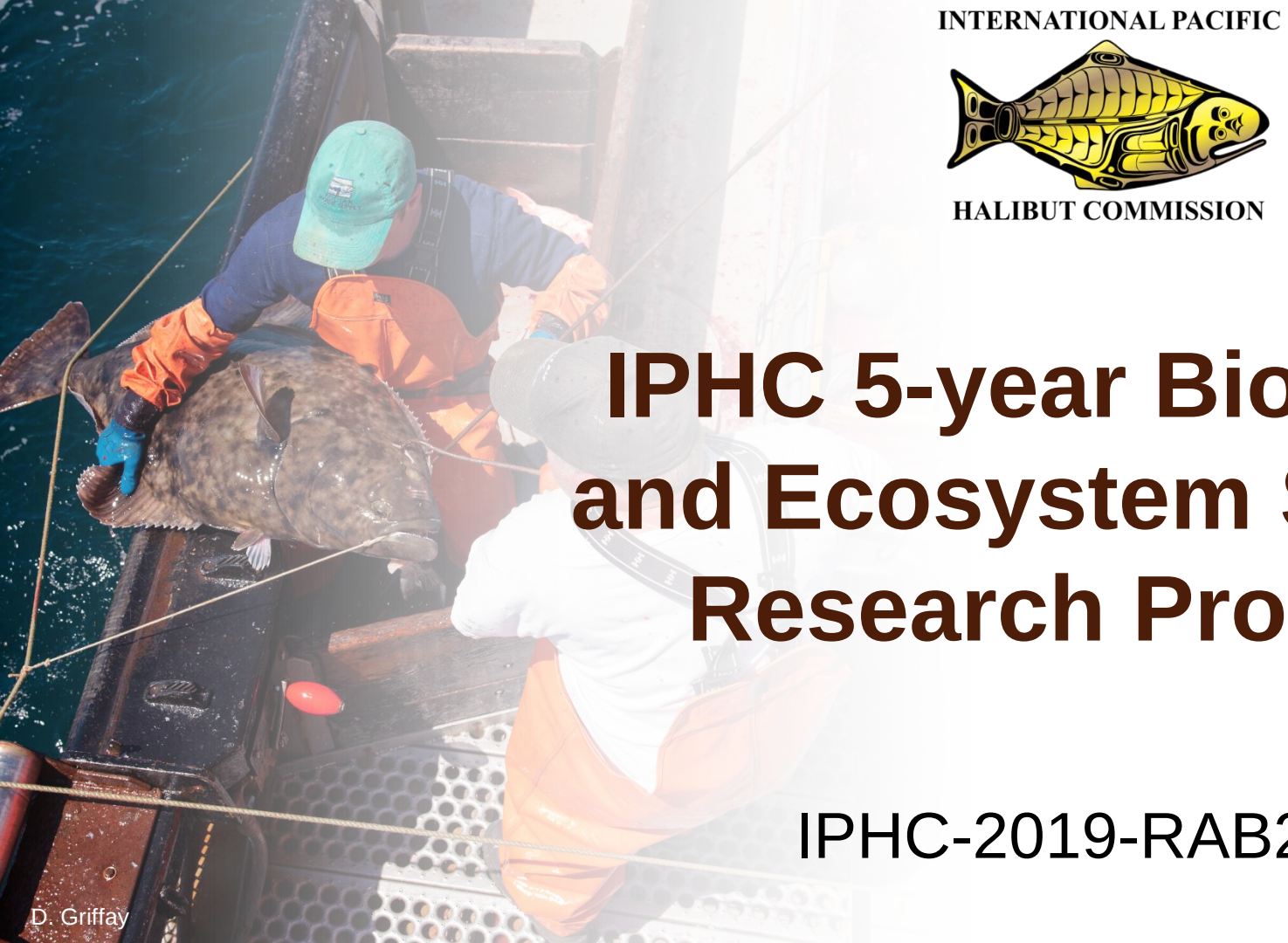


INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC 5-year Biological and Ecosystem Science Research Program

IPHC-2019-RAB20-05

D. Griffay

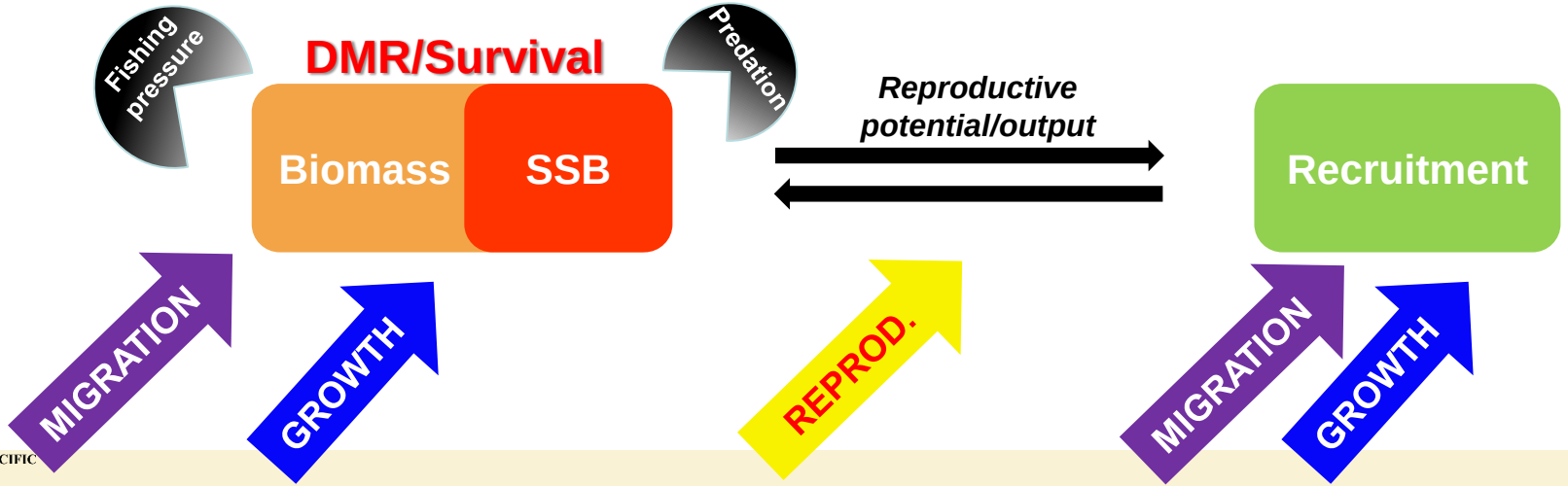
Description of IPHC research activities

1. **Overview of IPHC 5-year Biological and Ecosystem Sciences Research Plan (2017-2021)**
2. **Core research streams: Updates for key ongoing research activities (Project leaders)**
   - **Migration*:*** *Migratory behaviour and distribution of Pacific halibut* (L. Sadorus, T. Loher)
   - **Reproduction*:***
     - *Reproductive assessment of the Pacific halibut population* (J. Planas)
     - *Sex-marking at sea and application of genetics to determine the sex ratio of the commercial landings validation of sex identification* (T. Loher)
   - **Growth*:*** *Factors affecting somatic growth in juvenile Pacific halibut* (J. Planas)
   - ***Discard mortality rates:*** *Discard mortality rates and post-release survival in the Pacific halibut fisheries* (C. Dykstra)
3. **IPHC new research projects selected for 2019 (J. Planas)**

Primary research activities at IPHC

Primary objectives

- Identify and address *critical knowledge gaps* in the biology of Pacific halibut
- Understand the influence of *environmental conditions* on Pacific halibut biology
- Apply resulting knowledge to reduce *uncertainty* in current stock assessment models



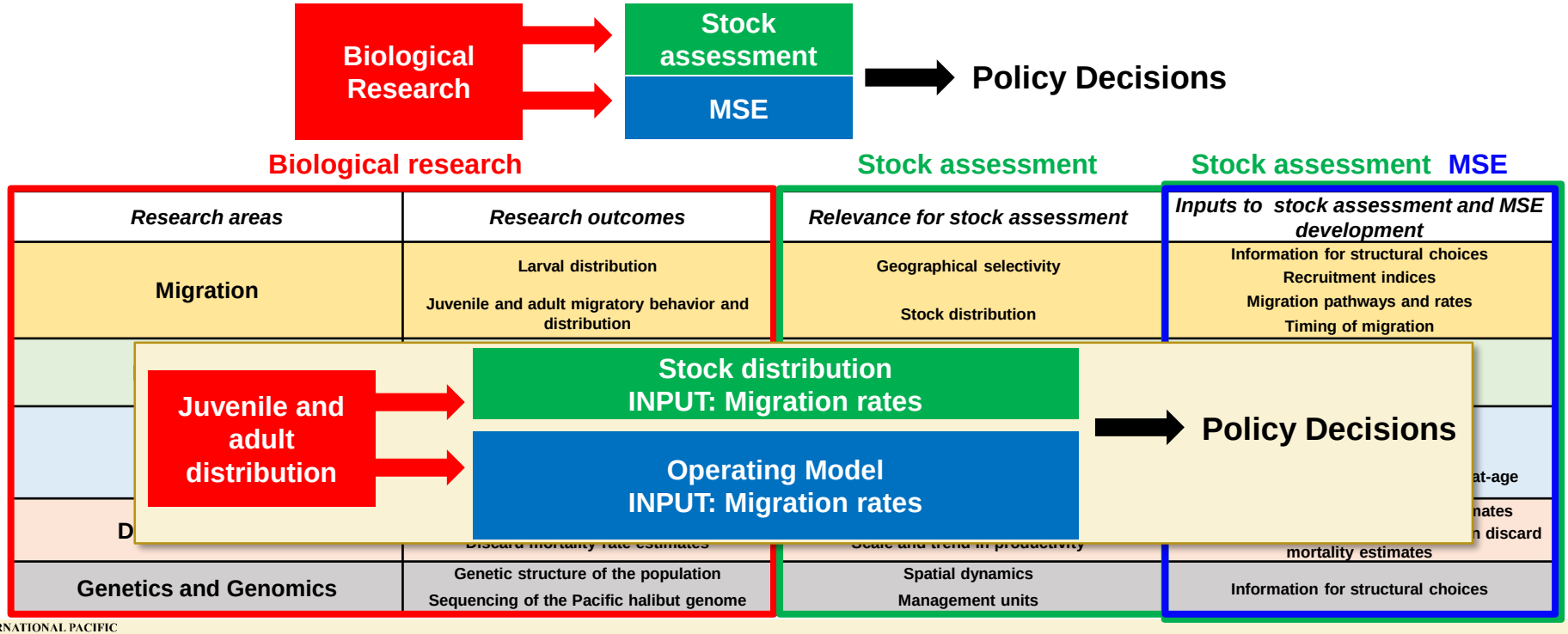
Five-year research plan and management implications

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

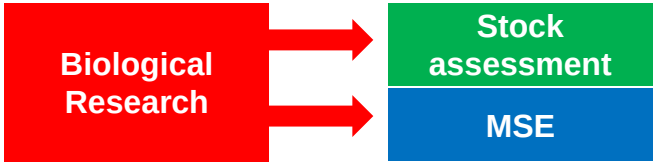
Integration of biological research, stock assessment, and policy

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
Growth	Identification of growth patterns Environmental effects on growth Growth influence in size-at-age variation	Temporal and spatial variation in growth Yield calculations Effects of ecosystem conditions Effects of fishing	Predicted weight-at-age Mechanisms for changes in weight-at-age
Discard Survival	Bycatch survival estimates Discard mortality rate estimates	Scale and trend in mortality Scale and trend in productivity	Bycatch and discard mortality estimates Variability in bycatch and uncertainty in discard mortality estimates
Genetics and Genomics	Genetic structure of the population Sequencing of the Pacific halibut genome	Spatial dynamics Management units	Information for structural choices

Integration of biological research, stock assessment, and policy



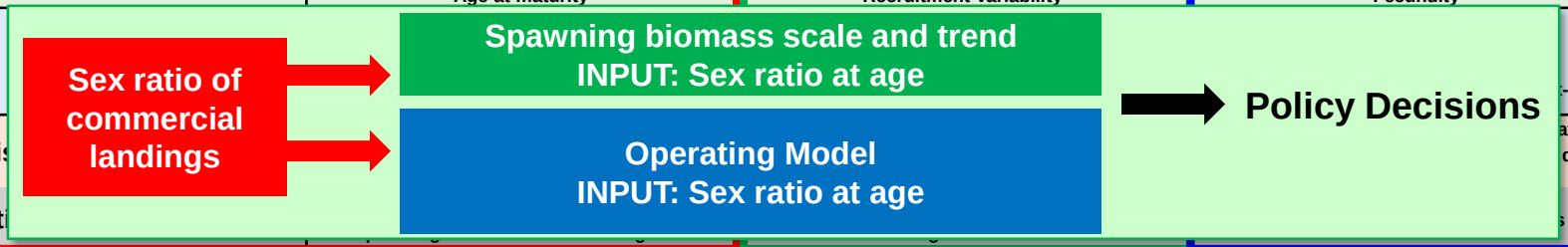
Integration of biological research, stock assessment, and policy



