



**PACIFIC SALMON
FOUNDATION**



**Fisheries and Oceans
Canada**



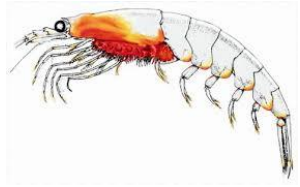
Genomic tools for the open ocean: eDNA and Fit-Chips



***BECI Workshop 3: Technology and
tools for monitoring and synthesis***

Christoph Deeg & Kristina Miller

Environmental (e)DNA

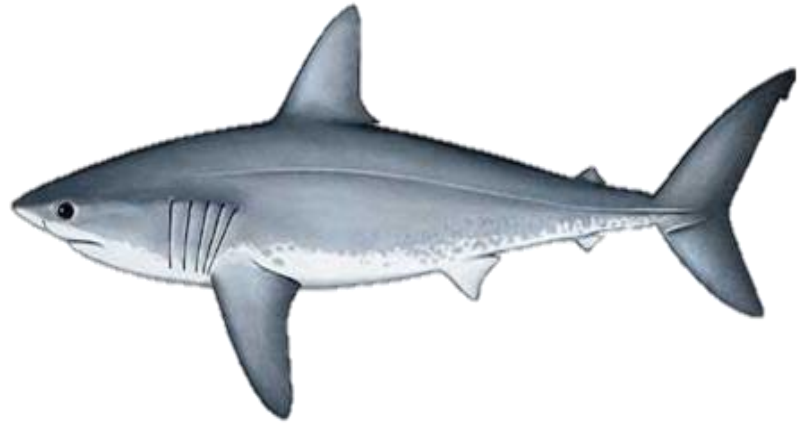


Prey



Paul Vecsei

Predators



Competitors

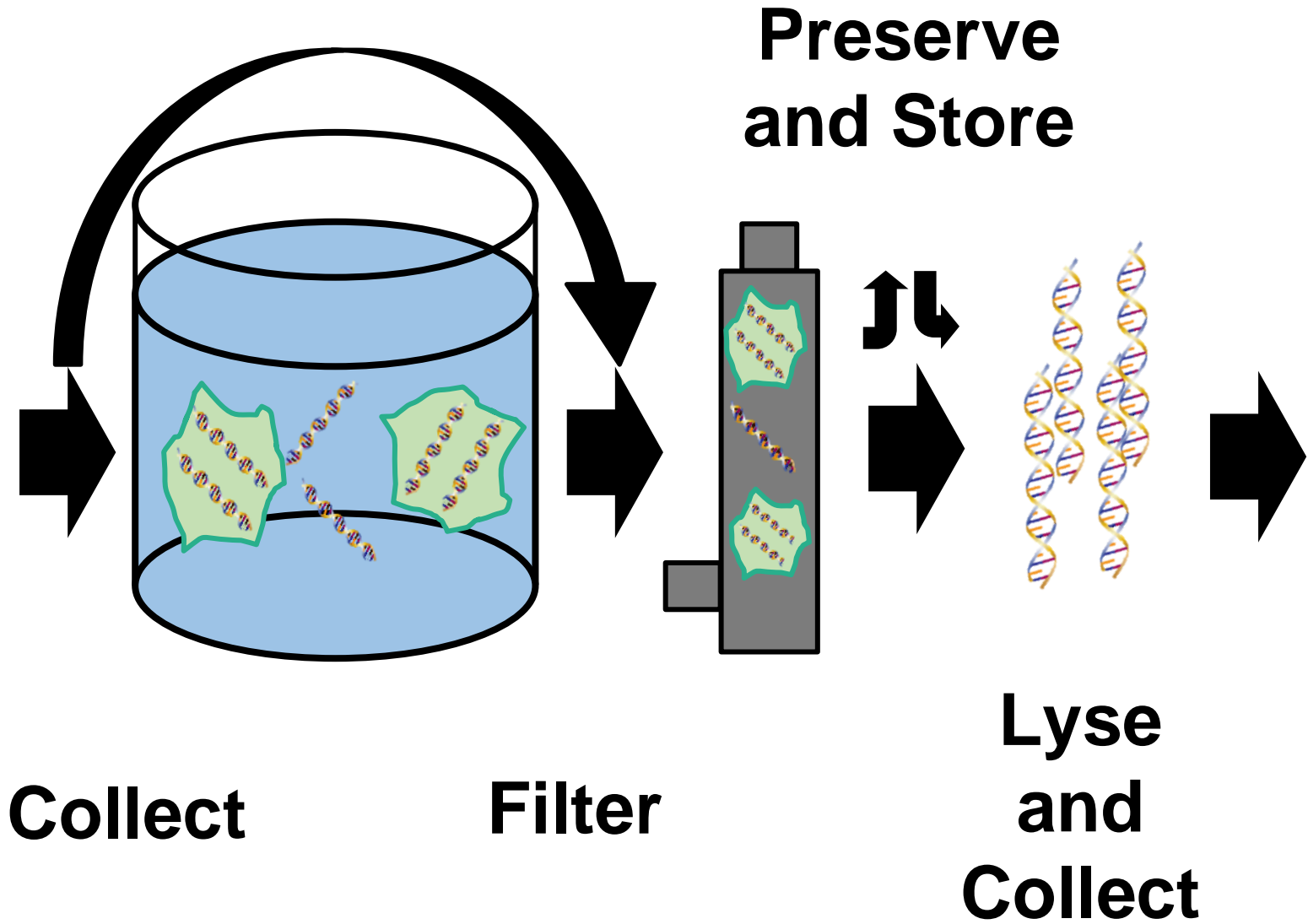
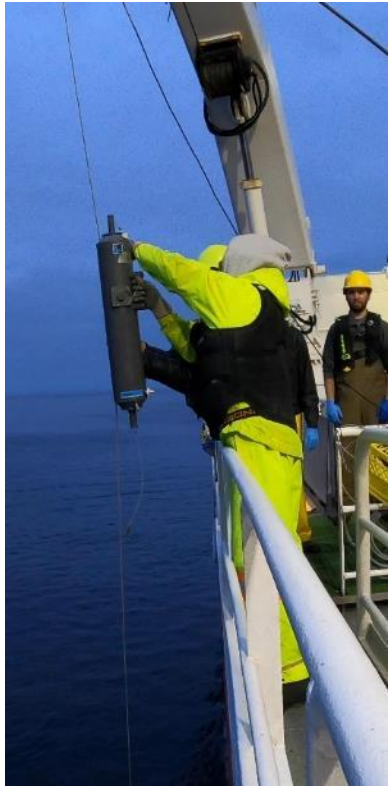


What is the **environment** like for salmon?

