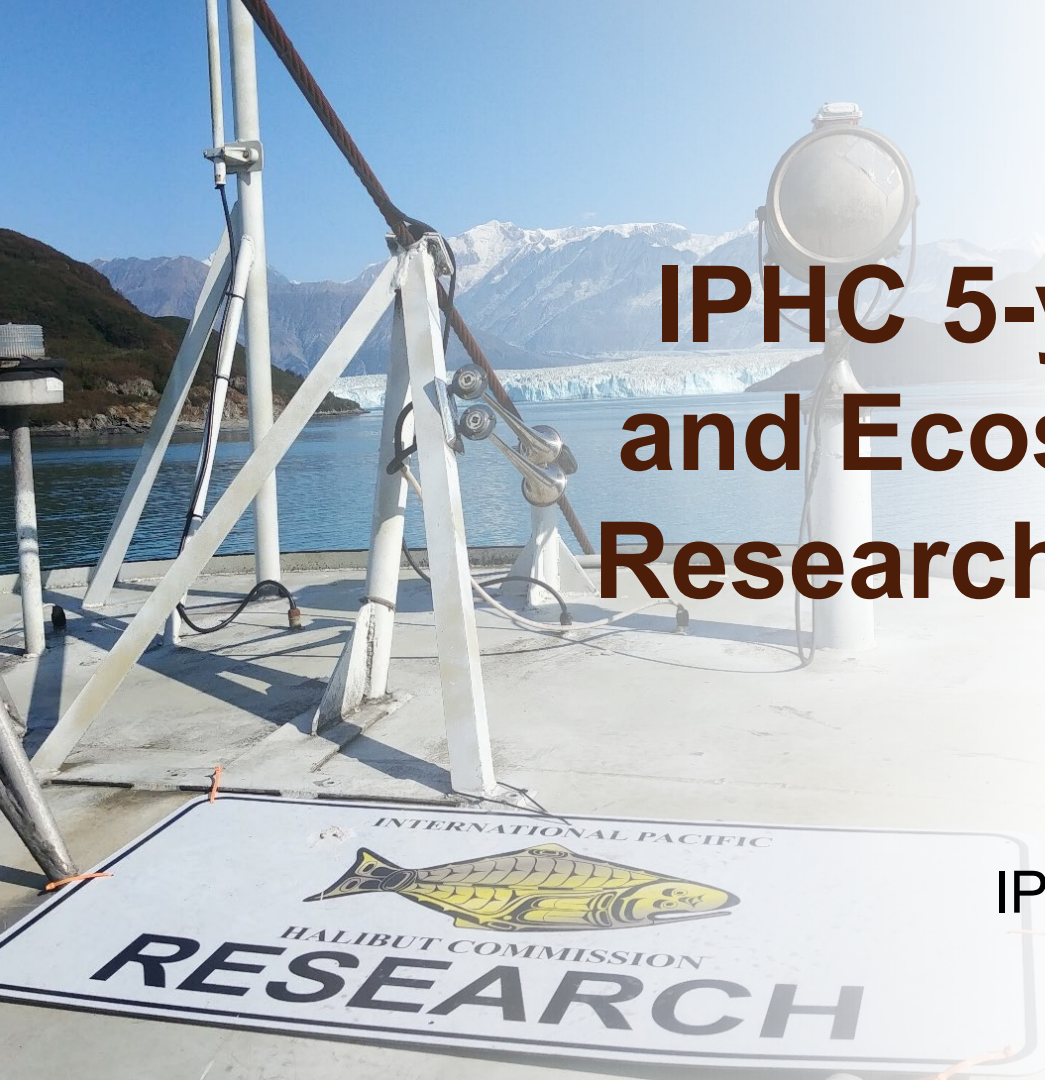


INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC 5-year Biological and Ecosystem Science Research Plan (2017-21): update

Agenda Item 6.1
IPHC-2021-IM097-11
(J. Planas)

Five-year research program and management implications (2017-2021)

5-Year Biological and Ecosystem Science Research Plan

Primary Research Areas	*Main Objectives*	*Management implications*
Migration	Improve understanding of migration throughout all life stages (larval, juvenile, adult feeding and reproductive migrations)	Stock distribution, regional management
Reproduction	Information on sex ratios of commercial landings and improved maturity estimates	Female stock spawning biomass
Growth	Improve understanding of factors responsible for changes in size-at-age and development of tools for monitoring growth and physiological condition	Biomass estimates
DMRs and discard survival	Improve estimates of DMRs in the directed longline and guided recreational fisheries	Discard mortality estimates
Genetics and genomics	Improve understanding of the genetic structure of the population and create genomic tools (genome)	Stock distribution, local adaptation