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			**discard**
Genet			



Policy Decisions

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

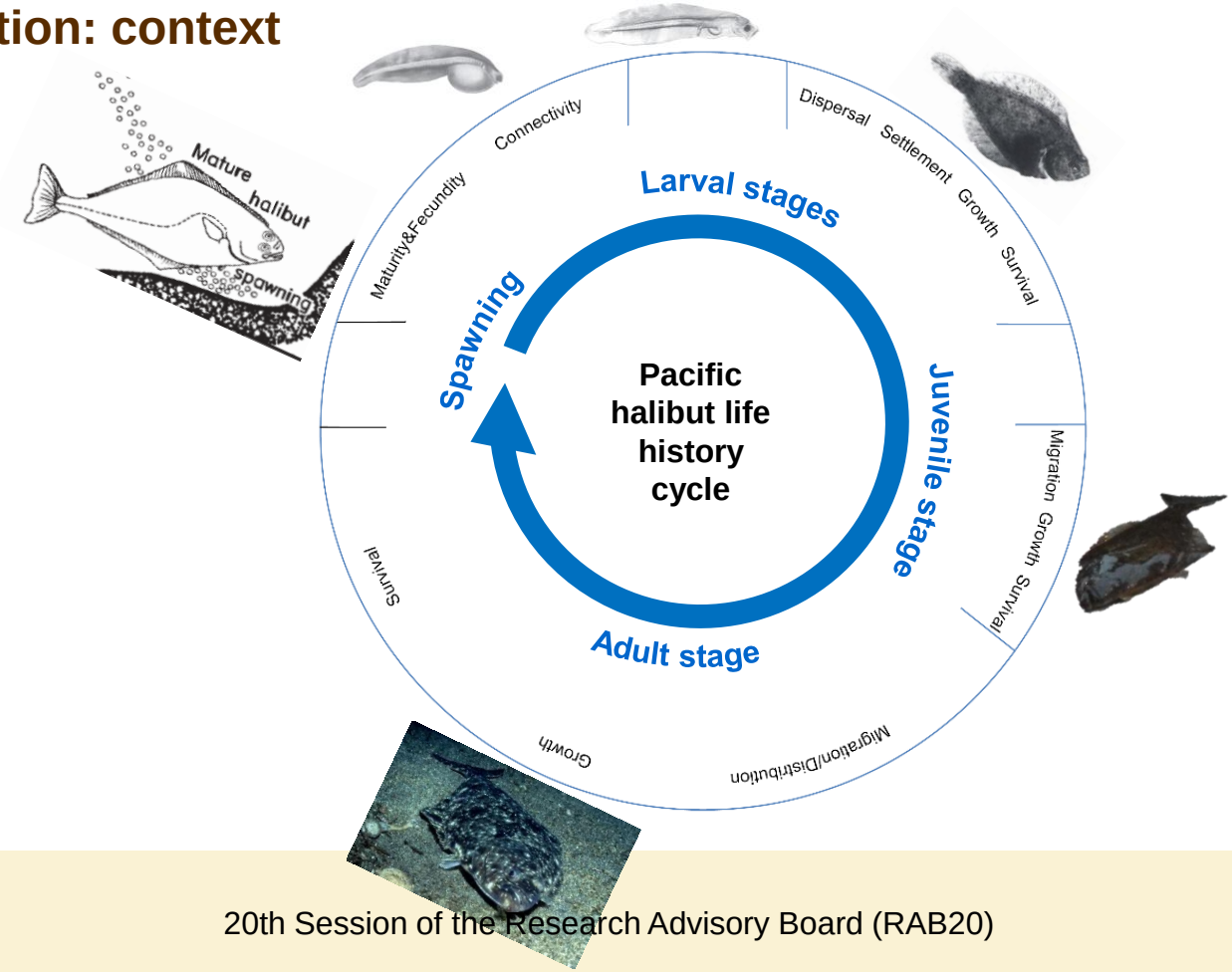
Research Area		2018	2019	2020	2021	2022
Migration	Larval distribution	Data analysis	Data synthesis	SA MSE	Sample collection	Data analysis	Data synthesis	
	Adult and juvenile migration	Tagging	Tagging	Data synthesis	SA MSE	Tagging	Data synthesis	SA MSE	Tagging	Data synthesis
		Data analysis				Data analysis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

Description of IPHC research activities

1. Overview of IPHC 5-year Biological and Ecosystem Sciences Research Plan (2017-2021)
2. **Core research streams: Updates for key ongoing research activities (Project leaders)**
   - **Migration*:*** *Migratory behaviour and distribution of Pacific halibut* (L. Sadorus, T. Loher)
   - **Reproduction*:***
     - *Reproductive assessment of the Pacific halibut population* (J. Planas)
     - *Sex-marking at sea and application of genetics to determine the sex ratio of the commercial landings validation of sex identification* (T. Loher)
   - **Growth*:*** *Factors affecting somatic growth in juvenile Pacific halibut* (J. Planas)
   - ***Discard mortality rates:*** *Discard mortality rates and post-release survival in the Pacific halibut fisheries* (C. Dykstra)
3. IPHC new research projects selected for 2019 (J. Planas)

Current research activities

1. Migration: context

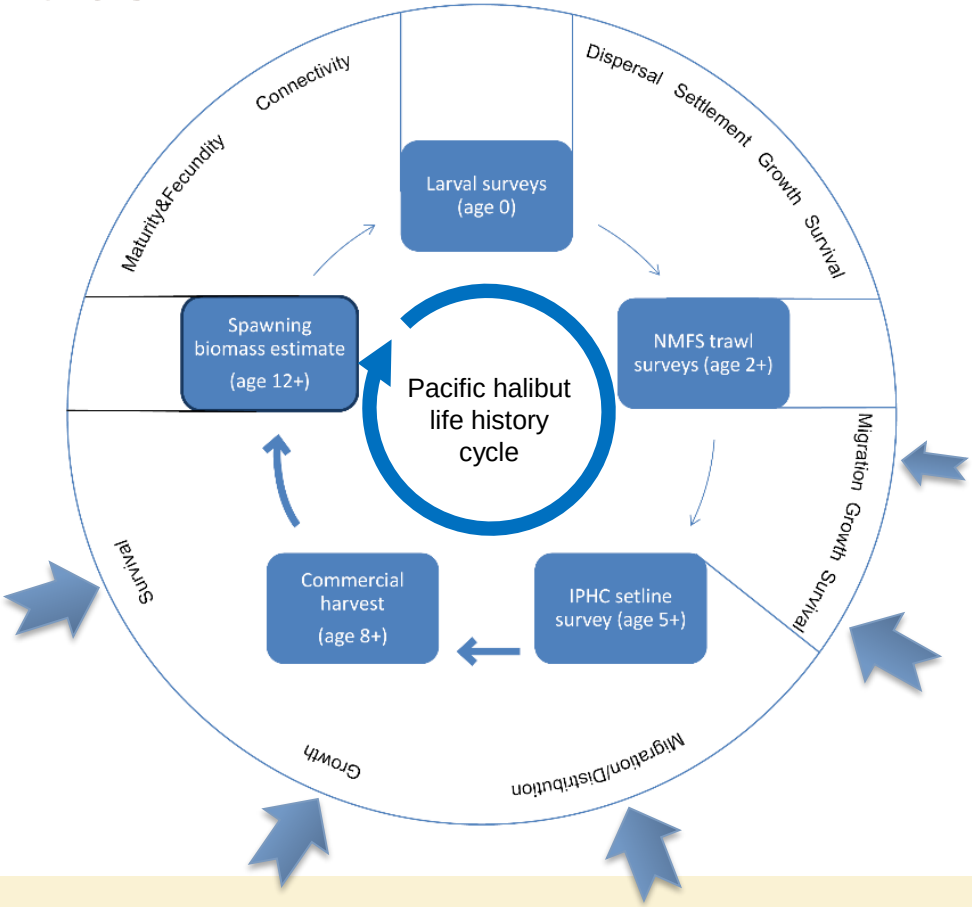


Current research activities

1. Migration: context

Historical IPHC studies

- Wire tagging: 1925-present – stock distribution, recruitment, migration, bycatch rates and survival
- Electronic tagging (satellite and archival): 2002-present – Movement between basins, connectivity of summer feeding and winter spawning grounds
- PIT tagging: 2003-2009 – mortality and migration rates
- Observational surveys: 1930s – GOA larval dispersal

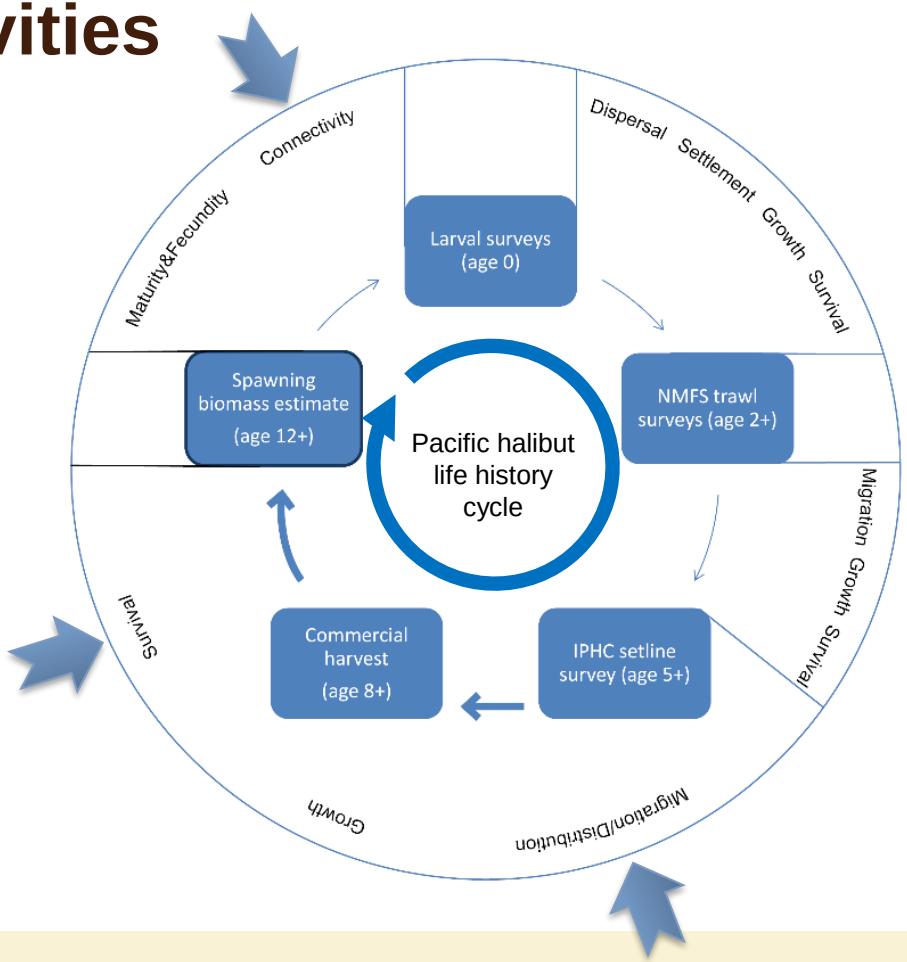


Current research activities

1. Migration: context

Historical IPHC studies

- Wire tagging: 1925-present – stock distribution, recruitment, migration, bycatch rates and survival
- Electronic tagging (satellite and archival): 2002-present – Movement between basins, connectivity of summer feeding and winter spawning grounds
- PIT tagging: 2003-2009 – mortality and migration rates
- Observational surveys: 1930s – GOA larval dispersal

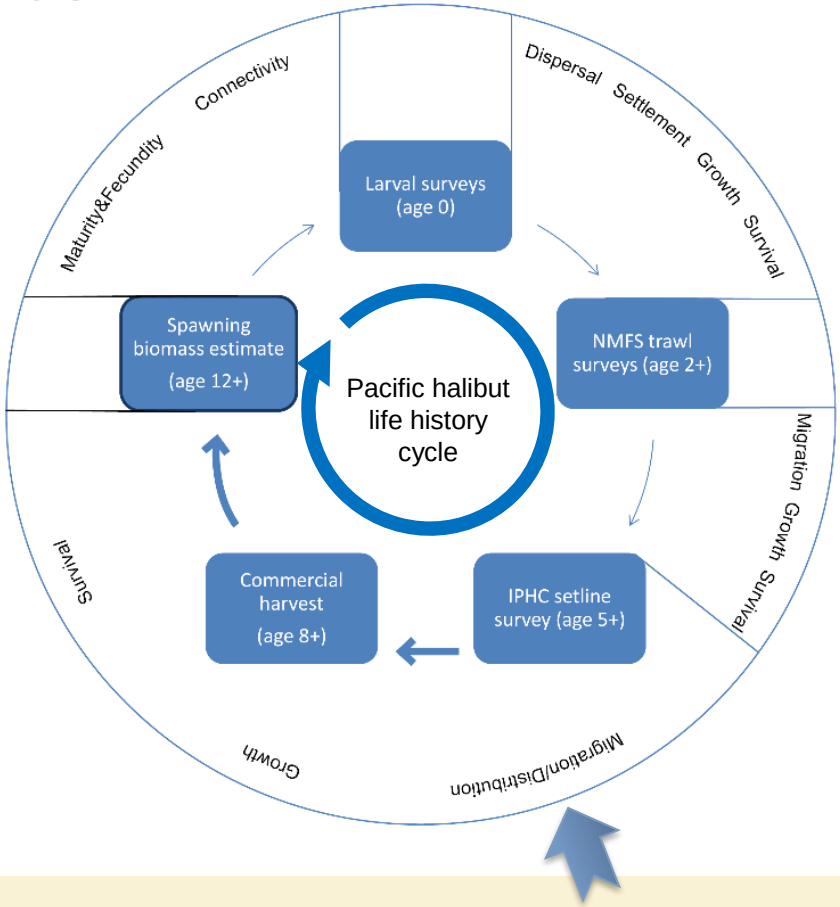


Current research activities

1. Migration: context

Historical IPHC studies

- Wire tagging: 1925-present – stock distribution, recruitment, migration, bycatch rates and survival
- Electronic tagging (satellite and archival): 2002-present – Movement between basins, connectivity of summer feeding and winter spawning grounds
- PIT tagging: 2003-2009 – mortality and migration rates
- Observational surveys: 1930s – GOA larval dispersal

