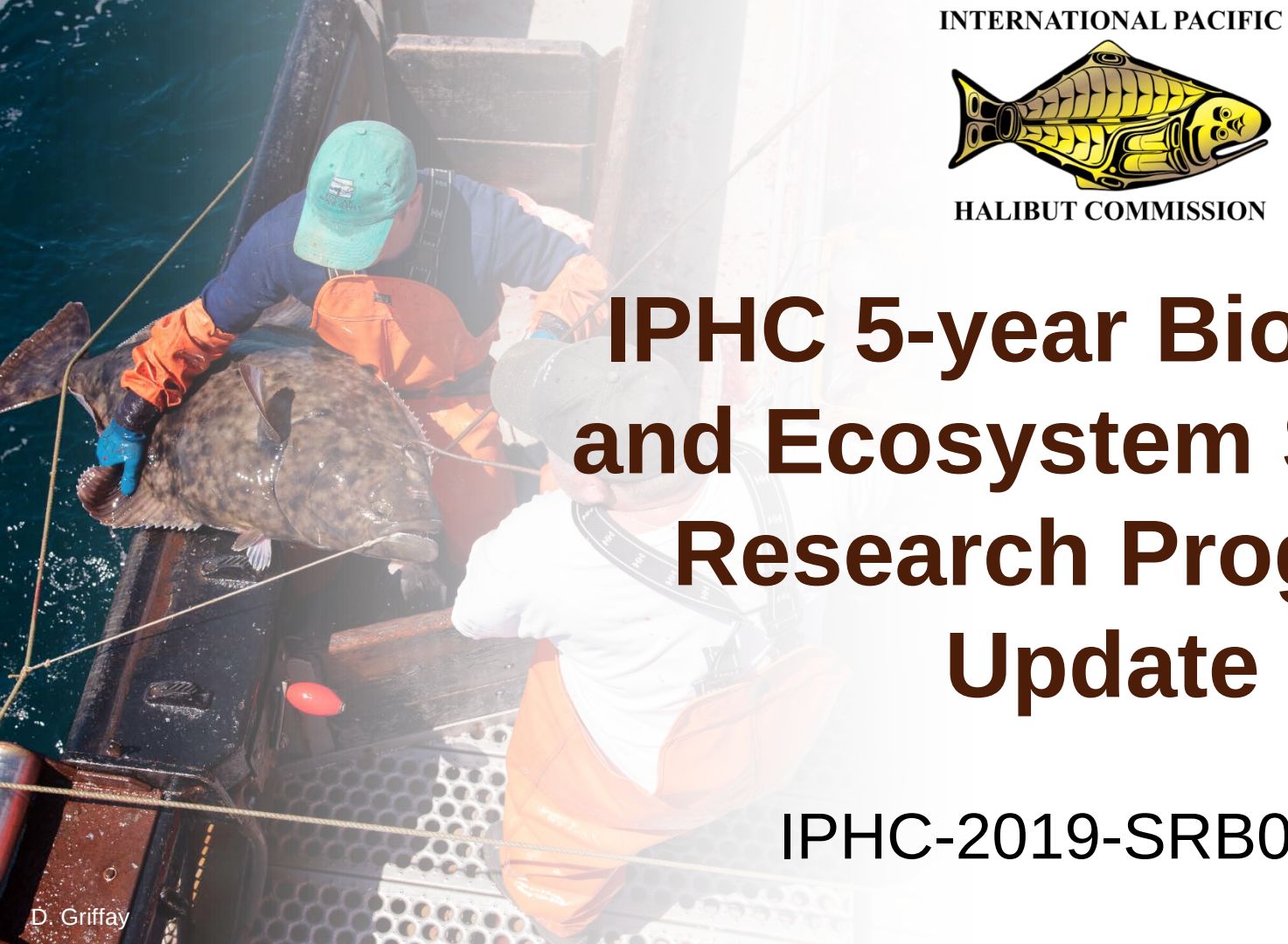


INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC 5-year Biological and Ecosystem Science Research Program: Update

IPHC-2019-SRB014-09

D. Griffay

Outline

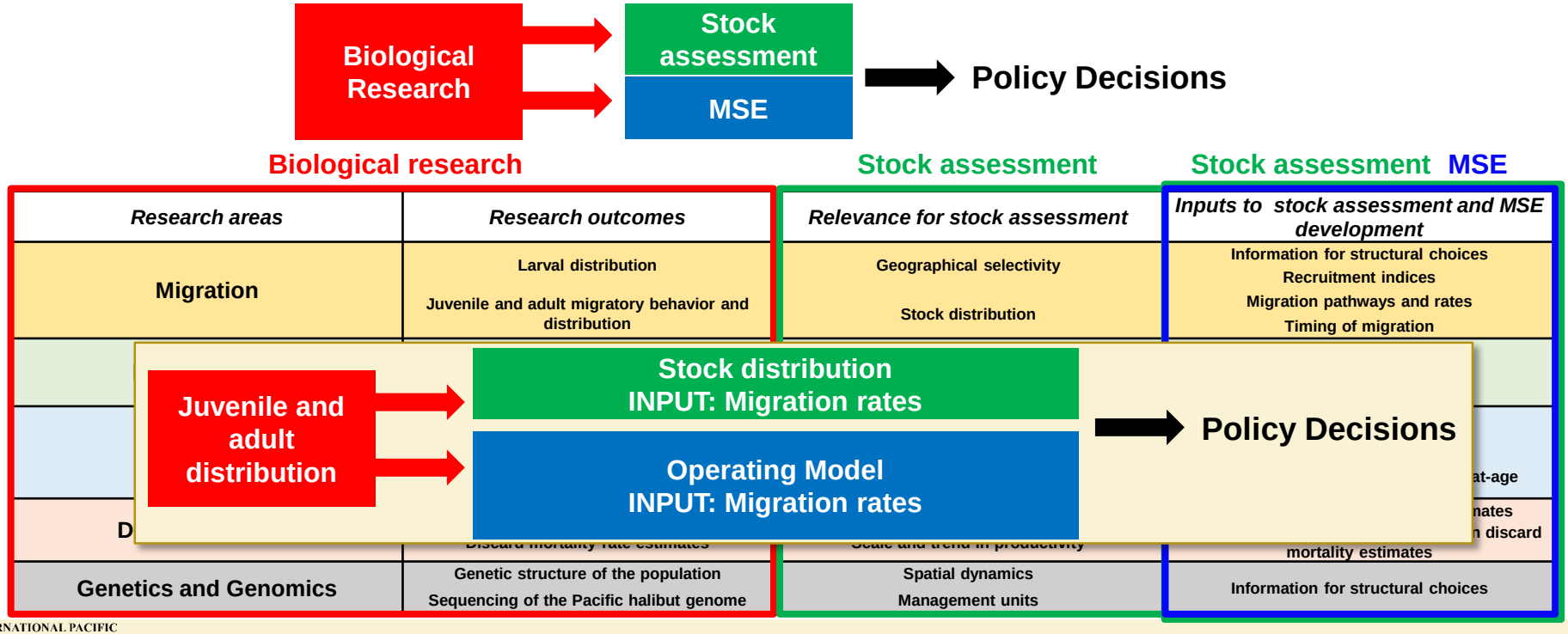
- **Five-year research program and management implications**
- **Progress on ongoing research projects**
- **Externally-funded collaborative research**

Five-year research program and management implications

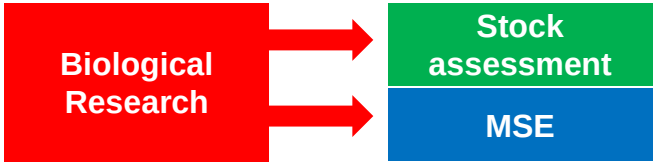
Primary Research Areas
Migration
Reproduction
Growth
DMRs and discard survival
Genetics and genomics

