but do not transmit virus to susceptible salmonids
- More than 30 wild marine species tested found negative for virus

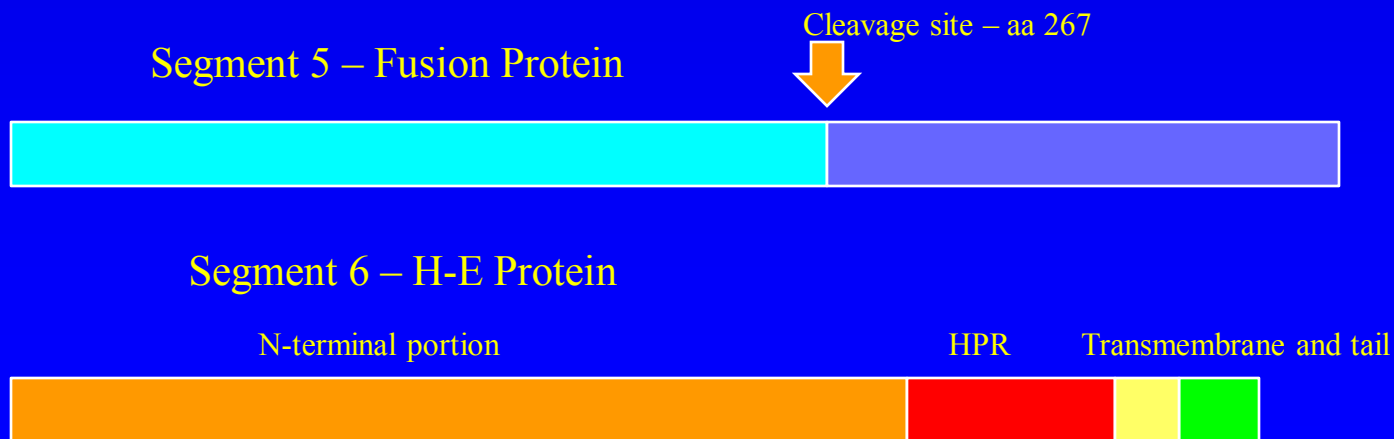
Infectious Salmon Anemia Virus

- First cultured in SHK cell line (1995). Leukocyte primary cultures (1996) and other established cell lines (AS, ASK, TO) support replication with CPE
- Pleomorphic virions of approximately 100 nm with surface projections
- Genetic analysis shows ISAV to be a member of the *Orthomyxoviridae*
- Eight independent genome segments of single-stranded RNA
 - Segment 1 – 2166 nt – PB2 Polymerase
 - Segment 2 – 2127 nt – PB1 Polymerase
 - Segment 3 – 1851 nt – Nucleoprotein
 - Segment 4 – 1737 nt – PA Polymerase
 - Segment 5 – 1332-1365 nt – Fusion protein
 - Segment 6 – 1164-1236 nt – Hemagglutinin-Esterase
 - Segment 7 – 903, 477 and 243 nt – NS1 and NEP proteins
 - Segment 8 – 726 and 591 nt – M1 and M2 matrix proteins



Infectious Salmon Anemia Virus - continued

- Two major genotypes identified (European and North American)
- Wild-type virus is avirulent for Atlantic salmon and cannot be grown in cell culture
- Fusion protein encoded by segment 5 has aa substitutions and/or insertions near the cleavage site that are associated with virulence
- Hemagglutinin-Esterase protein encoded by segment 6 contains a highly polymorphic region (HPR) of 33-105 nt associated with virulence
- Wild-type virus contains full-length H-E protein and no insertions in F



Infectious Salmon Anemia Virus in Western North America

- October 2011 - Researchers in British Columbia, Canada announce 2 of 48 wild, sockeye tested positive for ISAV - first detection on the west coast of North America
- October 2011 - Amendment to Appropriations Bill by Senators Cantwell (WA), Murray (WA), Murkowski (AK), Begich (AK), Wyden (OR), Merkley (OR), Boxer (CA), and Feinstein (CA) calls on the National Aquatic Animal Health Task Force to evaluate the risk of ISAV for native Pacific salmon and to develop a plan to address the threat
- Rapid Response: USGS scientists provided technical assistance to west coast fish health biologists and laboratories with information and materials



Infectious Salmon Anemia Virus Surveillance Plan

- Evaluate west coast Pacific salmon stocks for infectious salmon anemia virus during a two year period
- Surveillance plan led by USDA-APHIS in collaboration with regional partners
- Use internationally accepted diagnostic test to detect viral genome – assay validated by USDA-APHIS
- Surveillance samples run in USDA-APHIS-approved labs
- Duplicate set of samples collected from each location



Results from the 2012 – 2013 enhanced surveillance for infectious salmon anemia virus RNA in fish sampled from Washington State

Species	Washington Regions			Total
	Sampled fish (number of stocks sampled)			
	Greater Salish Sea	WA Coast	Columbia River	
Sockeye salmon	85 (3)	40 (2)	50 (1)	175
Chinook salmon	83 (5)	30 (2)	20 (2)	133
Coho salmon	70 (4)	65 (4)	45 (3)	180
Chum salmon	80 (4)	20 (1)		100
Steelhead trout	100 (2)	170 (4)	50 (1)	320
Atlantic salmon	15 (1)			15
Total	433 (19)	325 (13)	165 (7)	923

All samples negative

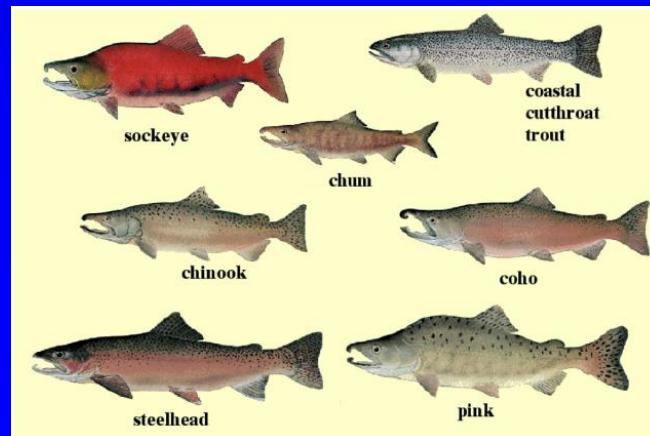
Results from the 2012 – 2013 enhanced surveillance for infectious salmon anemia virus RNA in fish sampled from State of Alaska

Species	Alaska Regions			Total
	Sampled fish (number of stock sampled)			
	Cook Inlet & Ayk	Kodiak & PWS	Southeast	
Sockeye salmon	60 (1)	57 (1)	60 (1)	177
Chinook salmon	60 (1)	60 (1)	180 (3)	300
Coho salmon	58 (1)	120 (2)	179 (3)	357
Chum salmon	58 (1)	60 (1)	179 (3)	297
Pink salmon	60 (1)	120 (2)	120 (2)	300
Total	296 (5)	417 (7)	718 (12)	1,431

All samples negative

Infectious Salmon Anemia Virus Surveillance Plan - Results

- All samples collected in Year 1 (2012-2013) from both Washington and Alaska were negative for ISAV (Amos et al. 2014)
- All samples collected in Year 2 (2013-2014) from Washington were negative for ISAV (unreported data)
- Samples collected in Year 2 (2013-2014) from Alaska are still in process



Acknowledgements

- Dr. Lori Gustafson USDA APHIS
- Dr. Steve Ellis USDA APHIS
- Dr. James Winton USGS
- Dr. Maureen Purcell USGS
- Kennebec River Biosciences
- Many contributors from our State, Federal, Canadian and Canadian Provincial Partners