Next 5-Year Research Plan (2022-26) in development

Ranked research priorities for SA

SA Rank	Research outcomes	Relevance for stock assessment	Specific analysis input	Research Area	Research activities
1. Biological input	Updated maturity schedule	Scale biomass and reference point estimates	Will be included in the stock assessment, replacing the current schedule last updated in 2006	Reproduction	Histological maturity assessment
	Incidence of skip spawning		Will be used to adjust the asymptote of the maturity schedule, if/when a time-series is available this will be used as a direct input to the stock assessment		Examination of potential skip spawning
	Fecundity-at-age and -size information		Will be used to move from spawning biomass to egg-output as the metric of reproductive capability in the stock assessment and management reference points		Fecundity assessment
	Revised field maturity classification		Revised time-series of historical (and future) maturity for input to the stock assessment		Examination of accuracy of current field macroscopic maturity classification
2. Biological input	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area	Altered structure of future stock assessments	If 4B is found to be functionally isolated, a separate assessment may be constructed for that IPHC Regulatory Area	Genetics and Genomics	Population structure
3. Biological input	Assignment of individuals to source populations and assessment of distribution changes	Improve estimates of productivity	Will be used to define management targets for minimum spawning biomass by Biological Region		Distribution
	Improved understanding of larval and juvenile distribution		Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	Migration	Larval and juvenile connectivity studies
1. Assessment data collection and processing	Sex ratio-at-age	Scale biomass and fishing intensity	Annual sex-ratio at age for the commercial fishery fit by the stock assessment	Reproduction	Sex ratio of current commercial landings
	Historical sex ratio-at-age		Annual sex-ratio at age for the commercial fishery fit by the stock assessment		Historical sex ratios based on archived otolith DNA analyses
2. Assessment data collection and processing	New tools for fishery avoidance/deterence; improved estimation of depredation mortality	Improve mortality accounting	May reduce depredation mortality, thereby increasing available yield for directed fisheries. May also be included as another explicit source of mortality in the stock assessment and mortality limit setting process depending on the estimated magnitude	Mortality and survival assessment	Whale depredation accounting and tools for avoidance
1. Fishery yield	Physiological and behavioral responses to fishing gear	Reduce incidental mortality	May increase yield available to directed fisheries	Mortality and survival assessment	Biological interactions with fishing gear
2. Fishery yield	Guidelines for reducing discard mortality	Improve estimates of unobserved mortality	May reduce discard mortality, thereby increasing available yield for directed fisheries	Mortality and survival assessment	Best handling practices: recreational fishery

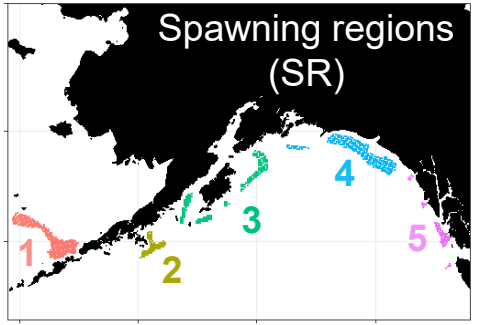
Ranked research priorities for MSE

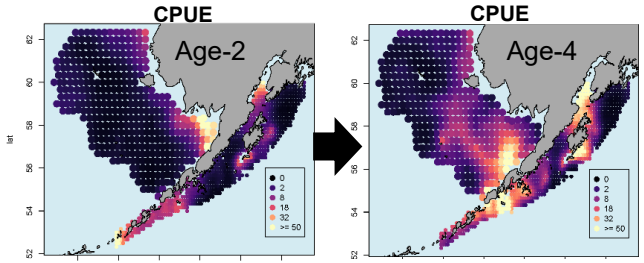
MSE Rank	Research outcomes	Relevance for MSE	Research Area	Research activities
1. Biological parameterization and validation of movement estimates	Improved understanding of larval and juvenile distribution	Improve parametization of the Operating Model	Migration	Larval and juvenile connectivity studies
	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area		Genetics and Genomics	Population structure
2. Biological parameterization and validation of recruitment variability and distribution	Assignment of individuals to source populations and assessment of distribution changes	Improve simulation of recruitment variability and parametization of recruitment distribution in the Operating Model		Distribution
	Establishment of temporal and spatial maturity and spawning patterns	Improve simulation of recruitment variability and parametization of recruitment distribution in the Operating Model	Reproduction	Recruitment strength and variability
3. Biological parameterization and validation for growth projections	Identification and application of markers for growth pattern evaluation	Improve simulation of variability and allow for scenarios investigating climate change	Growth	Evaluation of somatic growth variation as a driver for changes in size-at-age
	Environmental influences on growth patterns			
	Dietary influences on growth patterns and physiological condition			
1. Fishery parameterization	Experimentally-derived DMRs	Improve estimates of stock productivity	Mortality and survival assessment	Discard mortality rate estimate: recreational fishery