Integration of biological research, stock assessment, and policy

Integration of biological research, stock assessment, and policy



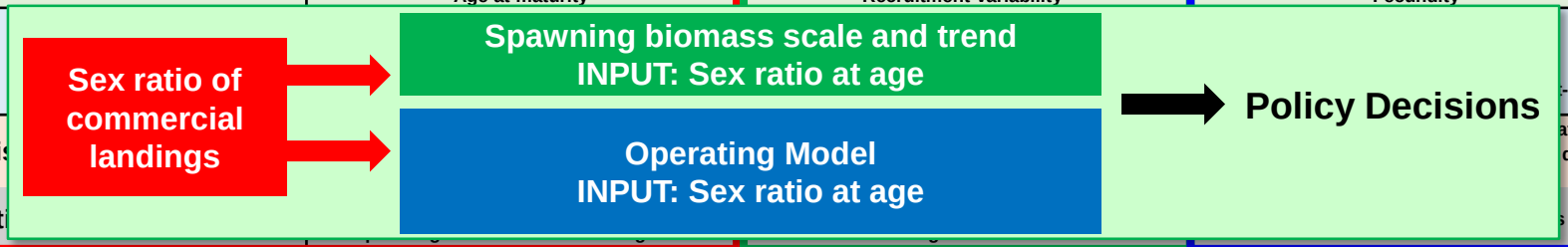
Integration of biological research, stock assessment, and policy



Policy Decisions

Biological research | **Stock assessment** | **Stock assessment** **MSE**

Research areas	*Research outcomes*	*Relevance for stock assessment*	*Inputs to stock assessment and MSE development*
Migration	**Larval distribution** **Juvenile and adult migratory behavior and distribution**	**Geographical selectivity** **Stock distribution**	**Information for structural choices** **Recruitment indices** **Migration pathways and rates** **Timing of migration**
Reproduction	**Sex ratio** **Spawning output** **Age at maturity**	**Spawning biomass scale and trend** **Stock productivity** **Recruitment variability**	**Sex ratio** **Maturity schedule** **Fecundity**
Dis			**ates** **discard**
Genet			



Integration of biological research, stock assessment, and policy: timelines

Research Area		2018	2019	2020	2021	2022
Migration	Larval distribution	Data analysis	Data synthesis	SA MSE	Sample collection	Data analysis	Data synthesis	
	Adult and juvenile migration	Tagging	Tagging	Data synthesis	SA MSE	Tagging	Data synthesis	SA MSE	Tagging	Data synthesis
		Data analysis				Data analysis			Data analysis	

Progress on ongoing research projects

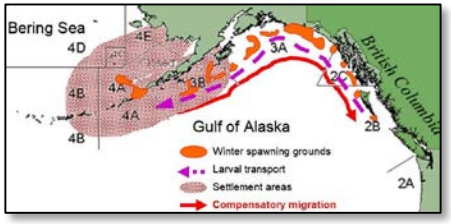
1. Migration and distribution

Projects:

1. Larval and early juvenile dispersal

2. Late juvenile migration

3. Tail pattern recognition



2. Reproduction

3. Growth

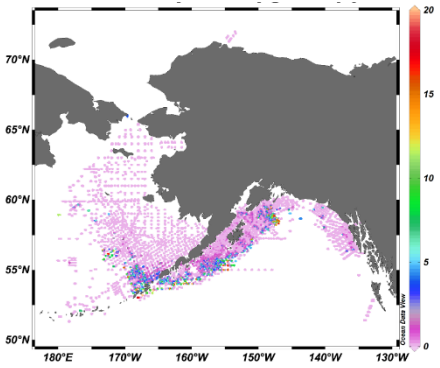
4. Discard Mortality

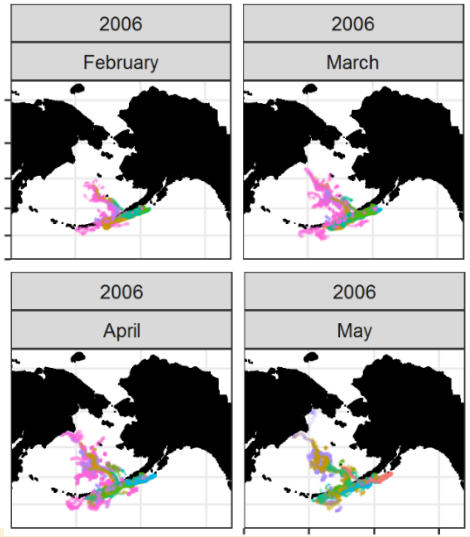
5. Genetics and genomics

Migration and Distribution

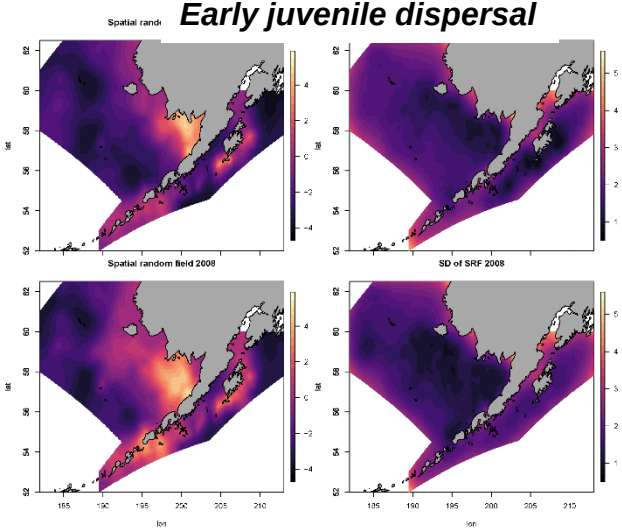
1. Larval and early juvenile dispersal

- **Contribution of spawning grounds to settlement grounds**
- **Connectivity of ocean basins**
- **Environmental effects on larval distribution**
- **Collaboration with NOAA/EcoFOCI**
- **Dispersal of young fish post-settlement**





Early juvenile dispersal



Migration and Distribution

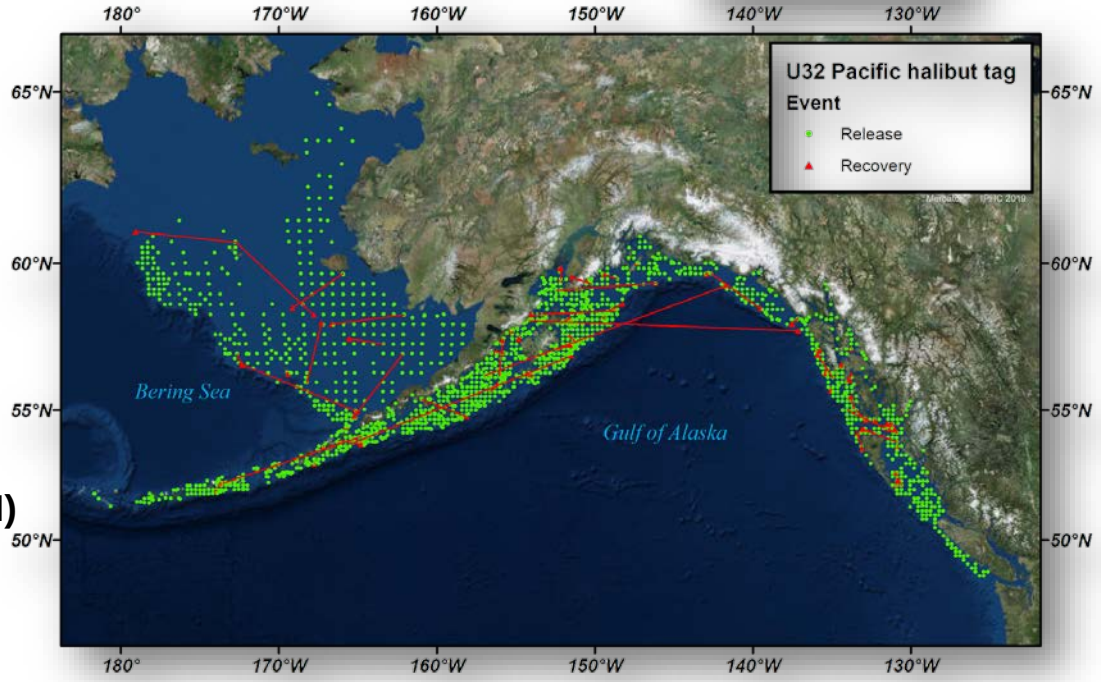
2. Late juvenile dispersal: wire tagging of U32 fish

Since 2015:

- **8,600 U32 fish wire tagged in FISS and NMFS Trawl Survey**
- **74 recoveries**

In 2018:

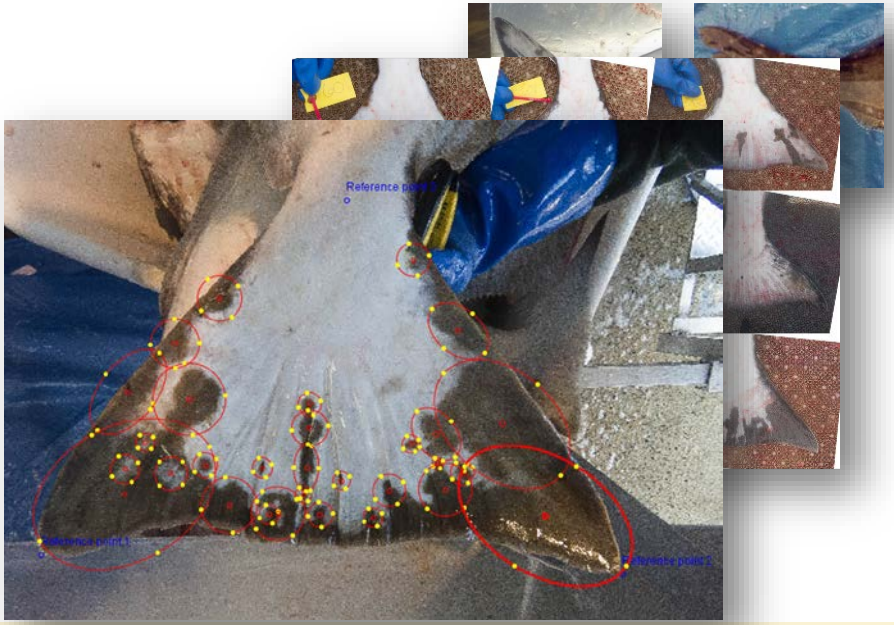
- **FISS (1,747 tags)**
- **NMFS (916 tags; BS/AI)**



Migration and Distribution

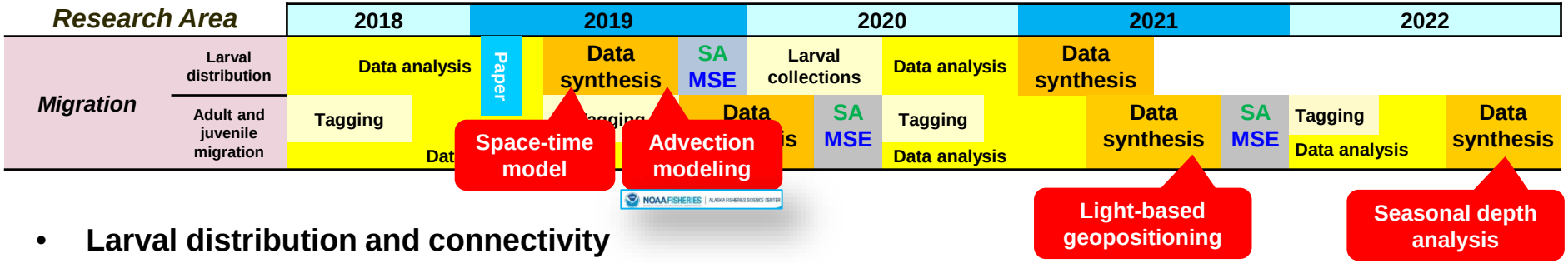
3. *Tail pattern recognition*

Objective: Use natural markings to identify individuals over time and inform on movement patterns and growth



- **Blind side of tail is preferable for imaging**
- **Spots and patterns appear to be unique**
- **Markings could be used to identify individuals with image recognition software**
- **Future could integrate into vessel/shoreside electronic monitoring (EM) or recreational fisher applications**
- **In 2018, 827 U32 Pacific halibut photographed and wire tagged as part of this project**

Migration and distribution: timeline and integration with stock assessment, and MSE



- Larval distribution and connectivity
- Electronic archival tagging:
  - Analyze age- and sex-specific movement patterns
  - Generate "dispersal kernels" for use in spatially-explicit models (*assessment, metapopulation*) that incorporate migration
  - Analyze onshore-offshore and spawning movements to refine definitions of effective spawning biomass

Reproduction

Projects:

1. Identification of sex in the commercial landings

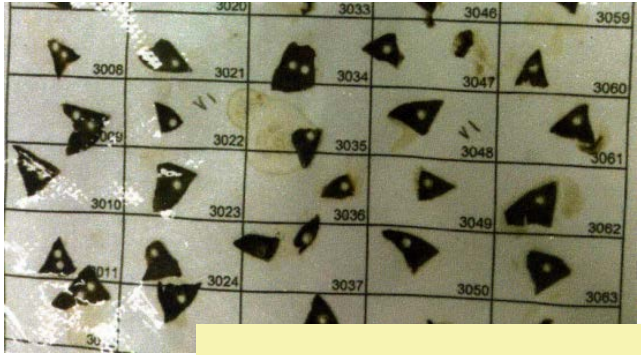
2. Full characterization of the annual reproductive cycle

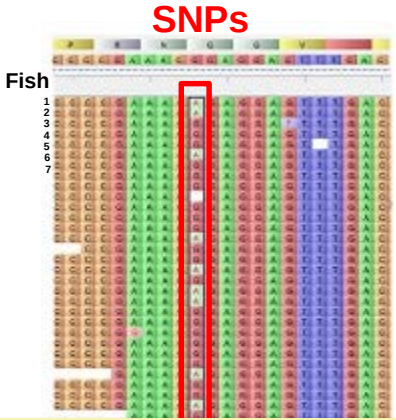
Reproduction

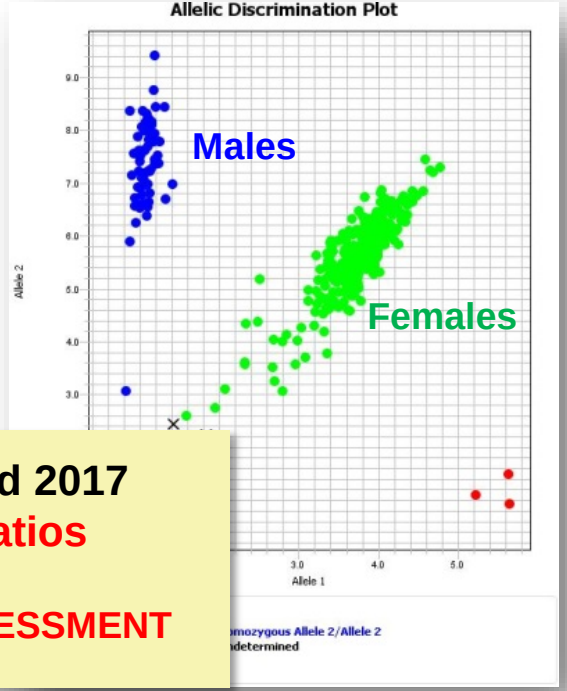
1. Identification of sex in the commercial landings

To generate sex-ratio data for use in assessment and policy analysis

Application of genetic techniques (SNPs)







- **Completed**: Fin clips from entire set of aged 2017 commercial samples **(>10,000 fish)** : **sex ratios**

2019 FULL STOCK ASSESSMENT

Reproduction

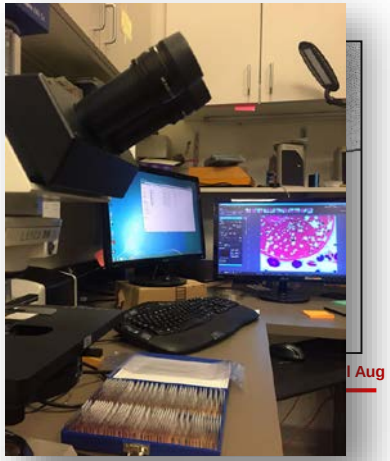
2. Full characterization of the annual reproductive cycle

Objective: Revise maturity estimates for male and female Pacific halibut

Annual reproductive cycle

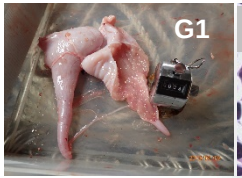
Gonadal growth	Maturation	Spawning

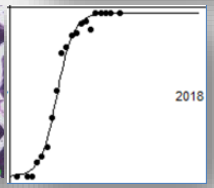
- Histological assessment of gonadal development
- Reproductive hormones in the blood
- Activation of the endocrine reproductive axis (pituitary and gonads)
- Energy levels (fat content/hepatosomatic index)
- Revised scoring criteria of maturity stages by macroscopic observations in the field



Deliverables:

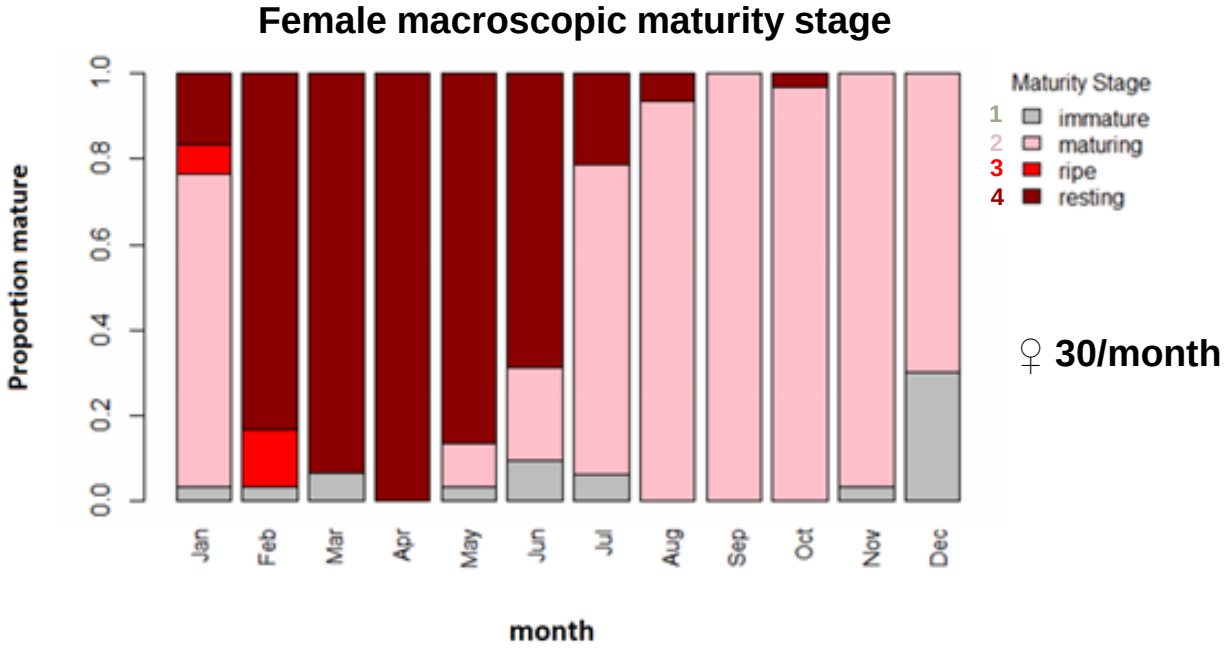
- Accurate staging of reproductive status
- Updated maturity-at-age estimates
- Estimates of skipped-spawning





Reproduction

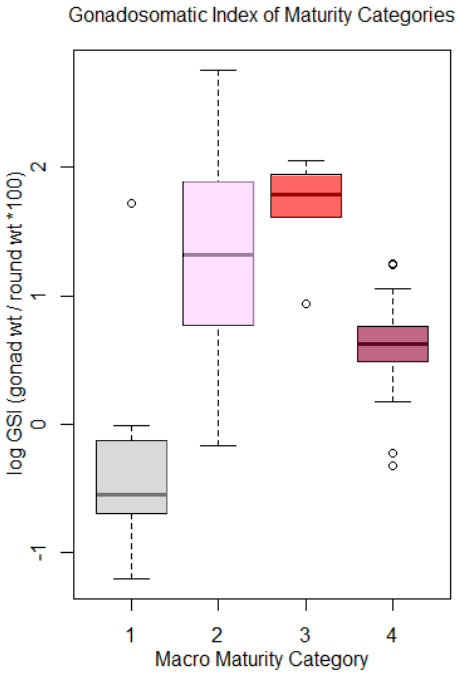
2. Full characterization of the annual reproductive cycle

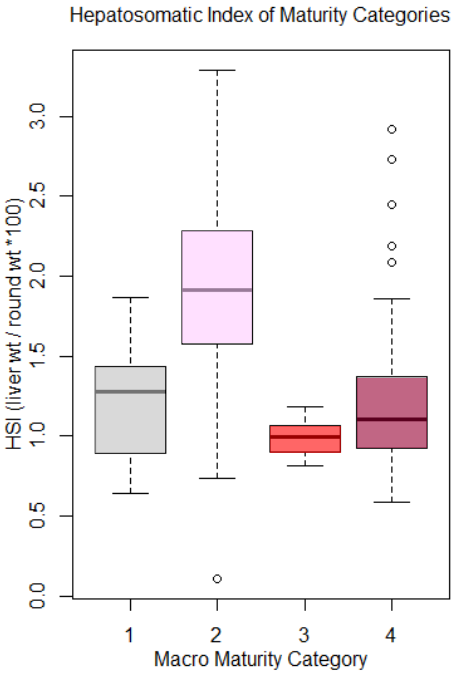


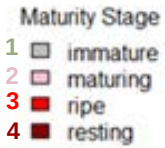
♀ **30/month**

Reproduction

2. Full characterization of the annual reproductive cycle

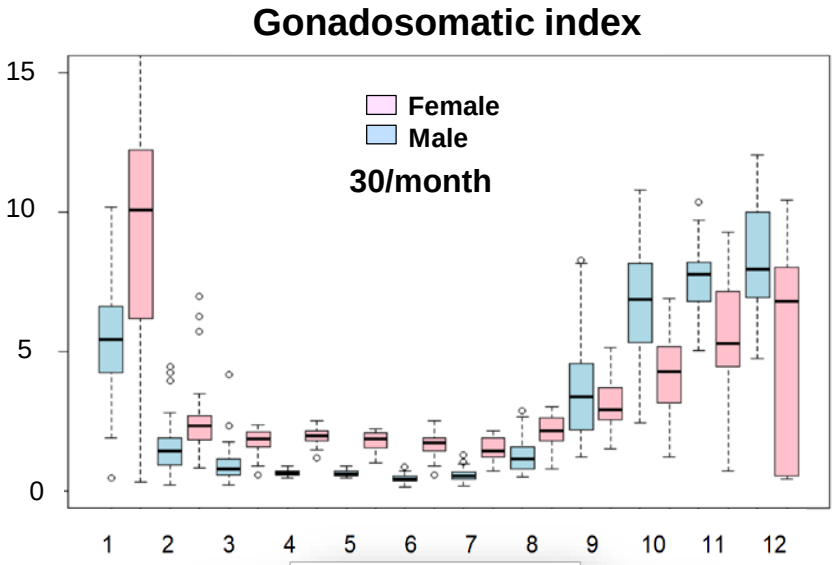


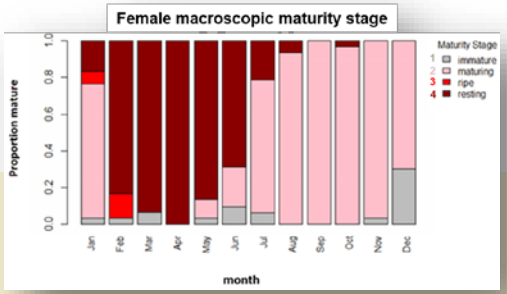




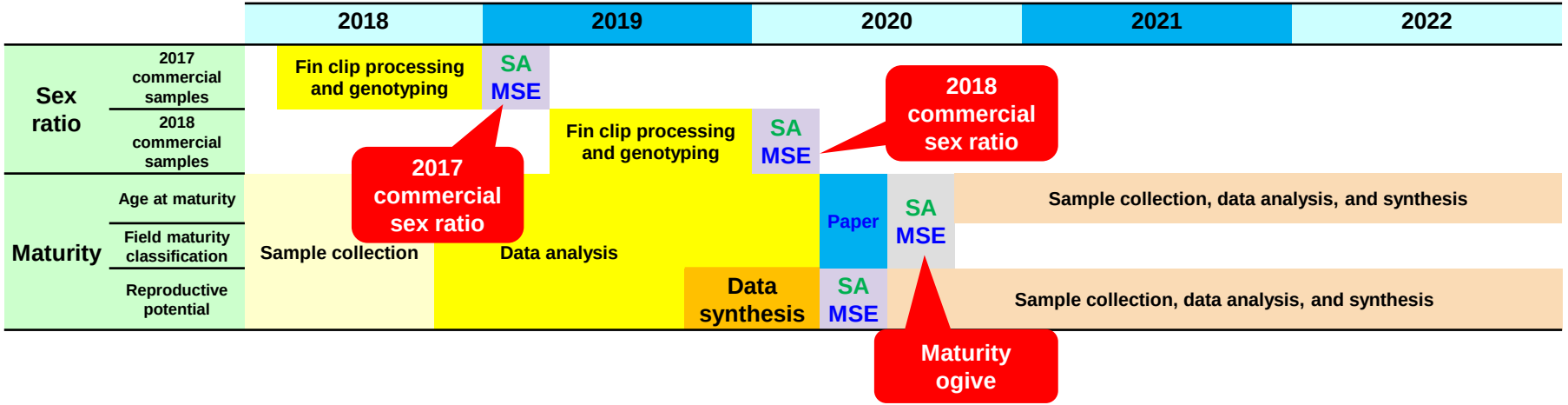
Reproduction

2. Full characterization of the annual reproductive cycle





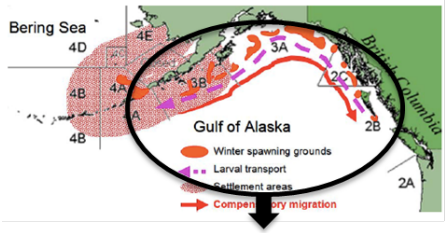
Reproduction: timeline and integration with stock assessment, and MSE

