

GENOMIC SCIENCE TOOLS BEING IMPLEMENTED ON SAMPLES FROM THE FIRST GULF OF ALASKA EXPEDITION IN 2019

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PICES - W16



Wild salmon declines – what is killing fish in the ocean?



Is a fish is stressed or unhealthy?

- Mortalities not observable in the ocean
- Behavioral shifts/clinical signs go unnoticed
- Sampling restricted to “live” fish -> gear selectivity
- Compromised fish have higher risk of predation

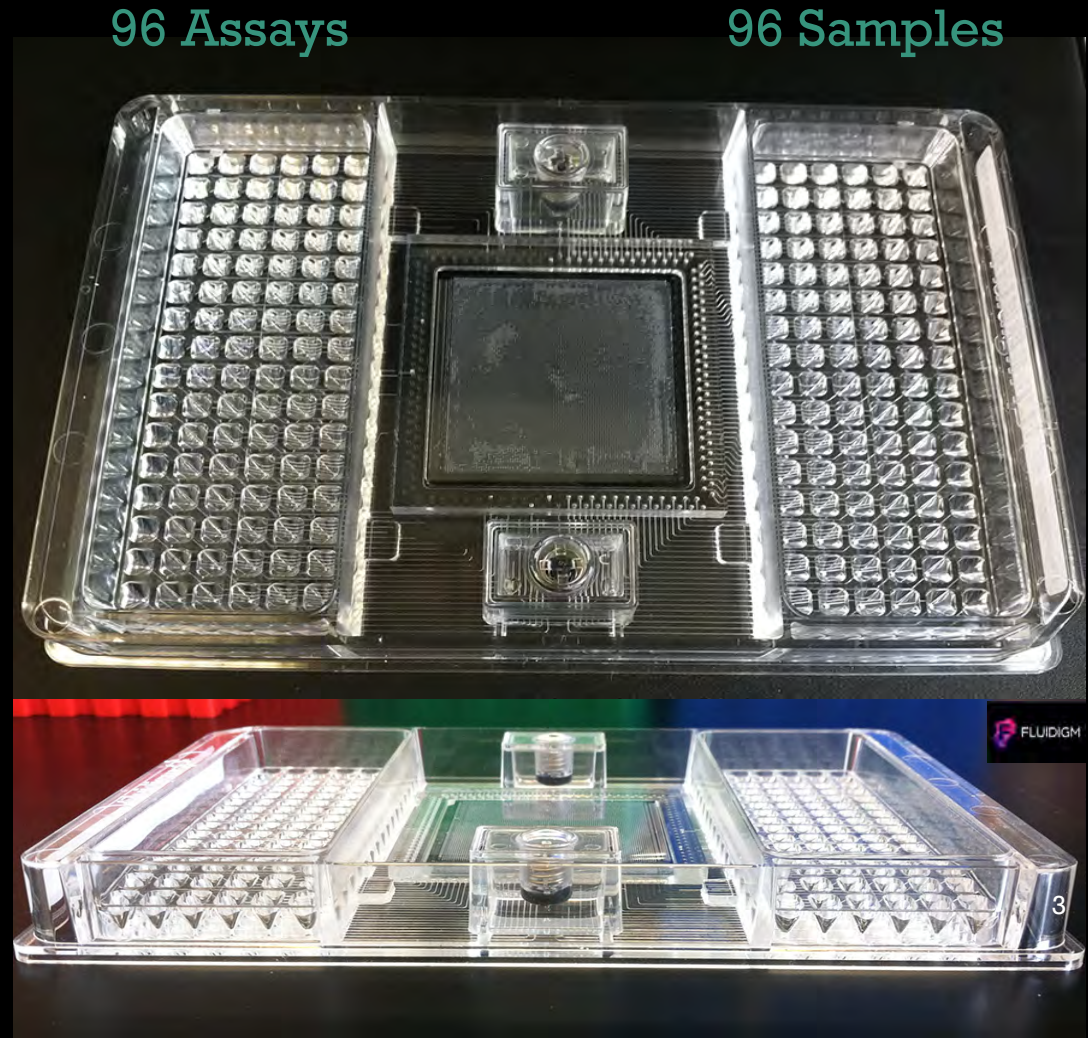
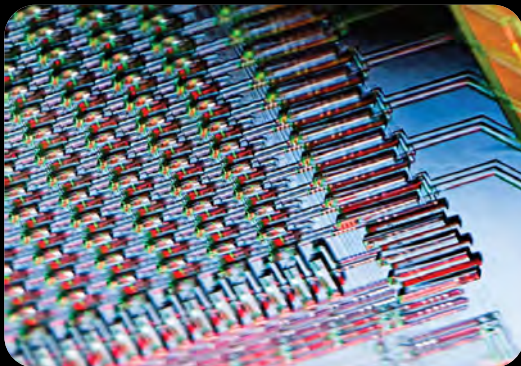
Cumulative stressors

- Effect of temperature, salinity, oxygen saturation, etc...
 - Impact on fish?

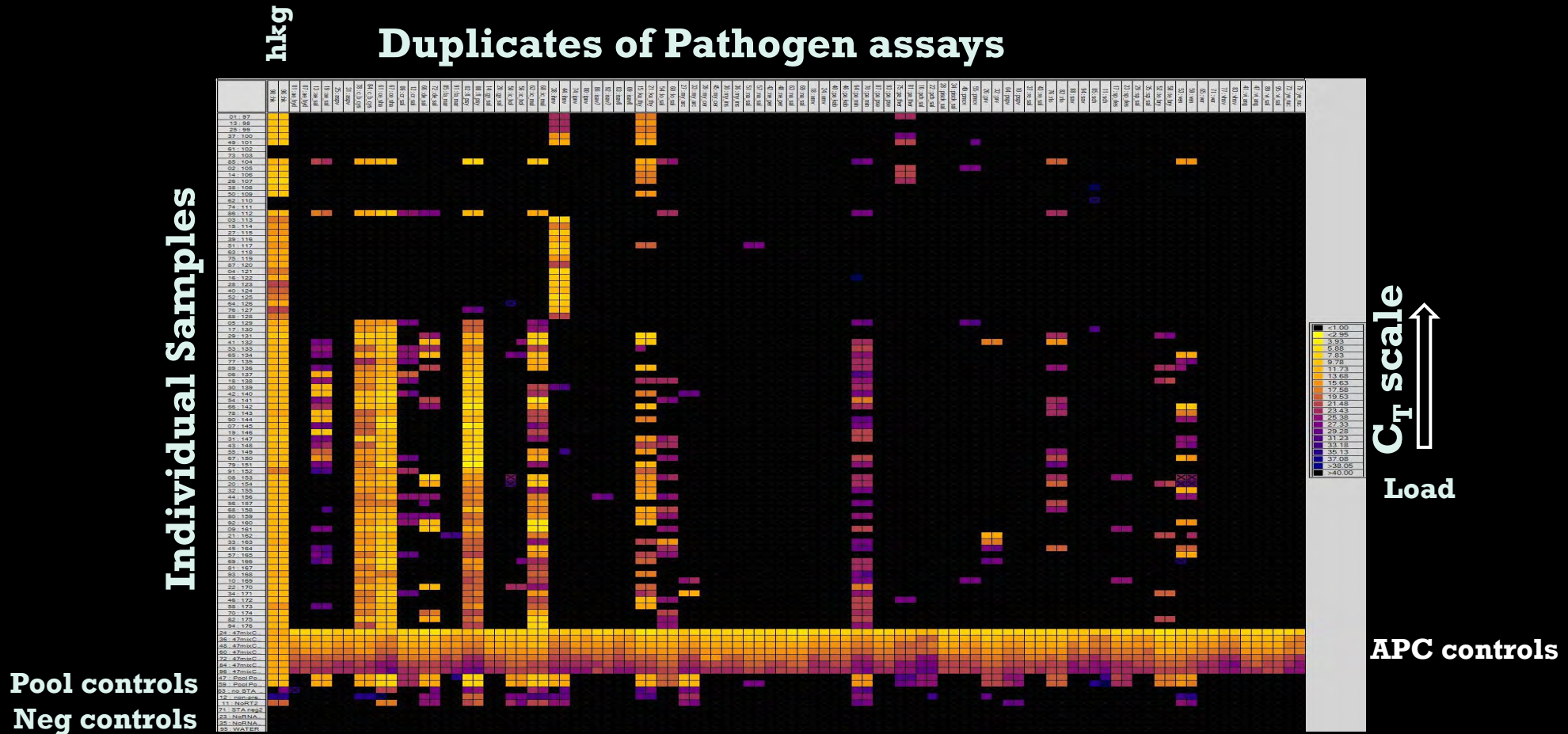
Identify molecular biomarkers that can recognize specific stressor and disease states

Genomic Tool to address salmon health

- Fluidigm BioMark™ Microfluidics System
 - High Throughput qRT-PCR
 - 96x96 Dynamic Array = 9,216 reactions / run
 - 96 individuals tested against 96 assays
 - Pathogens/harmful algal bloom species
 - Host gene expression



Fluidigm Biomark: Pathogen detection

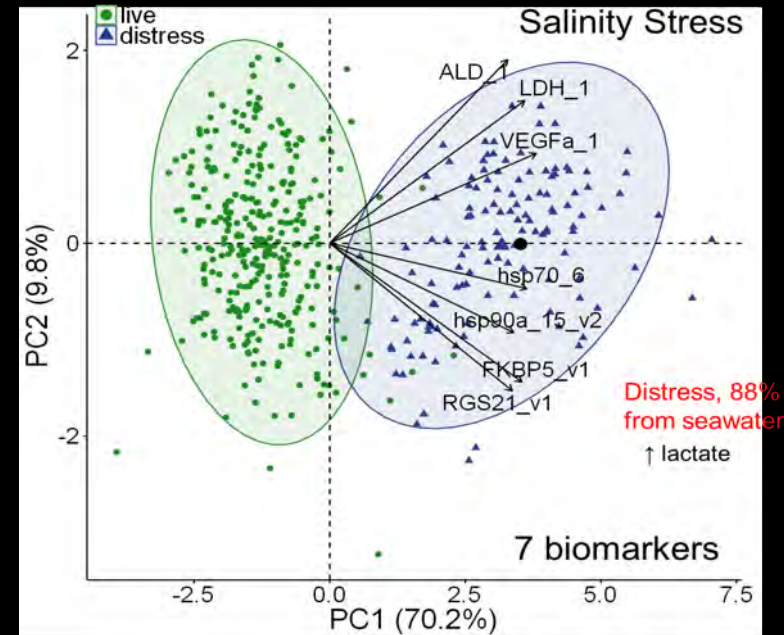
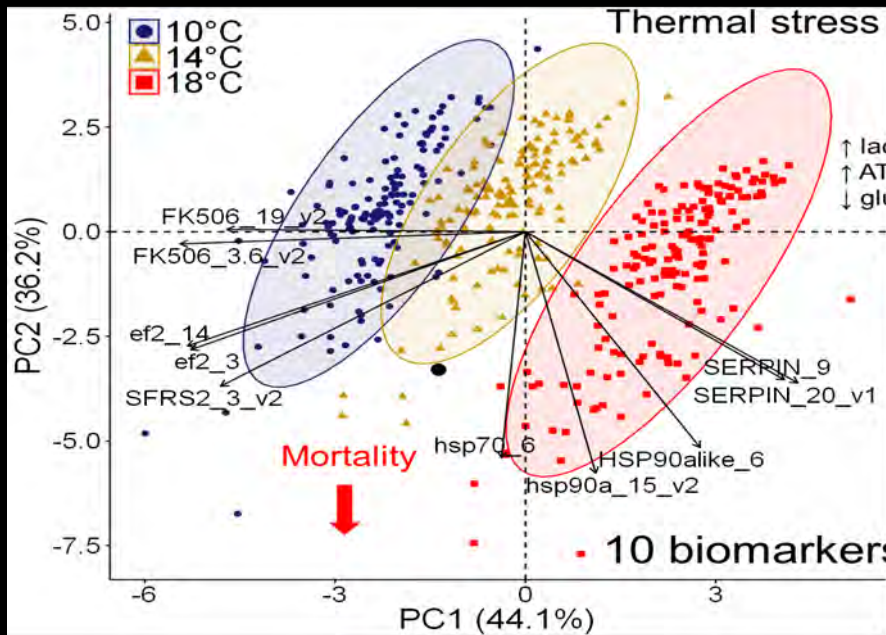