Ask the ocean by looking at DNA in the water (eDNA)



eDNA Background: Sample collection



Collect

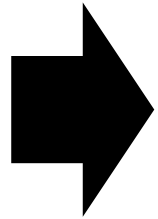
Filter

**Preserve
and Store**

**Lyse
and
Collect**

Analyze

eDNA Background: Species ID



GTAATGTT**T**CGTAAT**C**AGCT**A**TCGGGAT**A**CGTGCTACG

GTAATGTT**T**CGTAAT**C**AGCT**A**TCGGGAT**C**CGTGCTACG

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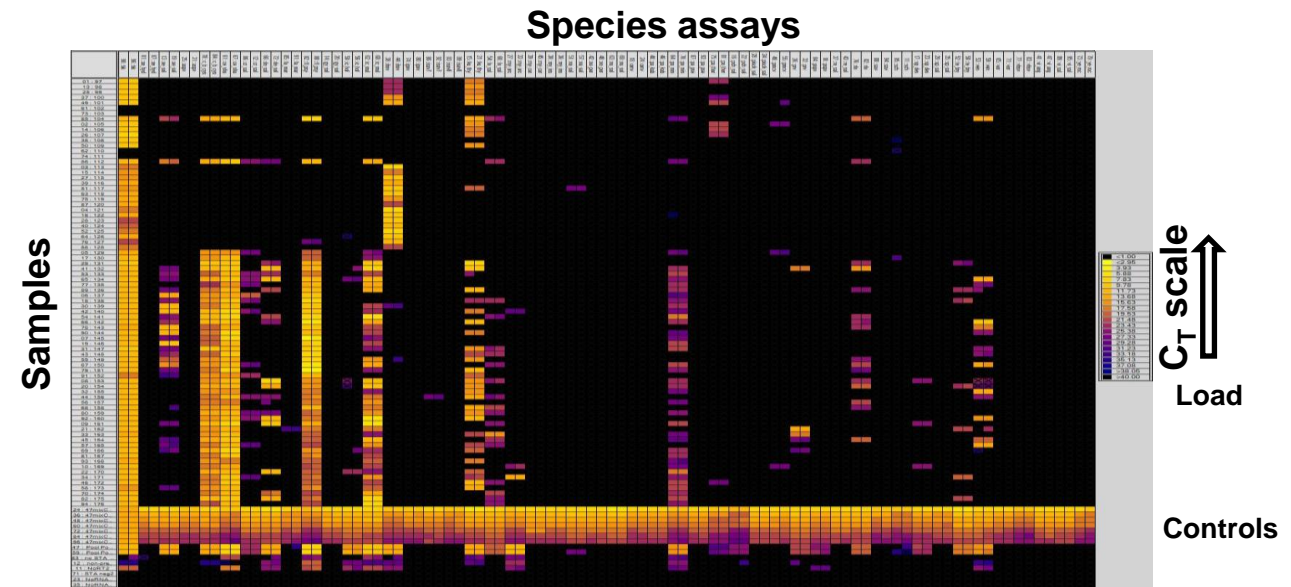


Species have unique DNA sequences:
Species ID by sequence!

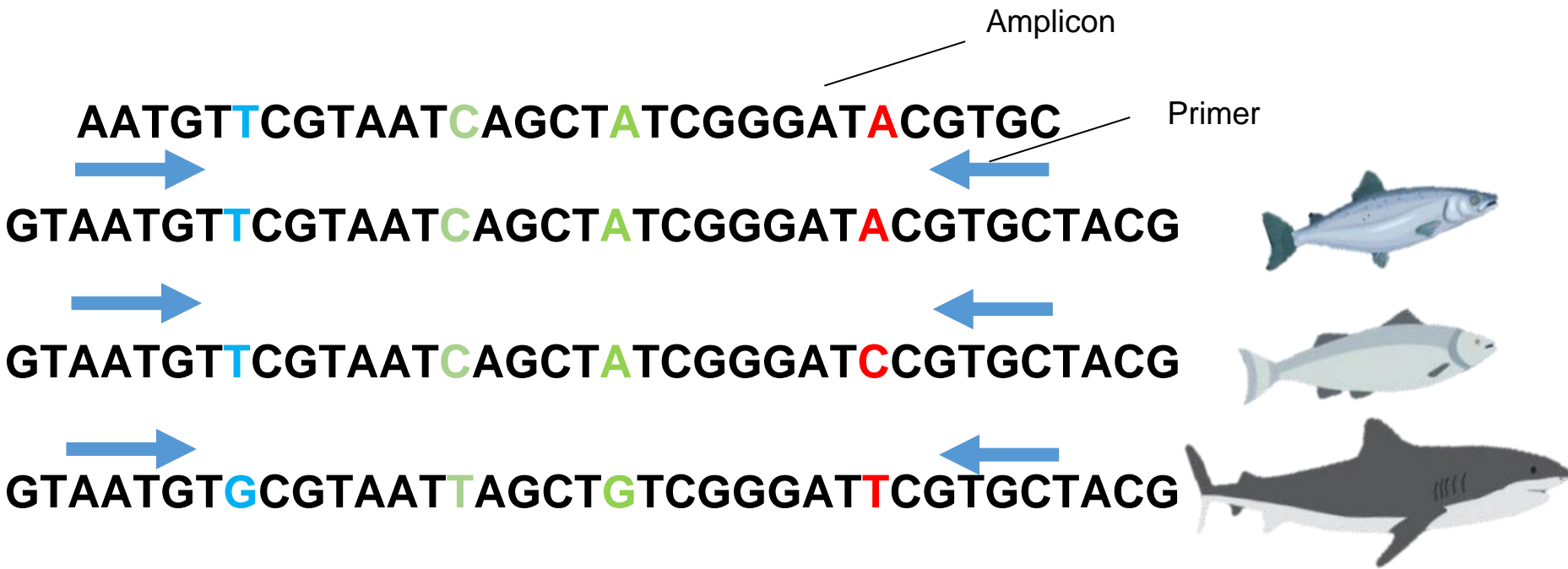
eDNA Analysis I: Quantitative (q)PCR



- Targeted detection of specific species/groups
- Quantify amount of target DNA in sample