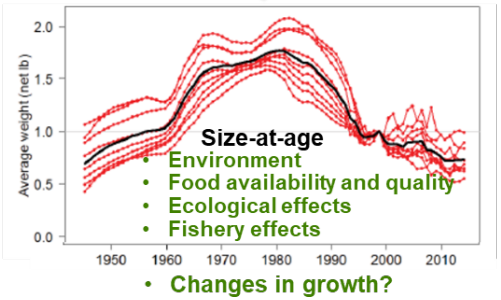


Growth

Projects:

1. ***Identification and validation of physiological markers for growth***
2. ***Evaluation of growth patterns in the Pacific halibut population and possible effects of environmental variability***





Growth

1. Identification and validation of physiological markers for growth

White muscle:

- **Transcriptomics**
- **Proteomics**
- **Stable isotopes**

Analyses completed

Temperature | **Population Density** | **Dominance** | **Capture Stress**

Effects on transcriptome and proteome

Identification of physiological growth markers

MUSCLE
LIVER

BIOCHEMICAL AND MOLECULAR GROWTH RESPONSES

Application to field studies

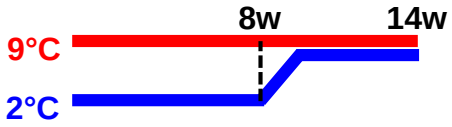
IPHC / AFSC-NOAA (Newport, OR)

Dr. Josep Planas (PI)

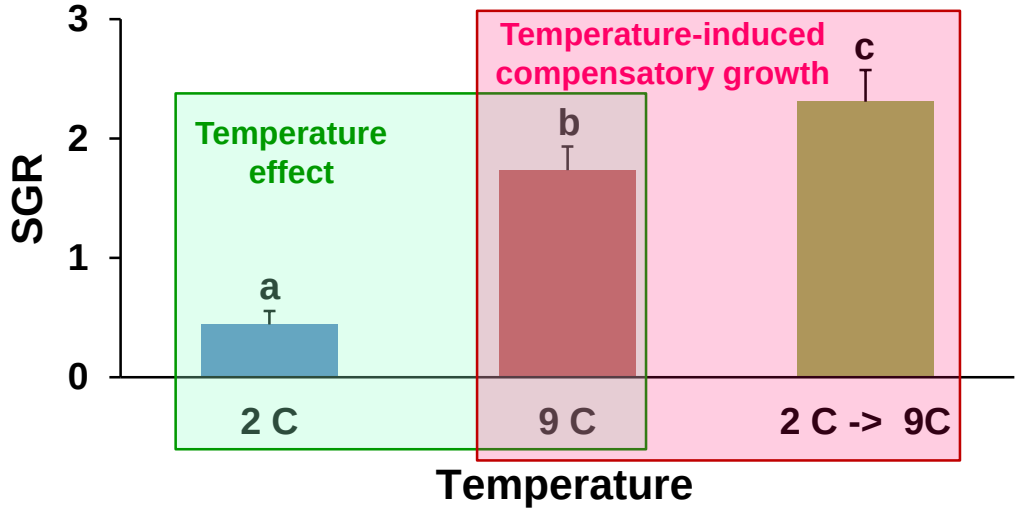
Dr. Thomas Hurst

NPRB Grant 1704 (2017-2019)

Growth: transcriptomic analyses



Specific Growth Rate (SGR)



RNA sequencing of white skeletal muscle

⬇

Differential gene expression

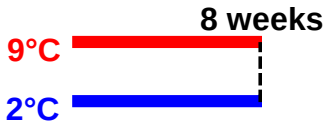
⬇

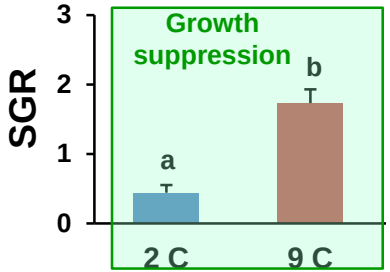
- ***Molecular signatures of temperature-regulated growth***
- ***Molecular signatures of rapid growth***

⬇

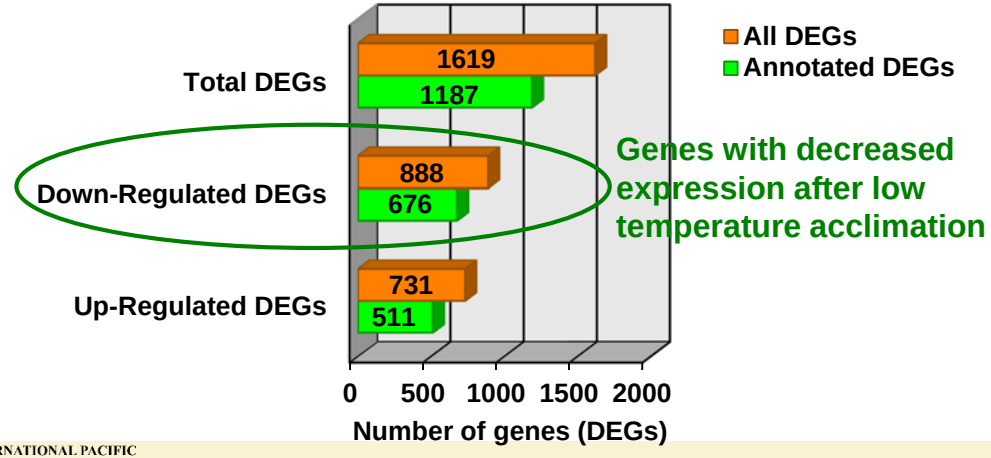
MOLECULAR GROWTH MARKERS

Growth: transcriptomic analyses





- Differentially expressed genes (DEGs):

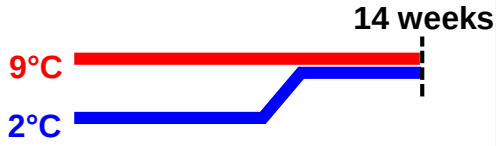


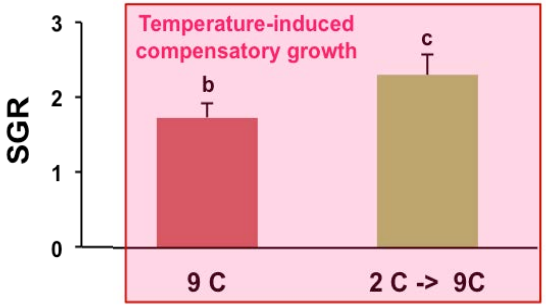
Genes with decreased expression after low temperature acclimation

- Functional categories (Down-regulated at 2ºC):