Health and Condition Salmon Fit-Chips

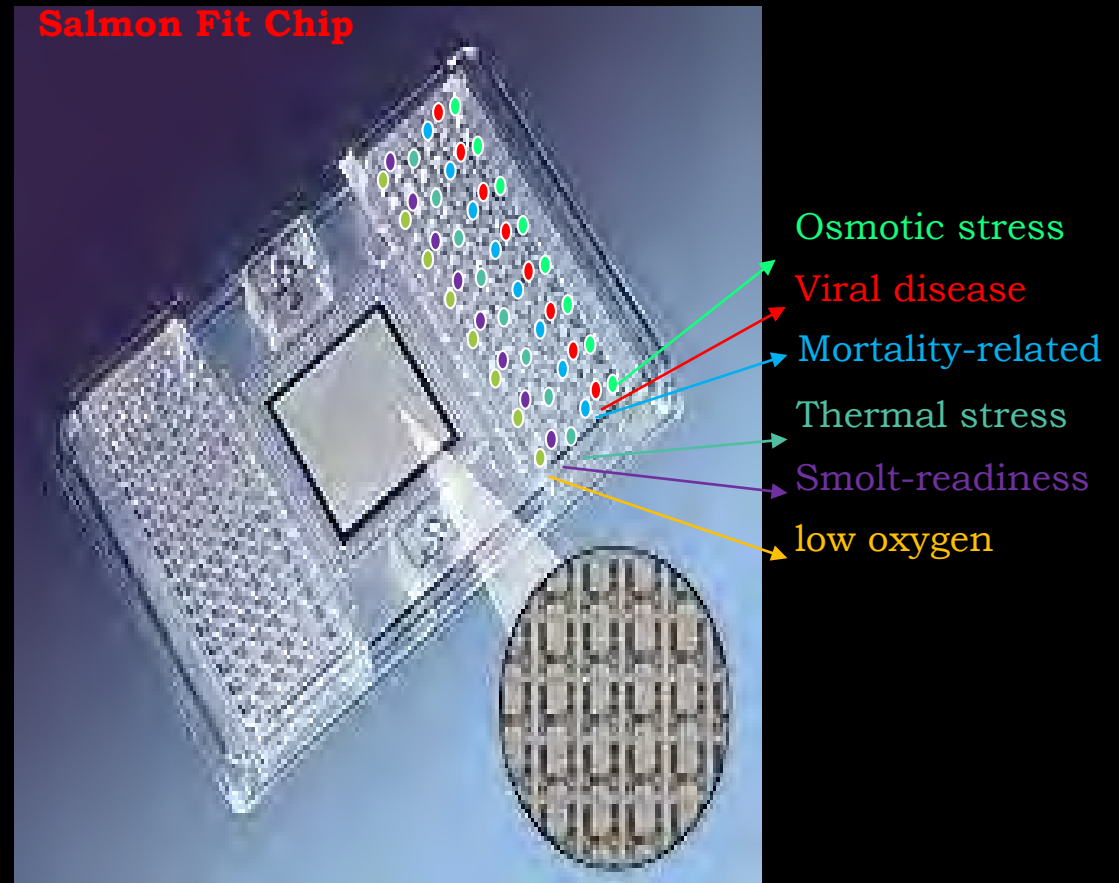


- Non-destructive gill clips to characterize stress and infection
- Biomarker panels of 8-10 genes per stressors/disease state
 - From transcriptome challenge studies
 - Validated in laboratory trials



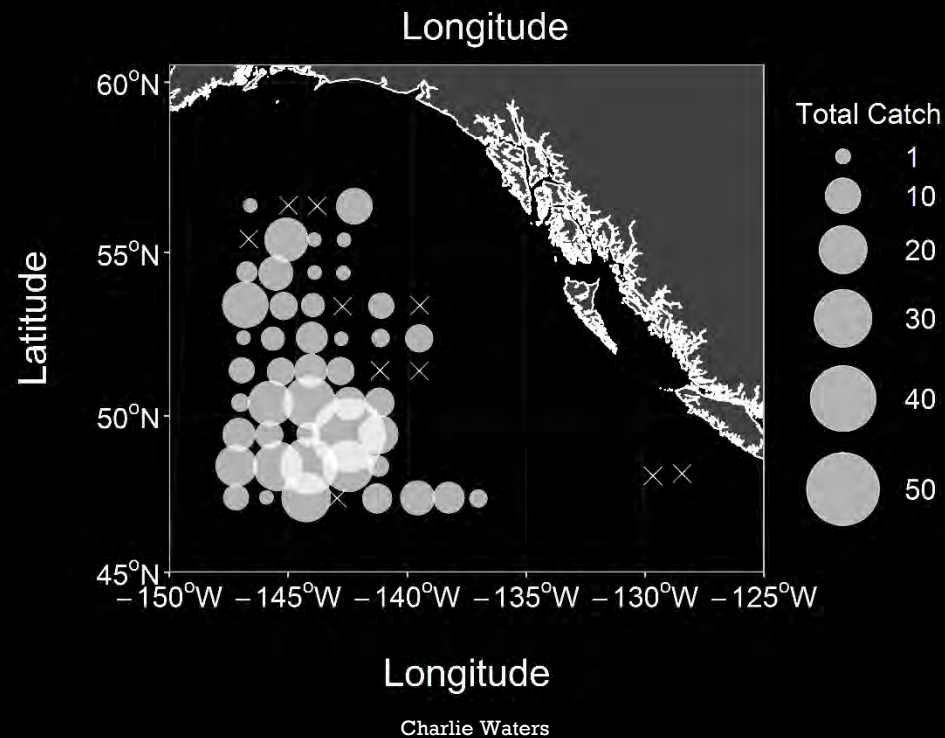
Fluidigm Biomark: Stressor Detection

- Curated host biomarker panels to identify specific stressor/disease states
 - Thermal stress
 - Osmotic stress
 - Hypoxia stress
 - Inflammation
 - Viral disease
 - Immune status
 - Imminent Mortality



IYS GoA Expedition – Unique insights into the salmon lifecycle

- Poorly understood oceanic phase of salmon lifecycle
- May contribute to variable ocean returns
 - As critically as early coastal marine life?
- Compare “health” to coastal margin



IYS GoA - Sample Collection

- Collected and dissected 255 salmon
 - Coho 80/94
 - Chum 84/223
 - Chinook 3/3
 - Pink 27/31
 - Sockeye 61/73
- Assistance:
 - **Alexey, Albina, Svetlana**



Pathogen detection in overwintering GoA Salmon

- Tested for 47 pathogens
 - 20 viruses (*many newly characterized in BC salmon)
 - 16 parasites
 - 11 bacteria

Aeromonas salmonicida

Candidatus Branchiomonas cysticola

Piscichlamydia salmonis

Piscirickettsia salmonis

Renibacterium salmoninarum

Rickettsia-like organism (RLO)

Gill chlamydia (Sch)

Tenacibaculum maritimum

Vibrio anguillarum

Vibrio salmonicida

Yersinia ruckeri

Ceratanova shasta

Dermocystidium salmonis

Ichthyophonus hoferi

Ichthyophthirius multifiliis

Kudoa thyrsites

Loma salmonae

Myxobolus arcticus

Myxobolus insidiosus

Nanophyetus salmincola

Neoparamoeba perurans

Parvicapsula kabatai

Parvicapsula minibicornis

Parvicapsula pseudobranchicola

Paranucleospora theridion

Sphaerothecum destruens

Tetracapsuloides bryosalmonae

**Arenavirus I MGL*

**Arenavirus II MGL*

**Bafini virus*

**Circo virus*

**Coronavirus MGL*

**Cutthroat Trout Virus MGL*

**Hantavirus*

**Nidovirus 2*

**Orthomyxovirus MGL*

**Picorna virus*

Piscine orthoreovirus

**Pacific salmon parvovirus*

**Qin virus*

**Reovirus MGL*

**Rhabdo virus*

SalmovirusWFRC1_virus

**MGL Small unknown RNA Virus*

Viral erythrocytic necrosis virus

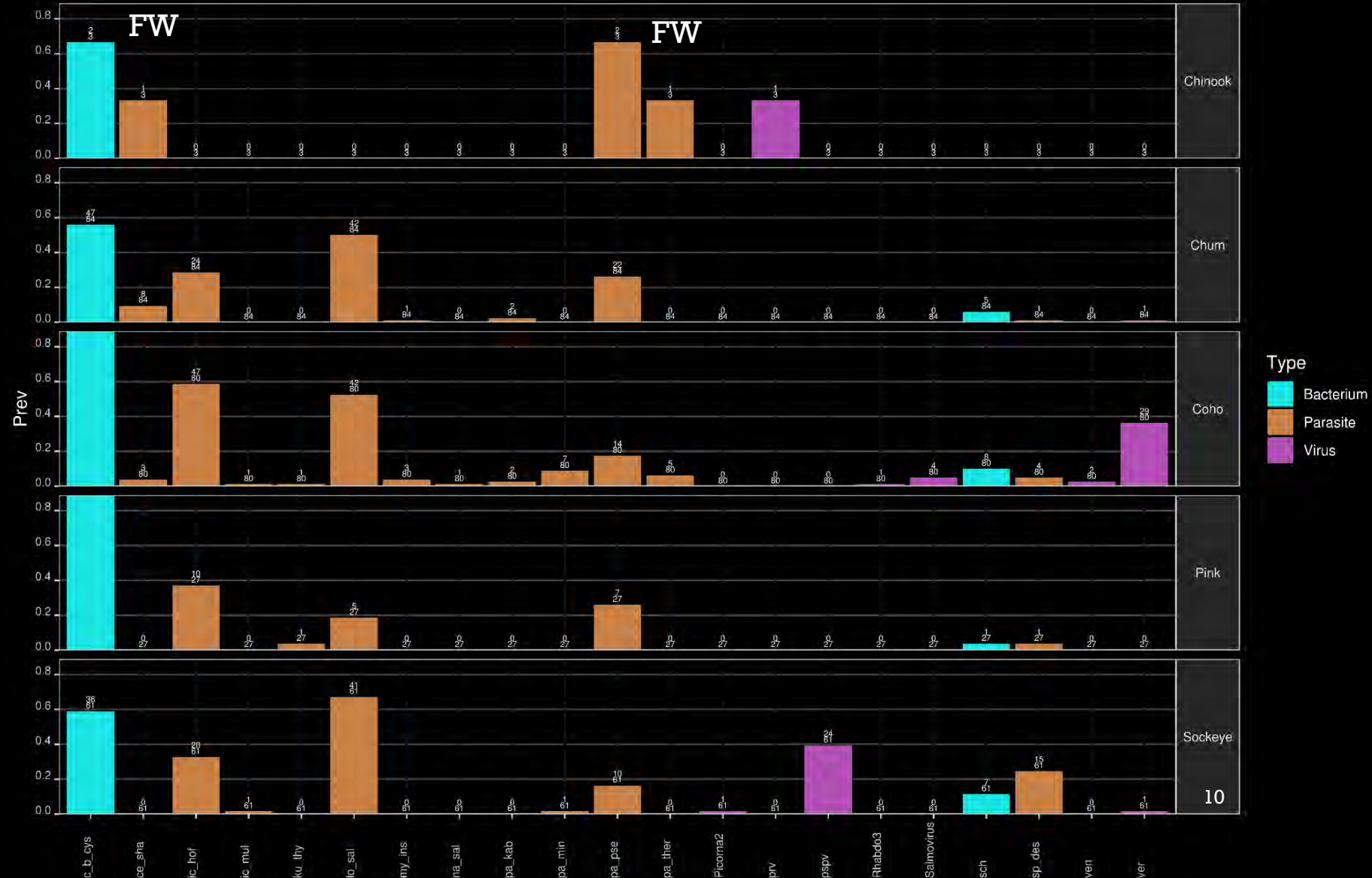
Viral encephalopathy and retinopathy virus

