

FAO/ASTF Project: GCP/RAF/510/MUL:

Enhancing capacity/risk reduction of emerging Tilapia Lake Virus (TiLV) to African tilapia aquaculture: Intensive Training Course on TiLV

4-13 December 2018. Kisumu, Kenya

in cooperation with Kenya Marine Fisheries Research Institute (KMFRI) and Kenya Fisheries Service (KeFS)

Epidemiology Session Lesson learned from the 2007-2009 ISAV epidemic in Chile



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Food and Agriculture
Organization of the
United Nations

Background

- Salmon farming activities started by mid-80's.
- Clean waters, fish meal & oil very cheap, easy permits, and low labor costs.
- After 15 years the industry become the most important animal production system, and the 2nd largest in the world.
- But an epidemic can wipe out everything...





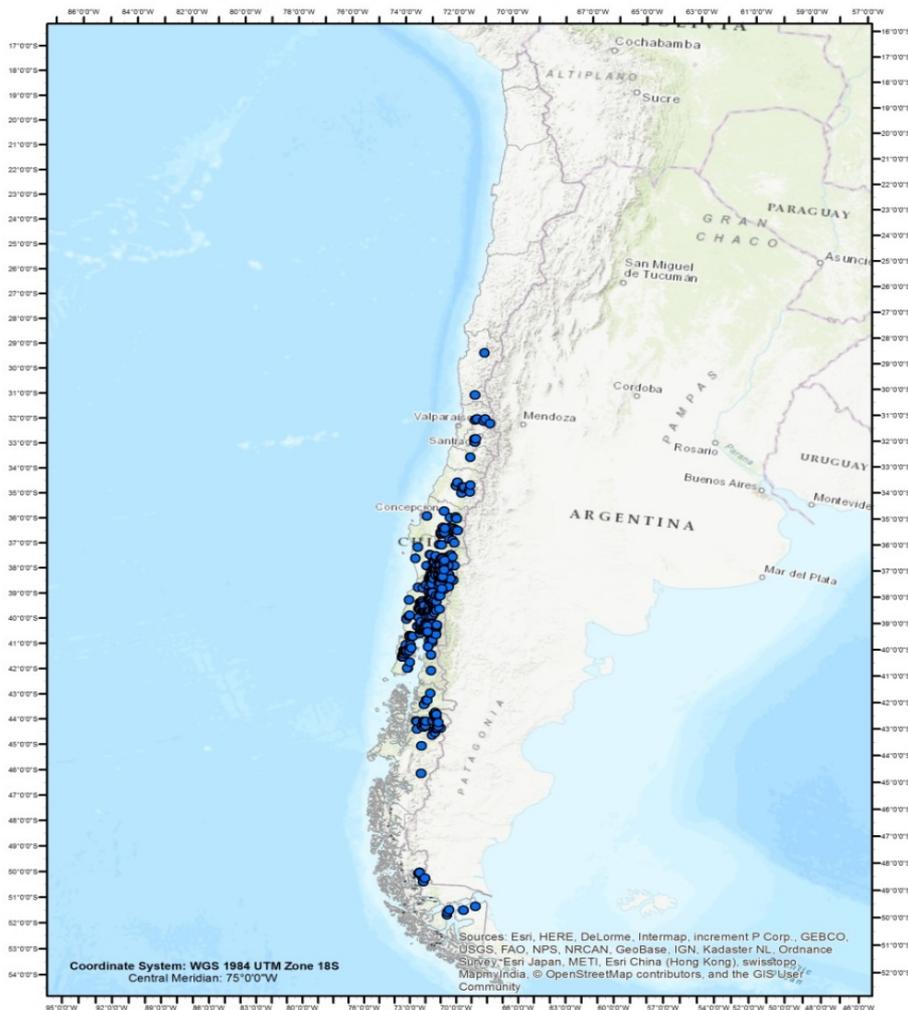




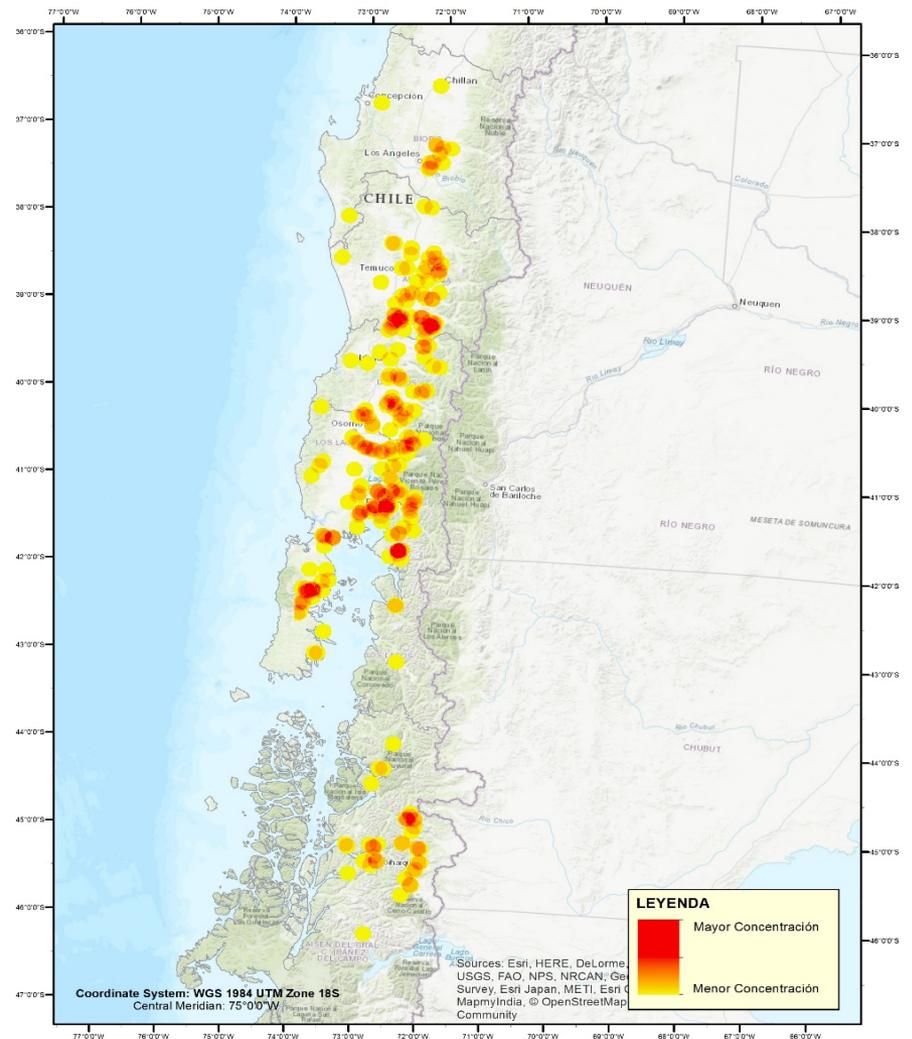


Location of hatcheries

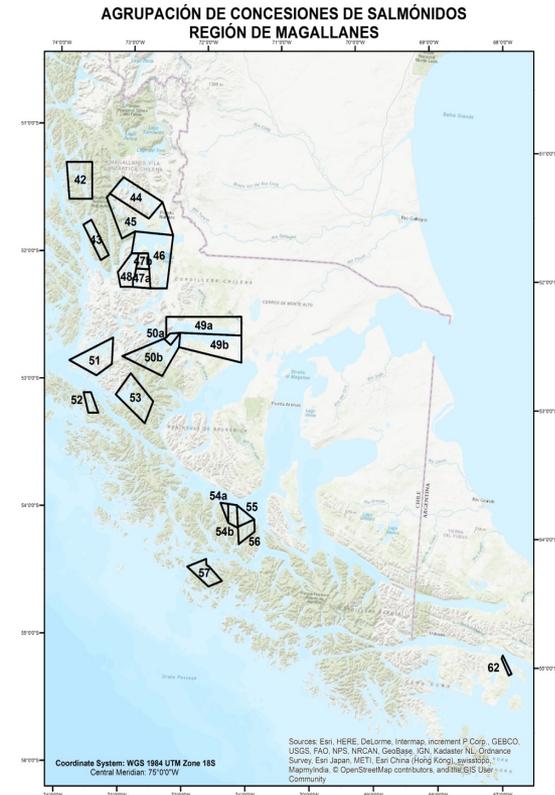
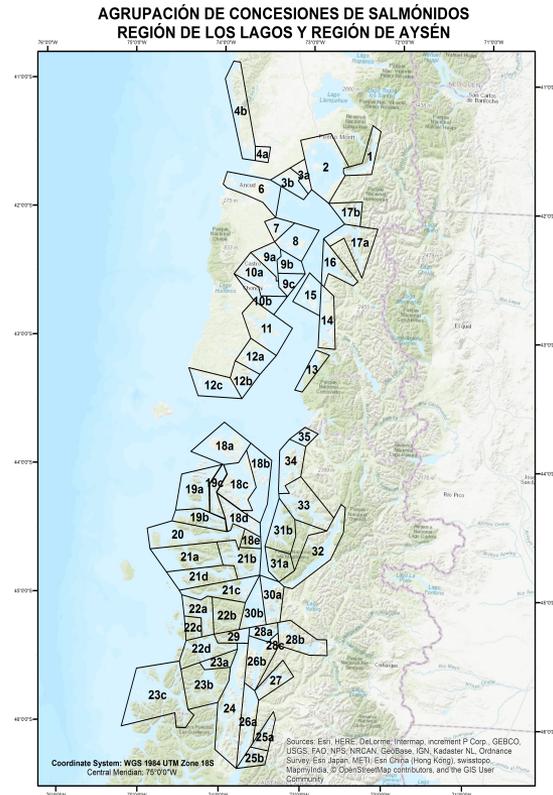
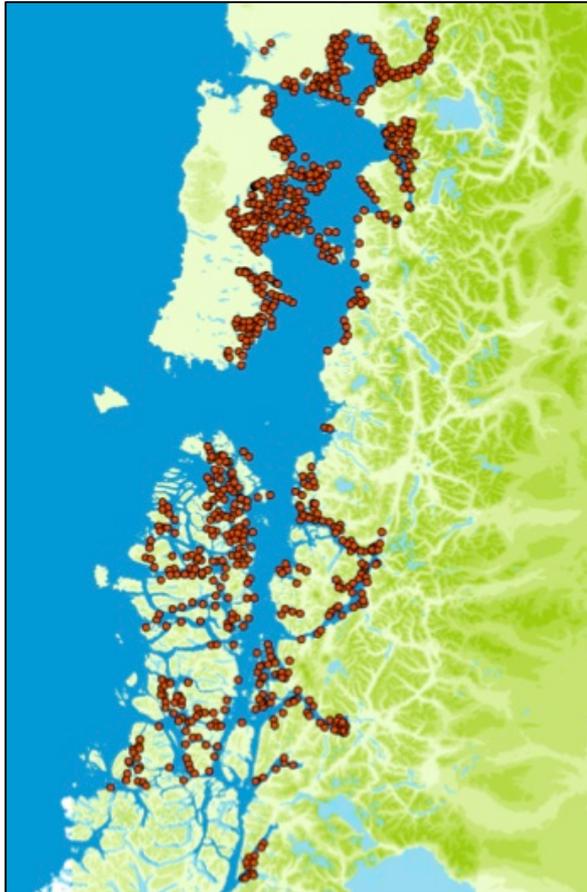
DISTRIBUCIÓN DE PISCICULTURAS A NIVEL NACIONAL