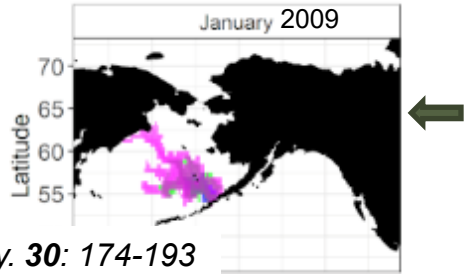
1. Migration and Distribution

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Migration	Larval and juvenile connectivity and early life history studies	Improved understanding of larval and juvenile distribution	Improve estimates of productivity	3. Biological input	Improve parametization of the Operating Model	1. Biological parameterization and validation of movement estimates

- **Key findings:**
  - Aleutian Islands constrain connectivity, but large island passes act as conduits between the GOA and Bering Sea
  - Degree of inter-basin larval connectivity is influenced by spawning location
  - Large degree of within-basin connectivity
  - Demersal stage fish in the Bering Sea migrate outward from Bristol Bay and reach Unimak Pass by age-4, widely dispersed by age-6





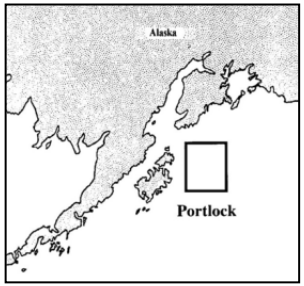


	% larvae reaching BS	
	Warm	Cold
Year	2005	2009
SR 1	100	100
SR 2	58.1	52.7
SR 3	15.2	17.2
SR 4	8.2	4.5
SR 5	0.6	0.08

Recent Publication: Sadorus et al. (2021). *Fisheries Oceanography.* ***30****: 174-193*

2. Reproduction

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE
Reproduction	Histological maturity assessment	Updated maturity schedule	Scale biomass and reference point estimates	1. Biological input	Improve simulation of spawning biomass in the Operating Model
	Examination of potential skip spawning	Incidence of skip spawning			
	Fecundity assessment	Fecundity-at-age and -size information			
	Examination of accuracy of current field macroscopic maturity	Revised field maturity classification			



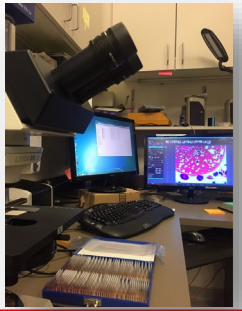
Sept Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