Viral hemorrhagic septicemia virus

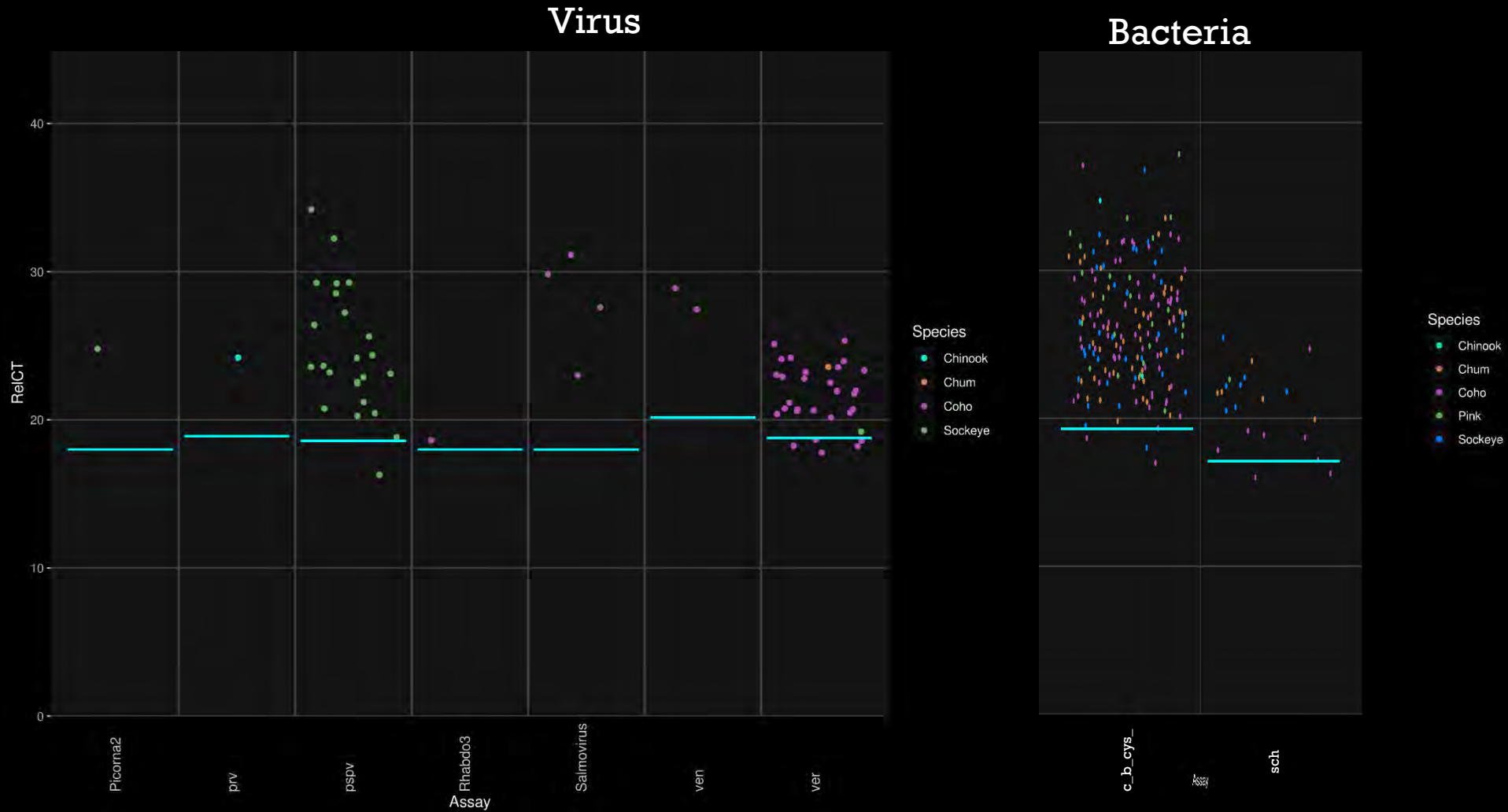
Housekeeping gene

Prevalence of 20 agents detected in GoA

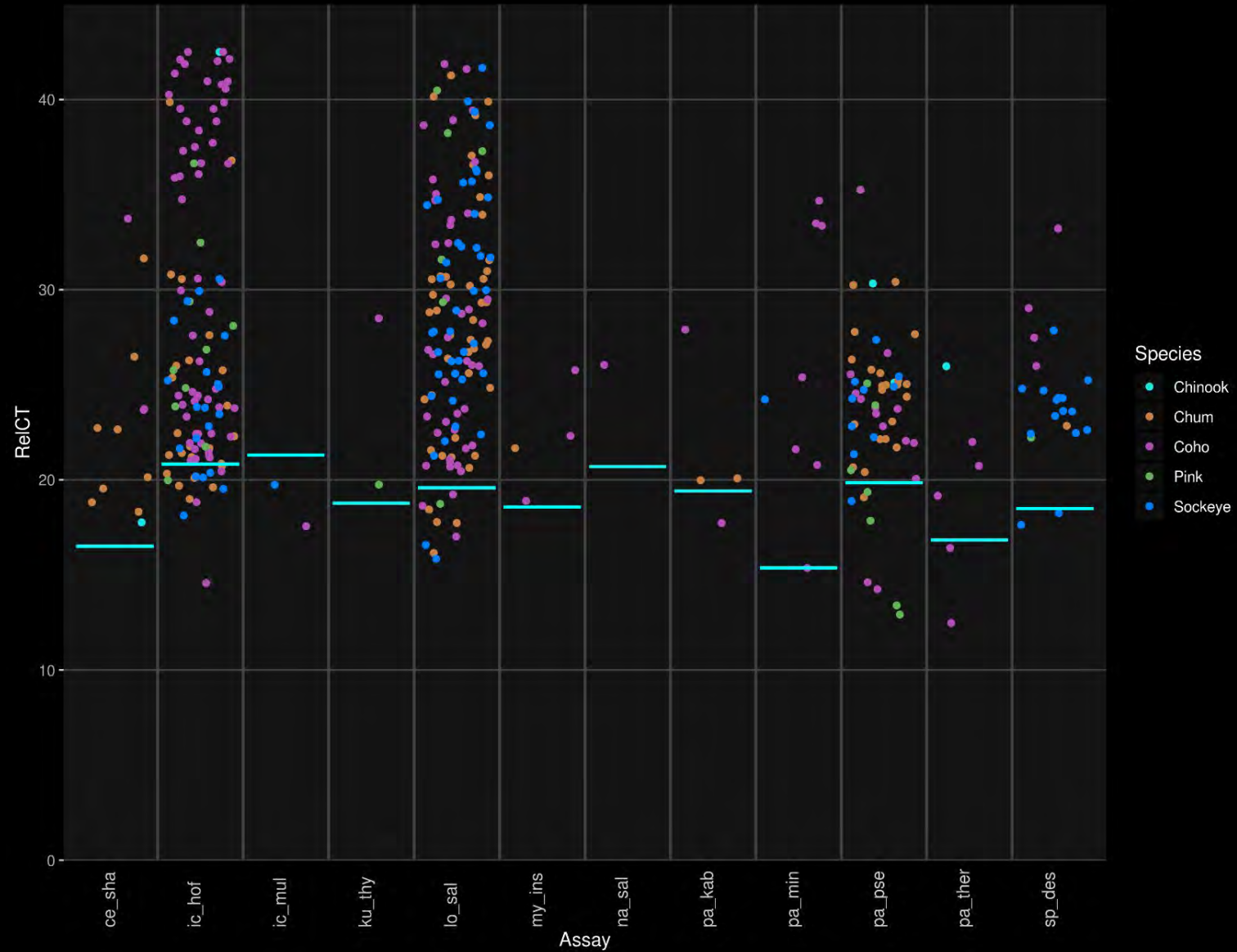
- Candidatus Branchiomonas cysticola**
- Ceratanova shasta**
- Ichthyophonus hoferi**
- Ichthyophthirius multifiliis**
- Kudoa thyrsites**
- Loma salmonae**
- Myxobolus insidiosus**
- Nanophyetus salmincola**
- Parvicapsula kabatai**
- Parvicapsula minibicornis**
- Parvicapsula pseudobranchicola**
- Paranucleospora theridion**
- Picornavirus***
- Piscine orthoreovirus**
- Pacific salmon parvovirus***
- *Rhabdovirus**
- SalmovirusWFRC1_virus***
- Gill chlamydia (Sch)**
- Sphaerothecum destruens**
- Erythrocytic necrosis virus**
- Encephalopathy and retinopathy virus**



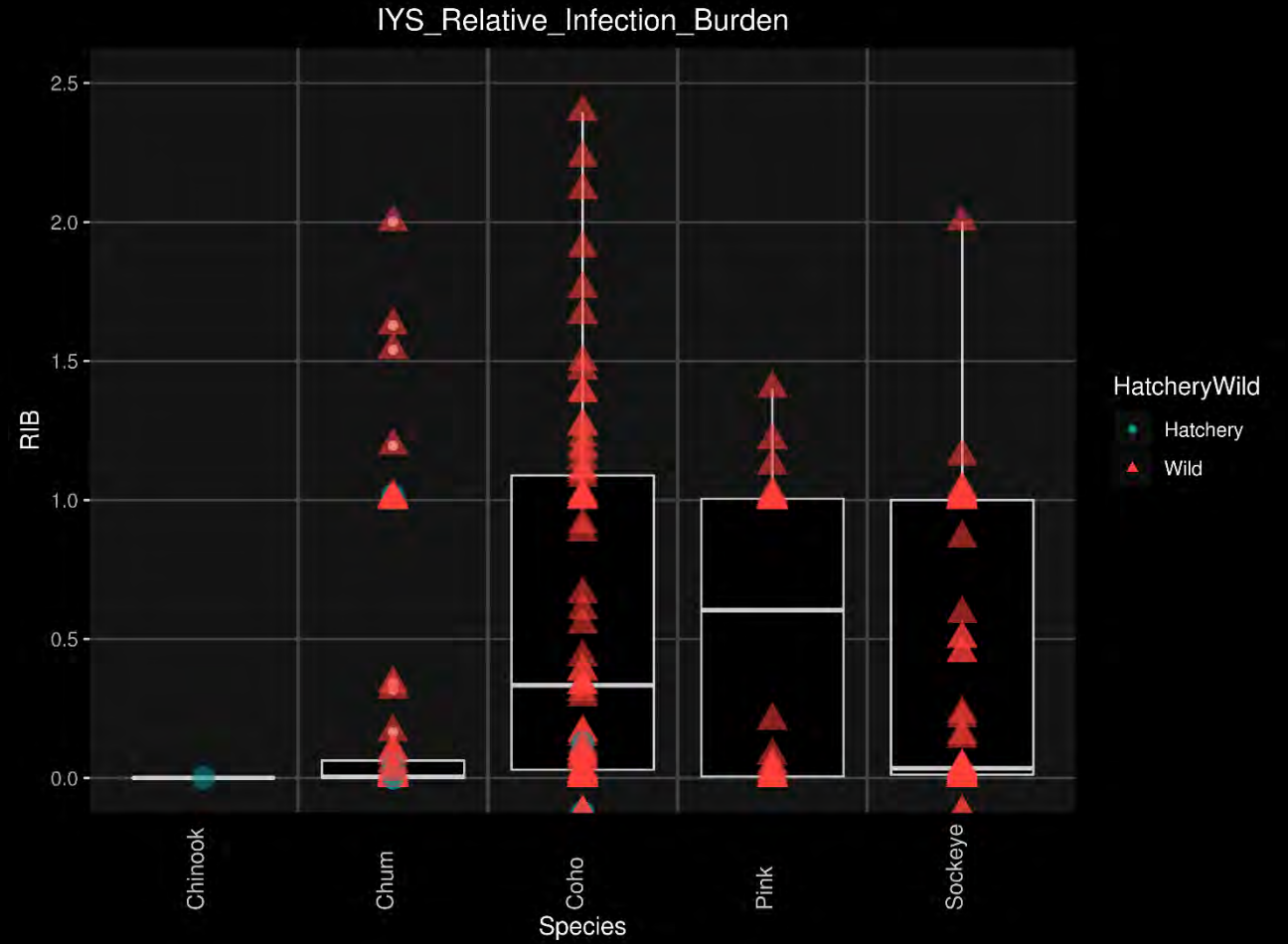
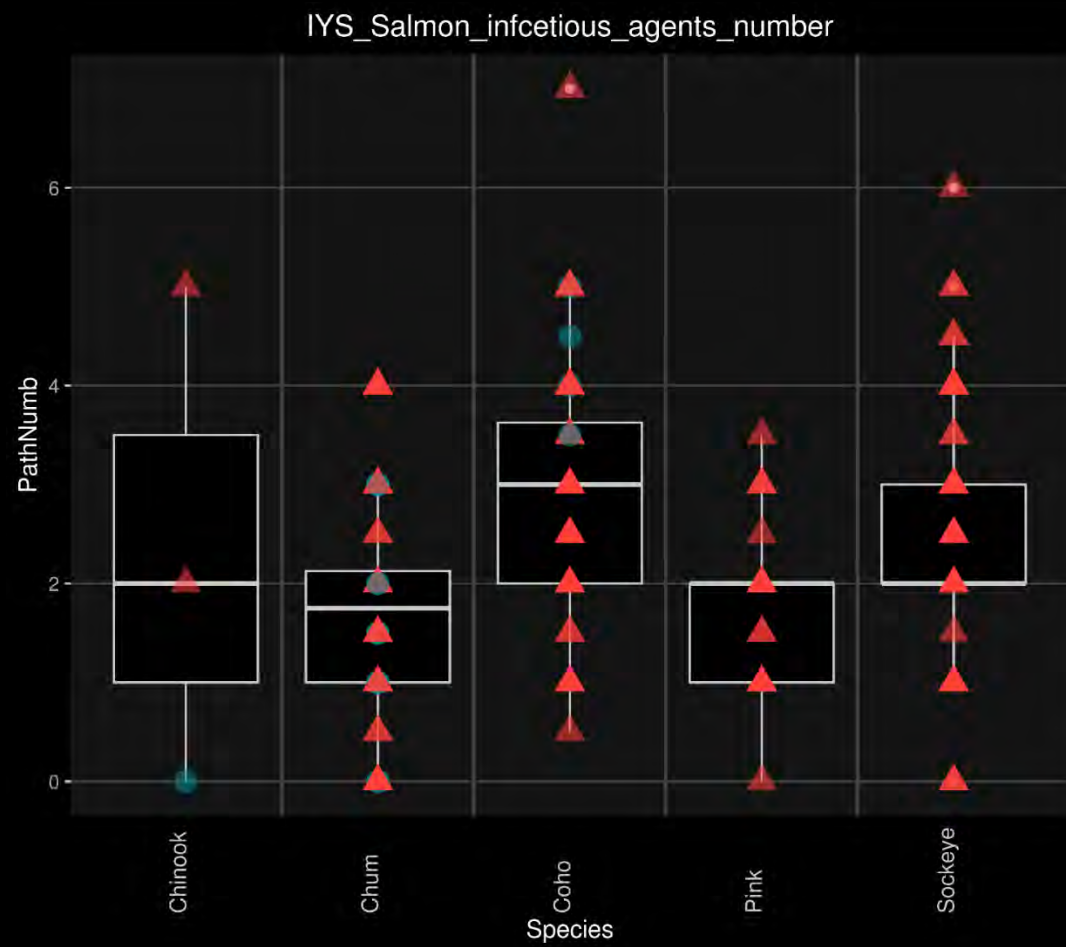
Pathogen-Load: Viruses - Bacteria