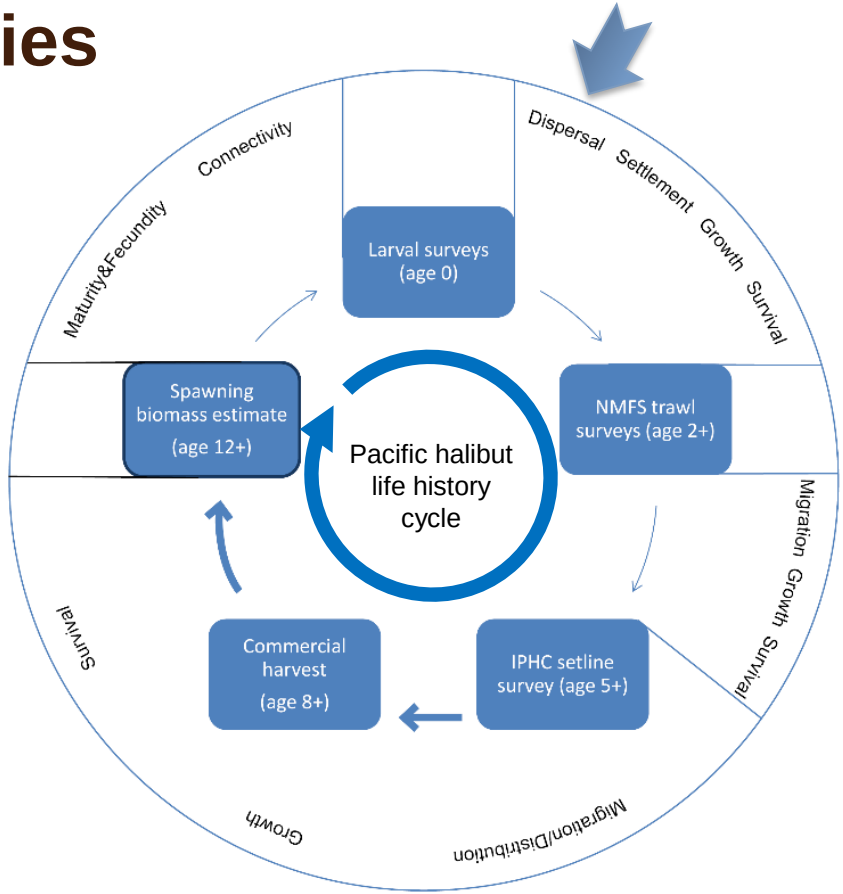


Current research activities

1. Migration: context

Historical IPHC studies

- Wire tagging: 1925-present – stock distribution, recruitment, migration, bycatch rates and survival
- Electronic tagging (satellite and archival): 2002-present – Movement between basins, connectivity of summer feeding and winter spawning grounds
- PIT tagging: 2003-2009 – mortality and migration rates
- Larval dispersal 1930s (IPHC), 1980s-present (NOAA)

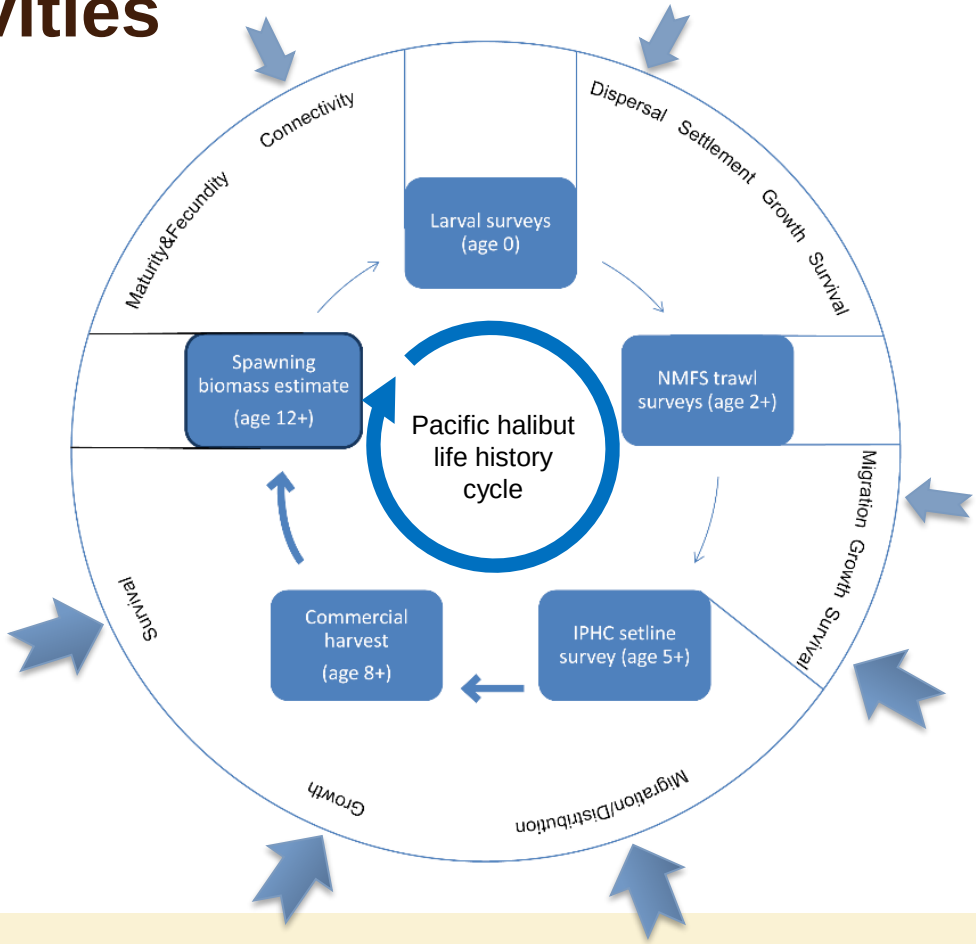


Current research activities

1. Migration: context

Historical IPHC studies

- Wire tagging: 1925-present – stock distribution, recruitment, migration, bycatch rates and survival
- Electronic tagging (satellite and archival): 2002-present – Movement between basins, connectivity of summer feeding and winter spawning grounds
- PIT tagging: 2003-2009 – mortality and migration rates
- Observational surveys: 1930s – GOA larval dispersal

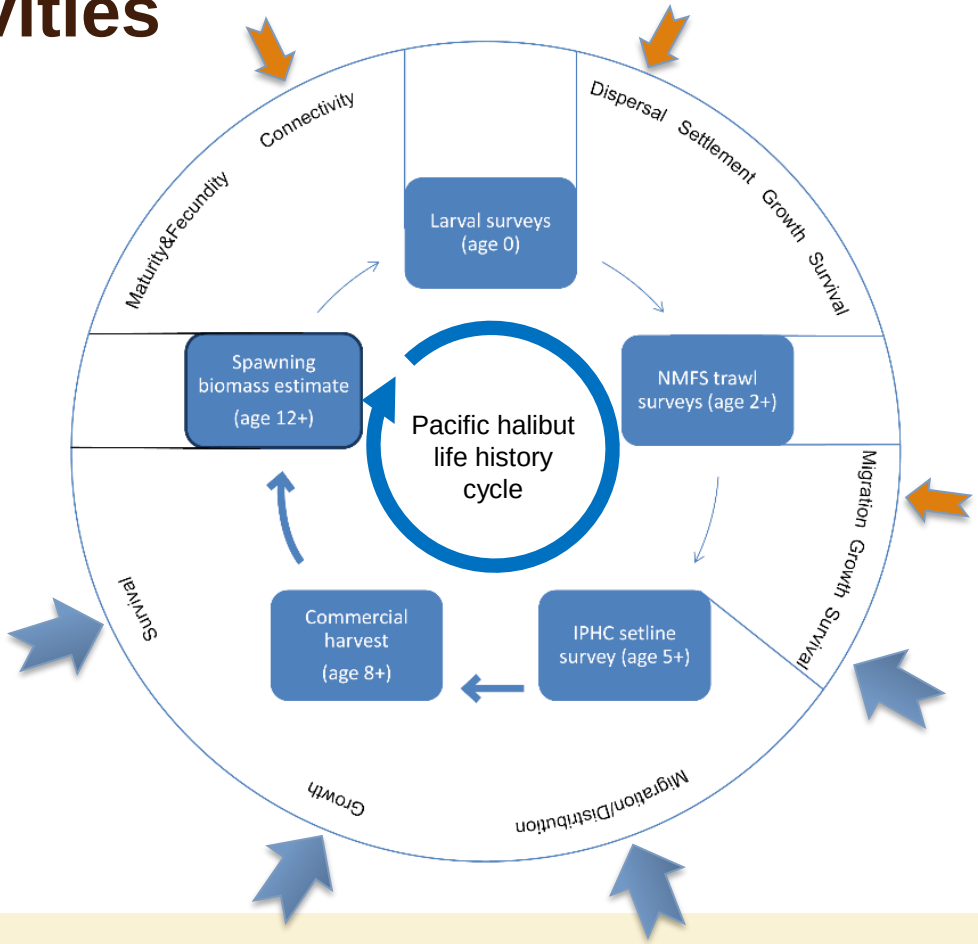


Current research activities

1. Migration: context

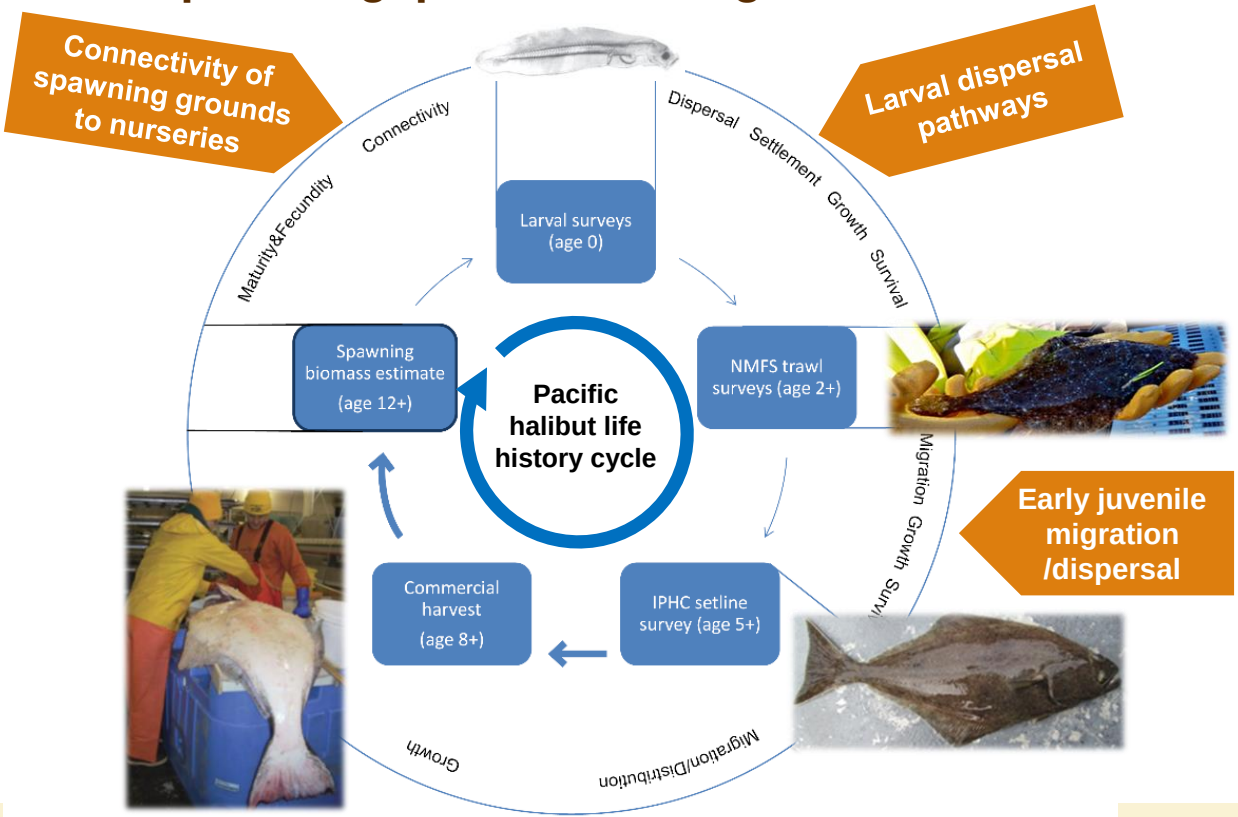
Historical IPHC studies

- Wire tagging: 1925-present – stock distribution, recruitment, migration, bycatch rates and survival
- Electronic tagging (satellite and archival): 2002-present – Movement between basins, connectivity of summer feeding and winter spawning grounds
- PIT tagging: 2003-2009 – mortality and migration rates
- Observational surveys: 1930s – GOA larval dispersal