CONCENTRACIÓN DE PISCICULTURAS EN MESOREGIÓN SUR-AUSTRAL

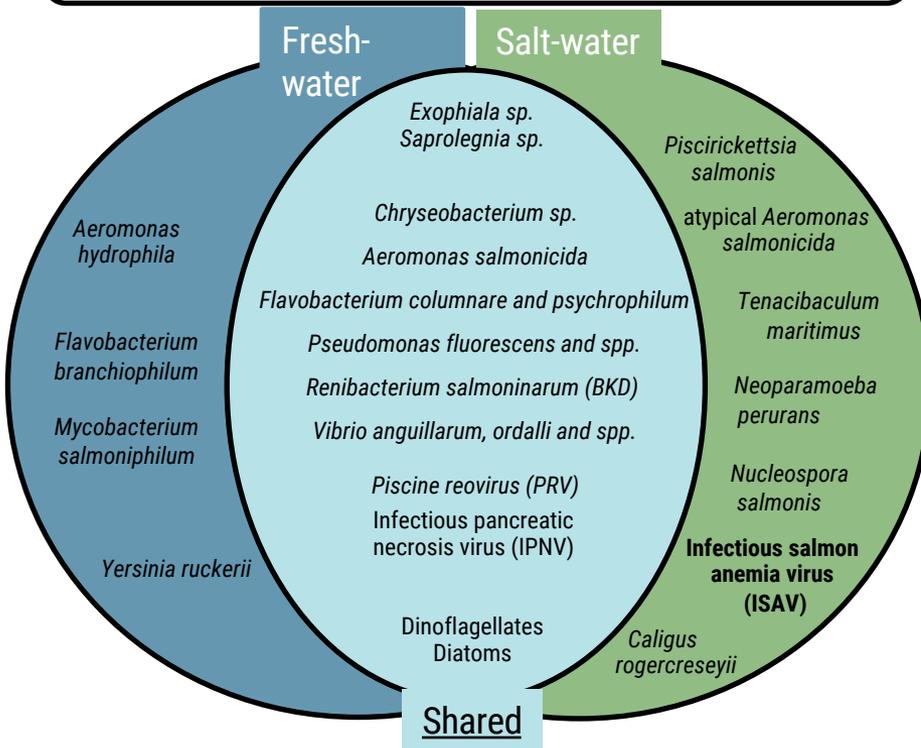


Locations of marine farms and management areas



27 organisms reported from farmed salmon in Chile

Source: Passive and Surveillance Reports in 2015, Sernapesca



Piscirickettsia salmonis

- Highly endemic bacterium
- 50-90% of infectious mortality
- USD 700 million yearly cost
- **Reason for large amount of antibiotics**

Sealice (*caligus rogercreseyii*)

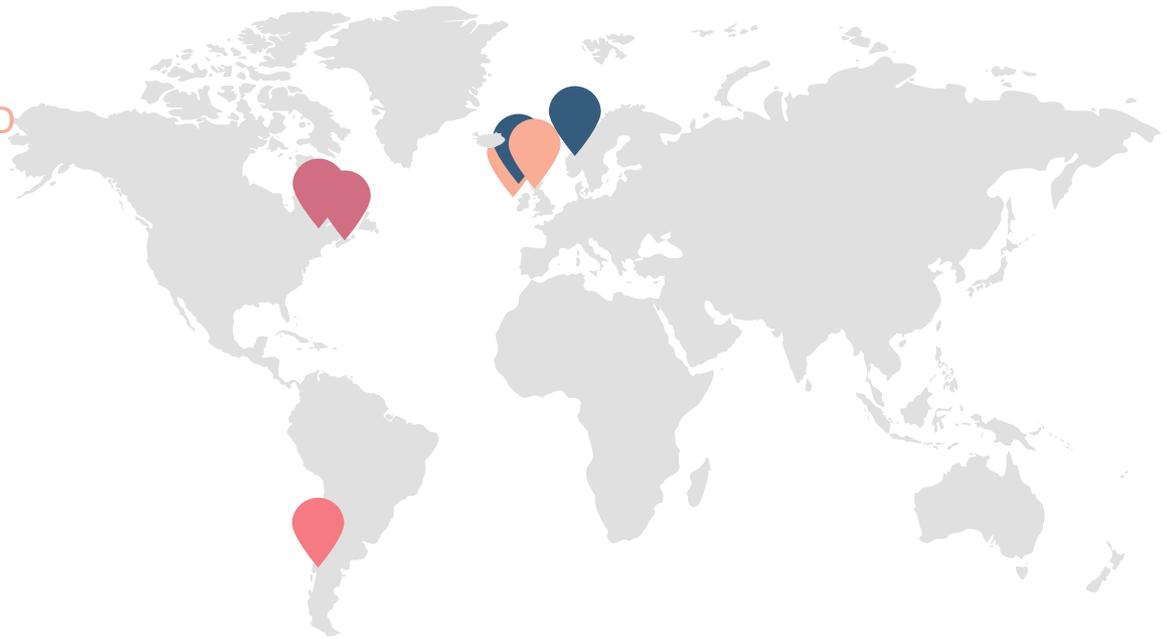
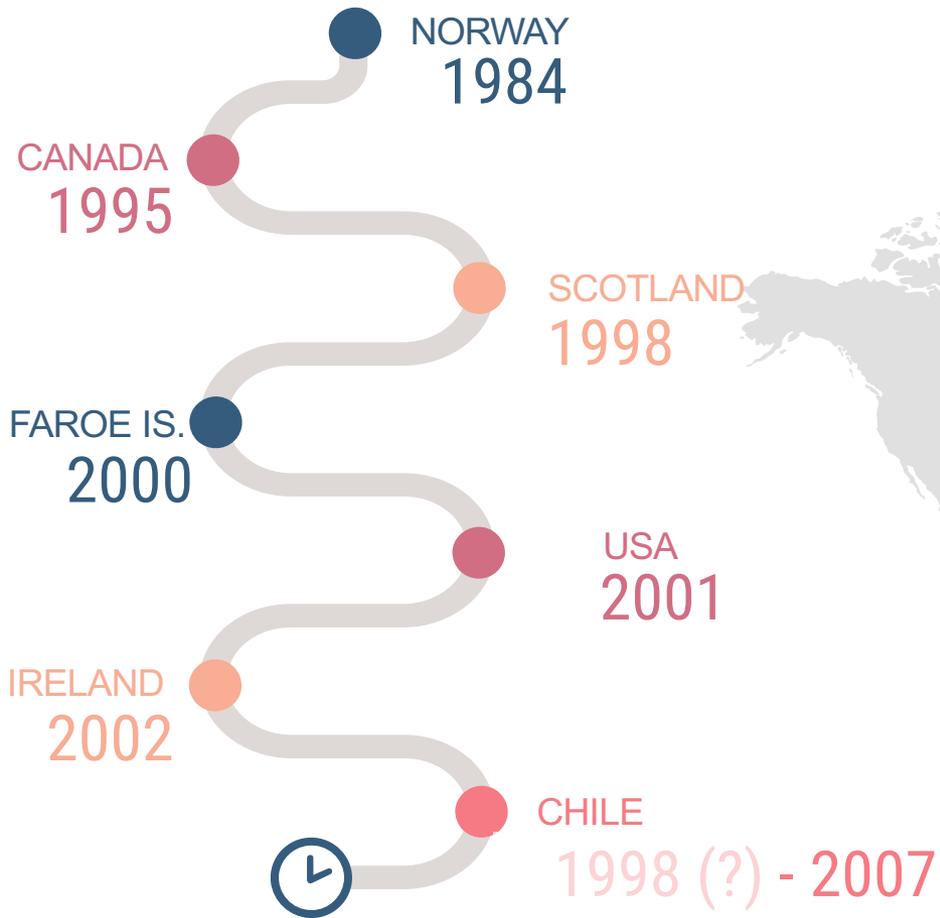
- Worldwide ectoparasite
- Risk factor and vector
- USD 300 million yearly cost
- **Reason for large amount of antiparasite bath treatments**

Infectious salmon anemia virus (ISAV)

- RNA virus; family *Orthomyxoviridae*
- World Animal Health Organization **notifiable** disease
- **Atlantic salmon (*Salmo salar*)** in marine sites (grow out).



Global emergence of ISAV



The index case (?)

- June 2007, two cages in a farm at the core of the industry at the 10th region, reported unexplained mortalities ~ 60% in 1 mo.
- Clinical signs associated with pale gills, hemorrhages in eyes, and exophthalmia.
- Internal signs included gut congestion, pale liver, petechiae of pyloric caeca, etc.