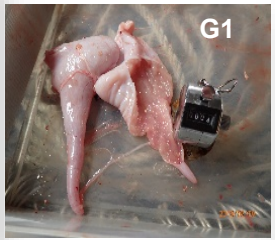
2017 2018

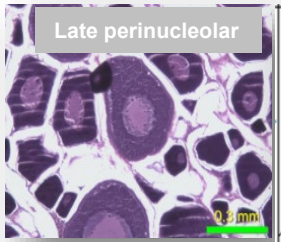
30♀ / 30♂

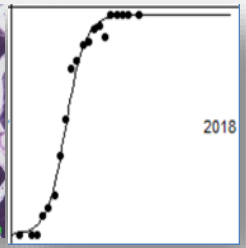
Reproductive cycle

Gonadal growth | Maturation | Spawning

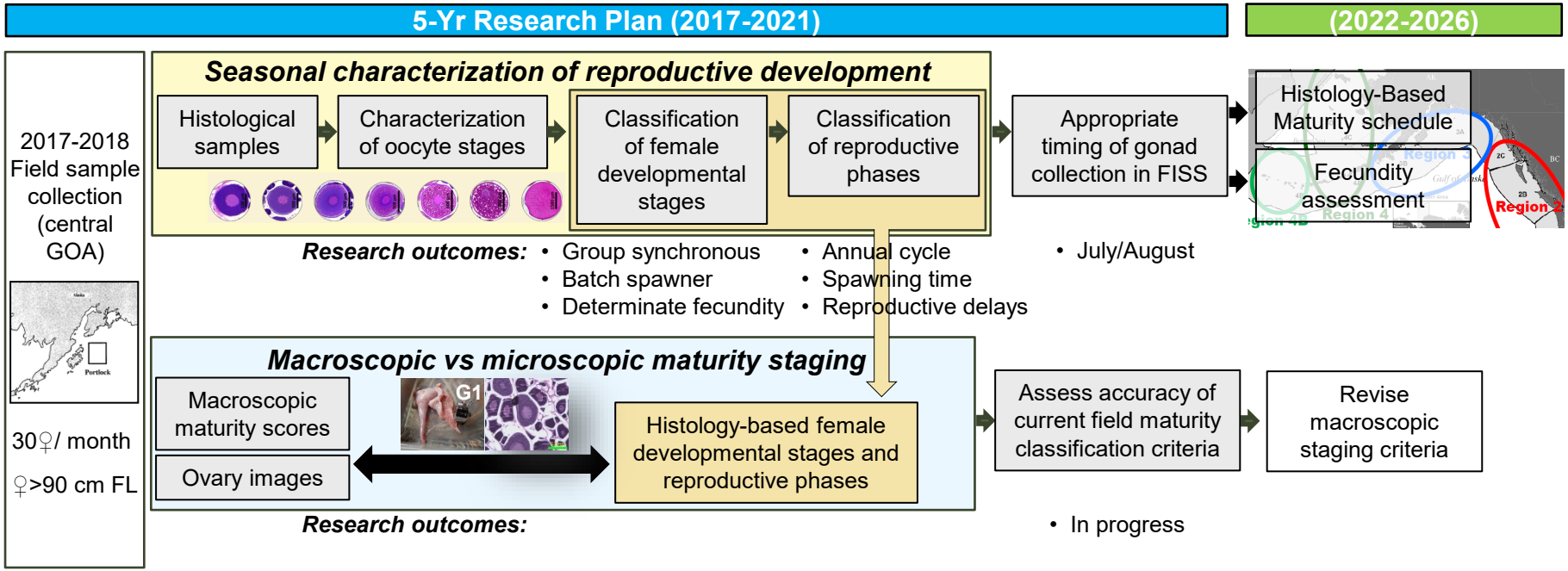








2. Reproduction



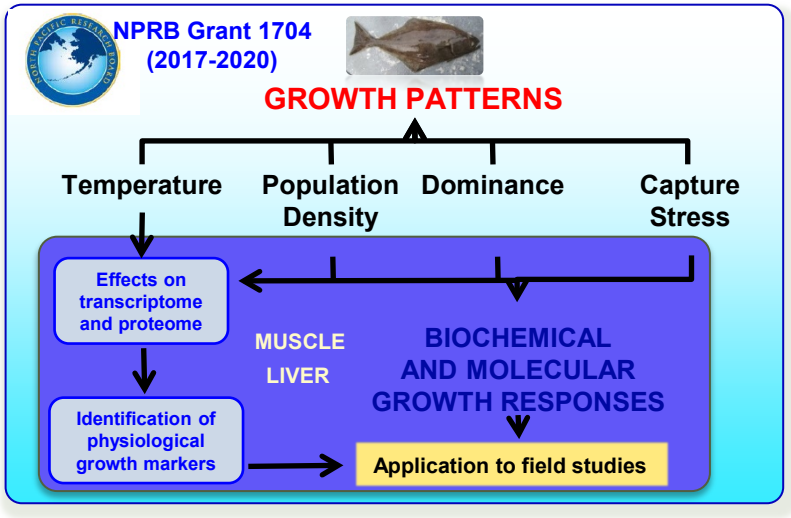
Staff involved: Teresa Fish, MSc candidate APU (2018-2020), Crystal Simchick, Tim Loher, Ian Stewart, Allan Hicks, Josep Planas

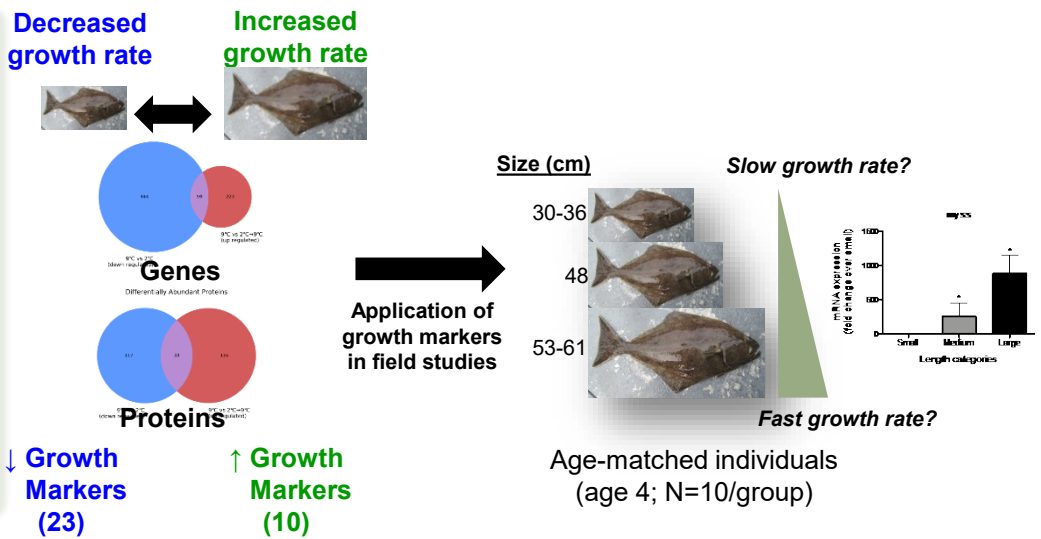
Funding: IPHC (2018-2020)