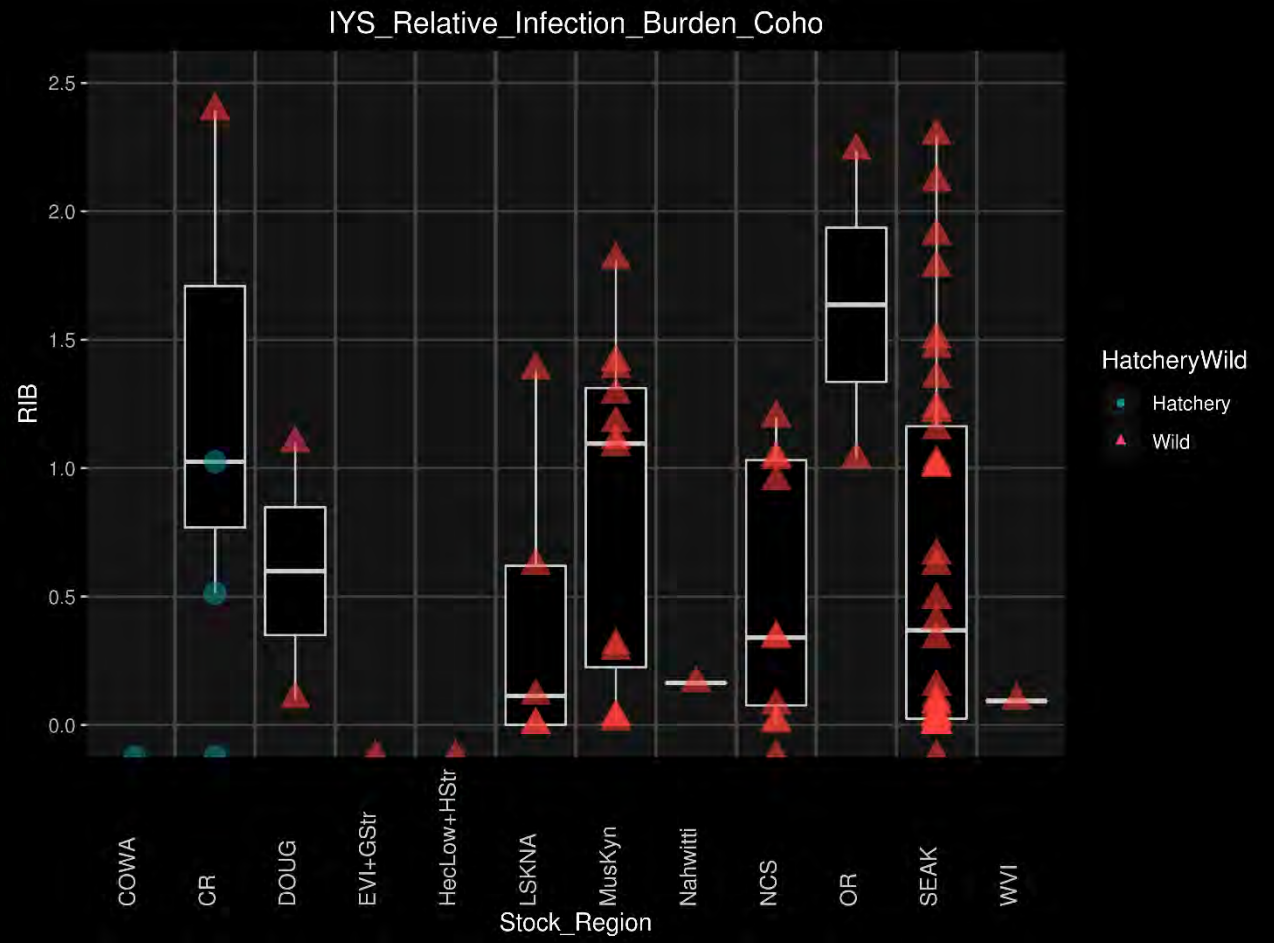
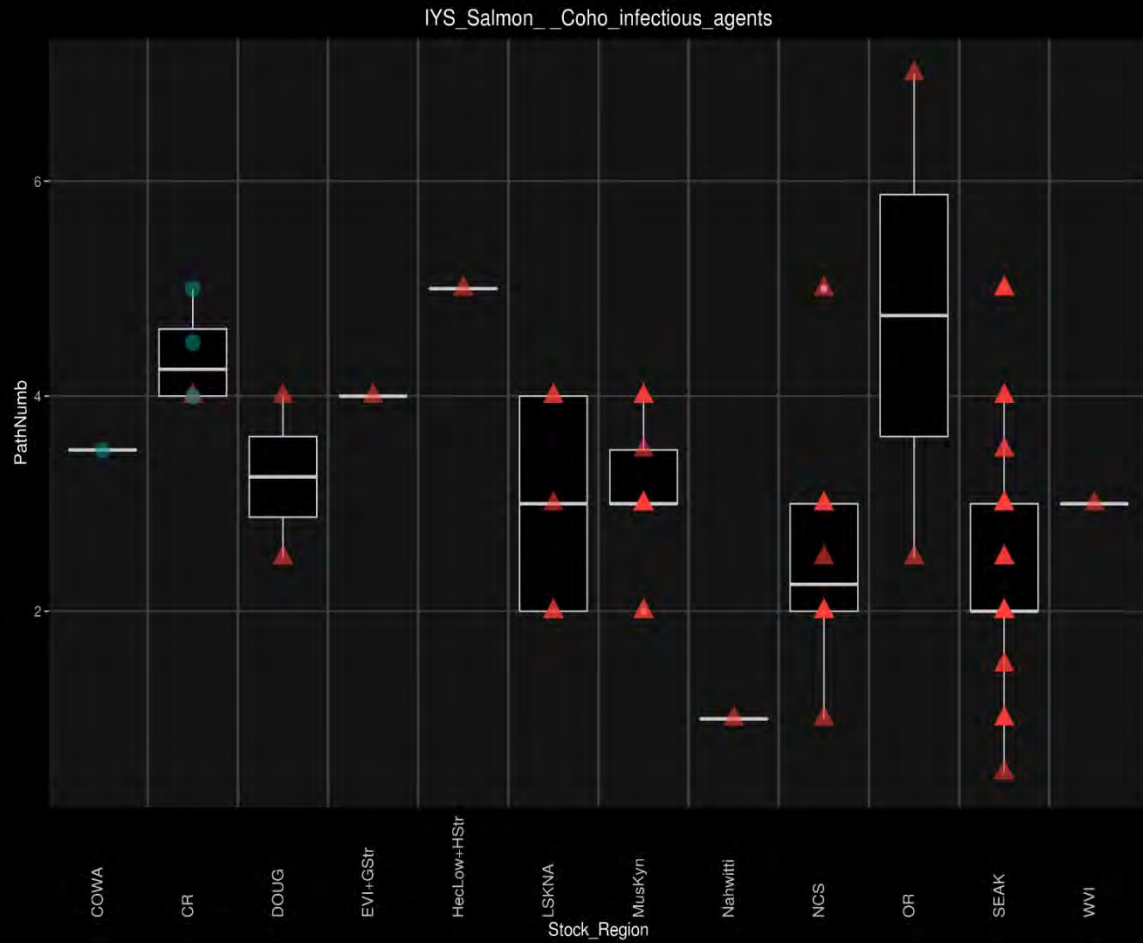
Pathogen-Load: Parasites