Current research activities

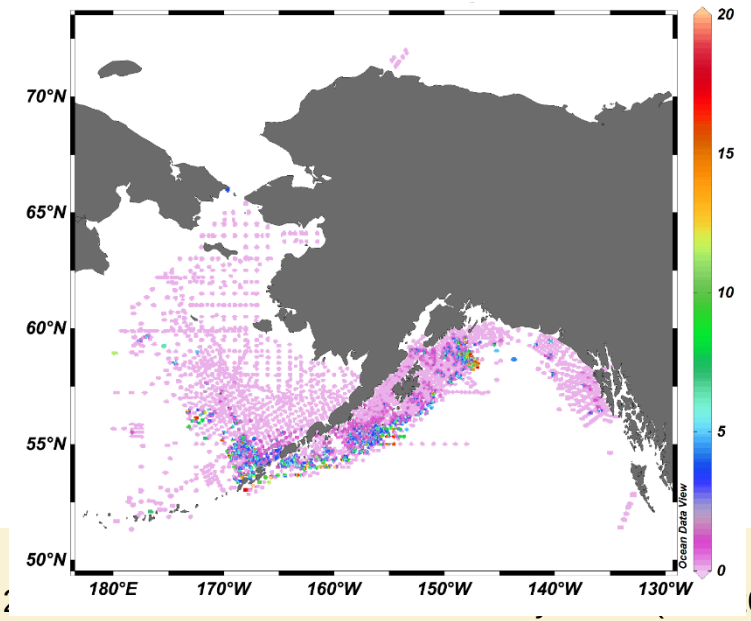
1. Migration: important gaps in knowledge



Current research activities

1. Migration: Early life history

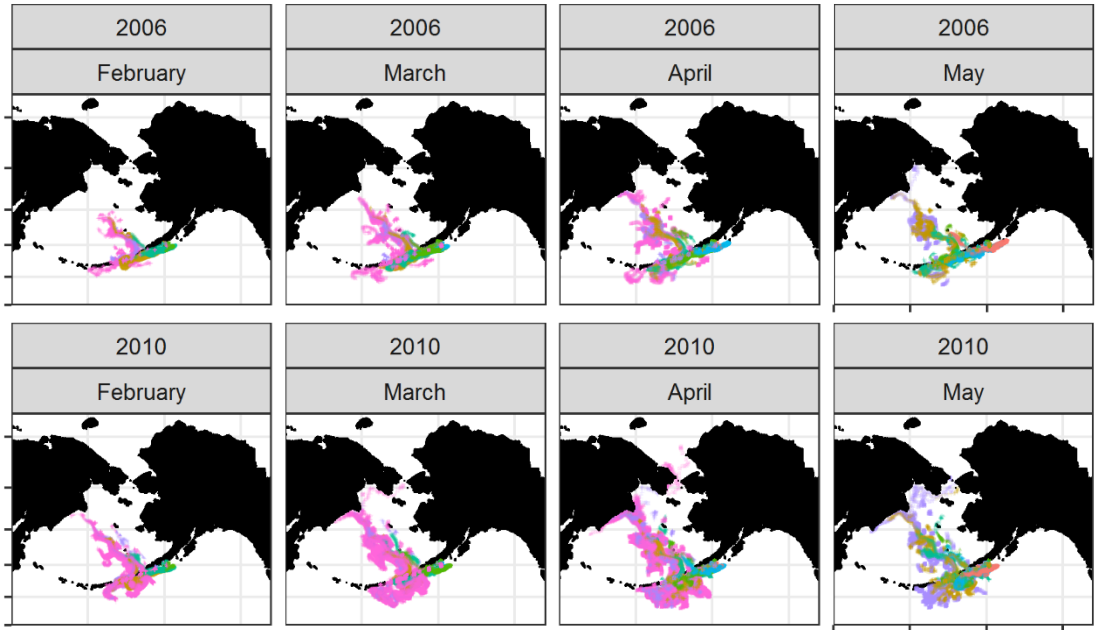
- Contribution of spawning grounds to settlement grounds
- Connectivity of ocean basins
- Environmental factors influencing distribution
- Dispersal of young fish post-settlement
- Collaboration with NOAA/EcoFOCI



Current research activities

1. Migration: Early life history

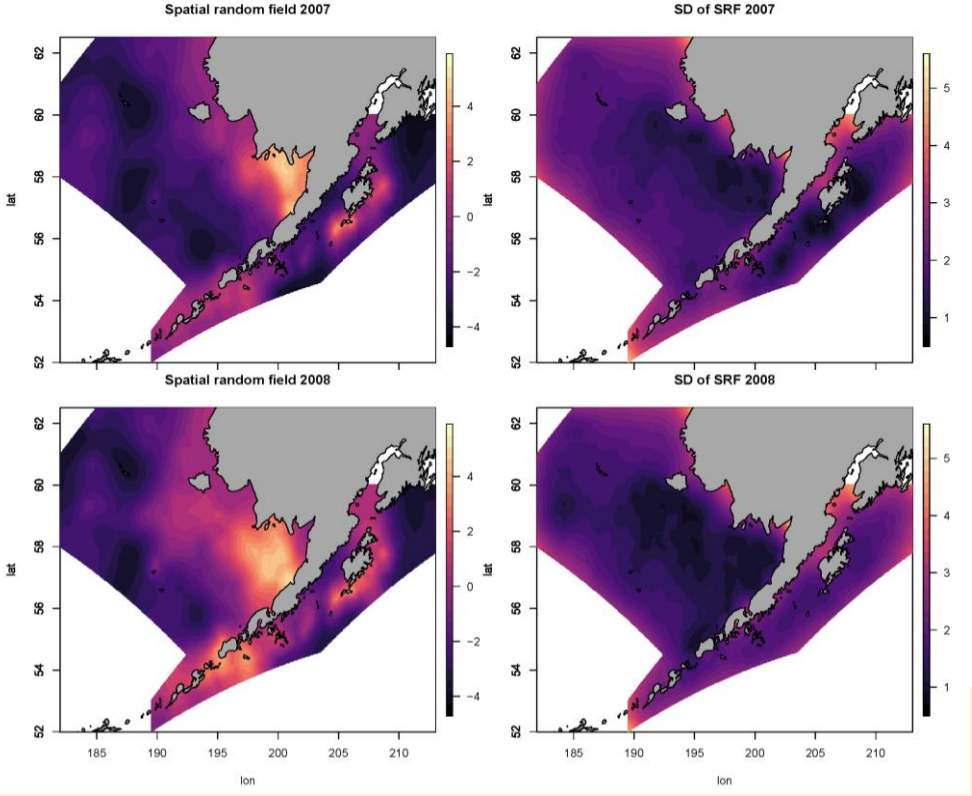
- Larval dispersal



Current research activities

1. Migration: Early life history

- Juvenile dispersal

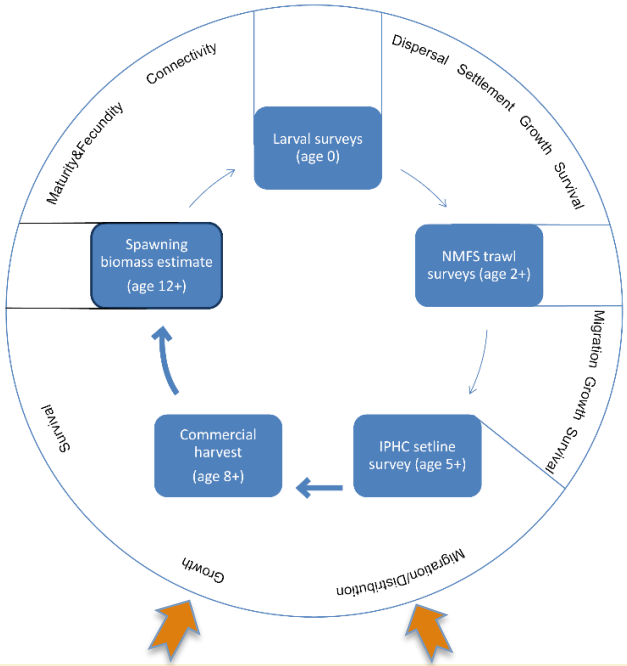


Current research activities

1. **Migration: Late juvenile dispersal**

Current research activities

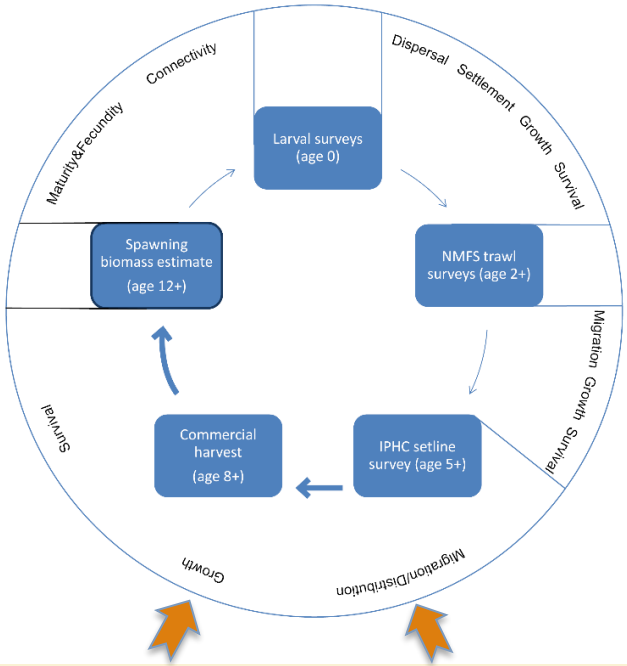
1. Migration: Late juvenile dispersal



Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**



Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

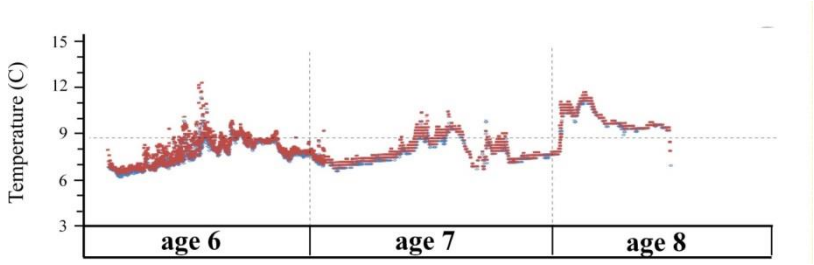
Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

Temperature time-series from tags



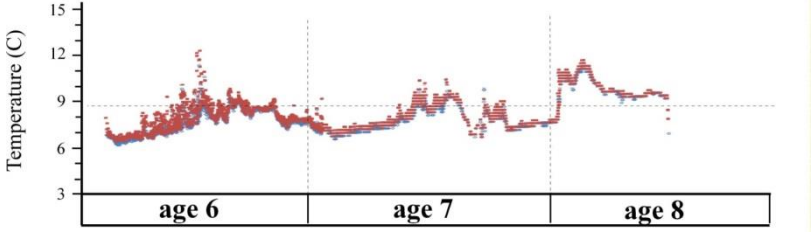
Current research activities

1. Migration: Late juvenile dispersal

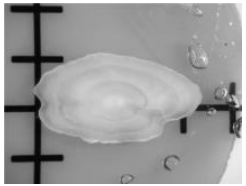
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

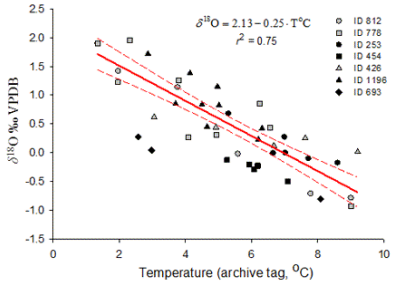
A) Relate rearing conditions to growth and regional productivity

Temperature time-series from tags



Temperature history from otolith microchemistry





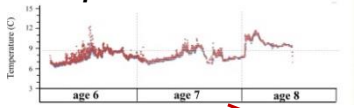
Current research activities

1. Migration: Late juvenile dispersal

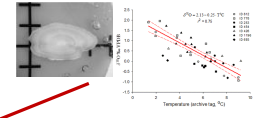
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