Publications: Fish et al. (2020) *J. Fish Biol*. **97**: 1880–1885 ; Fish et al. (in review)

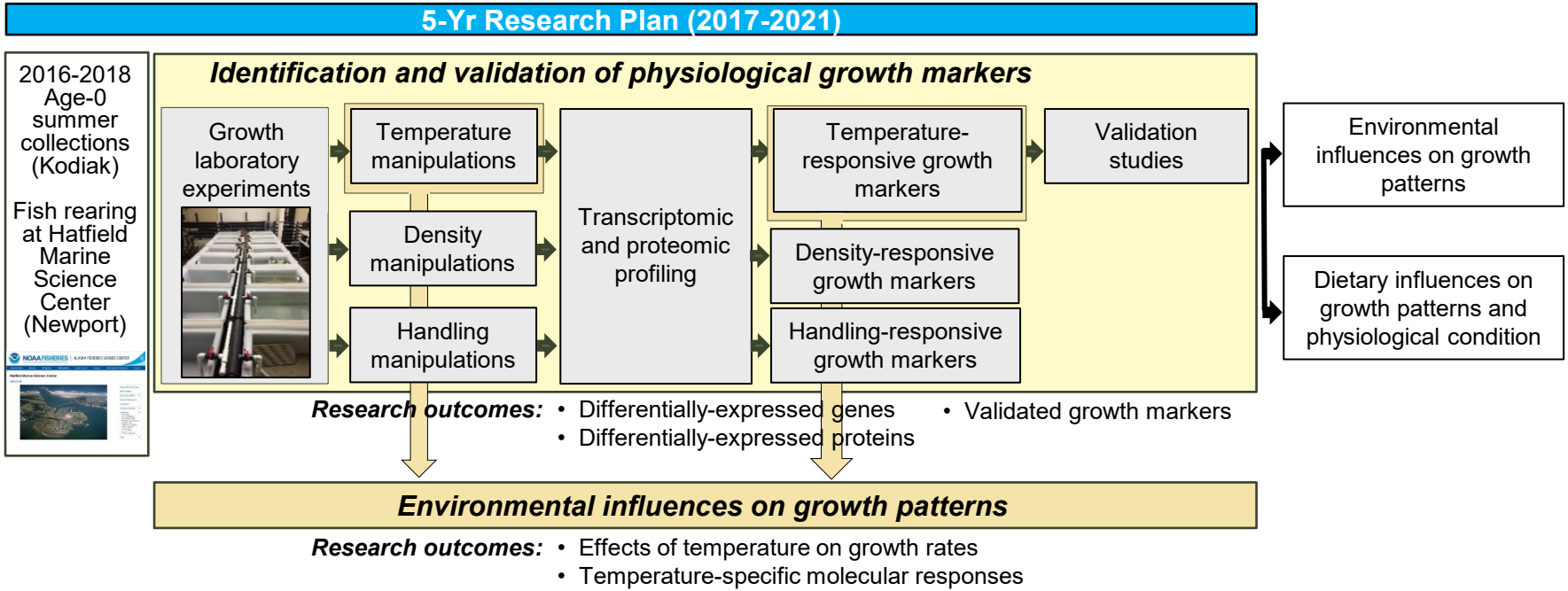
3. Growth

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Growth	Identification and application of markers for growth pattern evaluation	Identification and application of markers for growth pattern evaluation	Scale stock productivity and reference point estimates		Improve simulation of variability and allow for scenarios investigating climate change	3. Biological parameterization and validation for growth projections
	Environmental influences on growth patterns	Environmental influences on growth patterns				
	Dietary influences on growth patterns and physiological condition	Dietary influences on growth patterns and physiological condition				