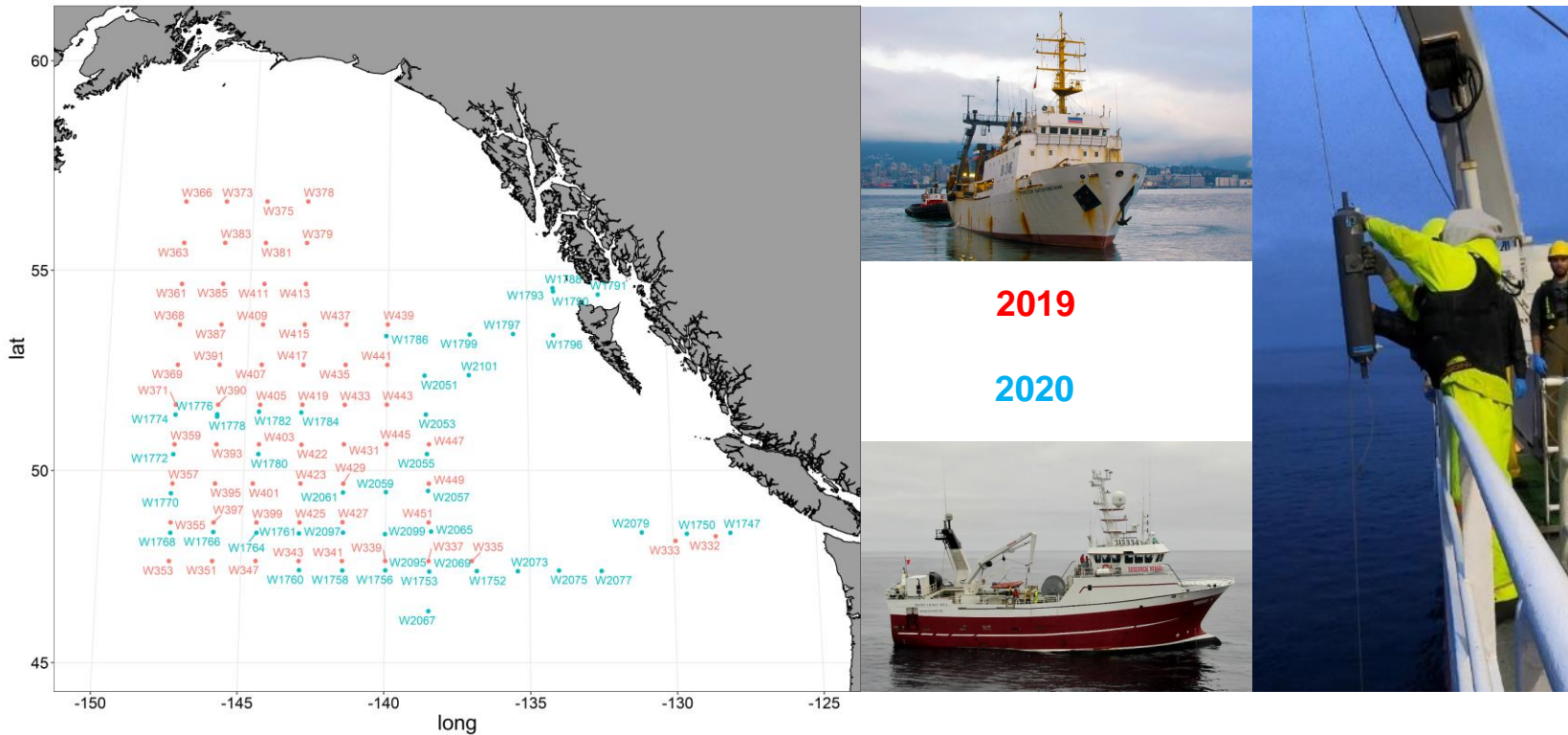


eDNA Analysis II: Metabarcoding



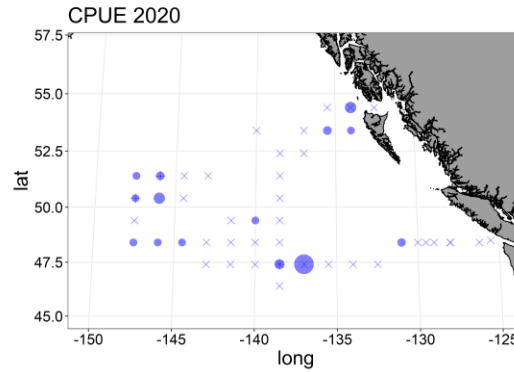
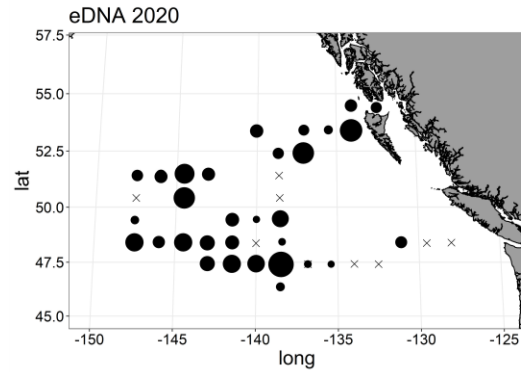
- Amplify and sequence stretch of DNA
- Cast “broad net”

eDNA Case study I: IYS surveys 2019/20

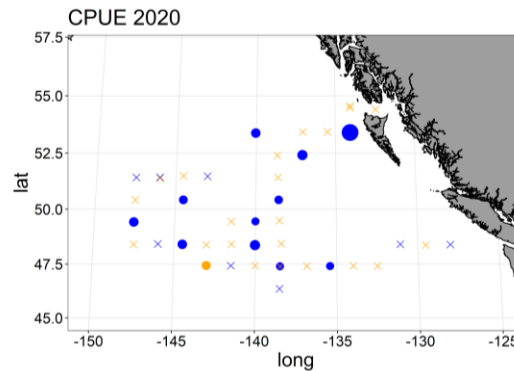
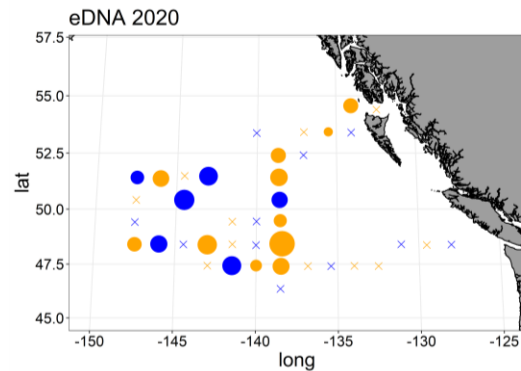