Clinical signs

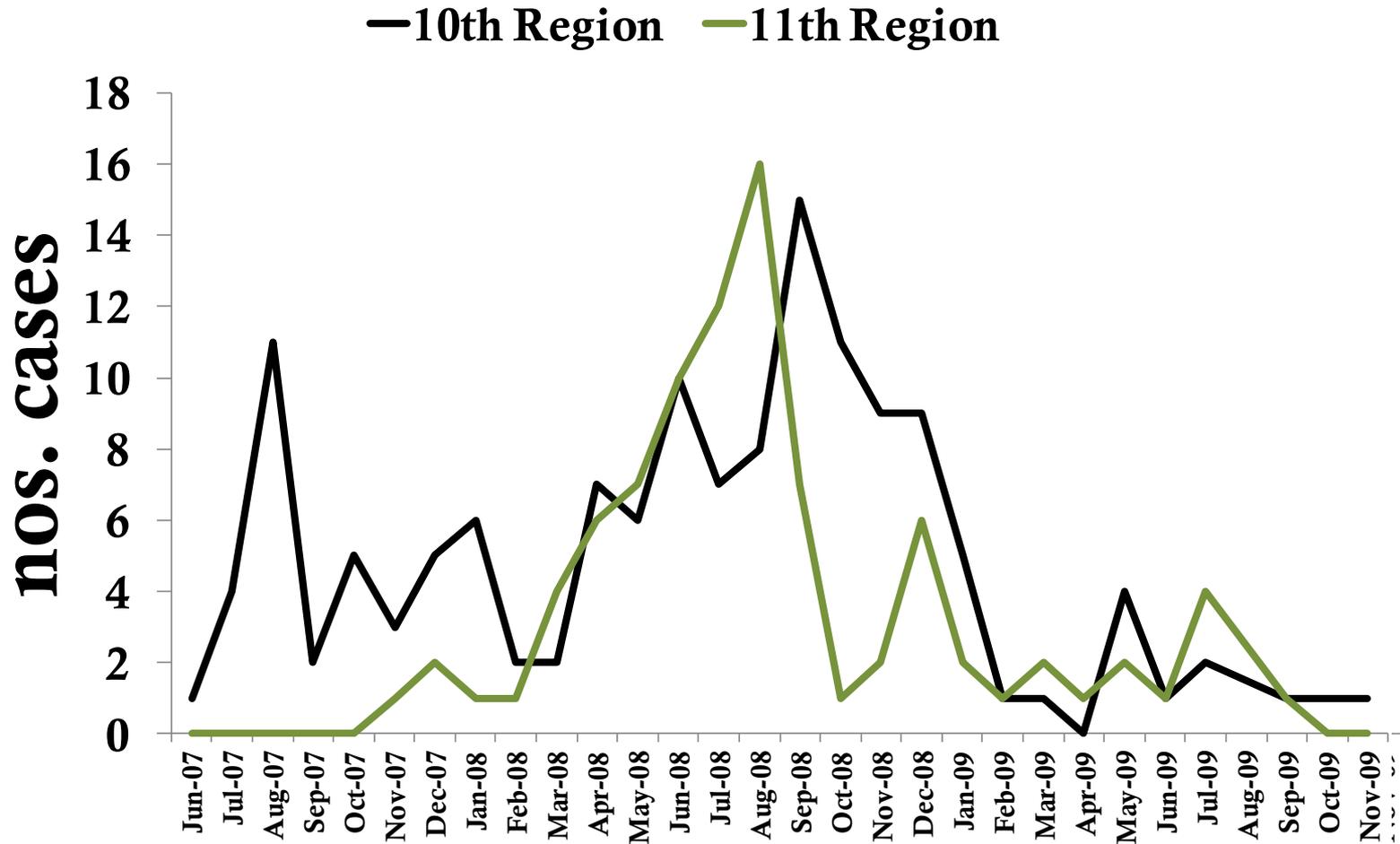


Incidence reporting inaccuracies

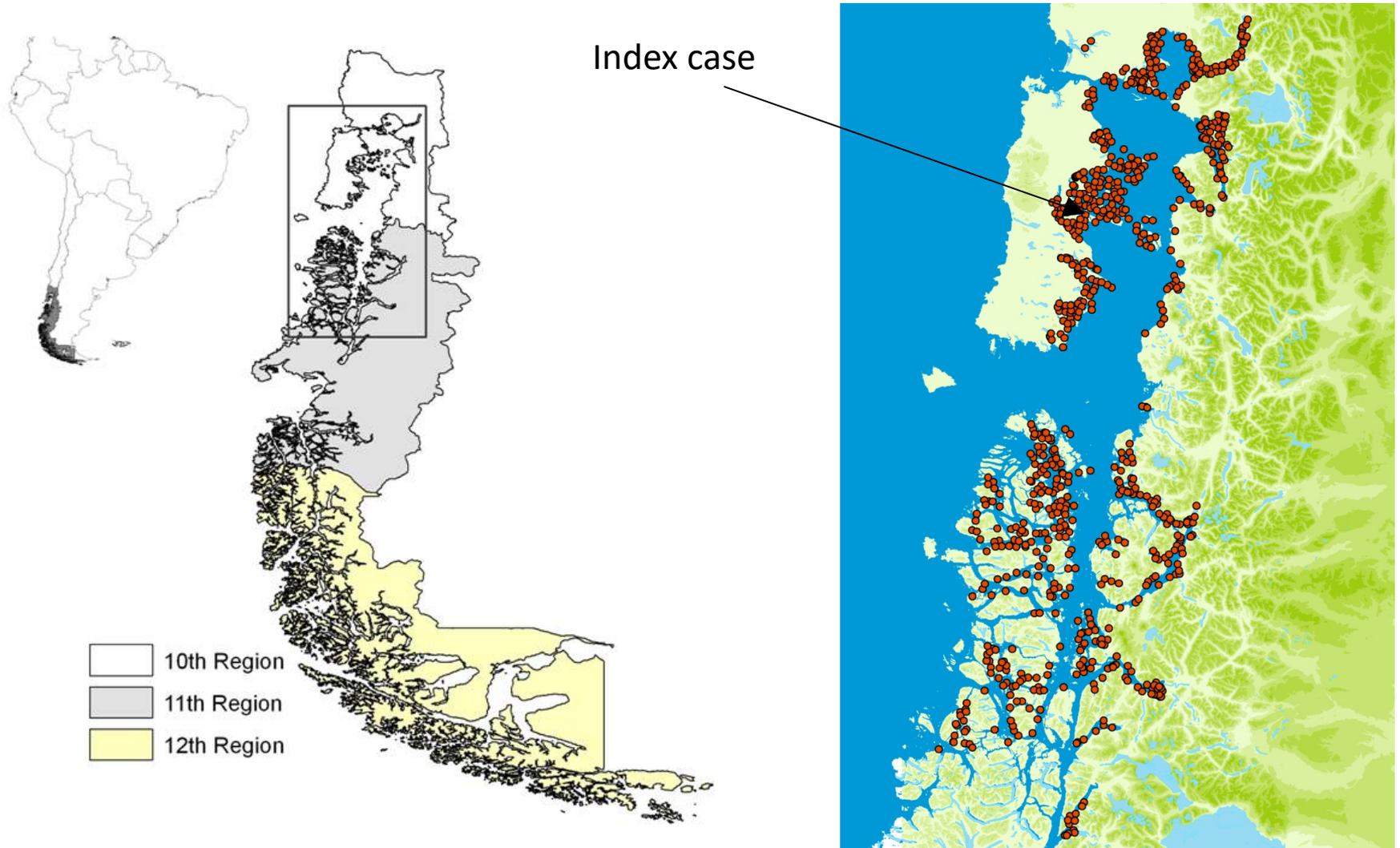


Epidemic curves

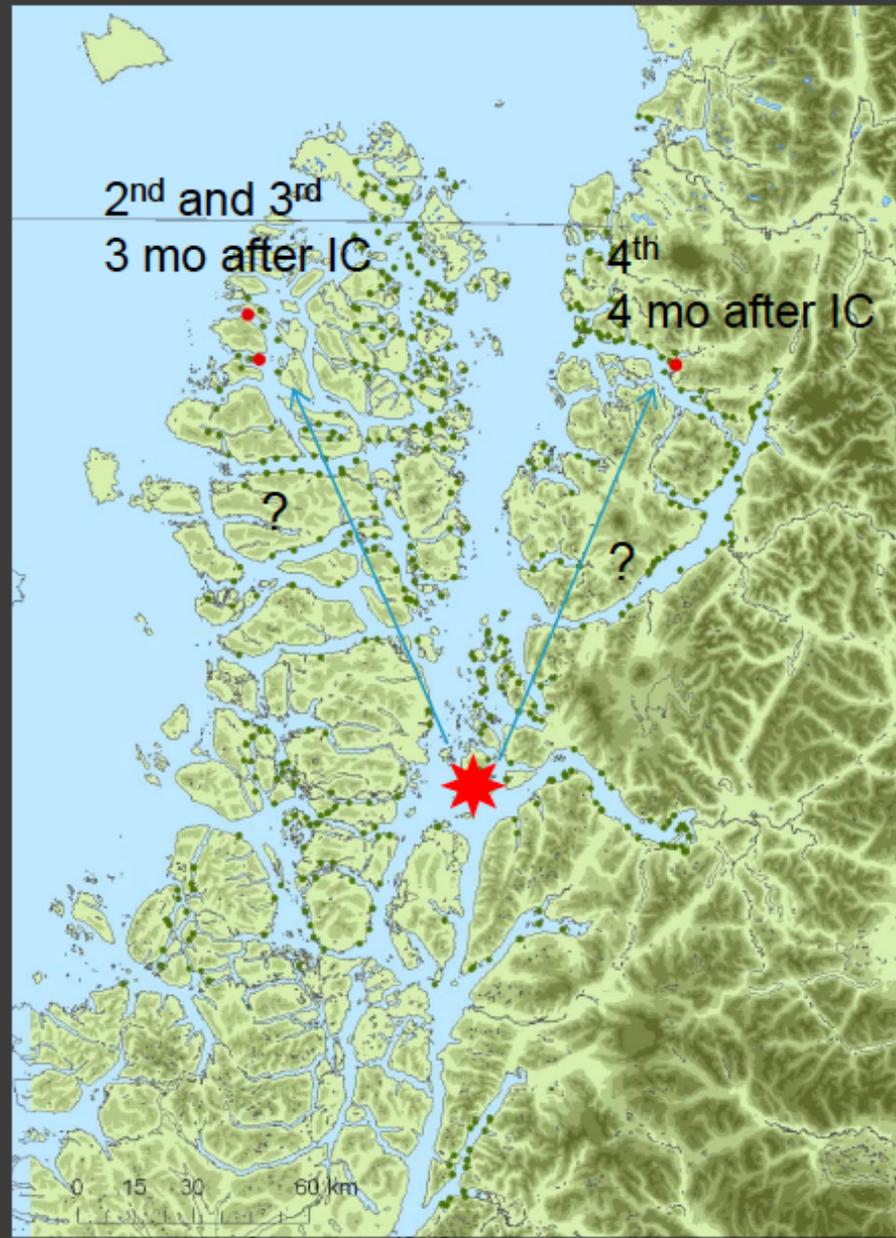
ISAV in Chile



First case in Chile



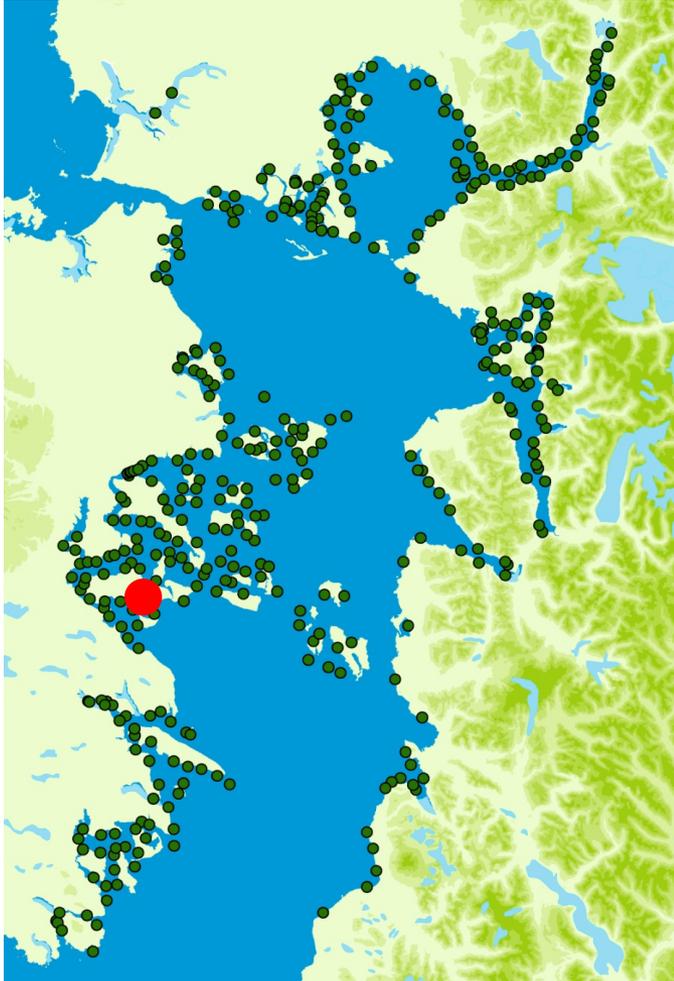




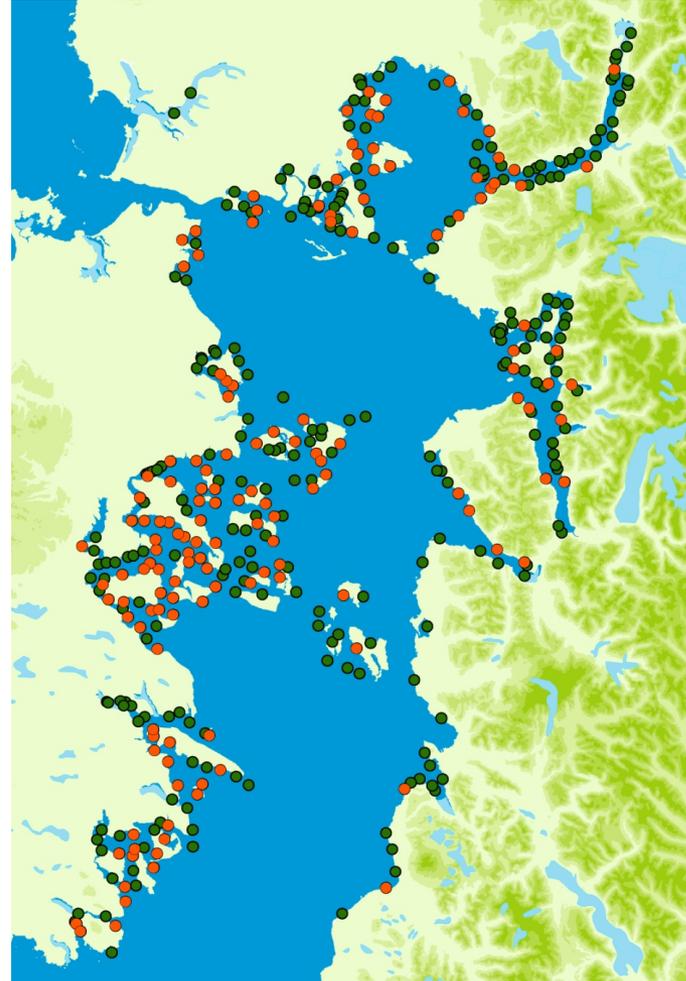
- 6 mo after the index case, ISAV was identified on the 11th region.
- 250 km from the nearest infected farm