3. Growth



Staff involved: Andy Jasonowicz, Crystal Simchick, Josep Planas
Funding: NPRB Grant#1704 (Sept. 2017-Feb. 2020)
Publications: Planas et al. (in preparation)

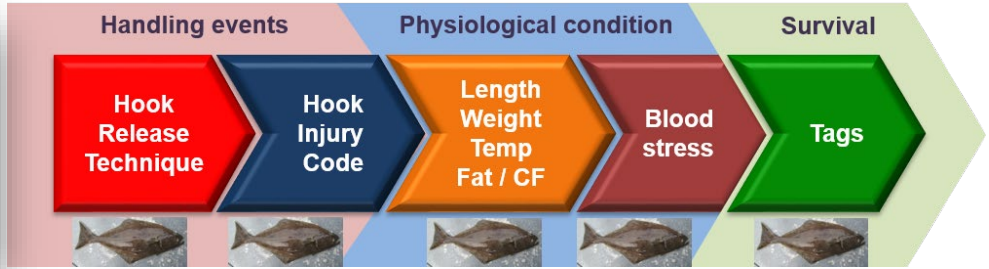
4. DMRs and Survival Assessment

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Directed longline fishery***

NOAA FISHERIES Saltonstall – Kennedy Grant NA17NMF4270240 (2017-2020)

ALASKA PACIFIC UNIVERSITY



DMR
Best predictors of mortality
Best practices

4. DMRs and Survival Assessment

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Guided recreational fishery***

NFWF National Fish and Wildlife Foundation

NPRB Grant No. 2009

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**

- Sitka, AK (2C): 21 – 27 May 2021

Size classes (cm)				
≤ 68	69-77	78-93	≥ 94	Total
63	**75**	**66**	**39**	**243**

- Two gear sizes: 12/0 and 16/0 hooks
- Observations and samples: hooking time, time on deck, weight, length, hook injury type and picture, viability, fat content, fish temperature, blood sample, fin clip, wire tag.

4. DMRs and Survival Assessment

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve estimates of unobserved mortality		Improve estimates of stock productivity	1. Fishery parameterization
	Discard mortality rate estimate: recreational fishery					2. Fishery parameterization
	Best handling practices: longline fishery	Guidelines for reducing discard mortality		2. Fishery yield		
	Best handling practices: recreational fishery	Guidelines for reducing discard mortality		3. Fishery yield		

- ***Guided recreational fishery***

NFWF National Fish and Wildlife Foundation

NPRB Grant No. 2009

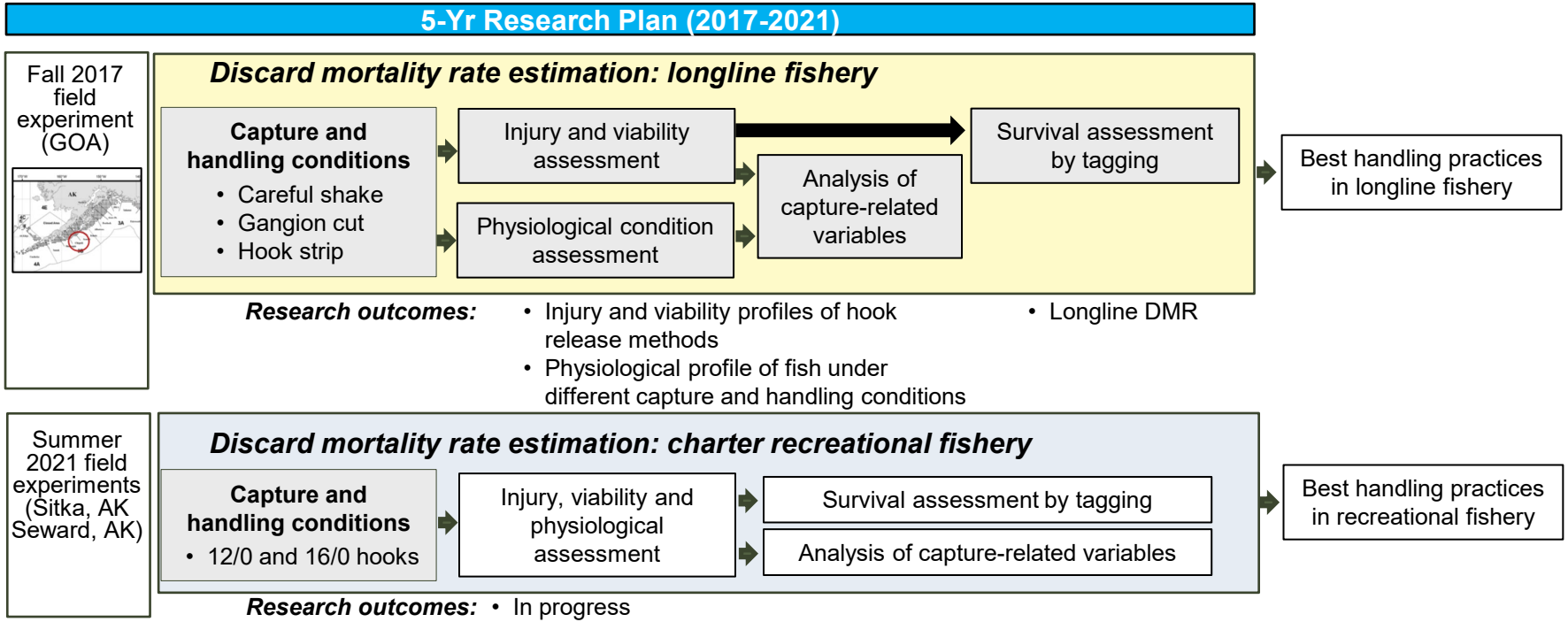
1. Collect information on hook types and sizes and handling practices
2. **Investigate the relationship between gear types and capture conditions and size composition of captured fish**
3. **Injury profiles and physiological stress levels of captured fish**
4. **Assessment of mortality of discarded fish**