- Point sampling
- Metabarcoding
 - Vertebrates
 - Salmon
 - Squid

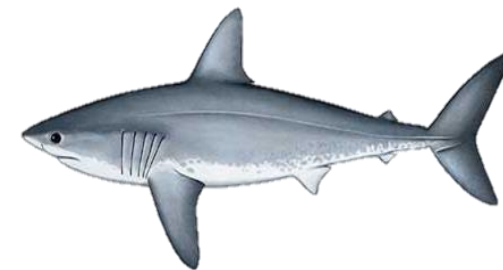
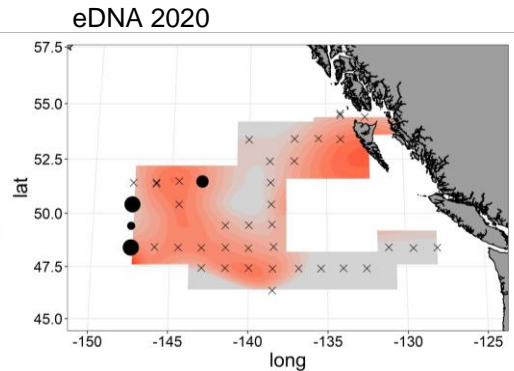
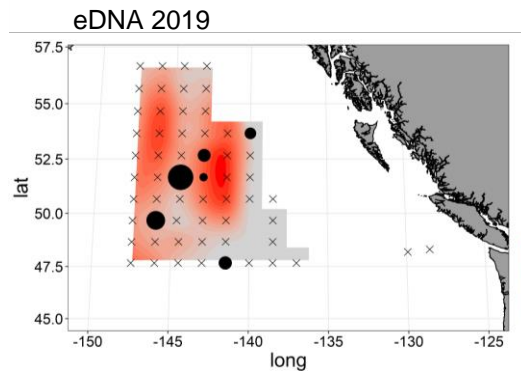
eDNA Case study I: IYS surveys 2019/20