10th region - 75% prevalence

June 2007



Dec. 2009



11th region - 54% prevalence

June 2007



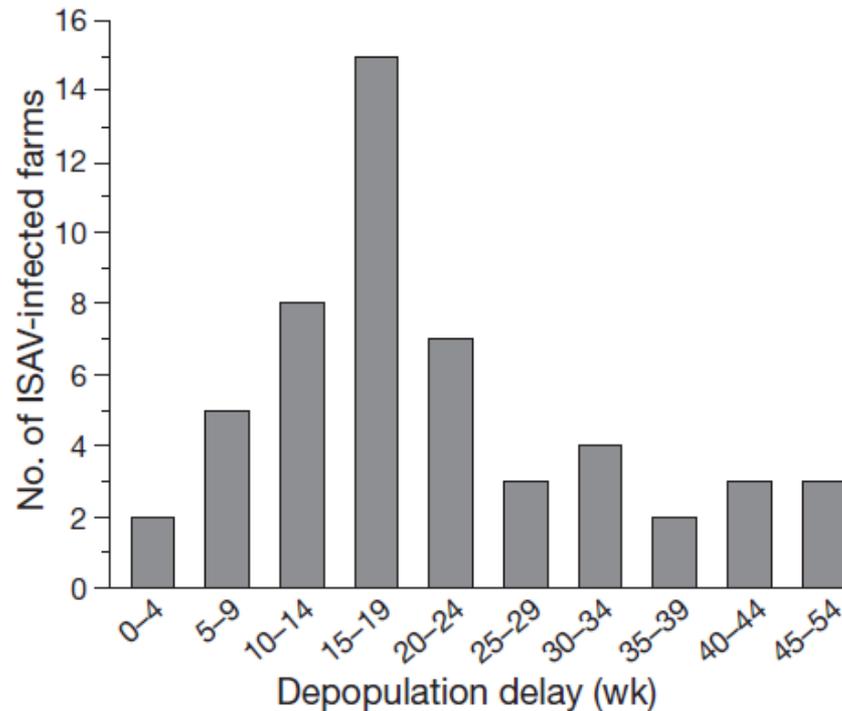
Dec. 2009



Epidemiologic investigation of the re-emergence of infectious salmon anemia virus in Chile

Fernando O. Mardones*, Andrés M. Perez, Tim E. Carpenter

Center for Animal Disease Modeling and Surveillance (CADMS), Department of Medicine and Epidemiology,
School of Veterinary Medicine, University of California, Davis, California 95616, USA



Reproduction number at farm level

10th region

Initial spread: explosive ($R_f=6.4-8.4$)

R_f throughout ISAV epidemic ranged from
1.6 – 2.5

Horizontal transmission predominantly, passive
movement of water (proximity)

Distances between infected farms were
significantly shorter (average=12km)

Efforts to prevent the epidemic would have been
sufficient if a 100% effective control
measure were to be in place for 38-50% of
the population.

11th region

Initial spread: lesser in magnitude ($R_f=3.4$)

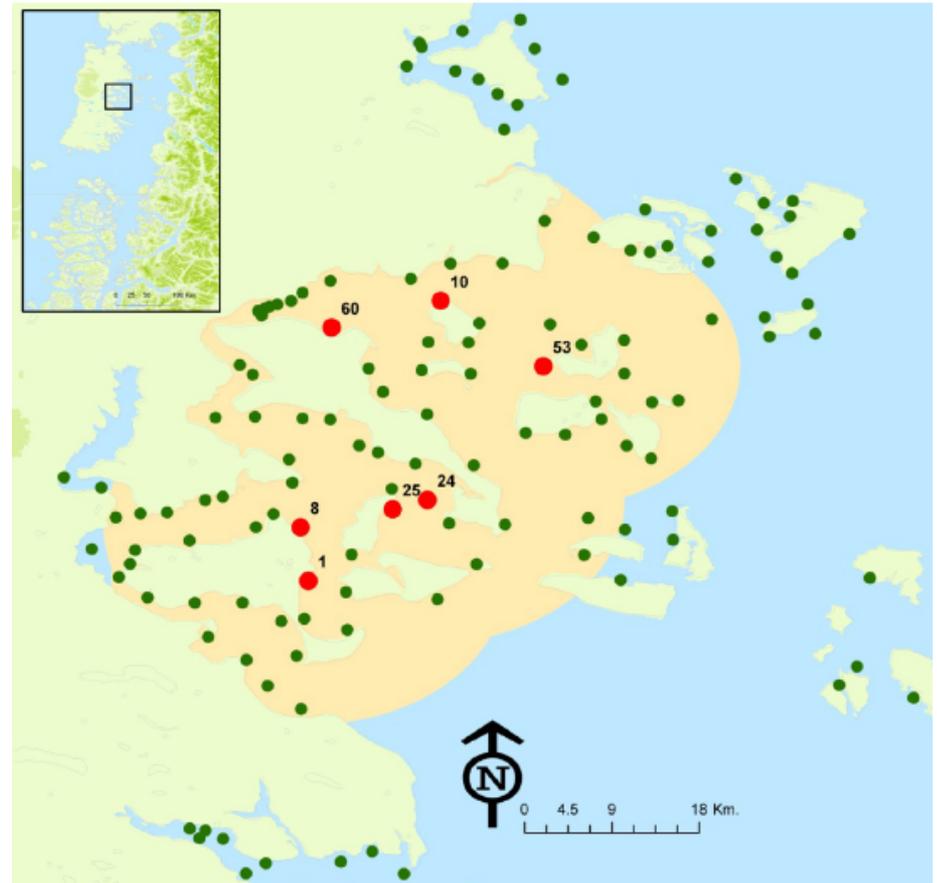
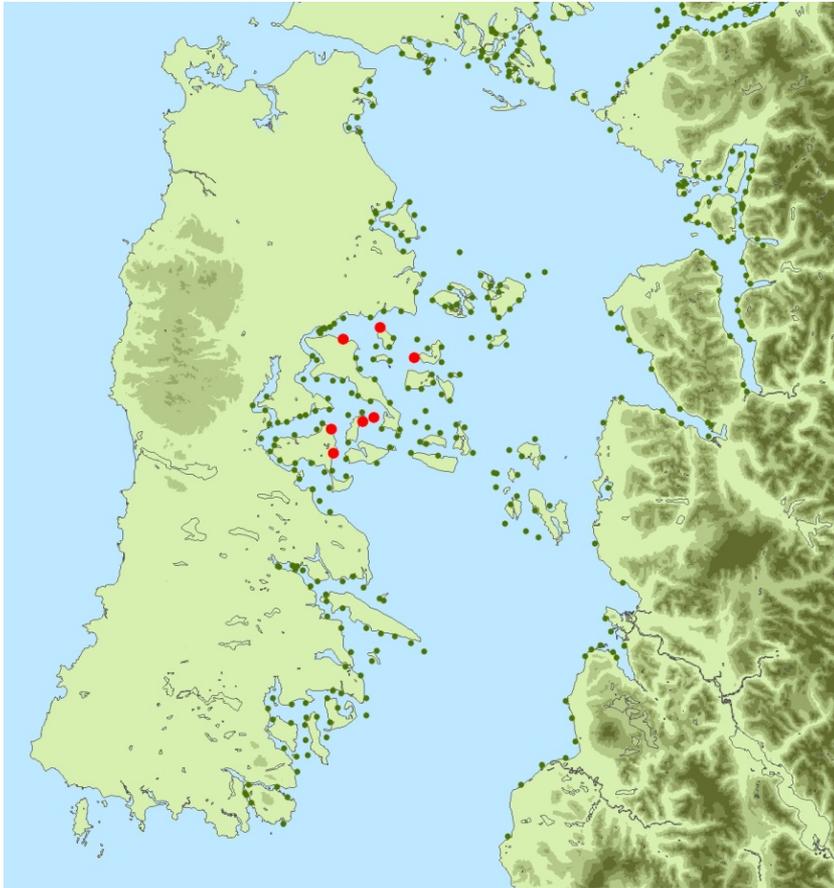
R_f throughout ISAV epidemic ranged
from 1.3 – 1.7

Horizontal transmission predominantly too, but may be
an important role on long distances
transmission, for example, movements of live
fish, contaminated vectors, etc.

Efforts to prevent the epidemic would have been
sufficient if a 100% effective control measure were
to be in place for 23-41% of the population.