Temperature time-series

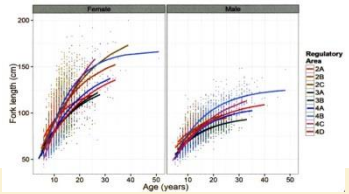


Temperature history



Providing input for productivity-based policy analyses

Length-at-age and growth in 2011 setline survey

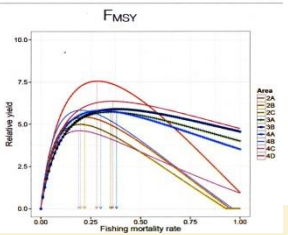


Growth parameters by regulatory area

		Large young fish	Average growth with large CV	Large variation in size-at-age	Below average growth	Below average growth	Near average growth	Largest & oldest fish	Linear female growth	Small young fish
		2A	2B	2C	3A	3B	4A	4B	4C	4DE
Linf	♀	126.2	165.3	192.3	147.7	135.7	153.7	167.3	199.6	153.4
	♂	99.3	107.7	104.3	97.8	97.1	107.1	126.9	125.7	114.6
k	♀	0.105	0.076	0.063	0.057	0.073	0.073	0.109	0.079	0.064
	♂	0.095	0.069	0.110	0.073	0.083	0.086	0.080	0.068	0.065
CV	♀	0.12	0.14	**0.16**	0.14	0.14	0.14	0.13	0.13	0.12
	♂	0.09	0.08	0.10	0.07	0.09	0.11	0.10	0.10	0.09

Base scenario

- Min SL = 81.3 cm
- Max SL = no limit
- Natural mortality = 0.15
- Steepness = 0.75
- 2011 survey selectivity
- *** no migration ***
- Growth (2011 size-at-age)
- CV in size-at-age (Reg Area)
- Other removals F = 0



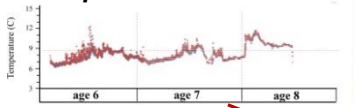
Current research activities

1. Migration: Late juvenile dispersal

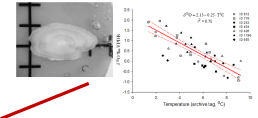
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

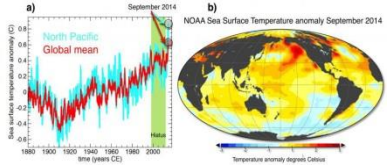
A) Relate rearing conditions to growth and regional productivity

Temperature time-series



Temperature history

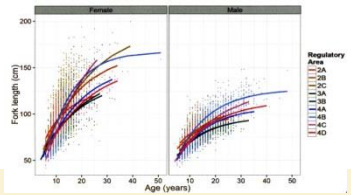




Providing input for productivity-based policy analyses

… in a context of climate change

Length-at-age and growth in 2011 setline survey

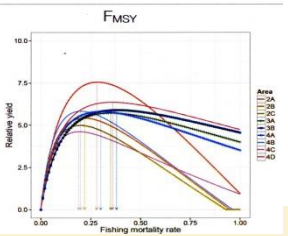


Growth parameters by regulatory area

		Large young fish	Average growth with large CV	Large variation in size-at-age	Below average growth	Below average growth	Near average growth	Largest & oldest fish	Linear female growth	Small young fish
		2A	2B	2C	3A	3B	4A	4B	4C	4DE
Linf	♀	126.2	165.3	192.3	147.7	135.7	153.7	167.3	199.6	153.4
	♂	99.3	107.7	104.3	97.8	97.1	107.1	126.9	125.7	114.6
k	♀	0.105	0.076	0.063	0.057	0.073	0.073	0.109	0.079	0.064
	♂	0.095	0.069	0.110	0.073	0.083	0.086	0.080	0.068	0.065
CV	♀	0.12	0.14	**0.16**	0.14	0.14	0.14	0.13	0.13	0.12
	♂	0.09	0.08	0.10	0.07	0.09	0.11	0.10	0.10	0.09

Base scenario

- Min SL = 81.3 cm
- Max SL = no limit
- Natural mortality = 0.15
- Steepness = 0.75
- 2011 survey selectivity
- *** no migration ***
- Growth (2011 size-at-age)
- CV in size-at-age (Reg Area)
- Other removals F = 0



Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds

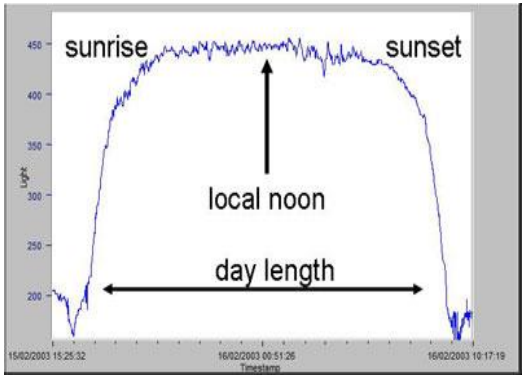
Current research activities

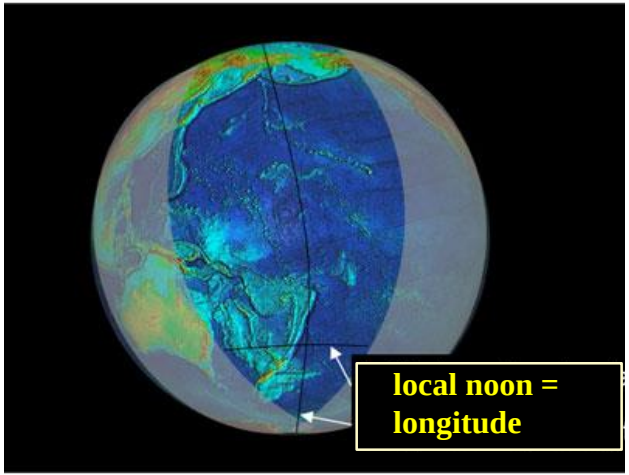
1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds





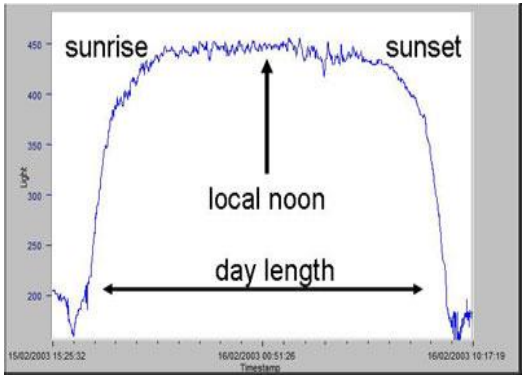
Current research activities

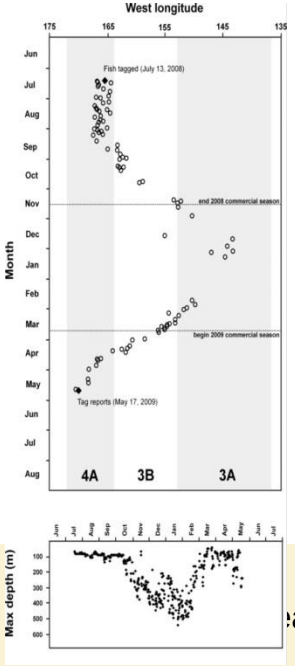
1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds





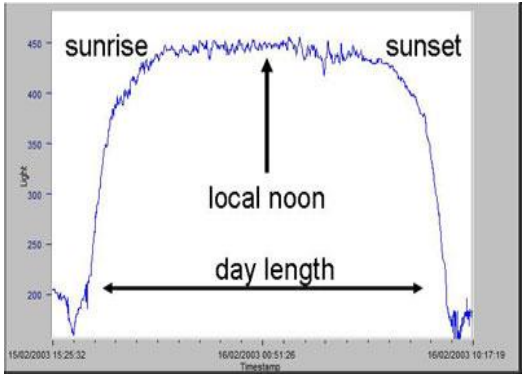
Current research activities

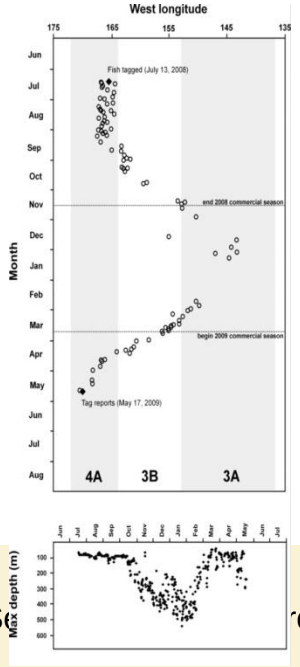
1. Migration: Late juvenile dispersal

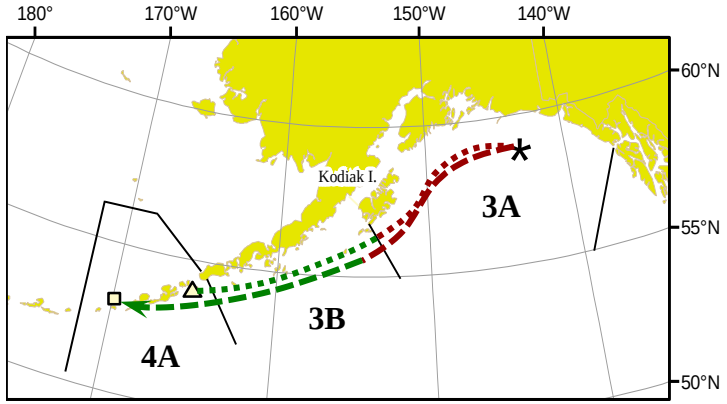
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds







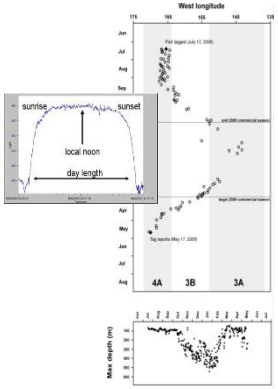
Current research activities

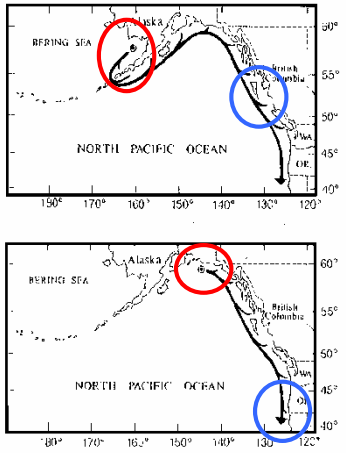
1. Migration: Late juvenile dispersal

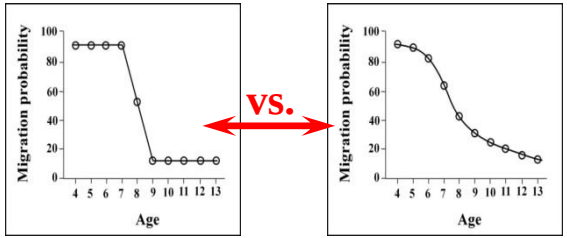
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds







Stepwise **Smooth**

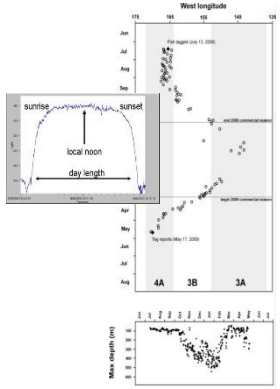
Current research activities

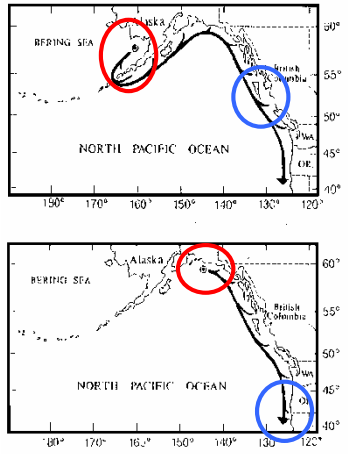
1. Migration: Late juvenile dispersal

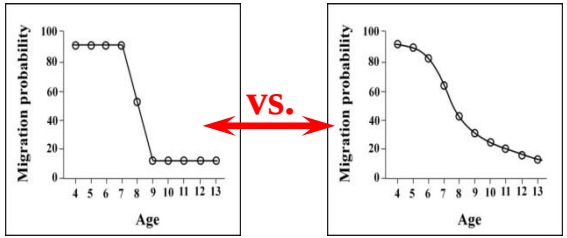
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds







Stepwise **Smooth**

Providing input for spatially-explicit population models that incorporate migration

Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds

C) Refine estimates of age-of-entry into the spawning population

Current research activities

1. Migration: Late juvenile dispersal

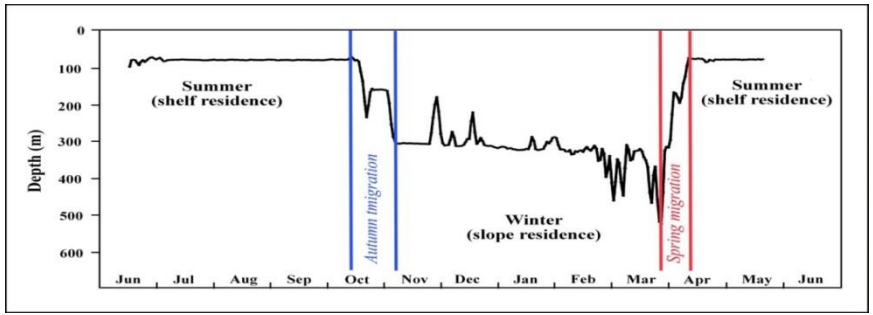
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds