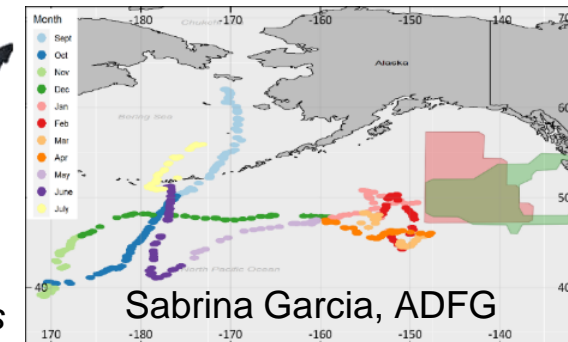
Chum salmon *Oncorhynchus keta*



Boreopacific armhook squid *Gonatopsis borealis*

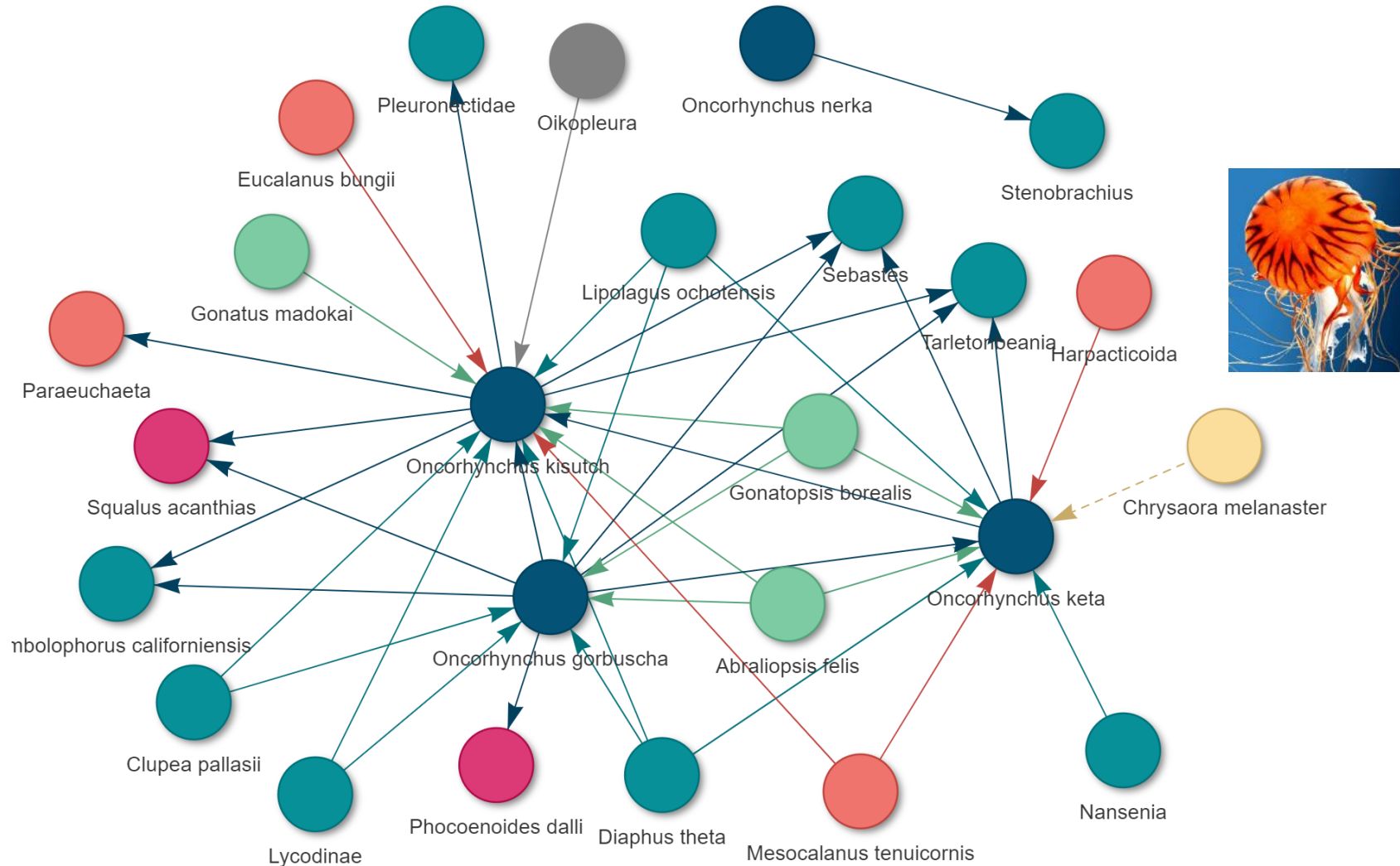


Salmon shark *Lamna ditropis*



Sabrina Garcia, ADFG

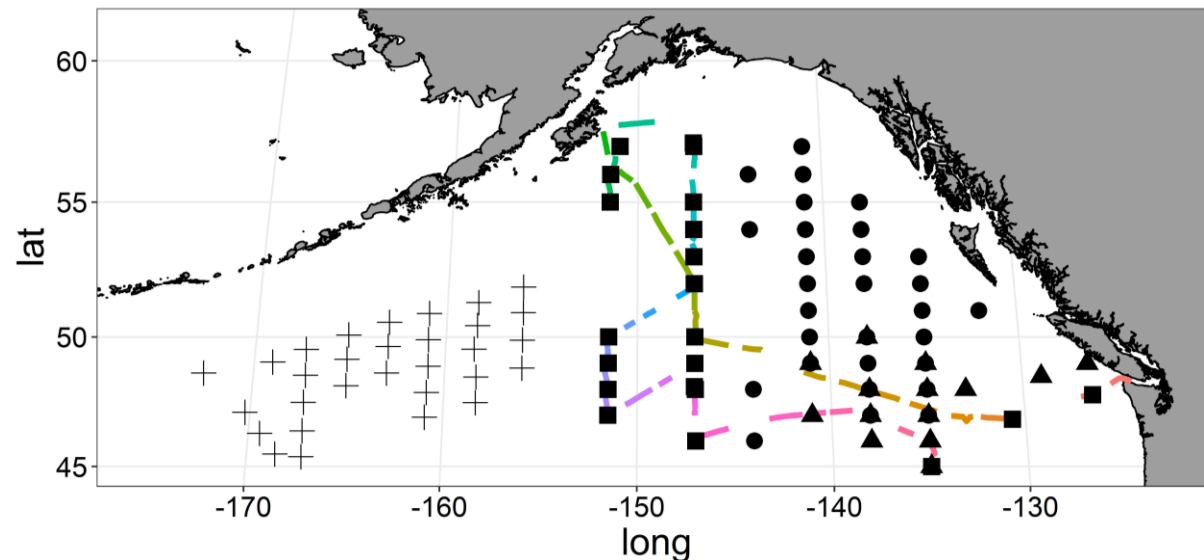
eDNA Case study I: IYS surveys 2019/20



Salmon centric co-occurrence network

- Salmon
- Fish
- Zooplankton
- Squid
- Predators
- Jellyfish

eDNA Case study II: IYS surveys 2022

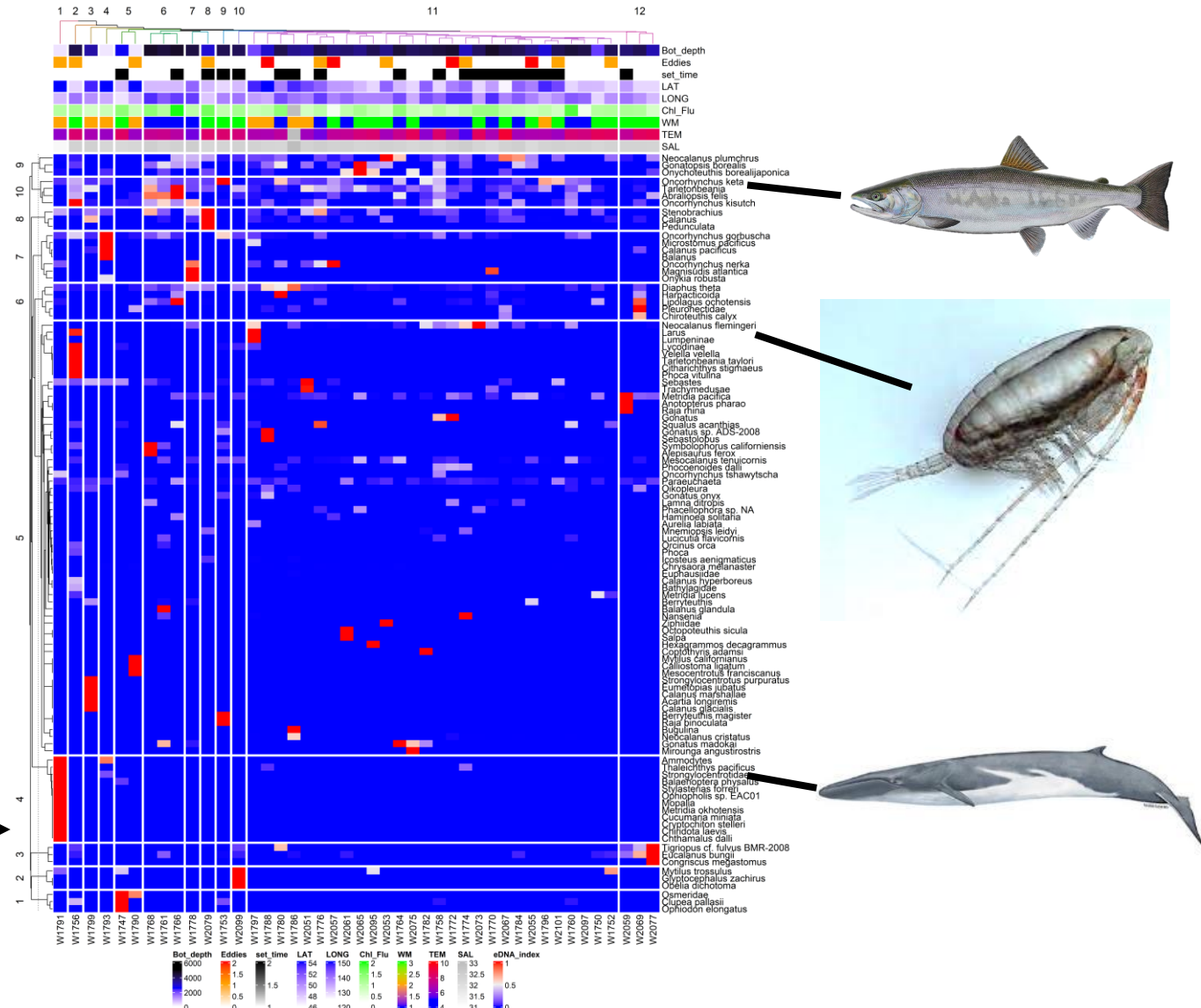
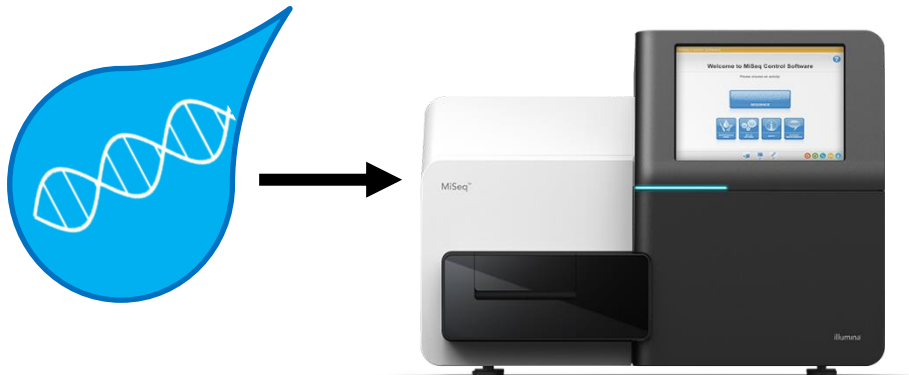