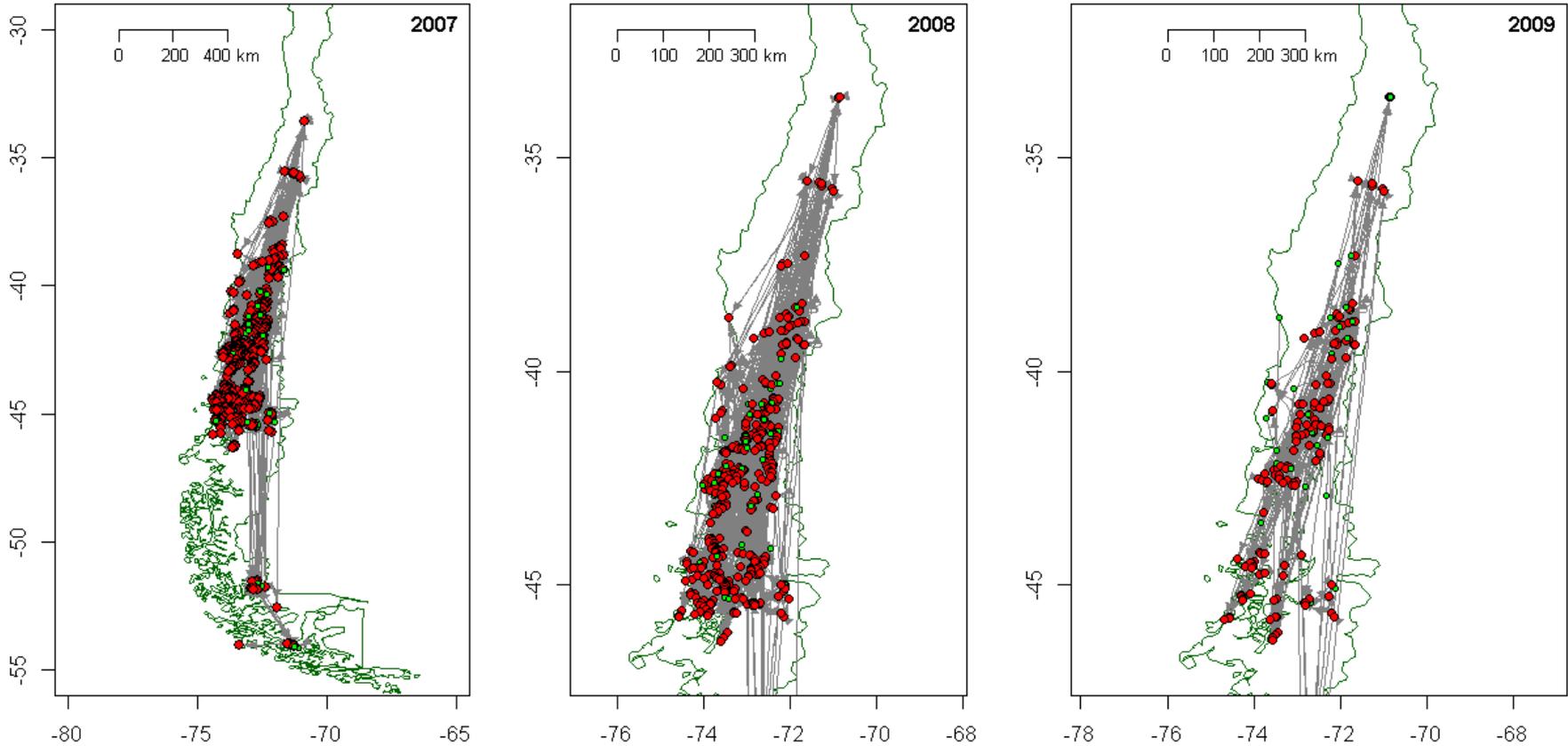
F.O. Mardones et al. / Preventive Veterinary Medicine 102 (2011) 175–184

Identification of 'Super-spreaders'



F.O. Mardones et al. / Preventive Veterinary Medicine 102 (2011) 175–184

The role of movements

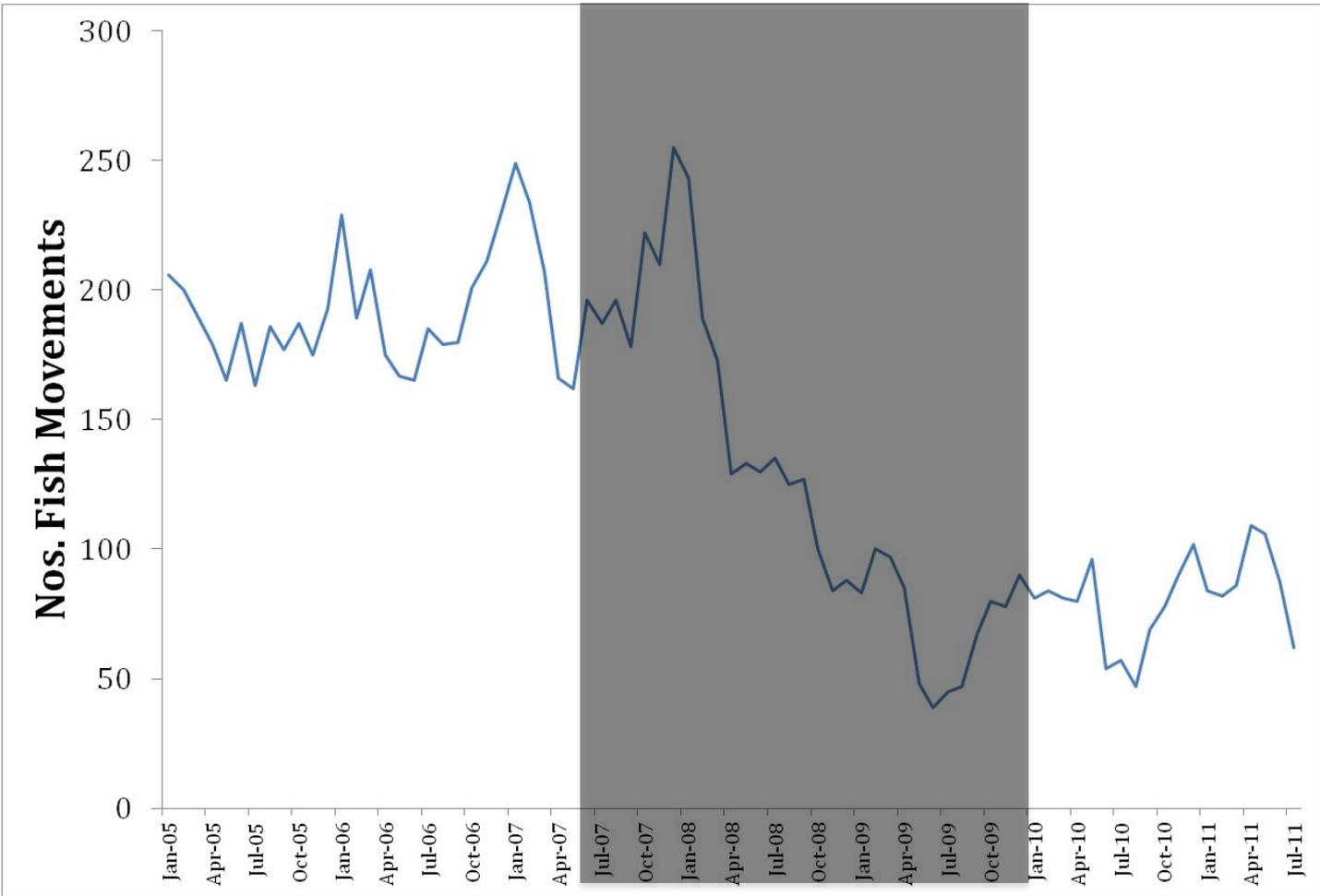


The role of fish movements and the spread of infectious salmon anemia virus (ISAV) in Chile, 2007–2009

F.O. Mardones^{a,b,*}, B. Martinez-Lopez^{a,1}, P. Valdes-Donoso^{a,c,1},
T.E. Carpenter^{a,d}, A.M. Perez^{a,e}

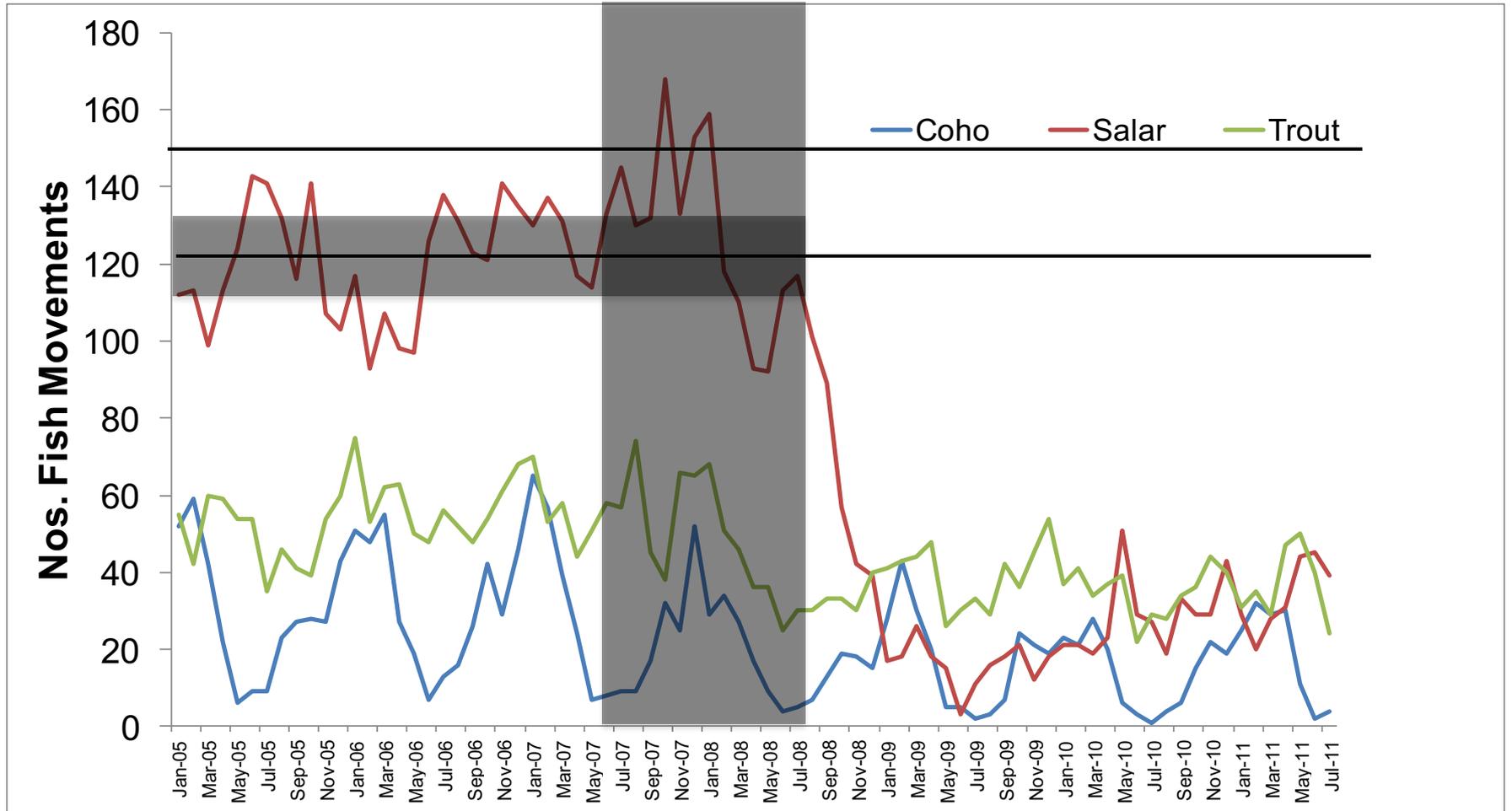


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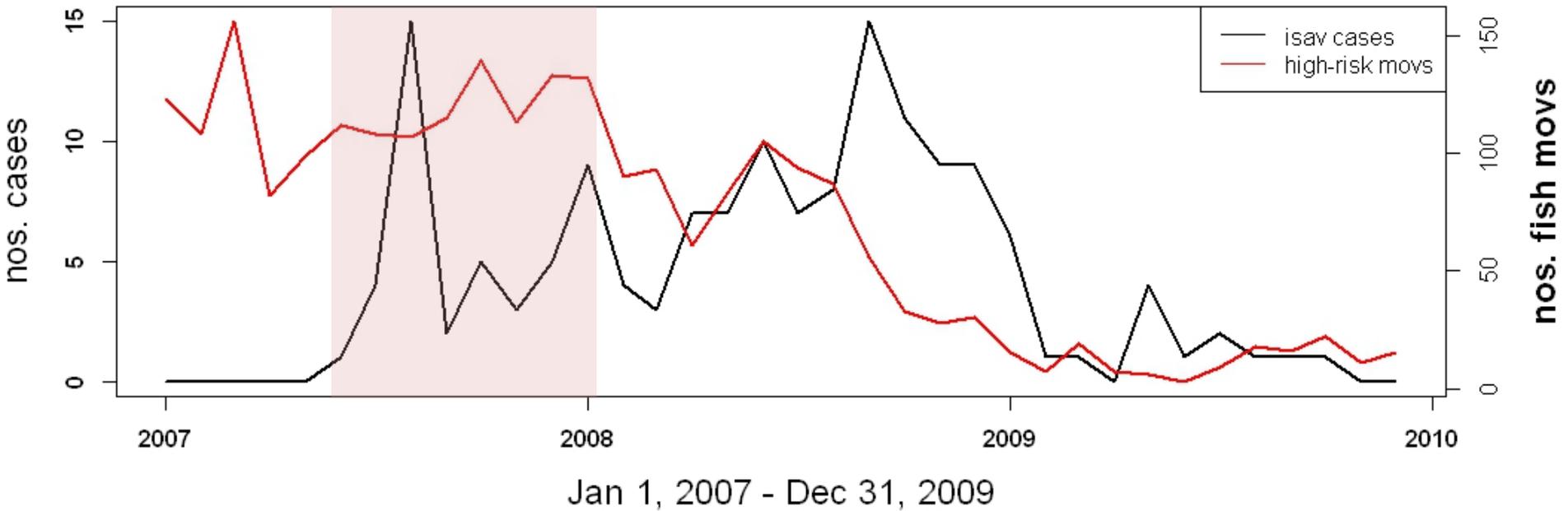