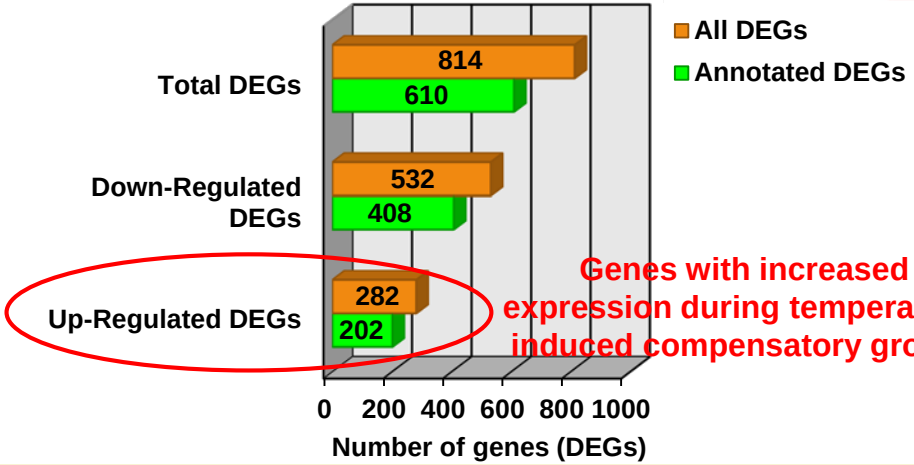
Change	Functional category
Down	Muscle development and contraction
Down	Transcription and translation
Down	Protein and carbohydrate metabolism
Down	Energy metabolism and transfer
Down	Cell division
Down	Stress response
Down	Immune response

Growth: transcriptomic analyses





• **Differentially expressed genes (DEGs):**

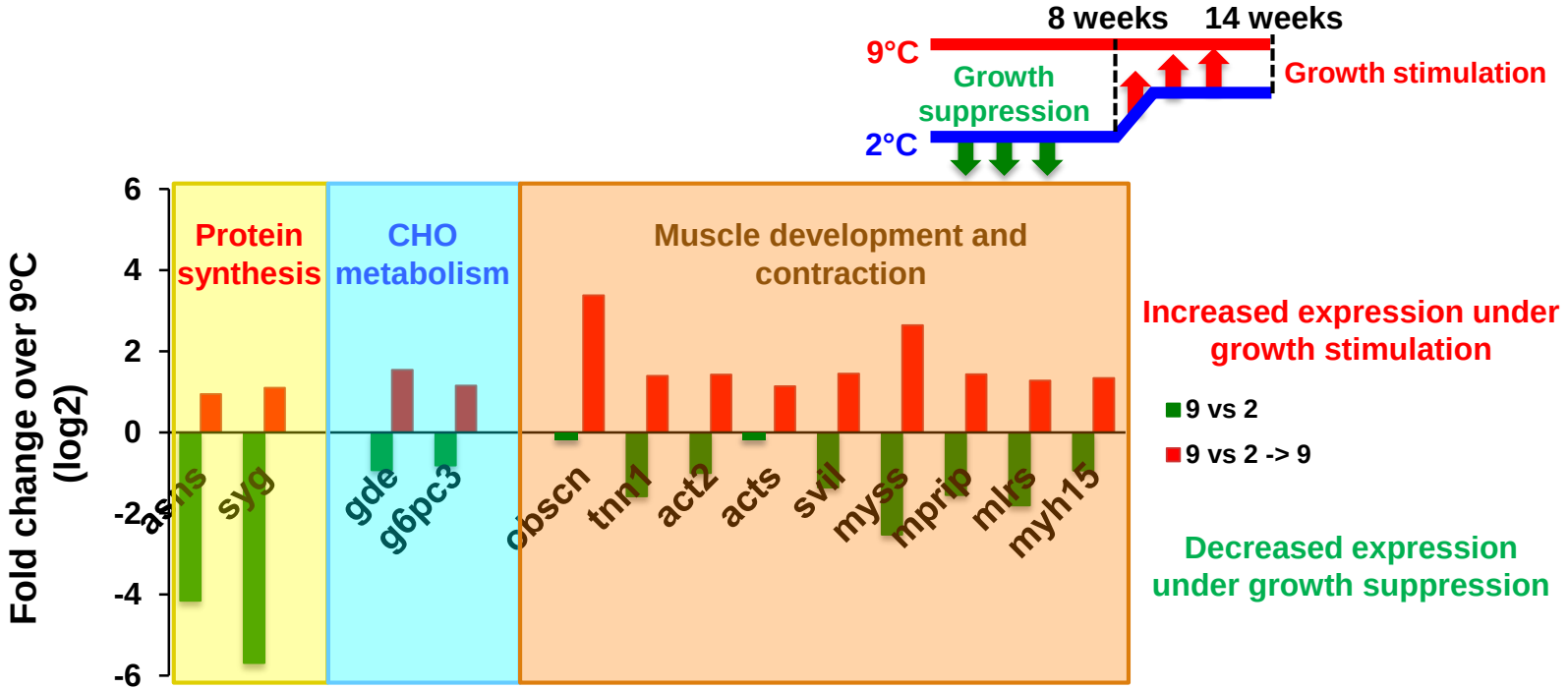


Genes with increased expression during temperature-induced compensatory growth

• **Functional categories (Up-regulated from 2ºC to 9ºC):**

Change	Functional category
Up	Muscle development and contraction
Up	Protein metabolism and modification
Up	Carbohydrate metabolism (for ATP)
Up	Iron transport and binding
Up	Hemoglobin synthesis
Up	Cell adhesion and proliferation
Up	Transcription and translation

Growth: transcriptomic analyses

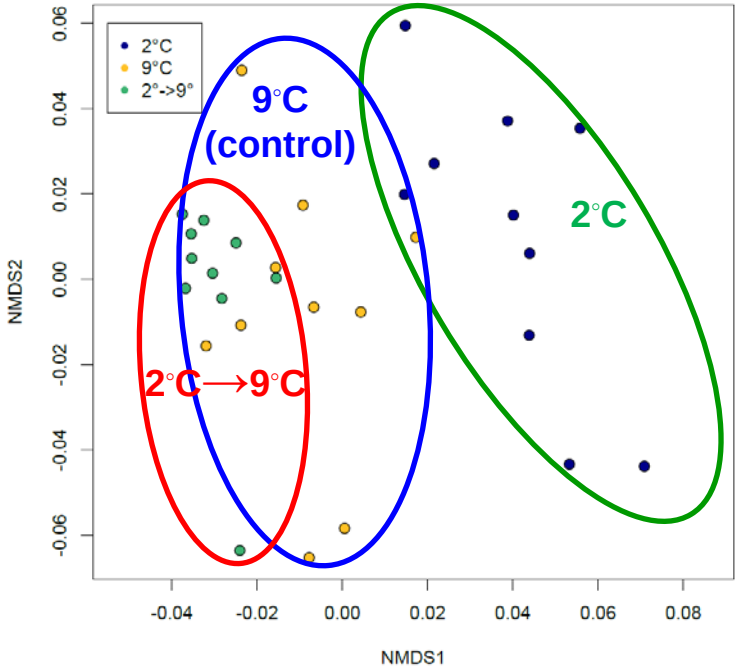


Potential molecular markers for growth alterations in skeletal muscle

qPCR assays for growth marker gene expression in development

Growth: proteomic analyses

Data Dependent Acquisition (DDA): LC-MS/MS



- **3140 annotated proteins**
- **Differentially expressed proteins:**
  - ✓ **Growth suppression: ↓150, ↑91**
  - ✓ **Growth stimulation: ↑149, ↓93**

Comparison between genes and proteins regulated by growth in progress

Selection of physiological growth markers

Growth

Physiological growth markers → **Application to field studies**

2. Evaluation of growth patterns in the Pacific halibut population

Age-matched skeletal muscle samples collected in the NMFS trawl survey (2016 – 2018) from 3 size categories:

<40 cm FL

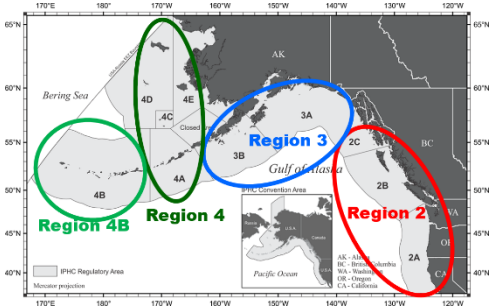
40-60 cm FL

60-80 cm FL

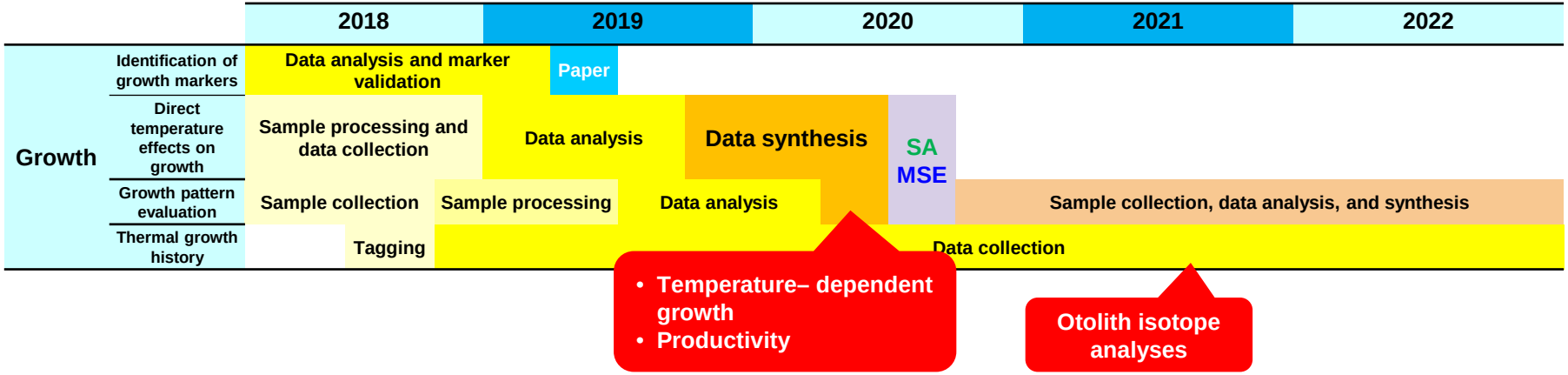
Slow growth rate?

Fast growth rate?

– **Regional monitoring of growth patterns**



Growth: timeline and integration with stock assessment, and MSE



Discard mortality rates and survival assessment

Projects:

1. Improve DMR estimations in the directed longline fishery

NOAA FISHERIES Saltonstall – Kennedy Grant NA17NMF4270240 ALASKA PACIFIC UNIVERSITY

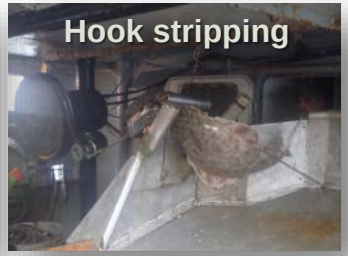
2. Estimate DMRs in the guided recreational fishery

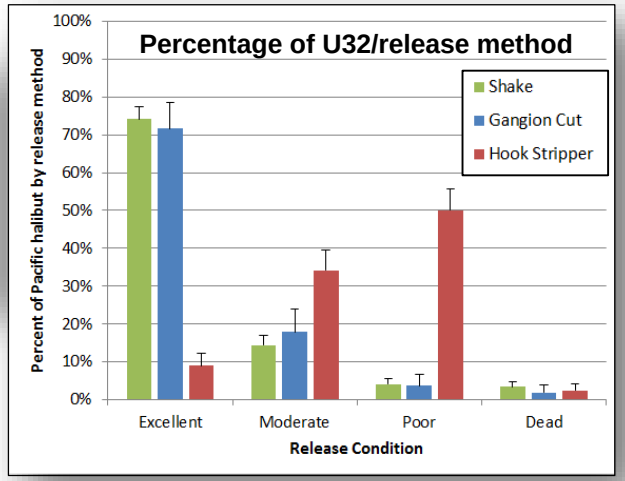
NFWF National Fish and Wildlife Foundation UAF UNIVERSITY OF ALASKA FAIRBANKS ALASKA PACIFIC UNIVERSITY ACA Alaska Charter Association

DMRs and survival assessment

1. *Directed longline fishery*: A. Relationship between *handling practices* and *injury levels* and *physiological condition* of released Pacific halibut

– **Assessed *injuries* associated with release techniques (careful shake, gangion cut, hook stripping).**





– ***Physiological condition* of released fish**

- **Condition factor indices**
- **Blood stress**
- **Fat content**

– ***Capture conditions***

- **Time**

- **Water temperature loggers**

- **Fish temperature**

Blood stress indicators:
- ✓ **Glucose**
- **Lactate**
- **Cortisol**

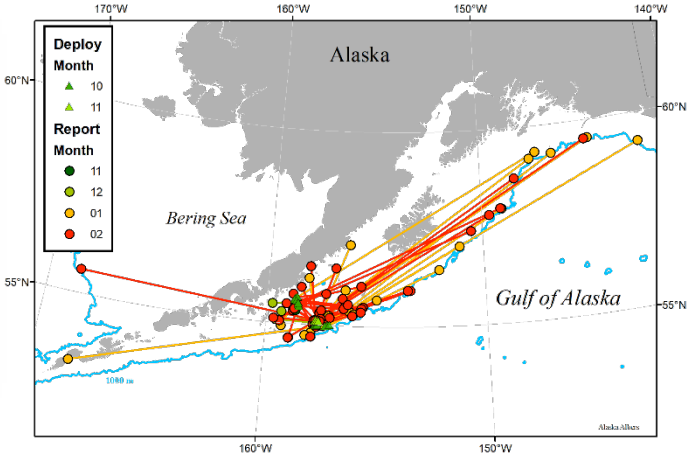
DMRs and survival assessment

B. Relationship between physiological condition post-capture and survival post-release as assessed by tagging

- **Wire tags (n=1,048): including all handling practices and release conditions**
- **Accelerometer tags (n=79): only fish in excellent condition**

Results: 4% mortality

After 96 days at liberty:



DMRs and survival assessment

C. Applicability of electronic monitoring (EM) in DMR estimation

- **Deployed EM system on a longline vessel**
- **Video recorded fish handling events during capture**
- **This will allow us to determine injury profile by release method**

DMRs and survival assessment

C. Applicability of EM in DMR estimation

– **Results: Comparison of EM-determined release method to the actual**

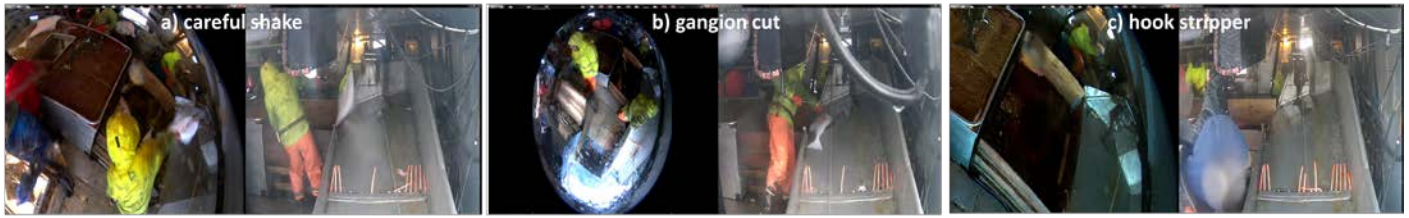
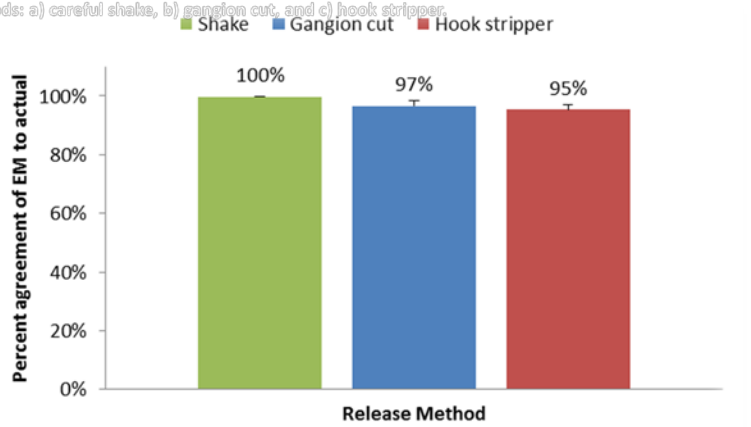


Figure 4. EM capture of hook release methods: a) careful shake, b) gangion cut, and c) hook stripper.