High performance filtration systems:

- Hollow membrane filters (5L)
- “Milk Machine”: 5 min 4 Niskin (10L)
- Synchronized automatic transects sampling
 - eDNA
 - Hydroacoustics
 - “CTD”: Salinity, Temperature, Chlorophyll

eDNA Strengths

- Non invasive
- One sample reflects entire ecosystem
- Automatable
- Archive sample



eDNA Challenge I: Target selection and Data base coverage

- Sequence limitations
 - Size
 - Divergence
- Trade-off
 - Specificity
 - Breadth
- Detection database limited!

GTAATGTT**TC**GTAAT**CAG**CT**AT**CGGGAT**AC**GTGCTACG

GTAATGTT**TC**GTAAT**CAG**CT**AT**CGGGAT**CC**GTGCTACG

GTAATGTT**G**CGTAAT**TAG**CT**G**TCGGGAT**T**CGTGCTACG

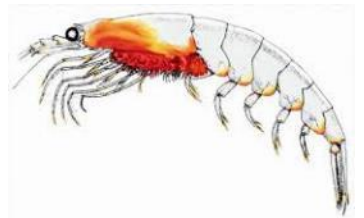


Can't differentiate between salmon

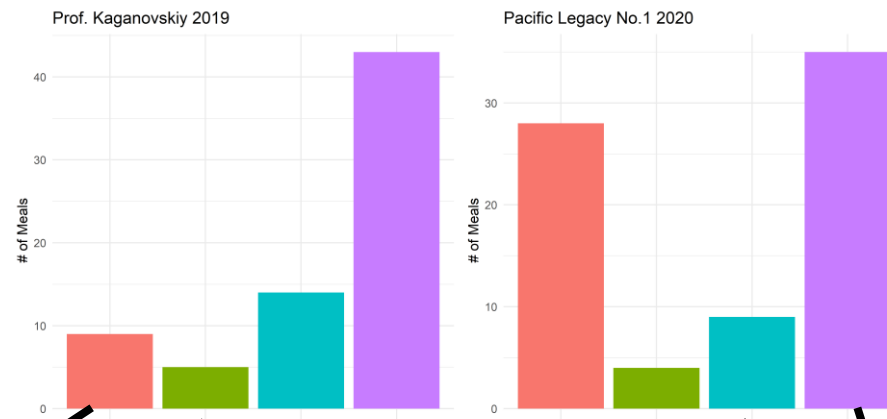
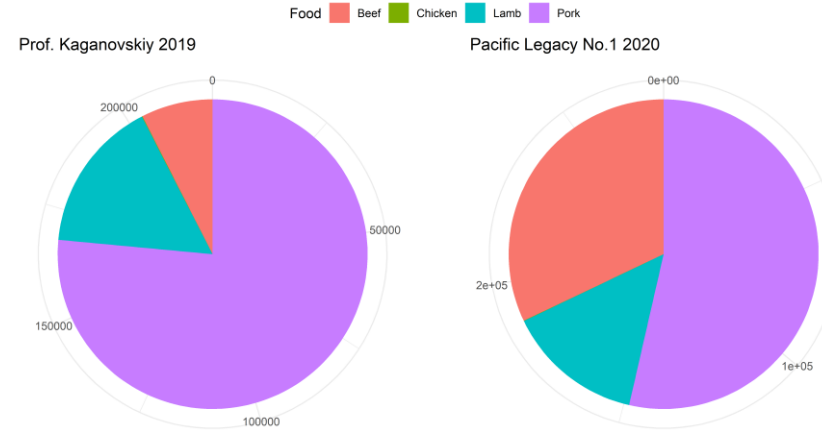


Can't amplify shark

GCCATAT**G**CG**ACT**ATT**AG**CACTGGGATGTT**CG**TC**GCG**TACG



eDNA Challenge II: Contamination!