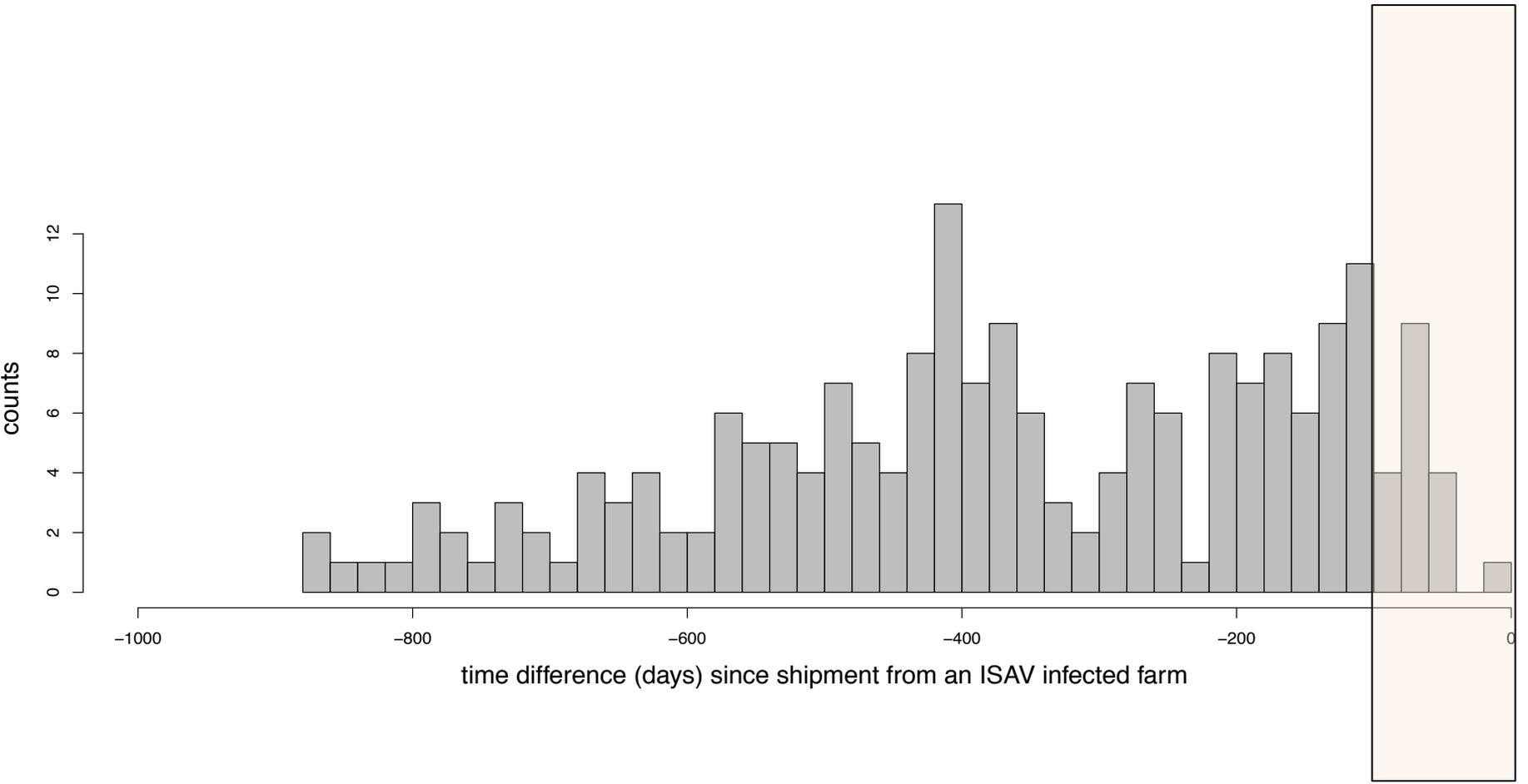
Official data (2005-2011)

Movements by salmon species



Fish movements vs ISA epidemic





Potential spread due to fish movements

6 salmon farms (red) shipped out 11 times live fish to 7 farms (black) during the ISAV epidemic

If shipments were truly infectious, about 7/239 (~3%) infections could be due to live fish movements

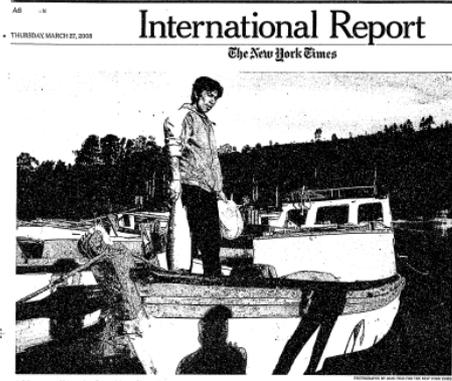


ISAV within-farm spread

Indicator	Mean	Median	Min-Max
Number of index cages	1.4	1	-
Outbreak duration (weeks)	30.4	26	11-64
% cages infected	57.4	55	17-89
Time to 2 nd infected cage (days)	51.3	23	3-186

Mardones et al 2013 *Dis Aquat Organ.* 106:7-16

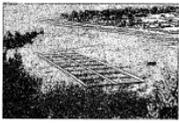
Economic, social & environmental consequences



A fisherman and his mate at Puerto Montt, Chile, where intensive salmon aquaculture is killing wild fish destined for export to Japan, Europe and Australia.

Virus Kills Chile's Salmon and Indicts Its Fishing Methods

By ALAN RAYBURN
SCIENTIFIC SOCIETY Chile's leading sea and river fishery is being decimated by a deadly virus that has killed millions of salmon in Chile and ravaged the fish farming industry there was probably brought over from Norway, a major salmon producer has acknowledged.
 A Chilean salmon producer has acknowledged that the virus that has killed millions of salmon in Chile and ravaged the fish farming industry there was probably brought over from Norway, a major salmon producer has acknowledged.
 The virus, infectious salmon anaemia, or I.S.A., was first reported at a Chilean salmon farm owned by Marine Harvest, another Norwegian company. It quickly spread through southern Chile, wrecking a fishing business that had become one of the country's biggest exporters during the past 35 years. The Chilean industry, whose major clients include the United States and Brazil, suffered more than \$2 billion in losses, saw its production of Atlantic salmon fall by half and had to lay off 28,000 workers.
 The outbreak in Chile also revealed structural problems within the industry, including overcrowding in pens that environmentalists say probably helped speed the spread of the virus. Since then, the industry and the Chilean government have instituted a wide range of reforms to try to contain outbreaks, but despite extensive efforts to rein in the virus continues to spread.
 Last week, Chilean authorities said 23 production centers were



Salmon pens in the Gulf of Reloncavi. Crowded pens are blamed for water pollution and potentially vulnerability to disease.

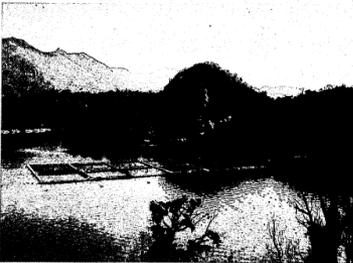
THE WALL STREET JOURNAL
Big Salmon Exporter Fights Virus --- Chile's Share of Global Output Expected to Fall
Risa Grais-Targow Wall Street Journal (Eastern edition) New York, N.Y., Jul 7, 2009, pp. B 6

Big Salmon Exporter Fights Virus

Chile's Share of Global Output Expected to Fall; Pickup Unlikely Until 2011

By RISA GRAIS-TARGOW

SANTIAGO—A virus is crippling Chile's farmed salmon industry, dumping exports and squeezing fish producers.
 Chile is currently the world's second-largest exporter of salmon and trout, with salmon exports of a record \$2.4 billion in 2008. But producers with infected salmon can't harvest until the virus is eliminated from their farms. As a result, exports have begun to fall and are likely to decline even more in 2010. The harvest cycle typically takes two years, so the industry isn't expected to pick up until 2011.
 The I.S.A. virus—infectious salmon anaemia—is a contagious threat to big fish farms the world over. Norway, the world's largest salmon producer, where the virus originated in the 1980s, has implemented measures to control it, including vaccines and limiting fish numbers. But Chile's industry is heavily reliant on antibiotics which has allowed harmful strains of bacteria to build immunity, and Chilean farms' close proximity and frequently overcrowded fish pens have led to the rapid spread of the disease.
 Chile is currently the world's second-largest exporter of salmon and trout. Above, farmed salmon cages in southern Chile. Right, workers process farmed salmon fillets.
 As a result, Chile's share of global salmon production is expected to fall to 20% in 2010 from 30% in 2008, according to a recent study by the Chilean Association of Banks.
 The virus first hit Chile in 2007 but worsened last year, it comes as a bad time for Chile's



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Call for cooperation to contain damage by Chile's salmon farms

Heike Vester & Marc Timme

Affiliations

Nature 465, 869 (17 June 2010) | doi:10.1038/465869d
 Published online 16 June 2010

Science News

Impacts of Chilean Salmon Farms On Coastal Ecosystem Discovered Accidentally

ScienceDaily (June 22, 2010) — Until recently, the disastrous scale of the threat posed by salmon farms to the fauna and National Park of the Aysén region of southern Chile was entirely unknown. The unexpected discovery was made by researchers from the Max Planck Institute for Dynamics and Self-Organization and the University of Göttingen, who were studying acoustic communication among the native whales in the region. The researchers not only discovered that the salmon industry is rapidly spreading to the hitherto largely unspoiled south of the region, they also documented the previously unknown threat to the region's native sea lions.