C) Refine estimates of age-of-entry into the spawning population

The "typical" depth-specific spawning migration…



Current research activities

1. Migration: Late juvenile dispersal

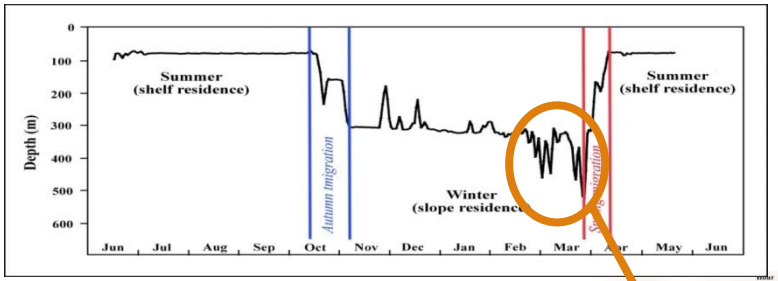
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

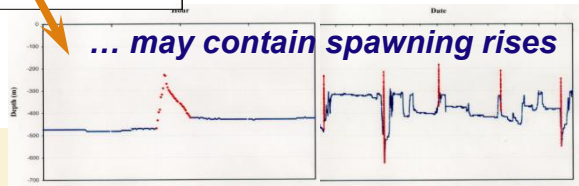
A) Relate rearing conditions to growth and regional productivity

B) Index rates (speed) of migration from rearing areas to adult feeding grounds

C) Refine estimates of age-of-entry into the spawning population

The "typical" depth-specific spawning migration…





… may contain spawning rises

Current research activities

1. Migration: Late juvenile dispersal

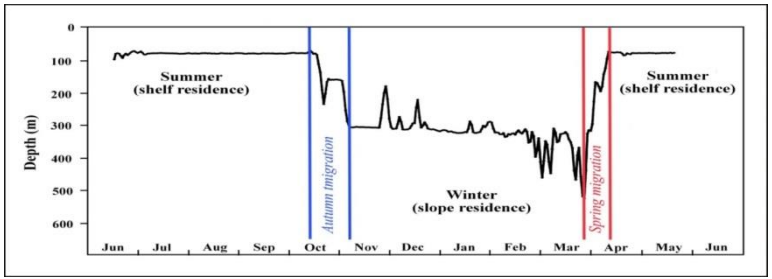
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

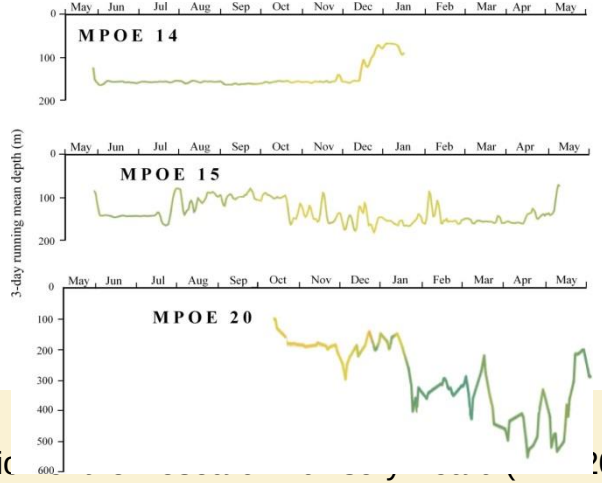
B) Index rates (speed) of migration from rearing areas to adult feeding grounds

C) Refine estimates of age-of-entry into the spawning population

The "typical" depth-specific spawning migration…



… varies among individuals



Current research activities

1. Migration: Late juvenile dispersal

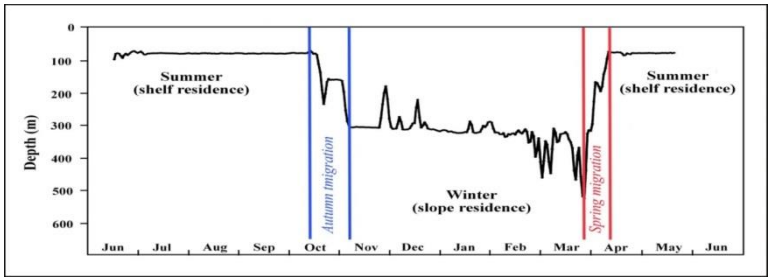
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

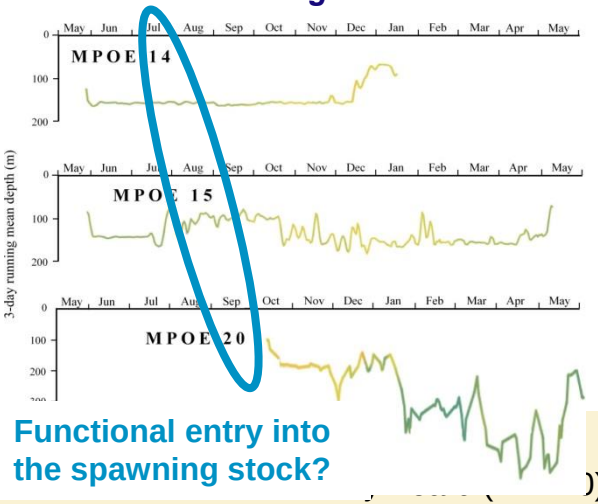
B) Index rates (speed) of migration from rearing areas to adult feeding grounds

C) Refine estimates of age-of-entry into the spawning population

The "typical" depth-specific spawning migration…



… varies among individuals



Functional entry into the spawning stock?

Current research activities

1. Migration: Late juvenile dispersal

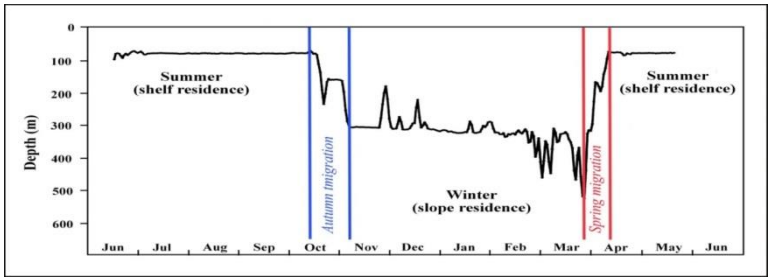
- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

A) Relate rearing conditions to growth and regional productivity

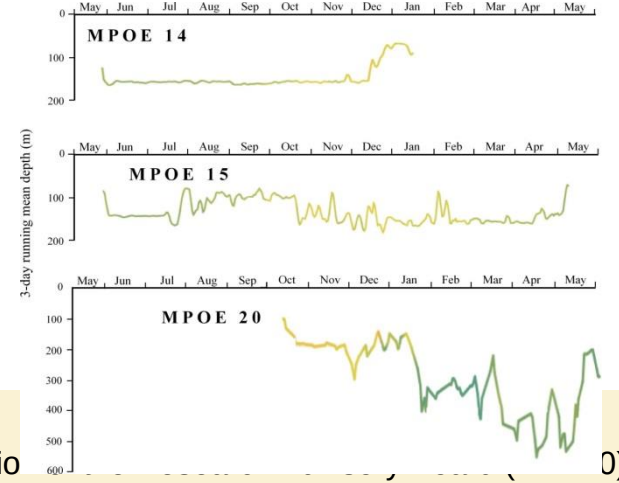
B) Index rates (speed) of migration from rearing areas to adult feeding grounds

C) Refine estimates of age-of-entry into the spawning population

The "typical" depth-specific spawning migration…



… varies among individuals

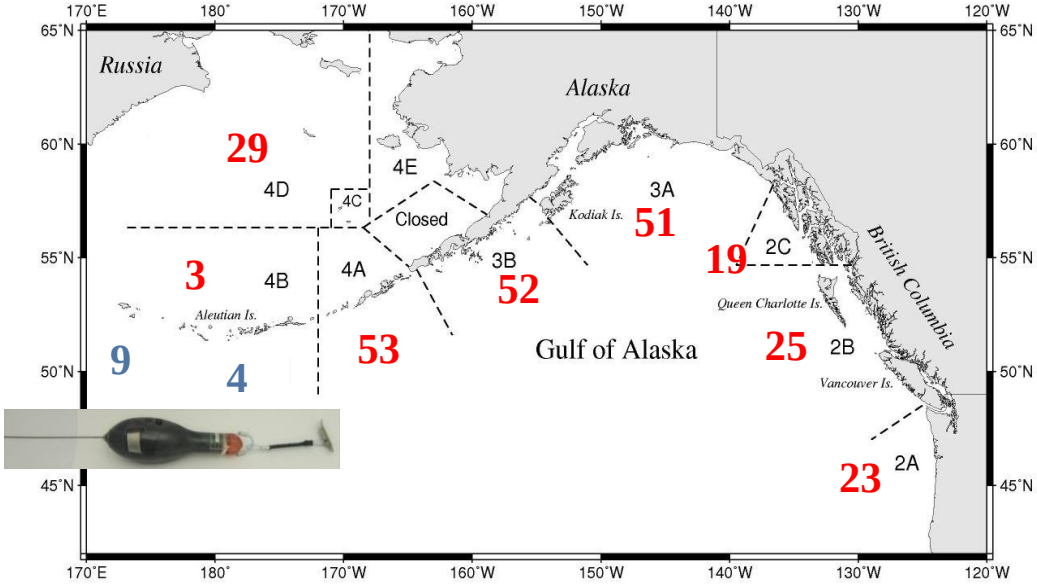


Providing input for refined estimates of spawning stock biomass

Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**

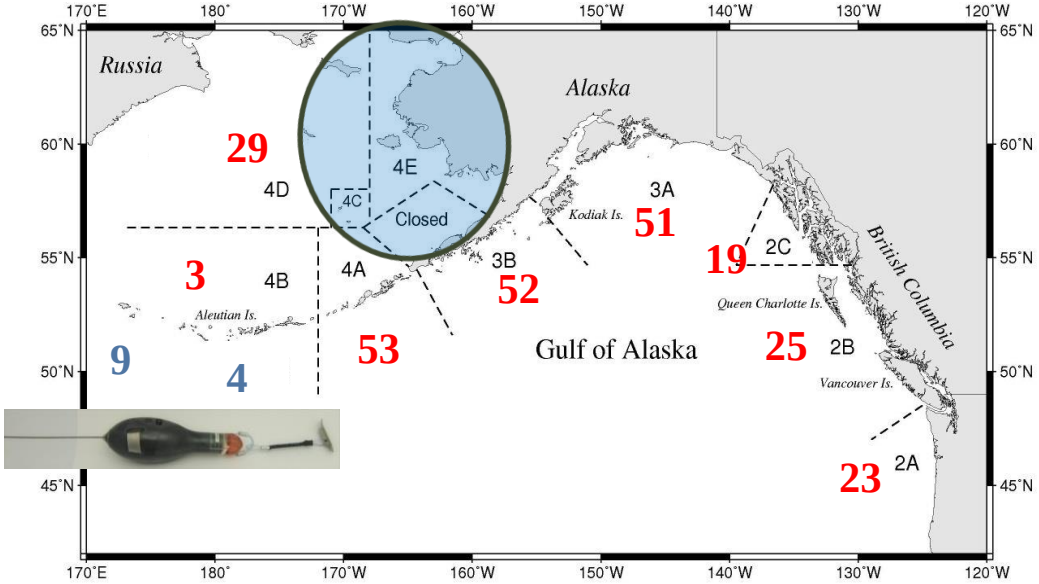


- **268 fish tagged coastwide in 2018**
- **13 were PAT tags released in 4B**
- **Rewards offered for tag and otolith recovery**

Current research activities

1. Migration: Late juvenile dispersal

- **Using electronic tags on U32s to record temperature, light, and depth for up to 7 years**



- **268 fish tagged coastwide in 2018**
- **13 were PAT tags released in 4B**
- **Rewards offered for tag and otolith recovery**
- **2019 deployments will focus on the Eastern Bering Sea shelf**

Current research activities

2. Reproduction

Projects:

1. Identification of sex in the commercial landings

2. Full characterization of the annual reproductive cycle

Current research activities

2. Reproduction: Identification of sex in the commercial landings

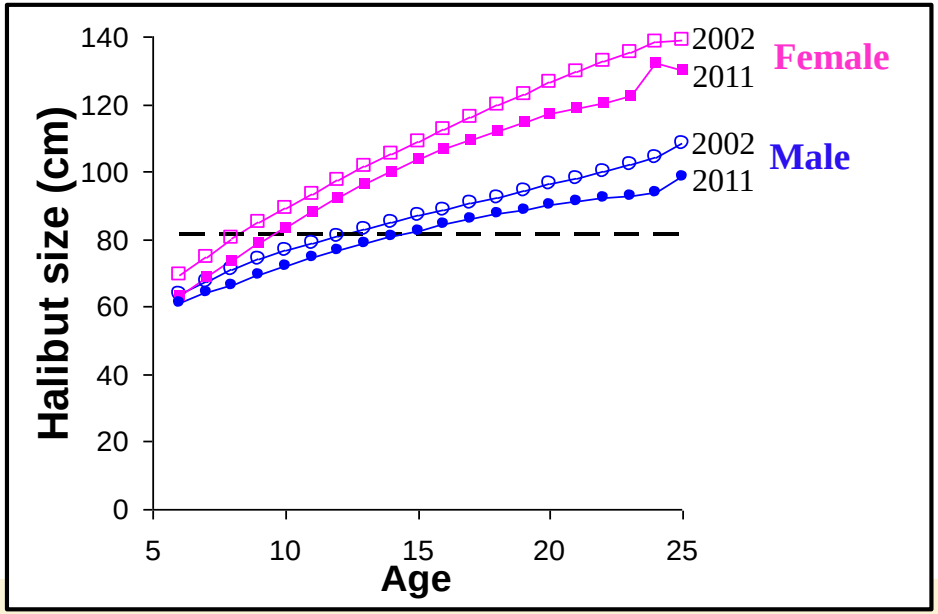
To generate sex-ratio data for use in assessment and policy analysis

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

Changes in size-at-age in combination with a constant size limit are expected to result in varying degrees of female-biased catch

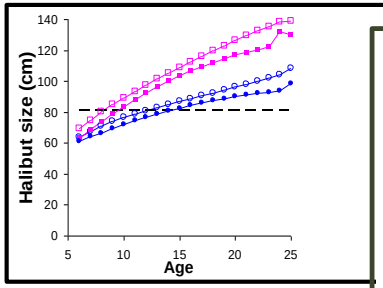


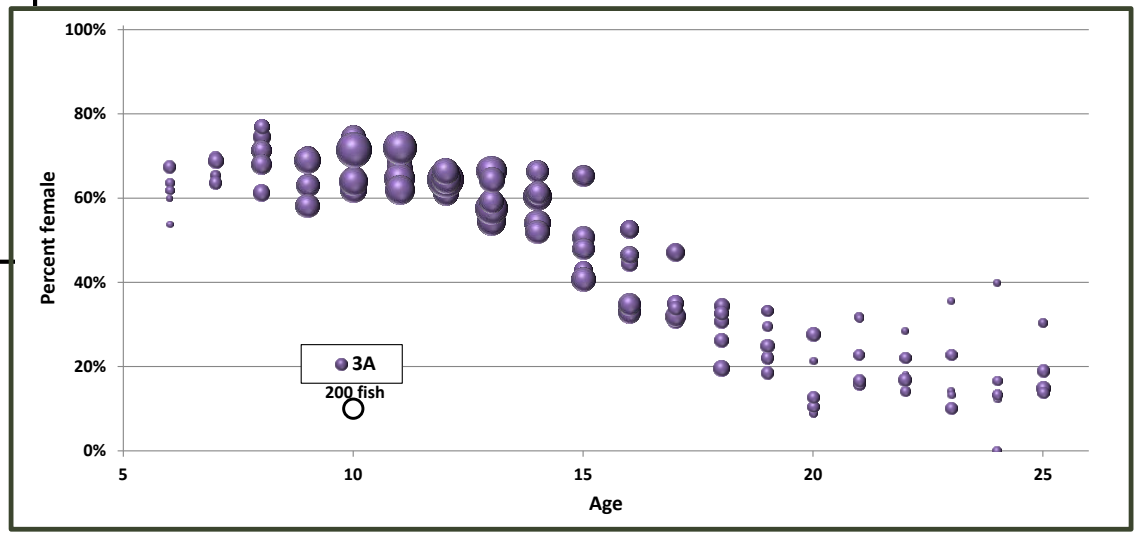
Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

Female-biased mortality will cause the sex ratio of each cohort to decline as it ages

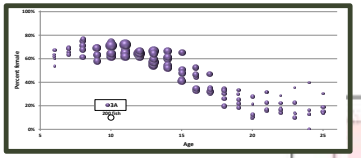




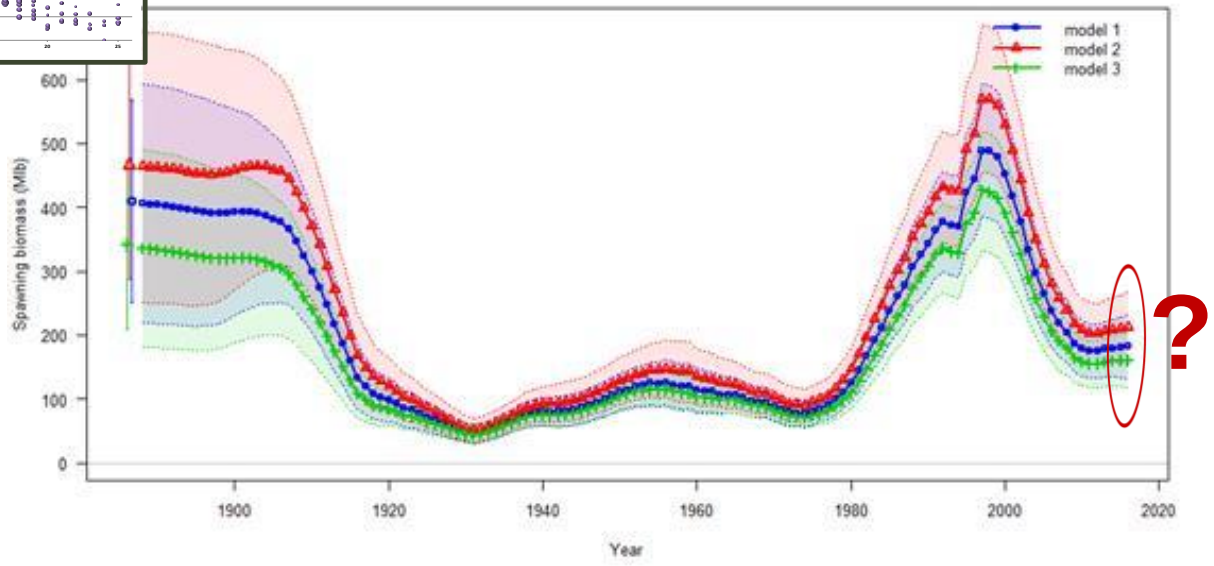
Current research activities

2. Reproduction: Identification of sex in the commercial landings

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



The result is uncertainty regarding
spawning biomass levels



Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

We need to know the harvested sex ratios

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

In 2004, Bill Clark developed a statistical methods for estimating harvested sex ratios

Meta-parameters															
	year	2010													
	area	2B													
	L50.b0	50.28713													
	L50.b1	2.776162													
	k.c0	0.034339													
	k.c1	0.020033													
	k.c2	-0.00047													
	L50.plus	112.9268													
	k.plus	0.274327													
	plus.age	25													
Proportion female at age/length															
L50	64.16794	66.9441	69.72026	72.49642	75.27258	78.04875	80.82491	83.60107	86.37723	89.15339	91.92956	94.70572	97.48188	100.258	
k	0.122854	0.137761	0.151736	0.164779	0.17689	0.188069	0.198316	0.207631	0.216014	0.223465	0.229984	0.235571	0.240226	0.243949	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
82	0.899	0.888	0.866	0.827	0.767	0.678	0.558	0.418	0.280	0.168	0.092	0.048	0.024	0.011	
83	0.910	0.901	0.882	0.850	0.797	0.717	0.606	0.469	0.325	0.202	0.114	0.060	0.030	0.015	
84	0.920	0.913	0.897	0.869	0.824	0.754	0.652	0.521	0.374	0.240	0.139	0.074	0.038	0.019	
85	0.928	0.923	0.910	0.887	0.848	0.787	0.696	0.572	0.426	0.283	0.169	0.092	0.047	0.024	
86	0.936	0.932	0.922	0.902	0.870	0.817	0.736	0.622	0.480	0.331	0.204	0.114	0.060	0.030	
87	0.943	0.941	0.932	0.916	0.888	0.843	0.773	0.669	0.534	0.382	0.243	0.140	0.075	0.038	
88	0.949	0.948	0.941	0.928	0.905	0.867	0.806	0.714	0.587	0.436	0.288	0.171	0.093	0.048	
89	0.955	0.954	0.949	0.938	0.919	0.887	0.835	0.754	0.638	0.491	0.338	0.207	0.115	0.060	
90	0.960	0.960	0.956	0.947	0.931	0.904	0.861	0.791	0.686	0.547	0.391	0.248	0.142	0.076	
91	0.964	0.965	0.962	0.955	0.942	0.920	0.883	0.823	0.731	0.602	0.447	0.295	0.174	0.095	
92	0.968	0.969	0.967	0.961	0.951	0.932	0.902	0.851	0.771	0.654	0.504	0.346	0.211	0.118	
93	0.972	0.973	0.972	0.967	0.958	0.943	0.918	0.876	0.807	0.703	0.561	0.401	0.254	0.145	
94	0.975	0.977	0.975	0.972	0.965	0.953	0.932	0.897	0.838	0.747	0.617	0.459	0.302	0.178	
95	0.978	0.979	0.979	0.976	0.970	0.960	0.943	0.914	0.866	0.787	0.670	0.517	0.355	0.217	
96	0.980	0.982	0.982	0.980	0.975	0.967	0.953	0.929	0.889	0.822	0.718	0.576	0.412	0.261	
97	0.983	0.984	0.984	0.983	0.979	0.972	0.961	0.942	0.908	0.852	0.762	0.632	0.471	0.311	
98	0.985	0.986	0.986	0.985	0.982	0.977	0.968	0.952	0.925	0.878	0.802	0.685	0.531	0.366	
99	0.986	0.988	0.988	0.987	0.985	0.981	0.974	0.961	0.939	0.900	0.836	0.733	0.590	0.424	
100	0.988	0.990	0.990	0.989	0.988	0.984	0.978	0.968	0.950	0.919	0.865	0.777	0.647	0.484	

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

In 2004, Bill Clark developed a statistical methods for estimating harvested sex ratios

***Caveat* – his method used setline survey data, our only good source of data regarding sex-size-age**

He warned that his method was *"… only … true for the summer survey period" and that "sex composition of the* {commercial} *catch could be different if male catchability is not the same as the survey"*

(e.g., if ratios-at-age vary by season or region, or are bait-specific)

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

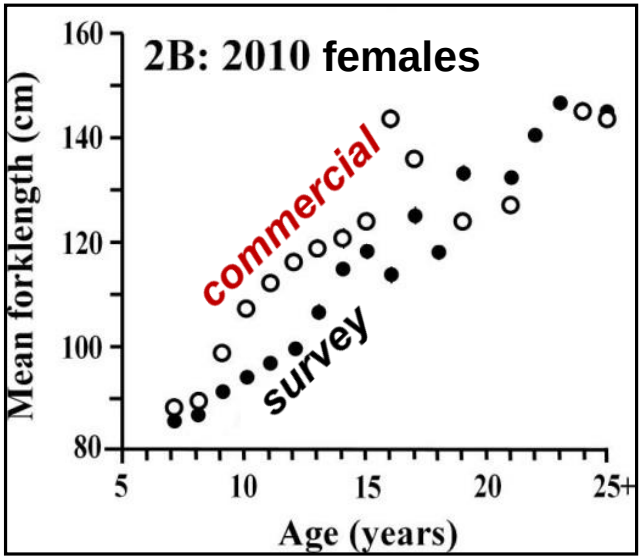
In 2010, we placed our summer intern (Monica Woods) on commercial vessels to monitor sex ratios

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

In 2010, we placed our summer intern (Monica Woods) on commercial vessels to monitor sex ratios

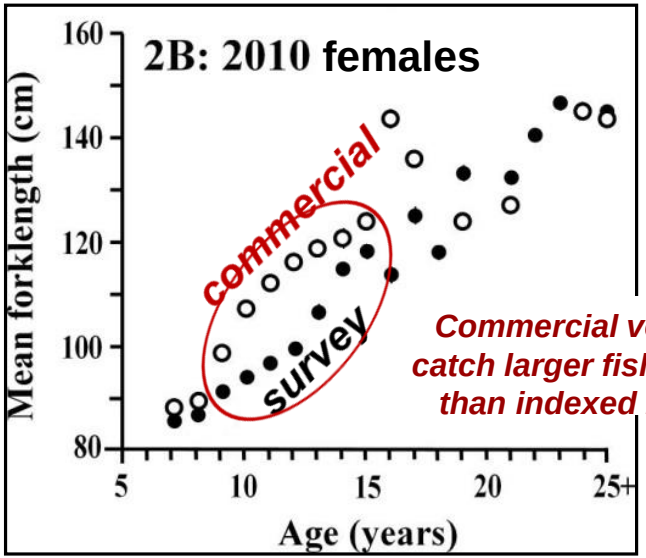


Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

In 2010, we placed our summer intern (Monica Woods) on commercial vessels to monitor sex ratios