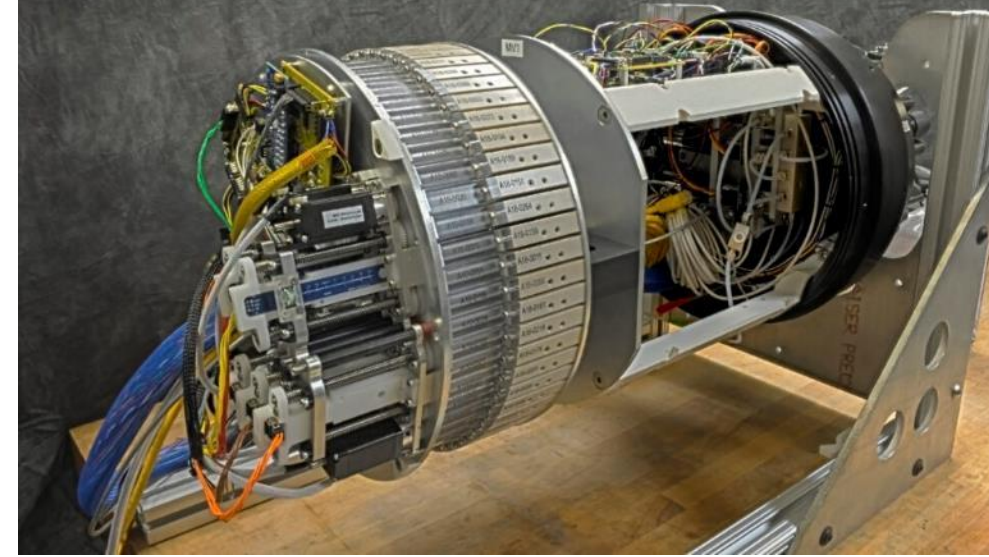
eDNA Opportunities

Automation and integration
for remote deployment

IYS 2022 automated and integrated sampling



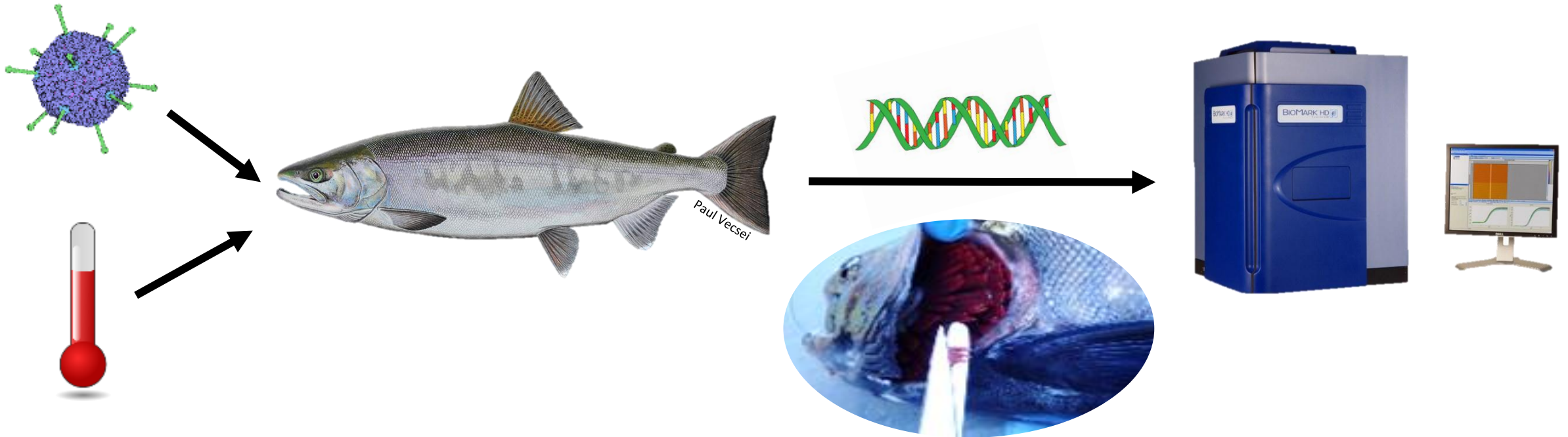
MBARI - ESP



Saildrone



Salmon Fit-Chips



How are salmon doing?

We ask the fish by looking at their DNA
Detect stresses response and pathogens

Salmon Fit-Chips: Cumulative impacts



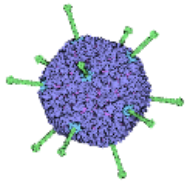
Work on salmon and trout species
Non-lethal gill samples



Stressors: thermal, salinity, low oxygen



Physiological states: viral disease, immune activation, imminent mortality, smolt readiness (hatchery application)

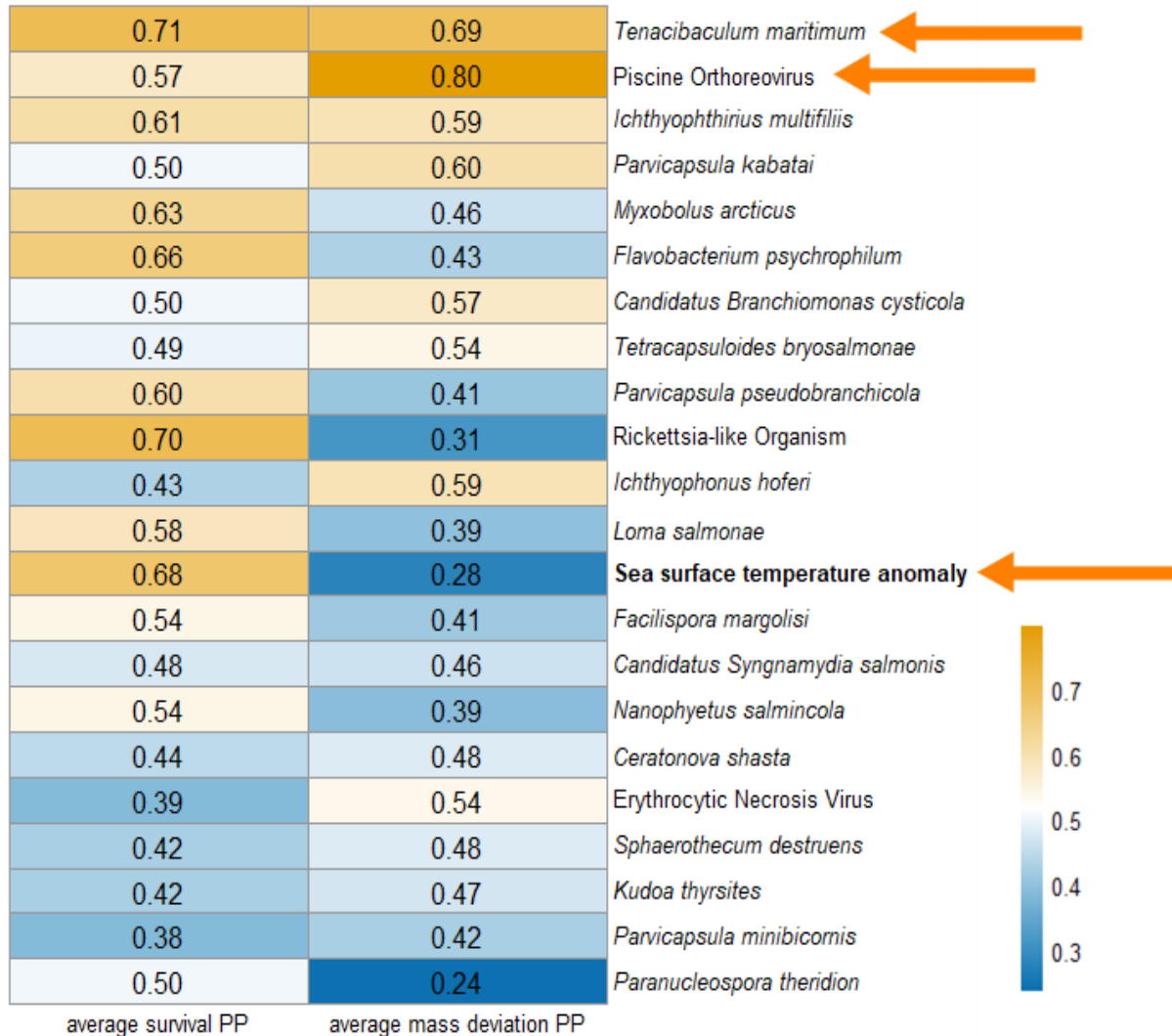


Pathogens: >60 available to survey



Harmful Algal blooms: 2 available, more coming

Fit-Chip case study I: Population level impacts of Pathogens



Pathogens are associated with poor survival and condition in Coho and Chinook: PRV and *Tenacibaculum maritimum* had the most negative associations outweighing SST anomaly