DMRs and survival assessment

2. *Guided recreational fishery: Estimation of DMRs*

– **Project initiated in 2019**

Objectives:

1. **Collect information on hook types and sizes and handling practices**
2. **Investigate the relationship between gear types and capture conditions and size composition of captured fish**
3. **Injury profiles and physiological stress levels of captured fish**
4. **Assessment of mortality of discarded fish**

Sport charter

Captured Pacific halibut

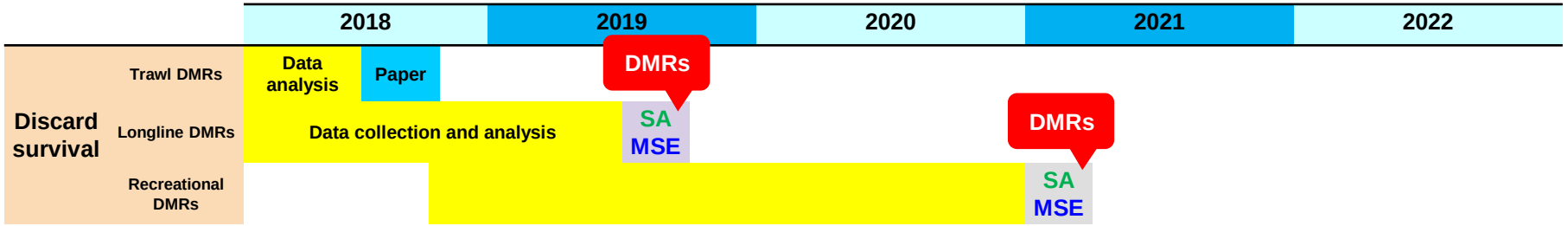
Hook injury assessment

Tagging with sPATs

NFWF National Fish and Wildlife Foundation

UAF University of Alaska Fairbanks · Alaska Pacific University · ACA Alaska Charter Association

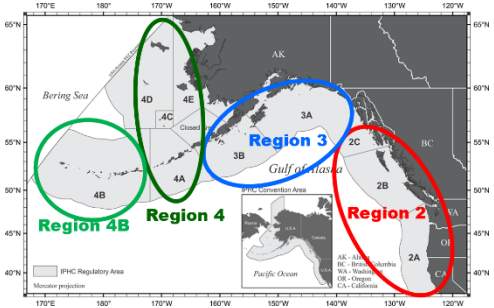
DMRs: timeline and integration with stock assessment, and MSE



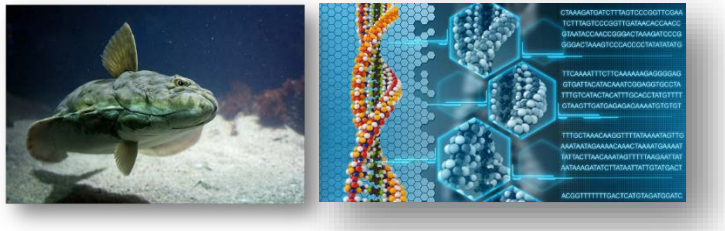
Genetics and Genomics

Projects:

1. ***Genetic structure of the Pacific halibut population***

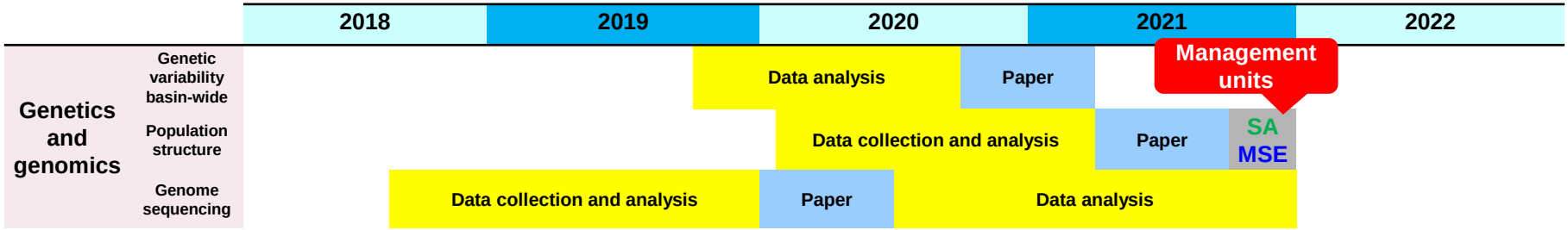


2. ***Genome sequencing***



- **Genomic DNA sequenced from one Pacific halibut female (WZ).**
- **Conducted first genome assembly:**
  - **Full genome sequenced. Genome size: 700 Mb**
  - **Non-continuous genome sequence.**
- **Additional sequencing is being conducted to complete assembly.**

Genetics and genomics: timeline and integration with stock assessment, and MSE



Outline

- Five-year research plan and management implications
- Progress on ongoing research projects
- **Externally-funded collaborative research**

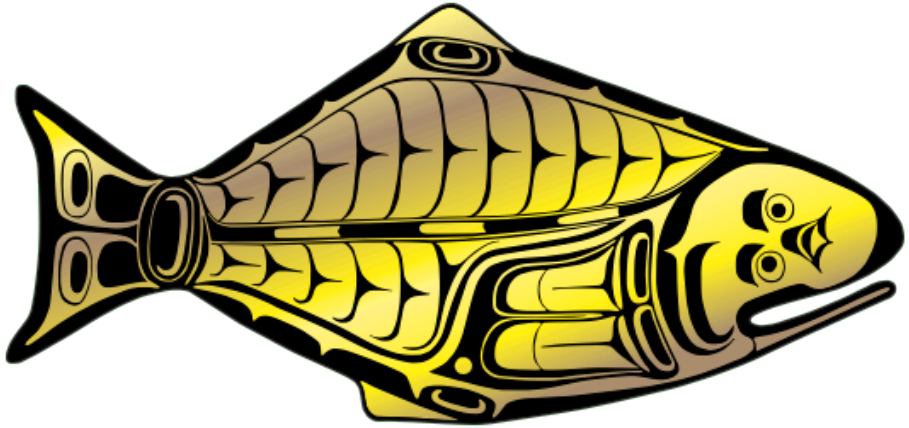
Externally-funded collaborative research

Project #	Grant agency	Project name	PI	Partners	IPHC Budget ($US)	Management implications	Grant period
1	Saltonstall-Kennedy NOAA	**Improving discard mortality rate estimates in the Pacific halibut by integrating handling practices, physiological condition and post-release survival (*Award No. NA17NMF4270240*)**	**IPHC**	Alaska Pacific University	$286,121	Discard estimates	September 2017 – August 2019
2	North Pacific Research Board	**Somatic growth processes in the Pacific halibut (*Hippoglossus stenolepis*) and their response to temperature, density and stress manipulation effects (*NPRB Award No. 1704*)**	**IPHC**	AFSC-NOAA-Newport, OR	$131,891	Changes in biomass/size-at-age	September 2017 – February 2020
3	Bycatch Reduction Engineering Program - NOAA	**Adapting towed array hydrophones to support information sharing networks to reduce interactions between sperm whales and longline gear in Alaska**	ALFA	IPHC, University of Alaska Southeast, AFSC-NOAA	-	Whale Depredation	September 2018 – August 2019
4	Bycatch Reduction Engineering Program - NOAA	**Use of LEDs to reduce Pacific halibut catches before trawl entrainment**	PSMFC	IPHC, NMFS	$1,750	Bycatch reduction	September 2018 – August 2019
5	National Fish and Wildlife Foundation	**Discard mortality rate characterization in the Pacific halibut recreational fishery (*NFWF Award No. 61484)***	**IPHC**	UA Fairbanks, APU, Grey Light Fisheries, Alaska Charter Association	$98,901	Discard estimates	2019-2020
				Total awarded ($)	**$518,663**		

Other collaborative research

Project #	Partners	Topic of collaboration
1	**Agencies from contracting parties** (NOAA-Fisheries, DFO, PHMA, PSMFC, ADEC)	**Collaborative research and data collection in IPHC FISS**
2	**Industry**	• **Collaborative research with trawl fishery and with Pacific halibut directed (longline) and recreational fisheries on discard mortality rate.** • **Collaborative research with Pacific halibut directed fishery on (1) sex marking at sea and (2) incidence of chalky halibut.**
3	**North Pacific Fisheries Management Council**	**Joint research priority list NPFMC-IPHC (last updated in 2018)**
4	**Scientific partners** 1. **Contracting parties: US** (AFSC-NOAA Fisheries, NWFSC-NOAA Fisheries, University of Washington, University of Alaska Fairbanks, Alaska Pacific University) 2. **Contracting parties: Canada** (Simon Fraser University, Dalhousie University) 3. **International: France** (INRA)	**Scientific collaborative research on various topics (genomics, genetics, migration, ecosystem studies, etc)**

INTERNATIONAL PACIFIC



HALIBUT COMMISSION

Scientific advice inputs into IPHC's research development and selection process