This is an abandoned salmon farm in a fjord north of the Aysén region of Chile. (Credit: Image: Heike Vester, MPI for Dynamics and Self-Organization)



Norwegians Concede a Role In Chilean Salmon Virus

By ALAN RAYBURN

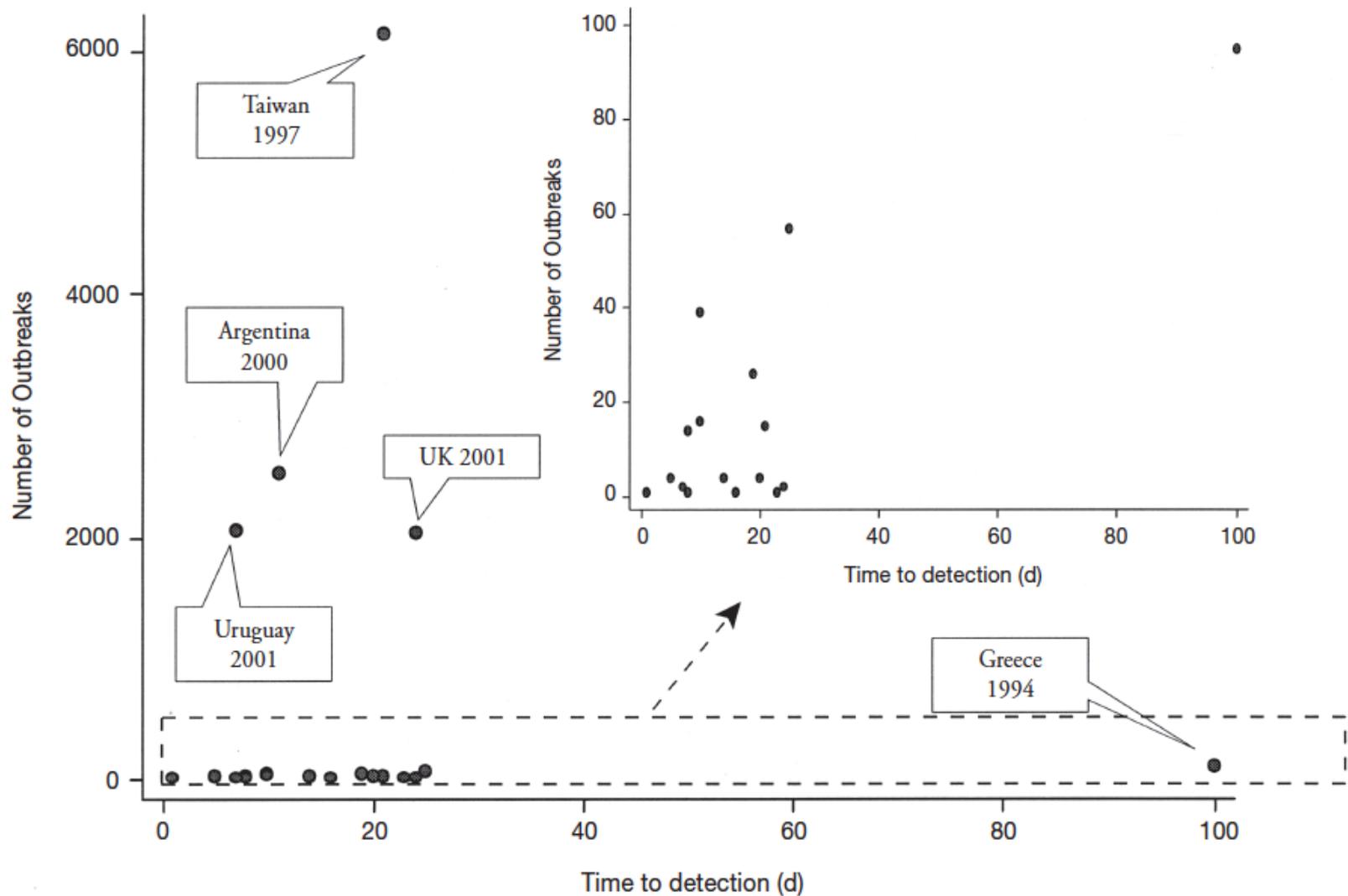
SÃO PAULO, Brazil — A virus that has killed millions of salmon in Chile and ravaged the fish farming industry there was probably brought over from Norway, a major salmon producer has acknowledged.

German, a state-controlled Norwegian aquaculture company that has become one of the principal exporters of salmon from Chile, has endorsed a scientific study concluding that salmon eggs shipped from Norway in Chile are the "likely reason" for the outbreak of the virus in 2007, according to Jøsef Bergan, a company spokesman.
 But, she argued, "the report didn't pinpoint any company" as the culprit.

The virus, infectious salmon anaemia, or I.S.A., was first reported at a Chilean salmon farm owned by Marine Harvest, another Norwegian company. It quickly spread through southern Chile, wrecking a fishing business that had become one of the country's biggest exporters during the past 35 years. The Chilean industry, whose major clients include the United States and Brazil, suffered more than \$2 billion in losses, saw its production of Atlantic salmon fall by half and had to lay off 28,000 workers.
 The outbreak in Chile also revealed structural problems within the industry, including overcrowding in pens that environmentalists say probably helped speed the spread of the virus. Since then, the industry and the Chilean government have instituted a wide range of reforms to try to contain outbreaks, but despite extensive efforts to rein in the virus continues to spread.
 Last week, Chilean authorities said 23 production centers were

An outbreak in 2007 revealed structural problems in the farmed-fish industry.