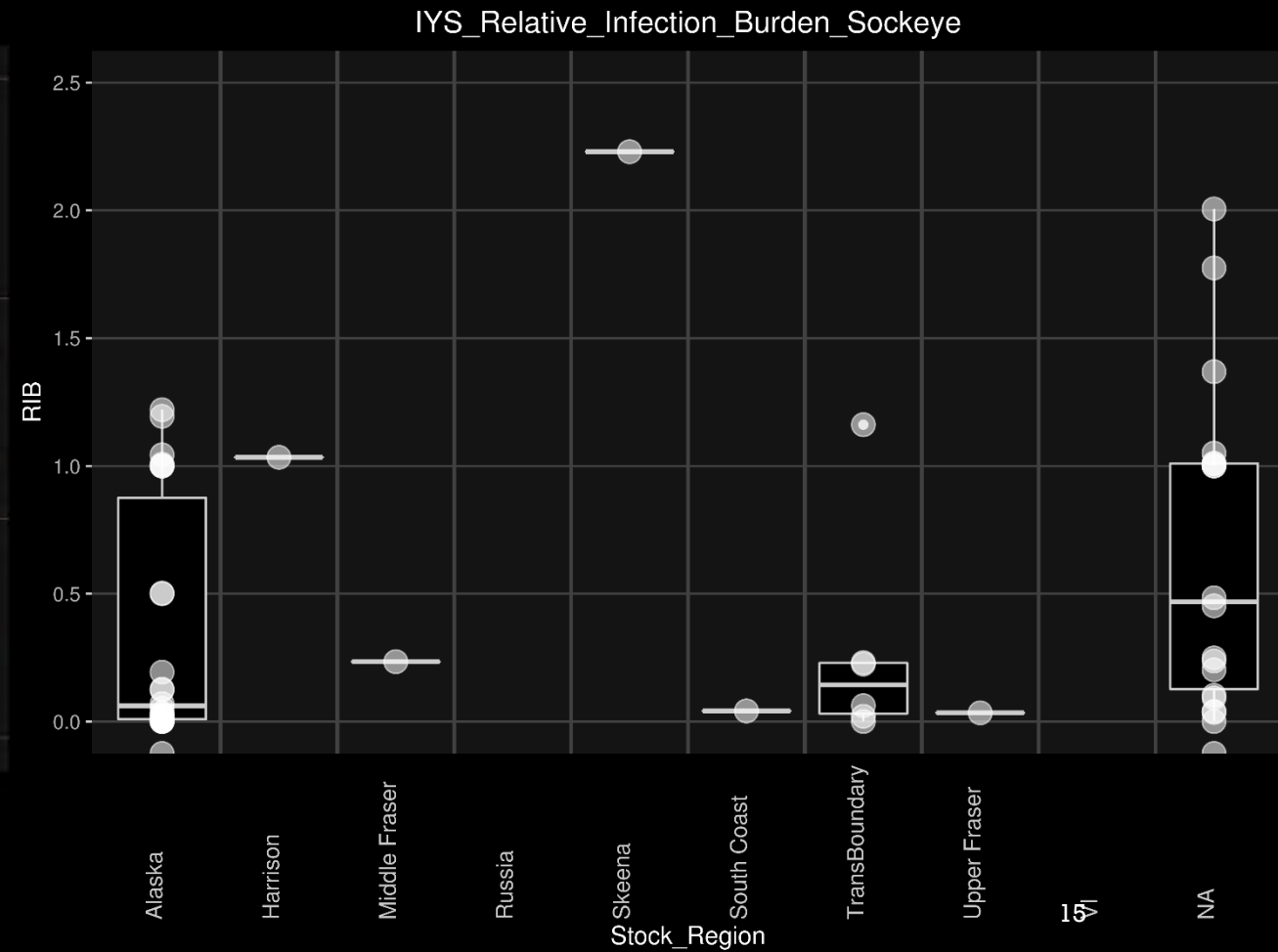
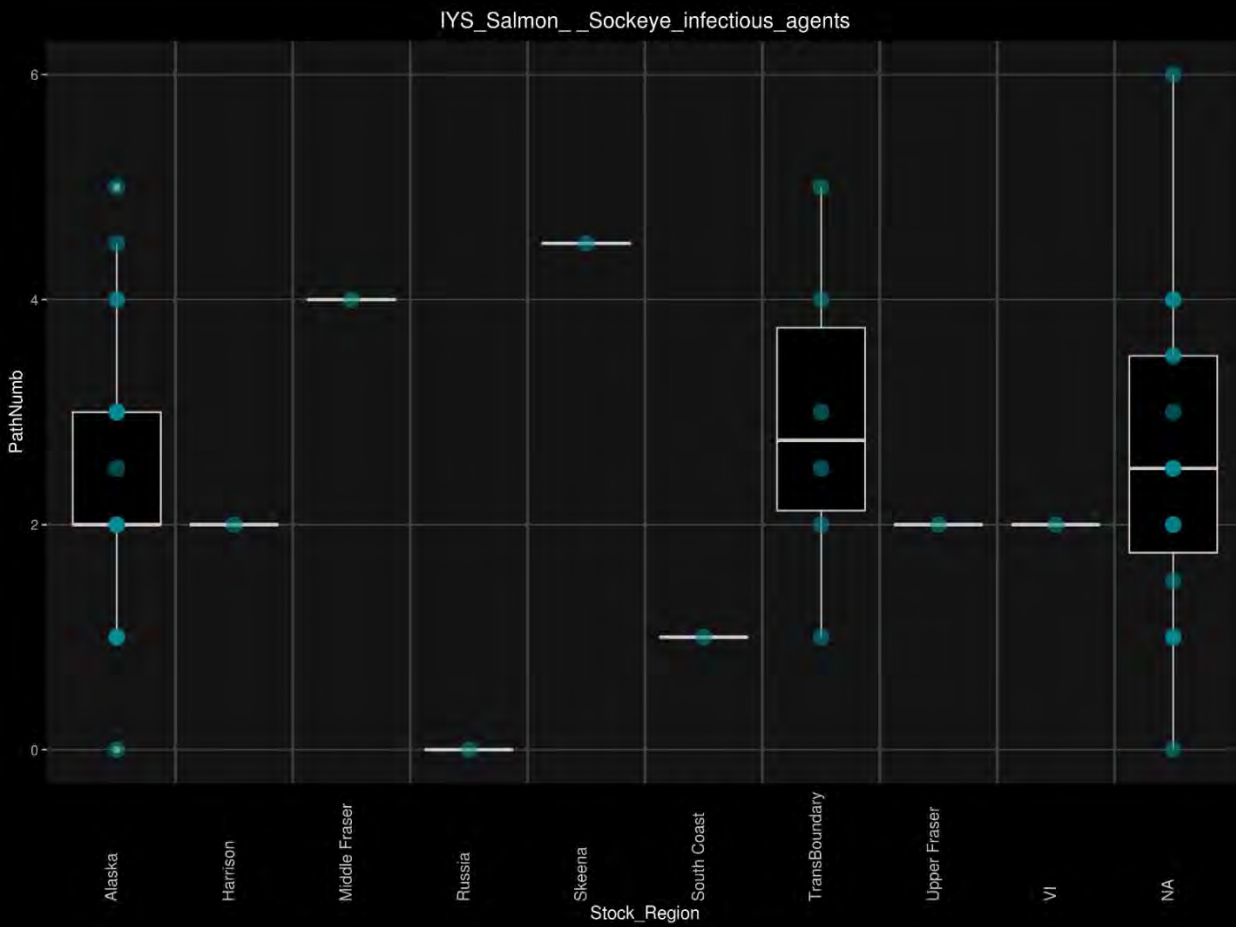
Pathogen number by species



Coho pathogens by stock (N=80)

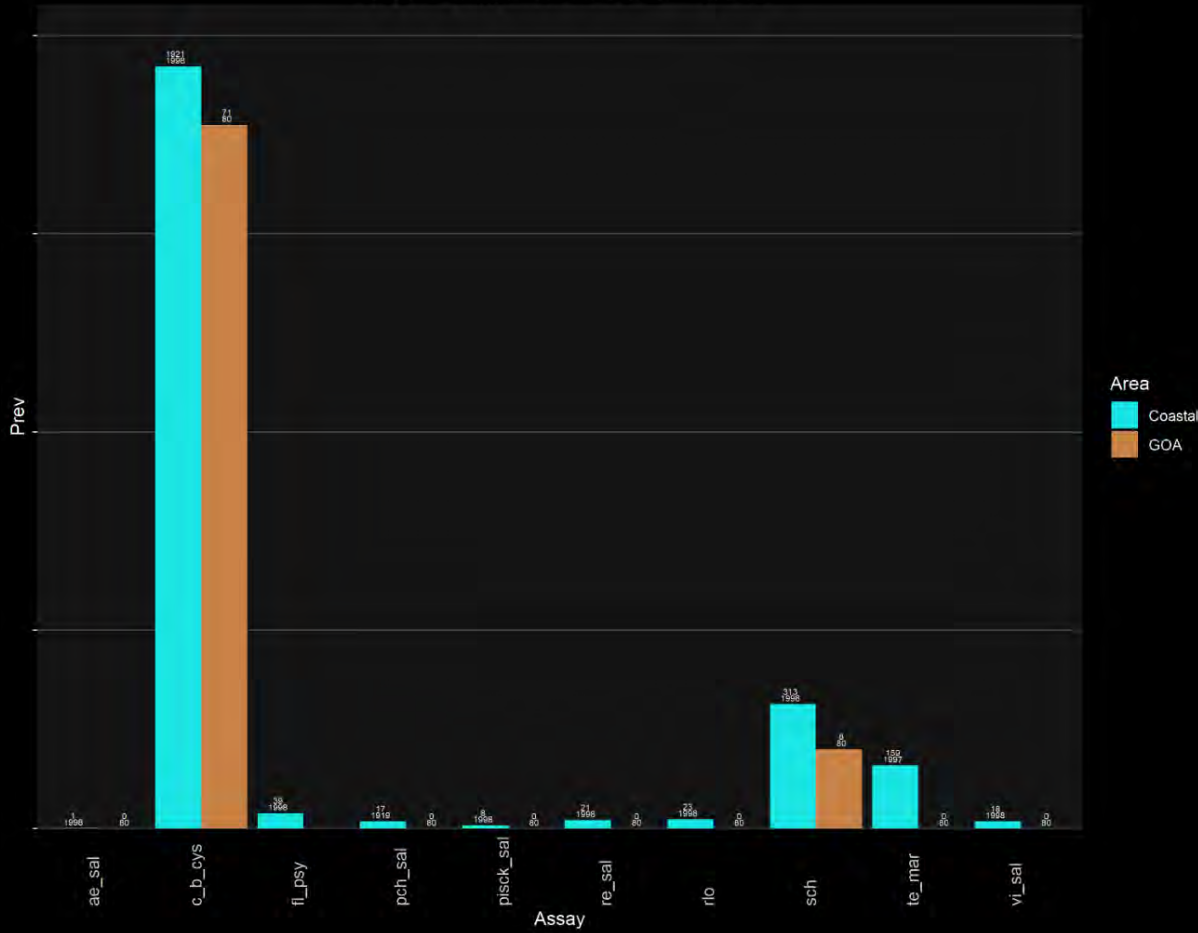


Sockeye pathogens by stock (N=61)