- Seward, AK (3A): 11 – 17 June 2021

Types of tags		
Wire	sPATs	Total
38	80	118

- Two gear sizes: 12/0 and 16/0 hooks
- Observations and samples: hooking time, time on deck, weight, length, hook injury type and picture, viability, fat content, fish temperature, blood sample, fin clip, wire tag.

4. Mortality and Survival Assessment



Staff involved: Claude Dykstra, Tim Loher, Allan Hicks, Ian Stewart, Josep Planas

Funding: Saltonstall-Kennedy NOAA (Sept. 2017-Aug. 2020); National Fish and Wildlife Foundation (Apr. 2019-Nov. 2021)

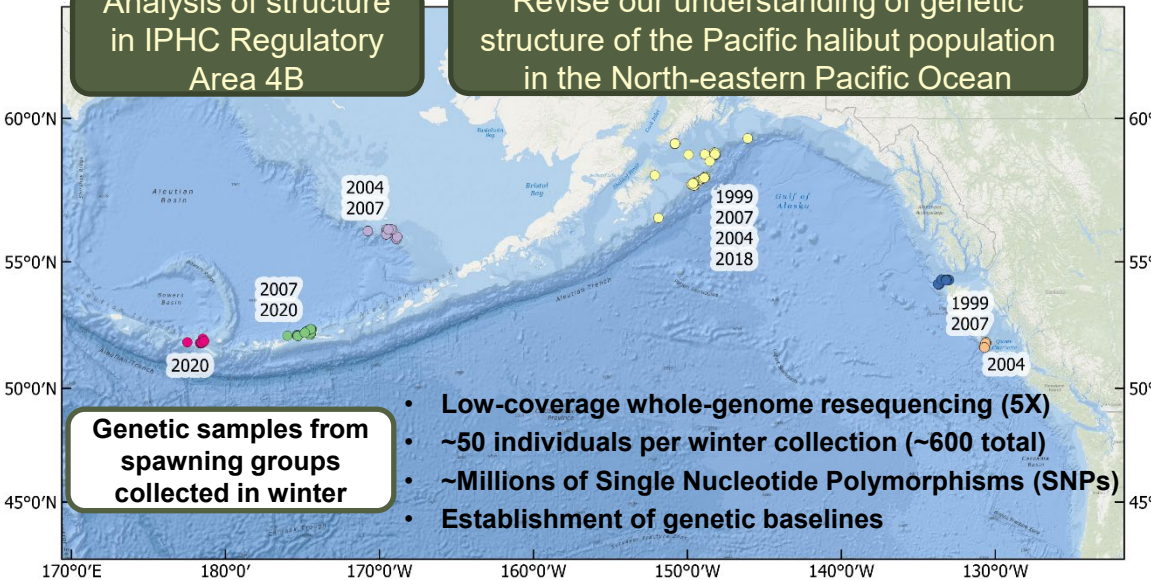
Publications: Kroska et al. (2021) *Conserv. Physiol.*; Loher et al. (2021) *North Amer. J. Fish. Manag.(In Press)*