Bass et al., FACETS. 7(): 742-773.
<https://doi.org/10.1139/facets-2021-0102>

Fit-Chip case study II: Sockeye experience heat stress during migration through the Strait of Georgia

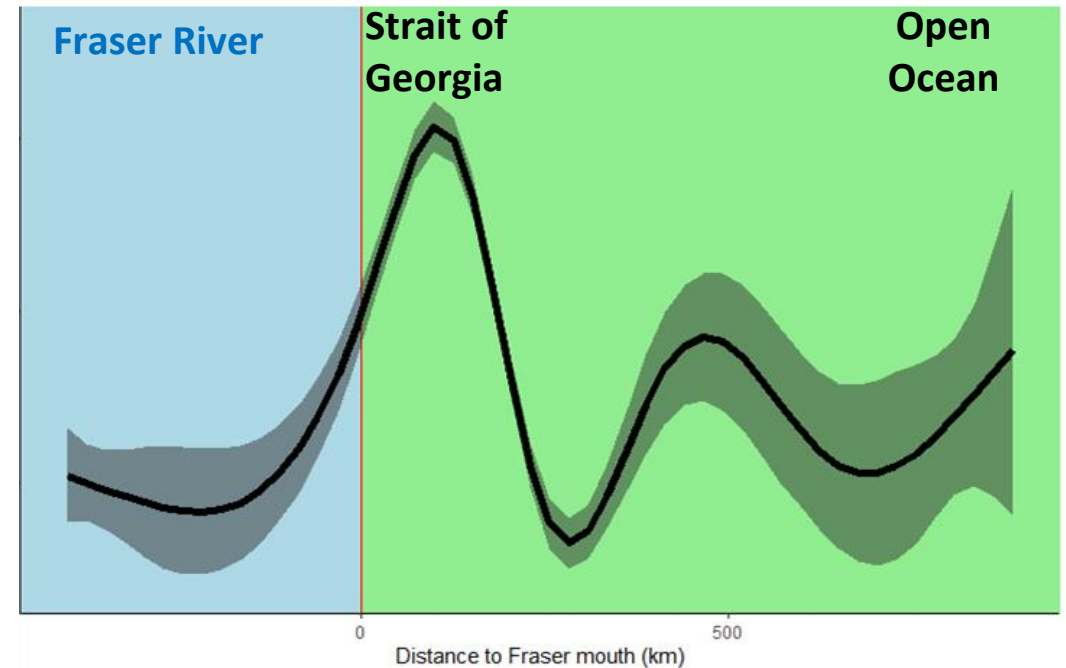
Arthur Bass



Photo credit: Tavish Campbell



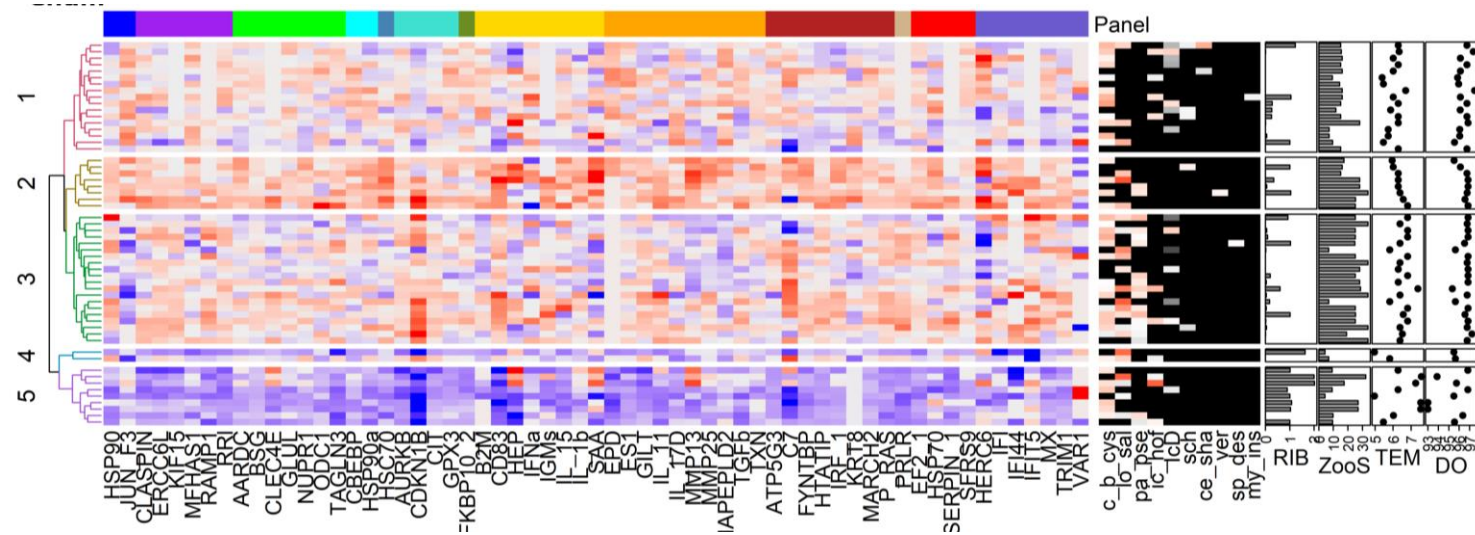
Ocean temperature



Fit-Chip case study III: Cumulative impacts of environment and pathogens in overwintering salmon



- Prey limitation is associated with SST anomaly and *Chrysaora melanaster*
- This is associated with downregulate expression immune genes and more infections



Chum salmon Fit-Chip data from Gulf of Alaska



Malnourished chum from Gulf of Alaska

Photo credit: Shigehiko Urawa

Fit-Chip: Strength

- Can be minimally invasive
- Direct evidence of impacts on salmon
- Numerical stress scoring available for Chinook, coho, and sockeye



Fit-Chip: Challenge

- Requires physical sample
- Sampling is time sensitive

Fit-Chip: Opportunities

- Numerical stress scoring available for pink and chum by 2023
- eDNA/eRNA integration



Thank you!

Questions?

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