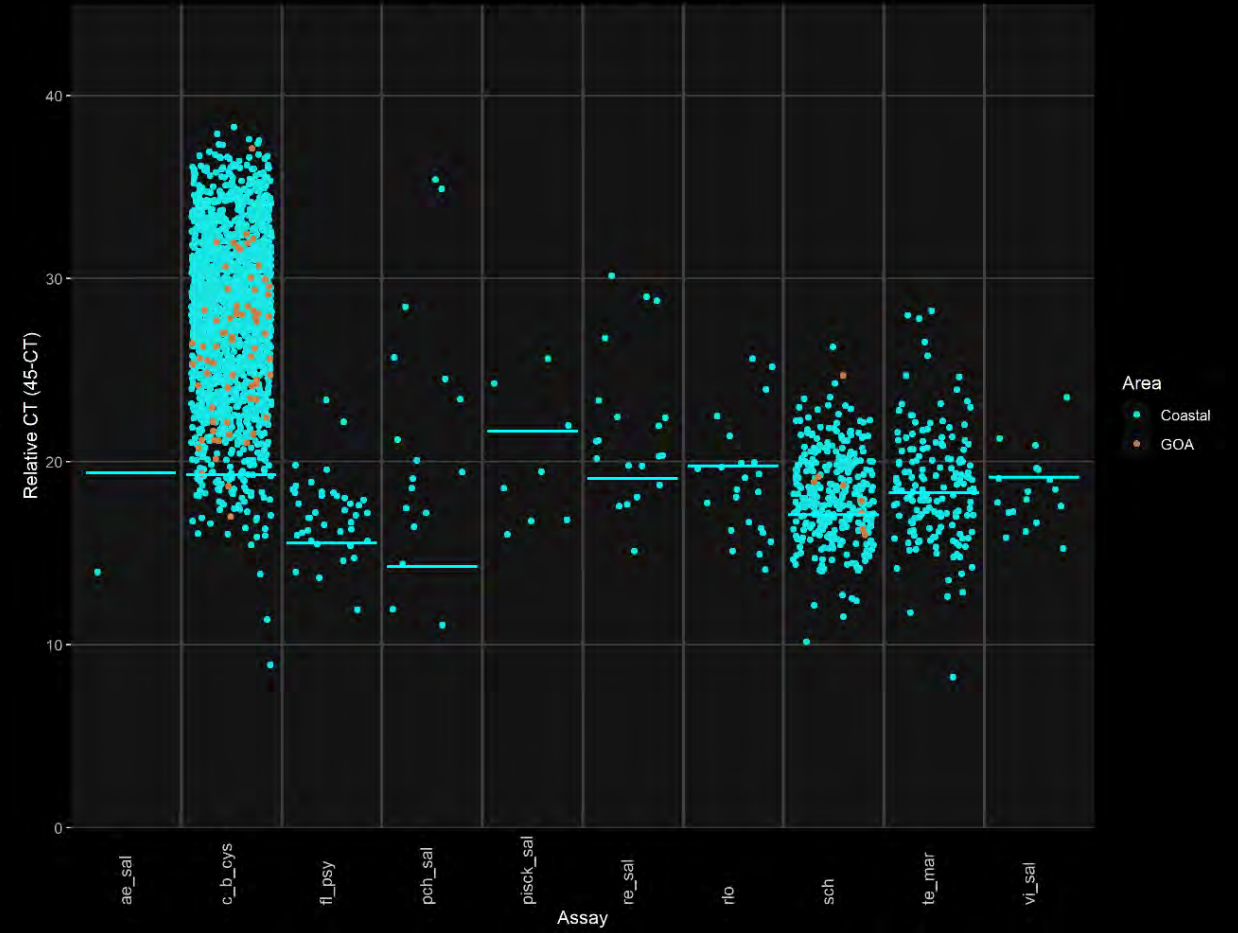


GoA vs BC Coast: Coho - Bacteria

IYS Coho Comparisons Bacterium No LOD

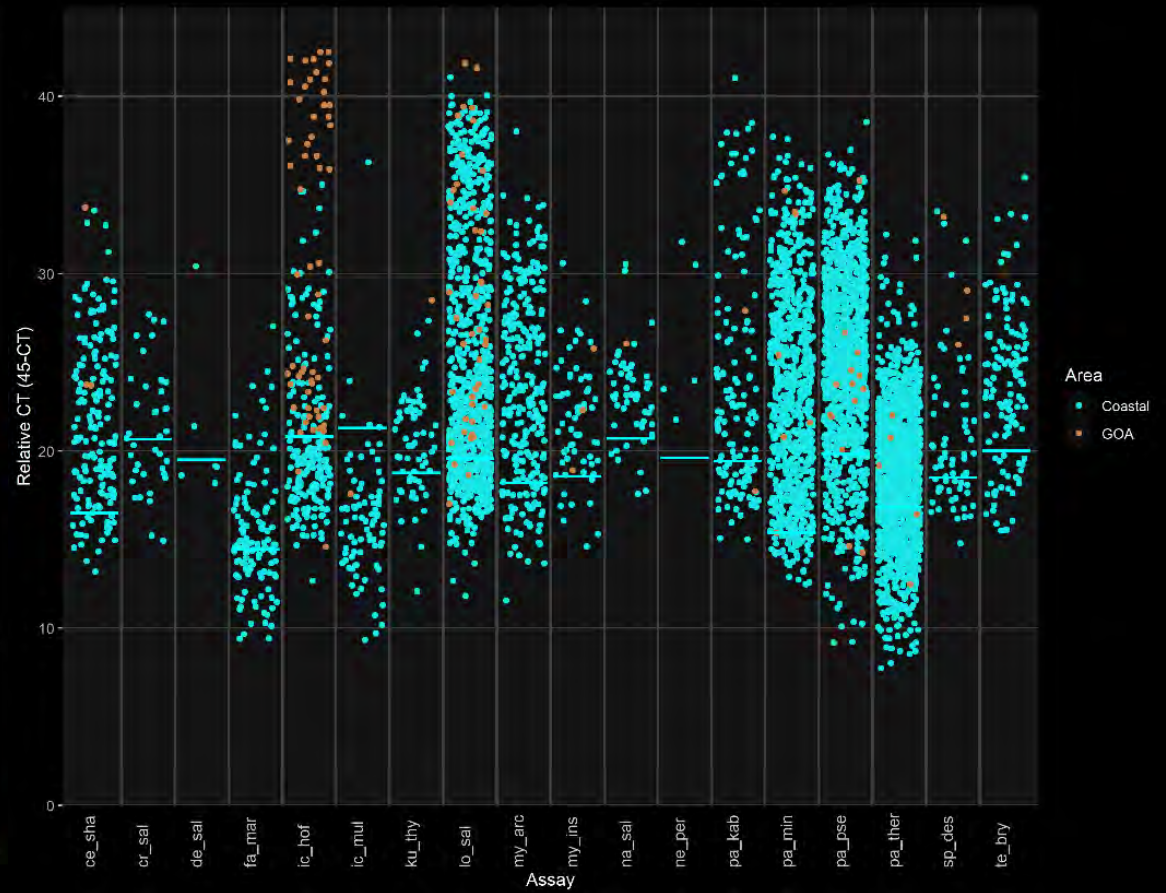
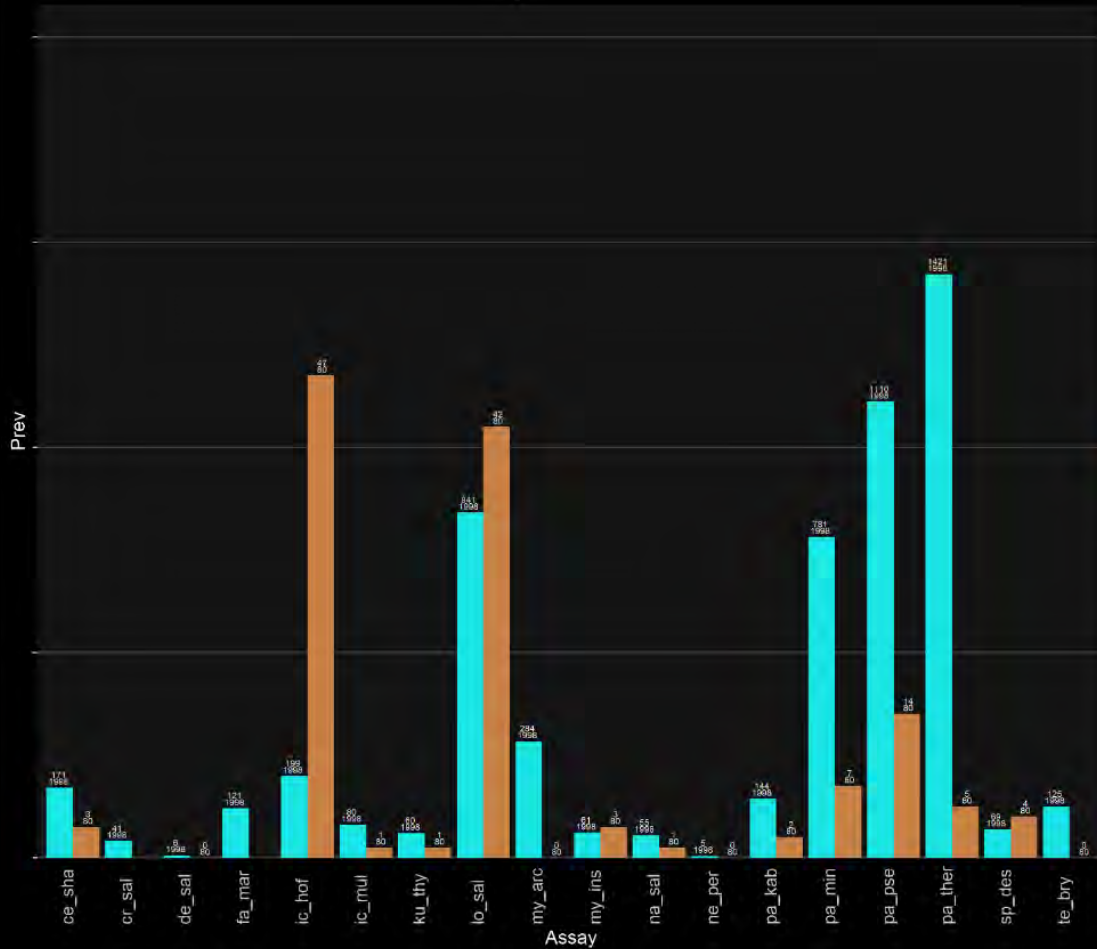


Coastal-GOA Bacterium Rel CT



Candidatus Branchiomonas cysticola
Gill chlamydia

GoA vs BC Coast: Coho - Parasites



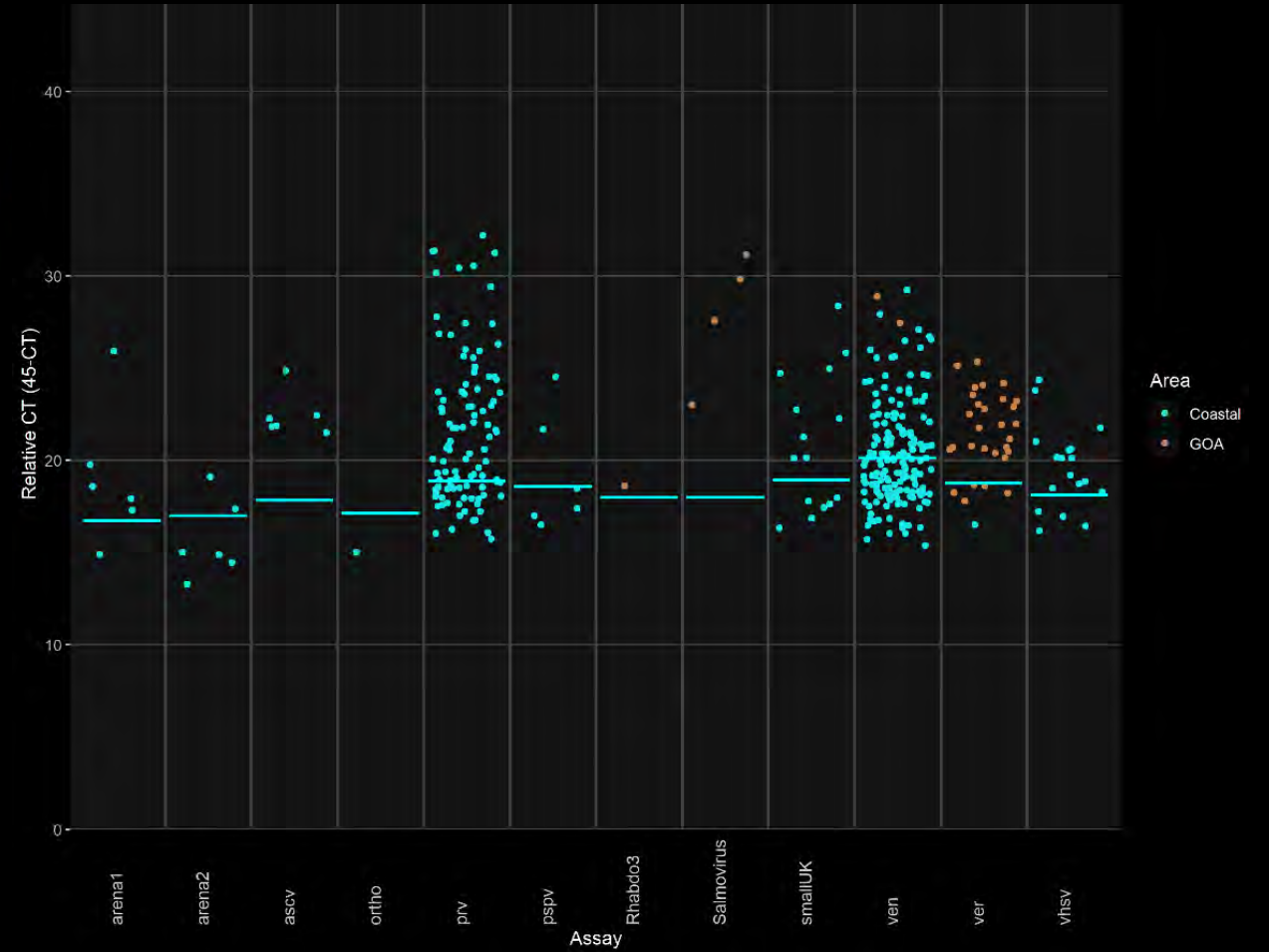
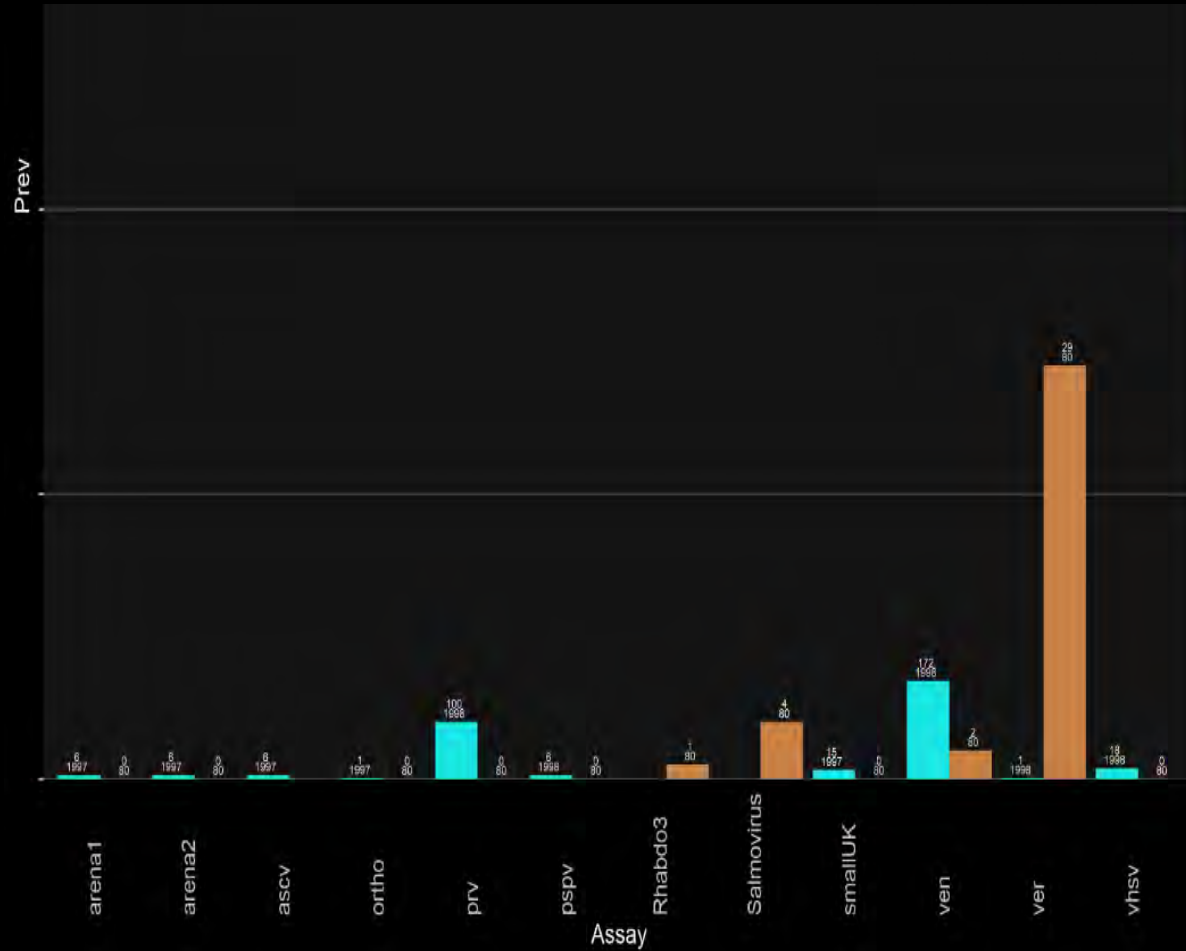
Ichthyophonus hoferi
Loma salmonae
(Sphaerothecum destruens)