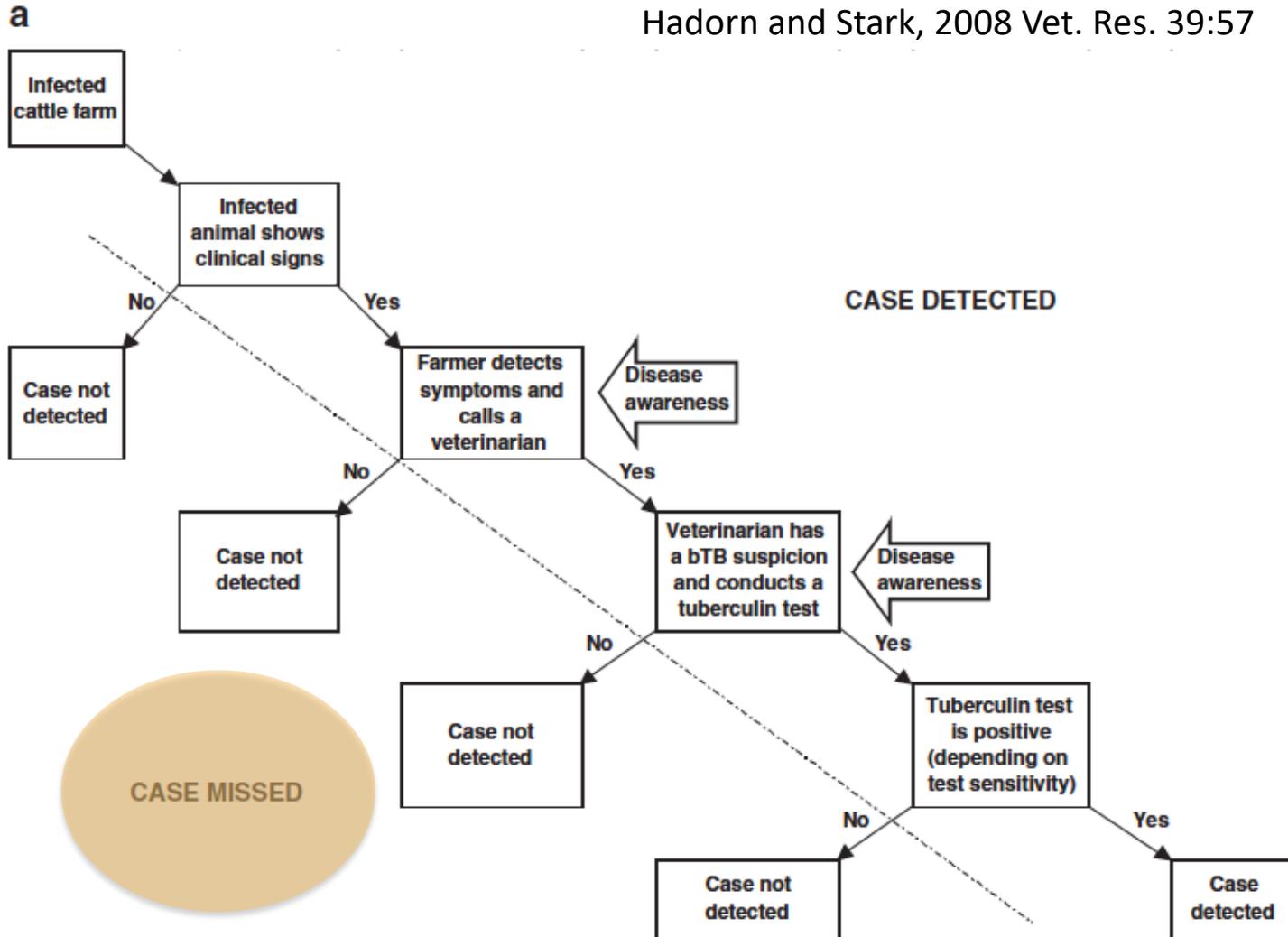
Early Detection of EADs

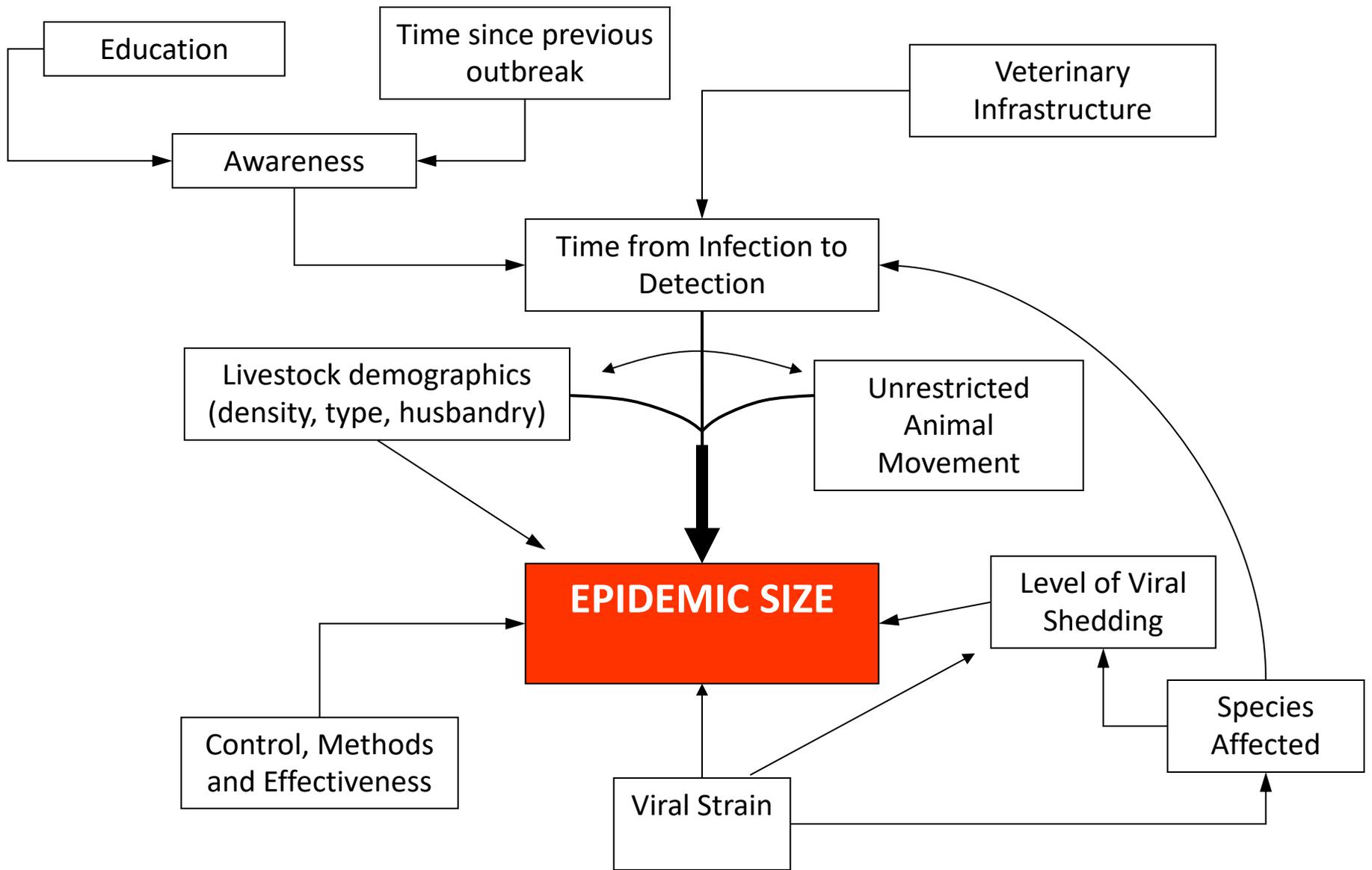


McLaws & Riddle, 2007 Can Vet J 48:1051-62

Disease Awareness

Hadorn and Stark, 2008 Vet. Res. 39:57

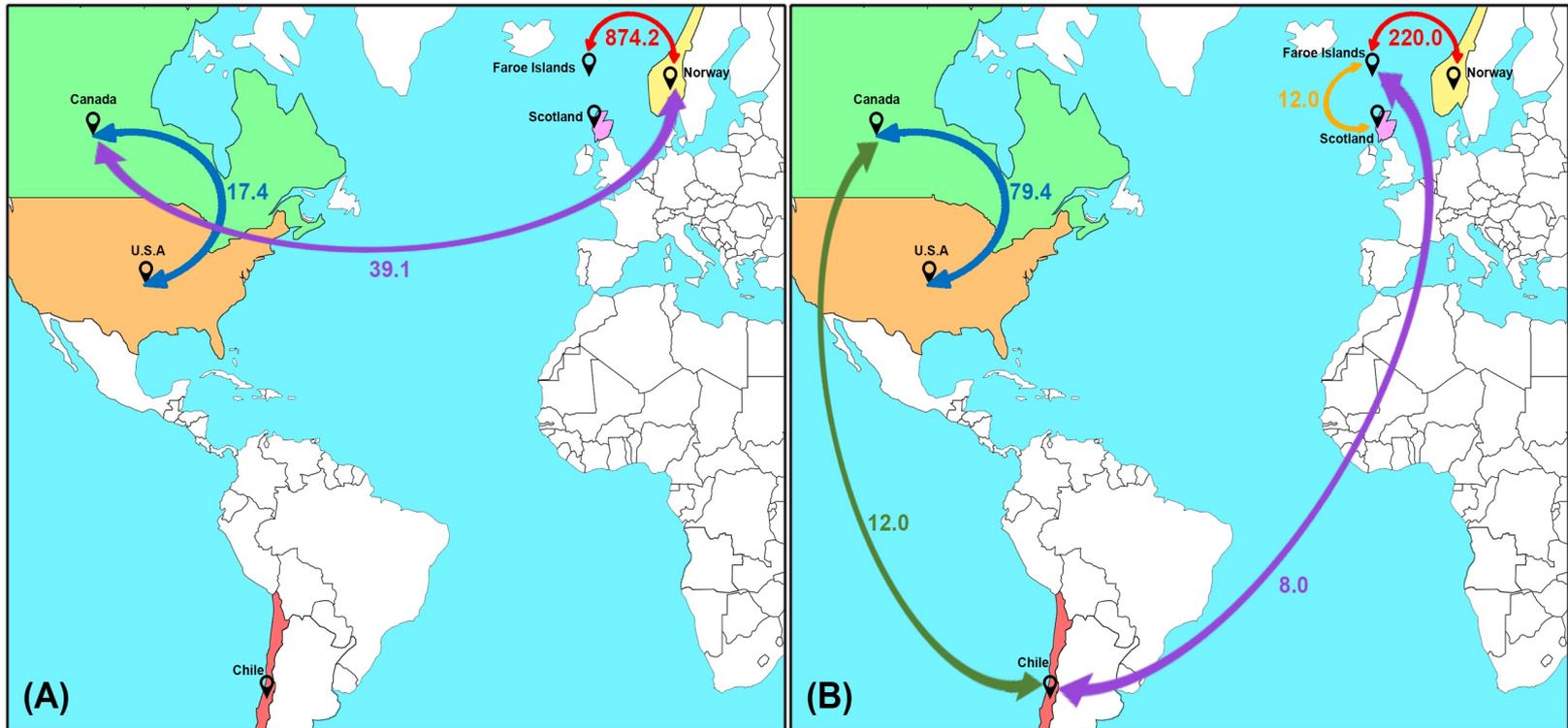




Lessons learned

- Early detection and reporting of cases
- Quickly spread to neighboring farms but “with help” of anthropogenic activities.
- Depopulation delay was crucial (4 times longer than the ISAV Scottish epidemic). How about subsidies?
- Identification of super-spreaders for risk-based monitoring and surveillance
- Evaluate restrictions of fish movements
- Within-farm spread provide clues about the infectious nature of ISAV and importance of quick depopulation of infected cages/farms.

Dispersal routes of the ISA virus between countries

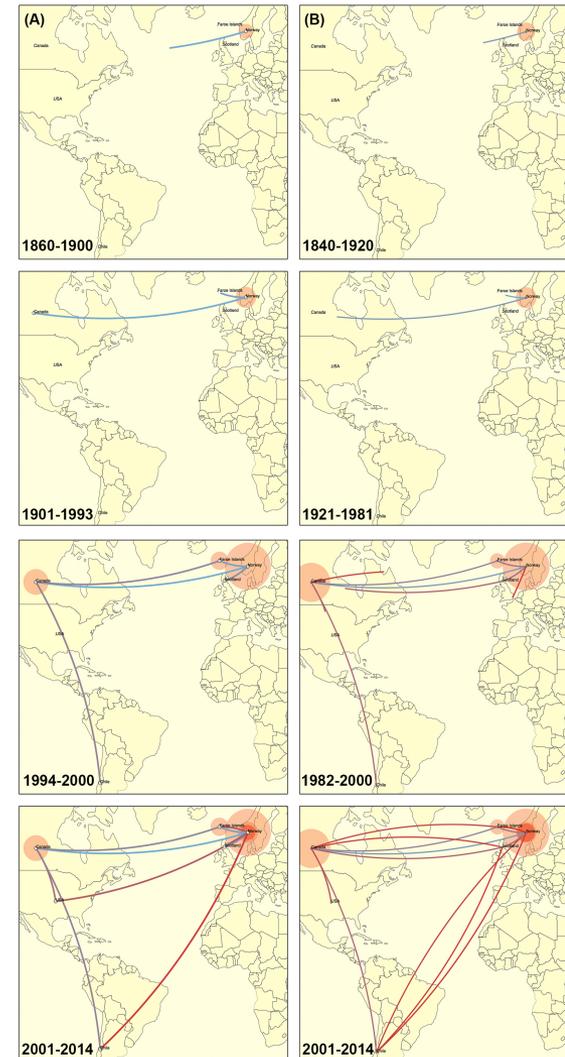


Mardones et al 2018 (internal review) used Bayesian stochastic search variable selection (BSSVS) to fit phylogeographic models to the FP gene (A) and HE gene (B) sequence dataset, and inferred geographic connections (transmission routes) using Bayes factors (BF).

ISAV spatiotemporal spread

- from 1860 to 2014 for FP gene (A)
- from 1840 to 2014 for HE gene (B)

Global maximum clade credibility (MCC) phylogenies of FP and HE gene of ISA virus annotated with spatial discrete traits shown at intervals of years onwards.





UNIVERSITY OF MINNESOTA



Estimation of the probability of freedom from ISAV in farmed Coho salmon in Chile using scenario tree modeling

Alba A, Monti G, Ibarra R, Tello A, Lara M, Montecinos K, Gallardo A, Sergeant E, Perez AM, **Mardones FO***.

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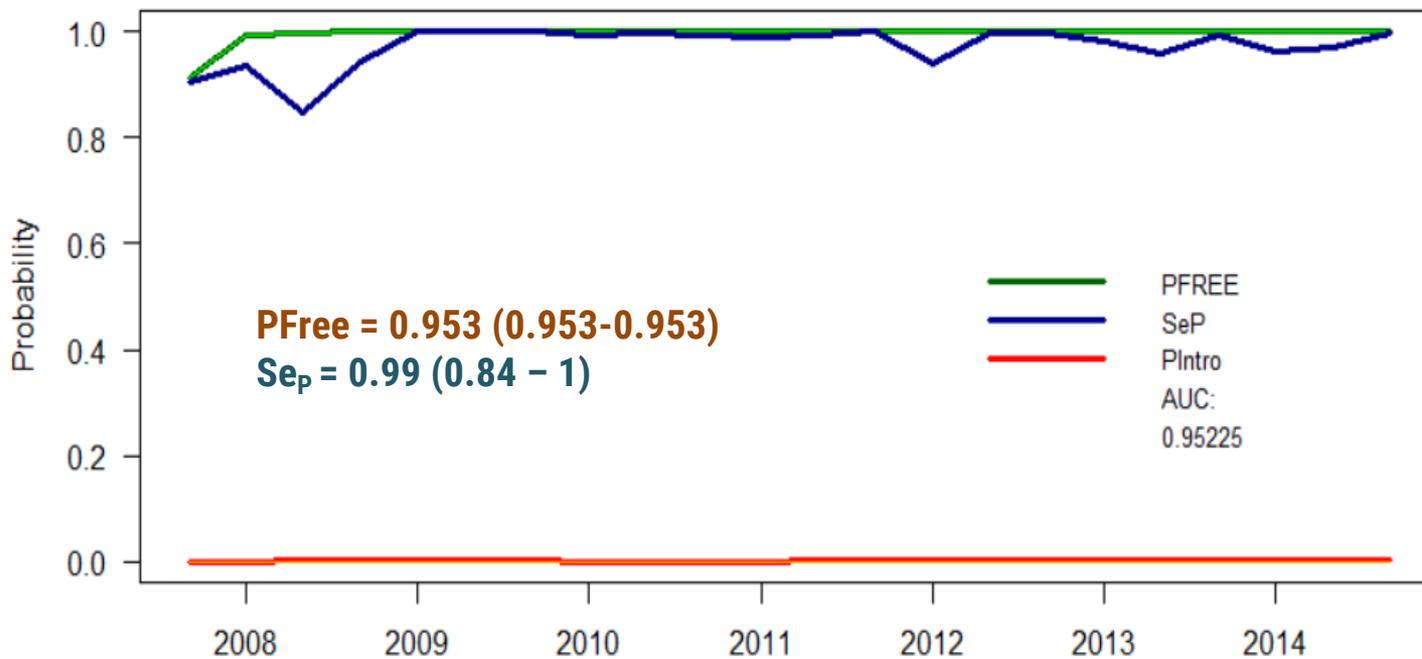
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Assessment of the overall surveillance for ISAV in farmed coho salmons



PFree = 0.953 (0.953-0.953)

Se_P = 0.99 (0.84 - 1)

— PFree
— SeP
— PIntro
AUC:
0.95225

Follow-up by quarter.Period: Sep 2007 - Dec 2014

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