5. Genetics and Genomics

Research area	Research activities	Research outcomes	Relevance for stock assessment (SA)	SA Rank	Relevance for MSE	MSE Rank
Genetics and genomics	Population structure	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area	Altered structure of future stock assessments	2. Biological input	Improve parametization of the Operating Model	1. Biological parameterization and validation of movement estimates. 2. Biological parameterization and validation of recruitment distribution
	Distribution	Assignment of individuals to source populations and assessment of distribution changes		3. Biological input		

Analysis of structure in IPHC Regulatory Area 4B

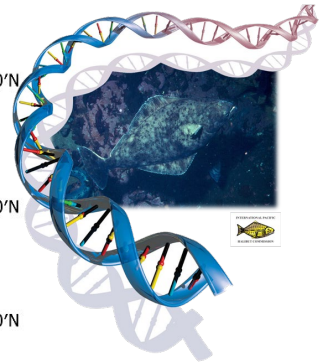
Revise our understanding of genetic structure of the Pacific halibut population in the North-eastern Pacific Ocean



Genetic samples from spawning groups collected in winter

- Low-coverage whole-genome resequencing (5X)
- ~50 individuals per winter collection (~600 total)
- ~Millions of Single Nucleotide Polymorphisms (SNPs)
- Establishment of genetic baselines

Pacific halibut genome



- Genomic analyses of population dynamics: stock structure and spatial connectivity.
- Identifying potential local and/or environmental adaptations.
- Provide genetic basis for life-history traits (e.g. growth, maturity, migratory behavior, etc.).

5. Genetics and Genomics

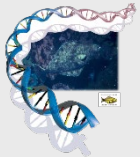
5-Yr Research Plan (2017-2021)

Collection of genetic samples of spawning aggregations spanning the Gulf of Alaska, Bering Sea and Aleutian Islands

(1999-2020)

Development and application of genomic approaches

Chromosome-level genome assembly



Development of methods based on low-coverage whole genome resequencing

Establishment of a bioinformatic pipeline in the cloud (Microsoft Azure)

Population structure analyses

Establishment of a baseline of genetic diversity

Delineation of fine-scale stock structure

Research outcomes:

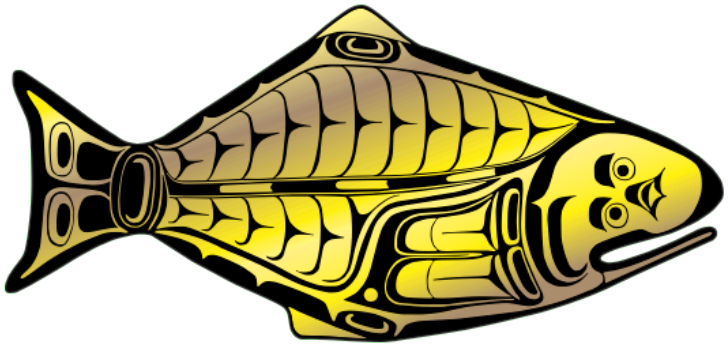
- Sequenced genome (size=586 Mbp)
- Full annotation (NCBI) (27,422 genes)
- 24 chromosome-length scaffolds
- SNP detection and genotyping

Staff involved: Andy Jasonowicz, Josep Planas
Funding: IPHC, NPRB

Externally-funded collaborative research

Project #	Grant agency	Project name	PI	Partners	IPHC Budget ($US)	Management implications	Grant period
1	National Fish & Wildlife Foundation	Improving the characterization of discard mortality of Pacific halibut in the recreational fisheries (NFWF Award No. 61484)	IPHC Dr J. Planas and Mr Claude Dykstra	Alaska Pacific University, U of A Fairbanks, charter industry	$98,902	Bycatch estimates	1 April 2019 – 1 November 2021
2	North Pacific Research Board	Pacific halibut discard mortality rates (NPRB Award No. 2009)	IPHC Dr. J. Planas	Alaska Pacific University	$210,502	Bycatch estimates	1 January 2021 – 31 March 2022
3	Bycatch Reduction Engineering Program-NOAA	Gear-based approaches to catch protection as a means for minimizing whale depredation in longline fisheries (NOAA Award Number NA21NMF4720534)	IPHC Mr. Claude Dykstra and Dr. I. Stewart	Deep Sea Fishermen's Union, Alaska Fisheries Science Center-NOAA, industry representatives	$99,700	Whale depredation	1 November 2021 – 30 April 2022
4	North Pacific Research Board	Pacific halibut population genomics (NPRB Award No. 2110)	IPHC Dr. J. Planas	Alaska Fisheries Science Center-NOAA	$193,685	Stock structure	1 February 2022 – 31 January 2024
Total awarded ($)					$602,789		

INTERNATIONAL PACIFIC



HALIBUT COMMISSION