FW:



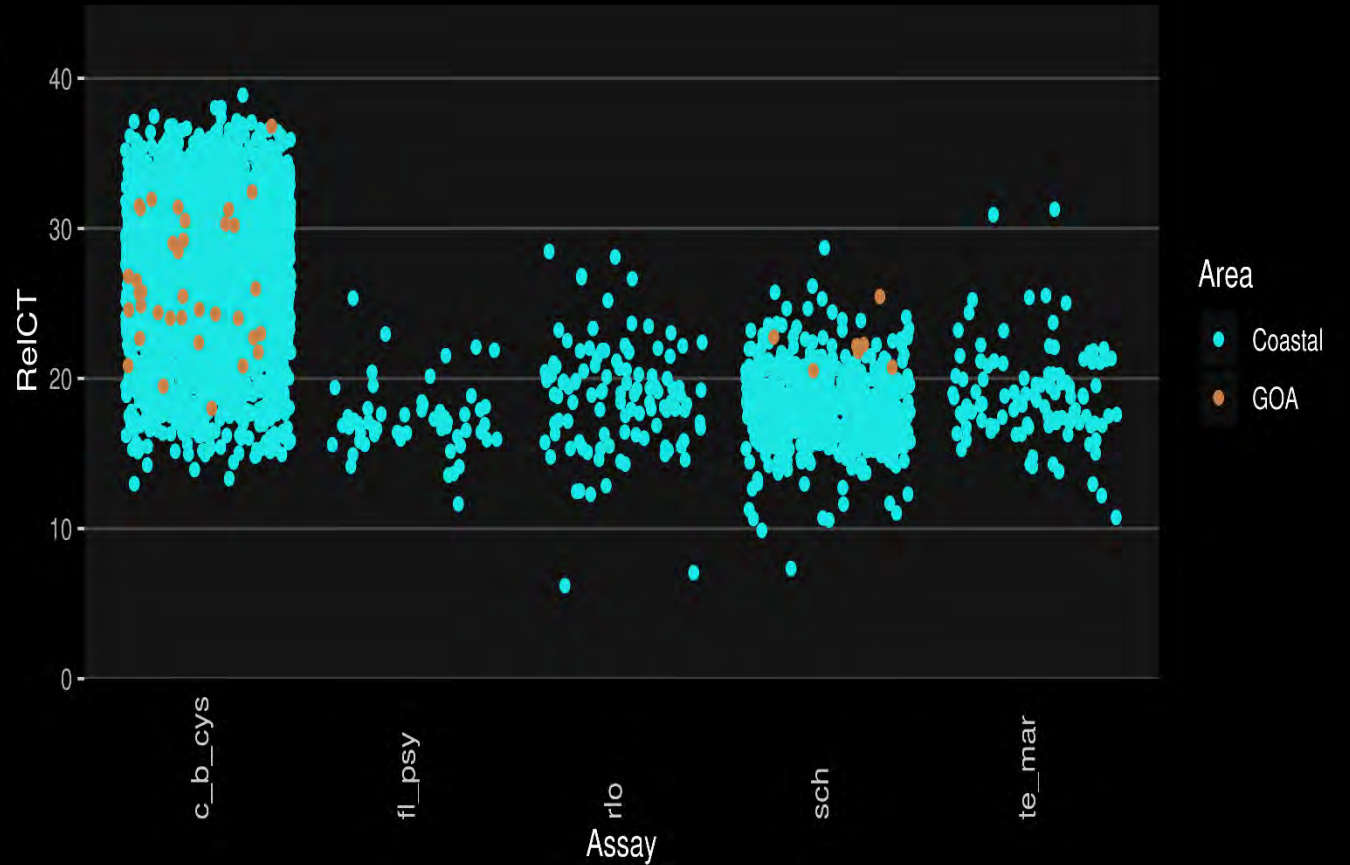
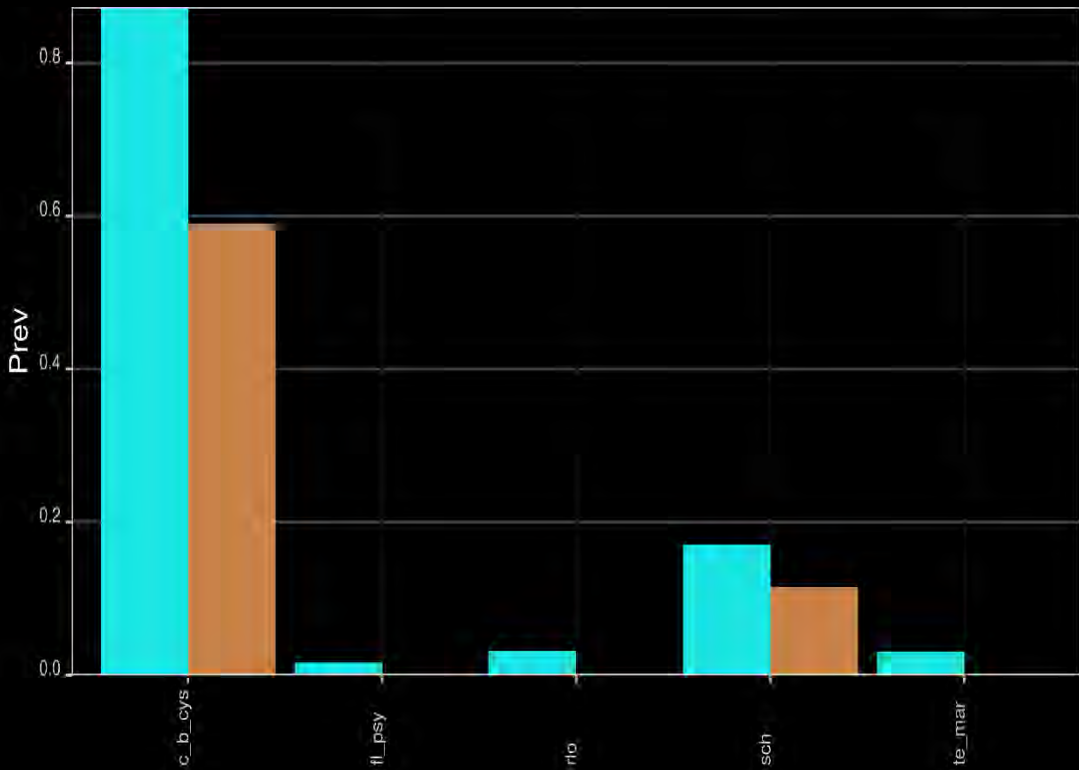
Ceratonova Shasta
Parvicapsula spp
Myxobolus insidiosus

GoA vs BC Coast: Coho - Viruses



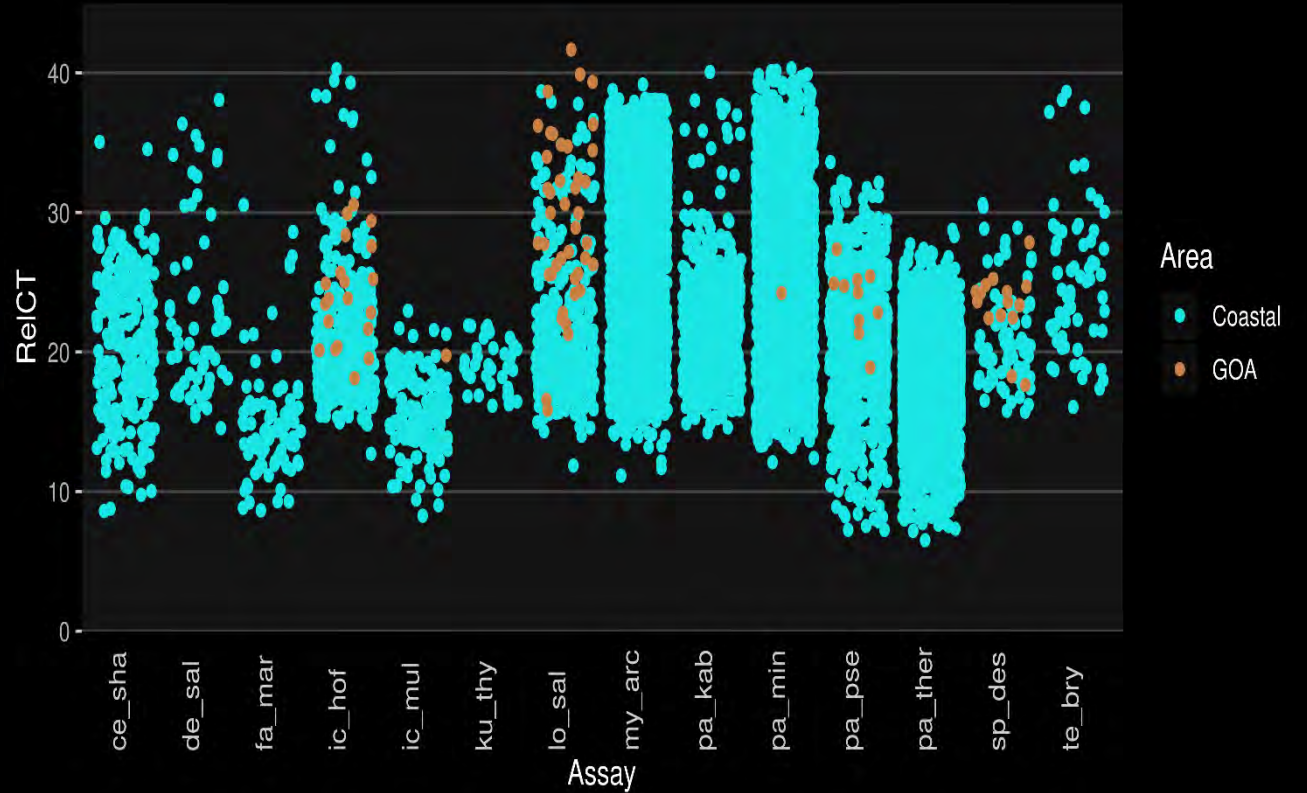
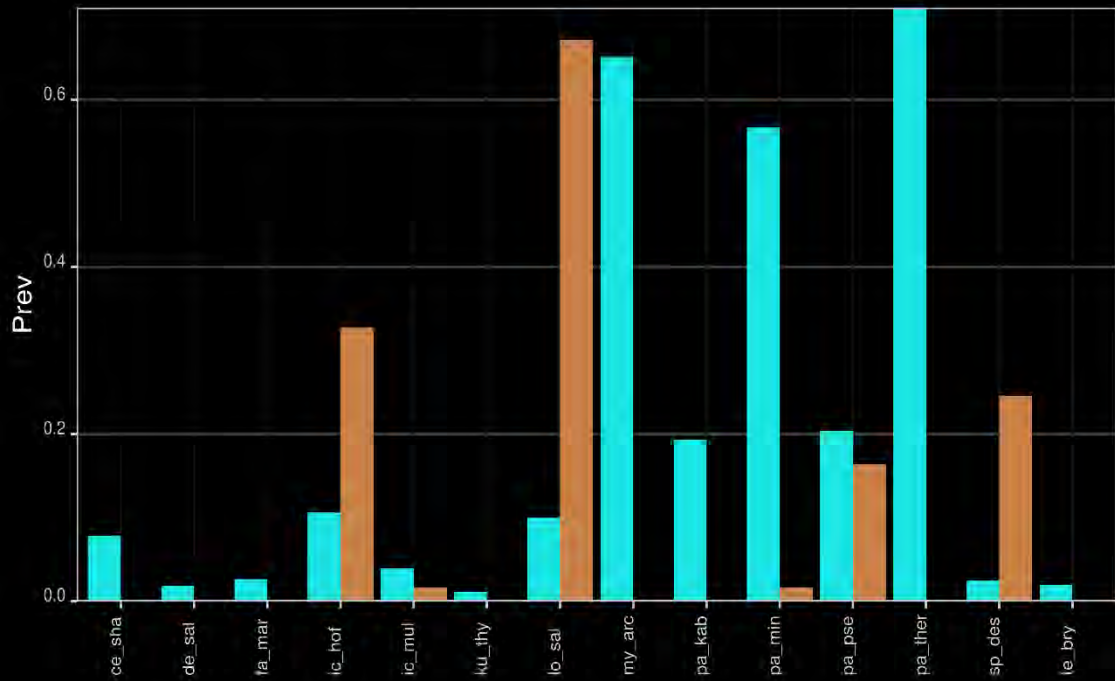

 Encephalopathy and retinopathy virus
 (SalmovirusWFRC1_virus)
 (*Rhabdo virus)


GoA vs BC Coast: Sockeye - Bacteria



C. B. cysticola
Gill chlamydia

GoA vs BC Coast: Sockeye - Parasites



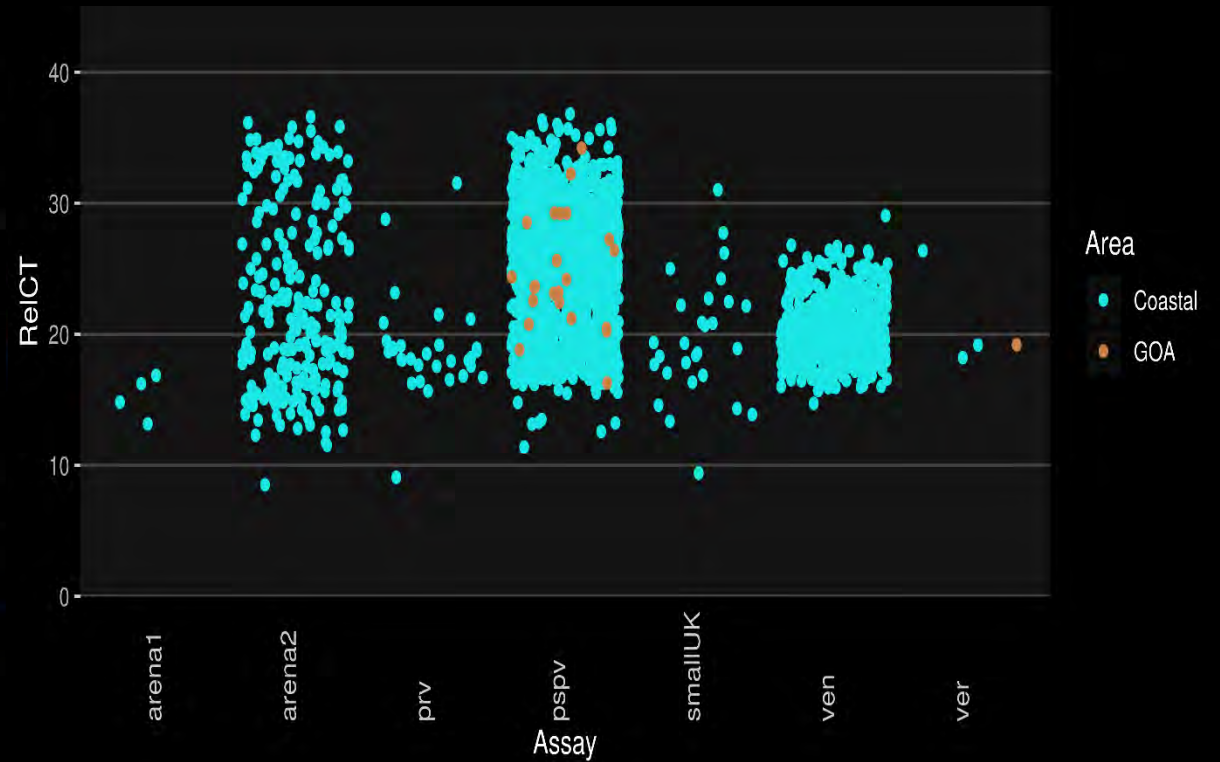
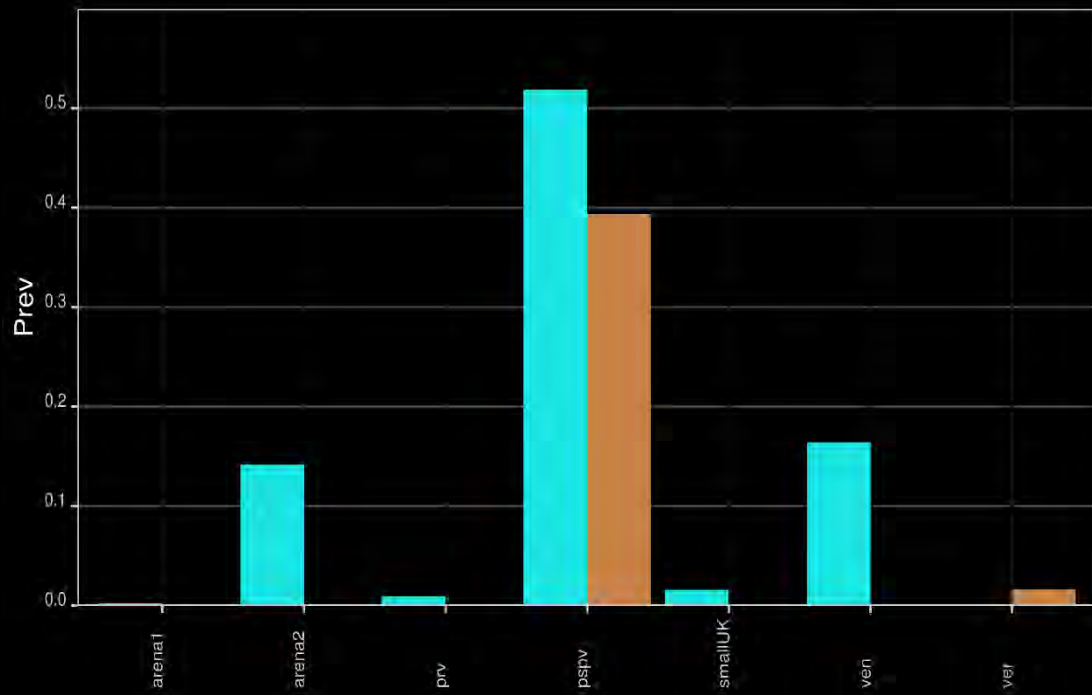


Ichthyophonus hoferi
Loma salmonae
Sphaerothecum destruens



Parvicapsula pseudobranchicola

GoA vs BC Coast: Sockeye - Viruses

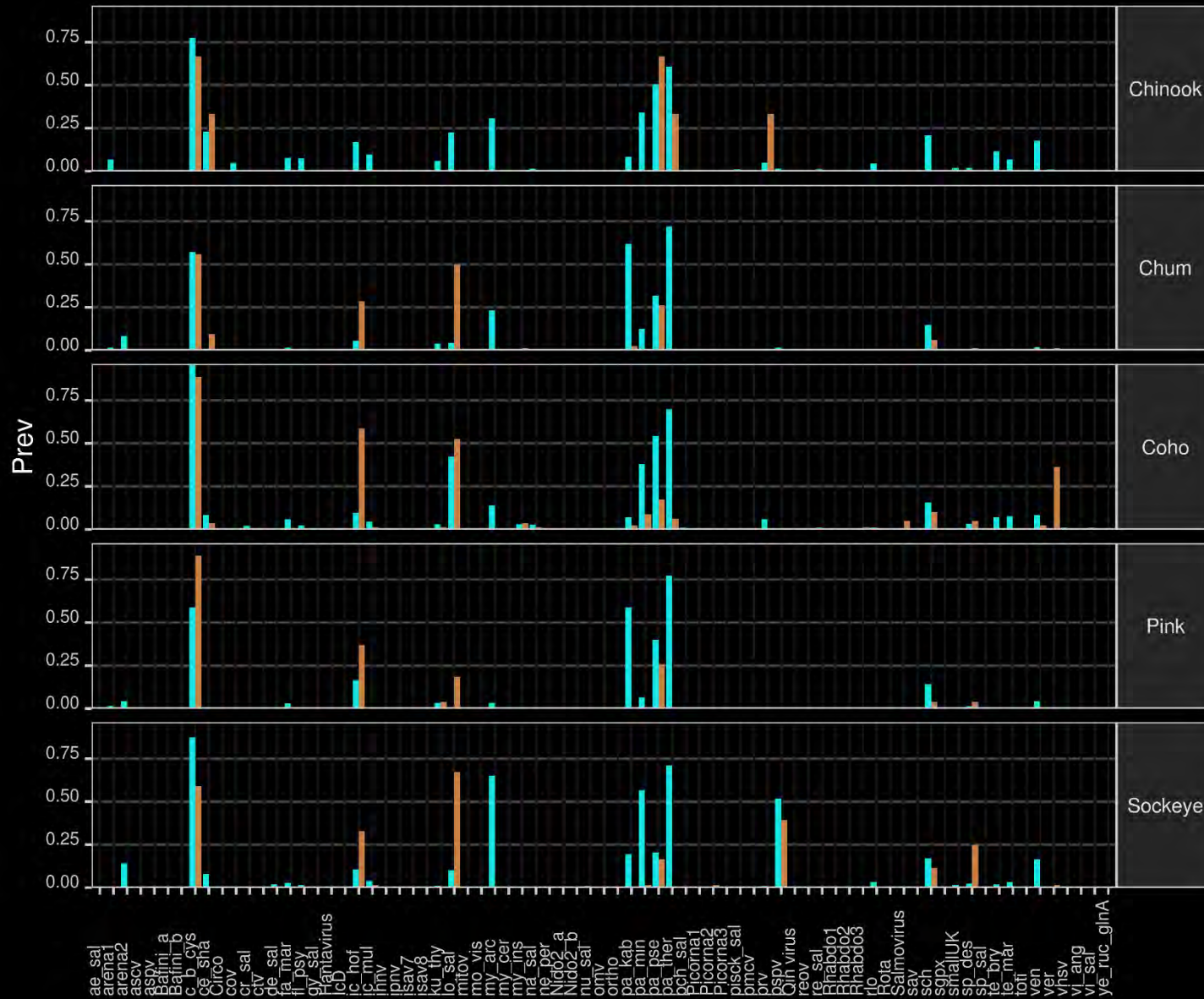


(Encephalopathy and retinopathy virus)



Pacific salmon parvovirus

GoA vs BC Coast: All Species



- Coho and Sockeye trends recapitulated:

- *L. salmonae, I. hoferi,*

- Rising prevalence:

- Pink: *Candidatus Branchiomonas cysticola*

- Persistence

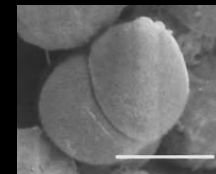
- *C. B. cysticola*

- *Parvicapsula pseudobranchicola*



GoA vs BC Coast: Summary

- Most pathogens drop in prevalence
 - Not enough data for Chinook
- Rising prevalence:
 - *Ichthyophonus hoferi* : All species - Prey associated
 - *Loma salmonae*: All species - secondary infection?
 - Encephalopathy and retinopathy virus: Coho - Prey associated (piscivorous)
 - *Sphaerothecum destruens*: Sockeye
 - *C. B. cysticola*: Pink
- Persistence:
 - *C. B. cysticola*: All
 - *Parvicapsula pseudobranchicola*: All - Prey associated ?
 - Pacific salmon parvovirus: Sockeye
 - FW origin: *P. minibicornis* and *C. shasta*



Summary

- GoA salmon have overall lower burden of pathogens than salmon sampled in their first fall/winter on the BC coast.
 - High mortality in early ocean phase / clearance of pathogens
 - Southern stocks from the US show a trend of higher pathogen prevalence and burden
- Pathogens of increasing prevalence are associated with lifestyle
 - Piscivorous diet!

Future work

- More detailed analysis
 - RIB comparison for all species
 - Correlation with condition and observations
 - Stock specific analysis once they become available
- Fit chip data
 - Correlate disease and stress with condition and stock
 - *I. hoferi* -> osmoregulation
 - Include Ichthyobodo
- Histopathology to determine disease potential of fish with high pathogen loads
 - *I. hoferi*
- **eDNA**



Prof. Kaganovsky crew

IYS team:

Alexey Somov,

Albina Kanzeparova,

Svetlana Esenkulova,

Thank you!

**Molecular
Genetics Lab:**

Karia Kaukinen,

Tobi Ming, Amy

Tabata, Angela

Schulze, Shaorong

Li, Emiliano Di

Cicco

Richard Beamish



INTERNATIONAL
YEAR OF THE SALMON