Commercial vessels tend to catch larger fish at a given age than indexed by the survey

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

We need direct observations of the harvested sex ratios

Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

Starting in 2014, we began a two-part program to obtain those data

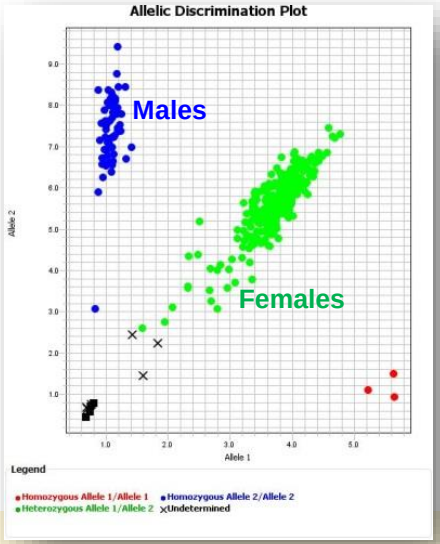
Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

Starting in 2014, we began a two-part program to obtain those data

A) Development of genetic techniques



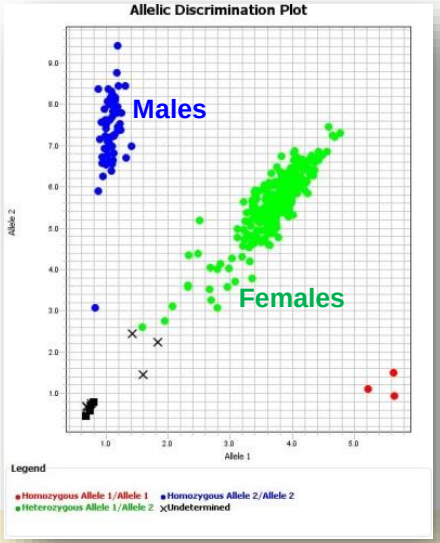
Current research activities

2. Reproduction: Identification of sex in the commercial landings

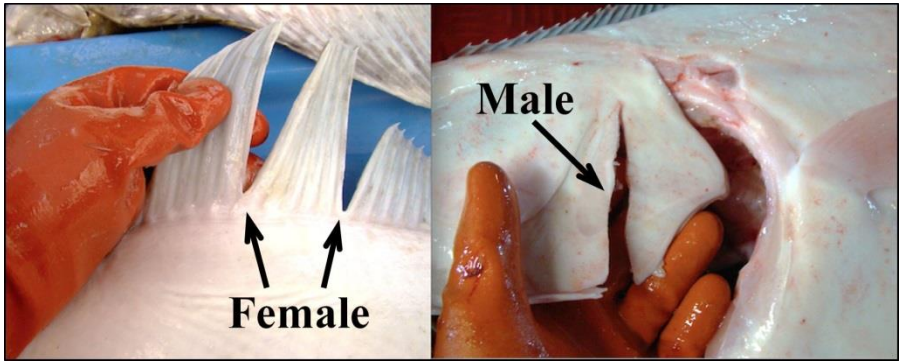
To generate sex-ratio data for use in assessment and policy analysis

Starting in 2014, we began a two-part program to obtain those data

A) Development of genetic techniques



B) At-sea commercial sex marking



Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

- **Pacific halibut females are “heterogametic” = ZW (same form as “XY” males in humans)**
- **Two genetic markers were identified that occur primarily in females**

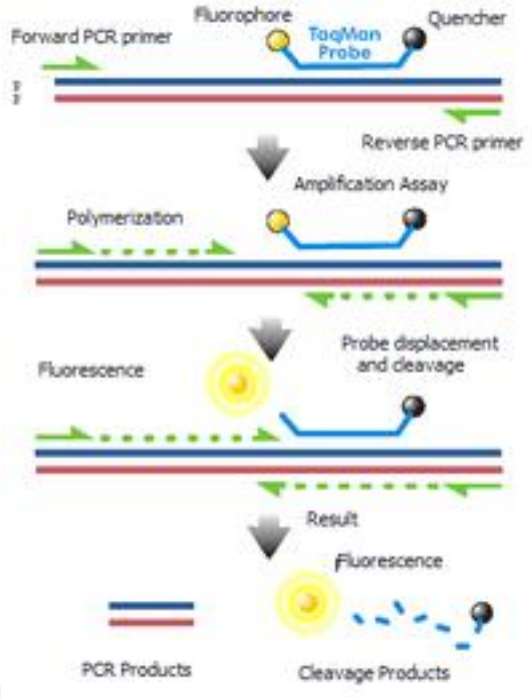
Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

- **Pacific halibut females are “heterogametic” = ZW (same form as “XY” males in humans)**
- **Two genetic markers were identified that occur primarily in females**
- **Using tissue samples (fin clips), a lab procedure was developed that attaches fluorescent “labels” to the DNA at those markers … and subsequently fall back off**



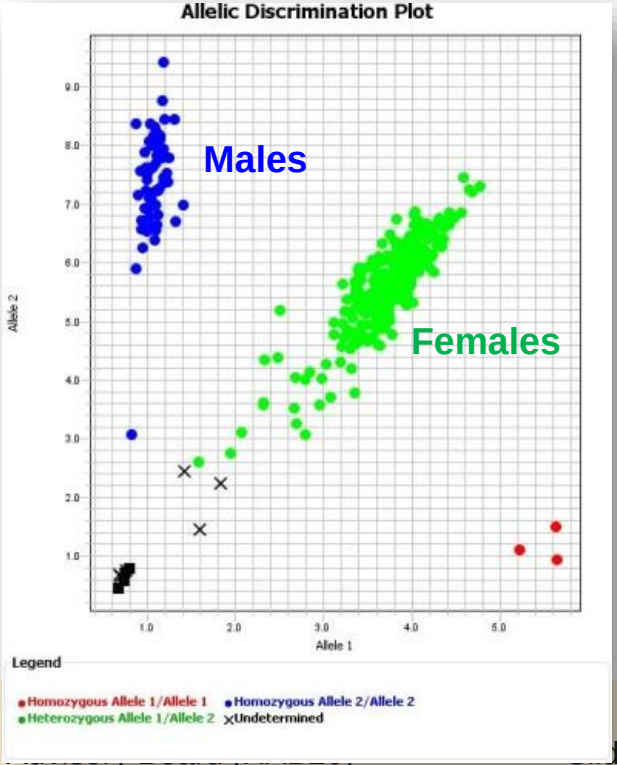
Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

- **Pacific halibut females are “heterogametic” = ZW (same form as “XY” males in humans)**
- **Two genetic markers were identified that occur primarily in females**
- **Using tissue samples (fin clips), a lab procedure was developed that attaches fluorescent “labels” to the DNA at those markers … and subsequently fall back off**
- **So, female samples “glow” while males do not**



Current research activities

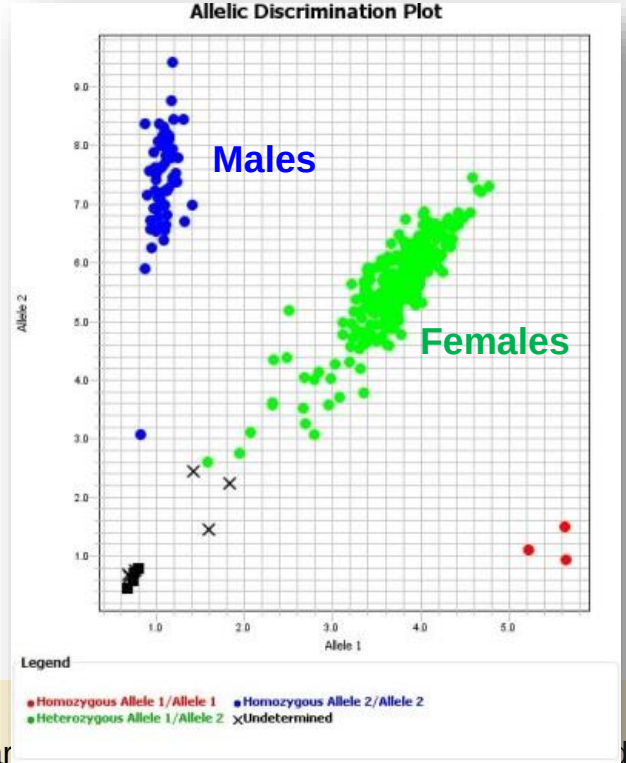
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

We intended to use this method to validate observations that were collected in the field



Current research activities

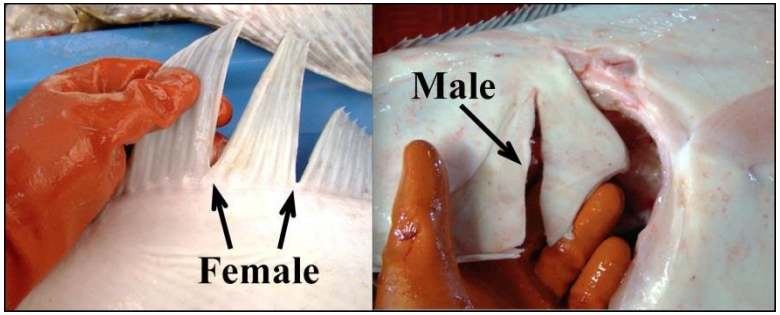
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**



Current research activities

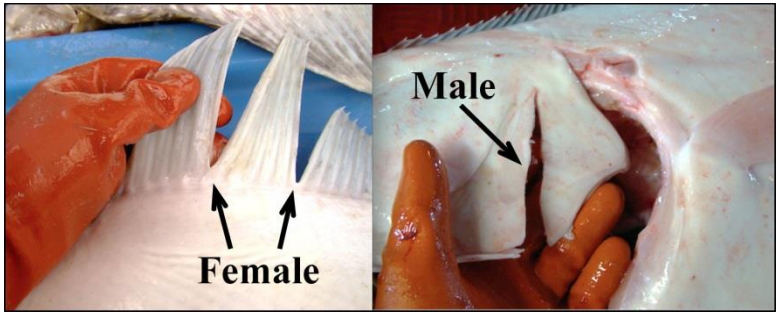
2. Reproduction: Identification of sex in the commercial landings

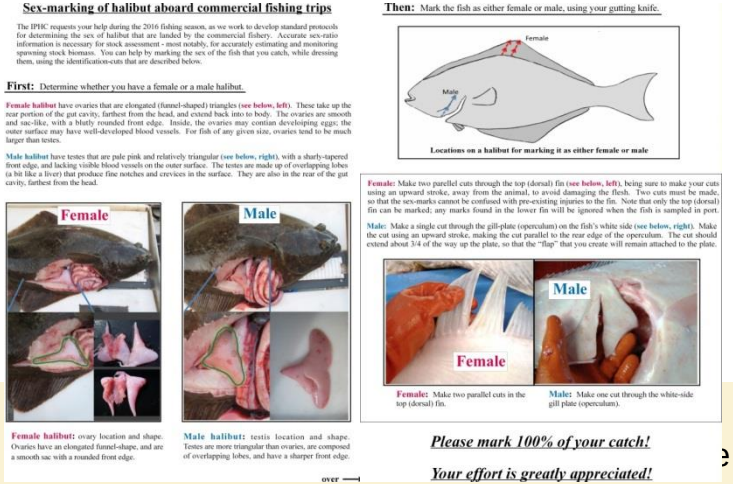
To generate sex-ratio data for use in assessment and policy analysis

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**
- **Test the technique via voluntary fleet participation**





Sex-marking of halibut aboard commercial fishing trips

The IPHC requests your help during the 2016 fishing season, as we work to develop standard protocols for determining the sex of halibut that are landed by the commercial fishery. Accurate sex-ratio information is necessary for stock assessment - most notably, for accurately estimating and monitoring spawning stock biomass. You can help by marking the sex of the fish that you catch, while dressing them, using the identification-cuts that are described below.

First: Determine whether you have a female or a male halibut.

Female halibut have ovaries that are elongated (funnel-shaped) triangles (see below, left). These take up the rear portion of the gut cavity, farthest from the head, and extend back into to body. The ovaries are smooth and sac-like, with a bluntly rounded front edge. Inside, the ovaries may contian developing eggs; the outer surface may have well-developed blood vessels. For fish of any given size, ovaries tend to be much larger than testes.

Male halibut have testes that are pale pink and relatively triangular (see below, right), with a sharly-tapered front edge, and lacking visible blood vessels on the outer surface. The testes are made up of overlapping lobes (a bit like a liver) that produce fine notches and crevices in the surface. They are also in the rear of the gut cavity, farthest from the head.

Female

Male

Female halibut: ovary location and shape. Ovaries have an elongated funnel-shape, and are a smooth sac with a rounded front edge.

Male halibut: testis location and shape. Testes are more triangular than ovaries, are composed of overlapping lobes, and have a sharper front edge.

over →

Then: Mark the fish as either female or male, using your gutting knife.

Female

Male

Locations on a halibut for marking it as either female or male

Female: Make two parellel cuts through the top (dorsal) fin (see below, left), being sure to make your cuts using an upward stroke, away from the animal, to avoid damaging the flesh. Two cuts must be made, so that the sex-marks cannot be confused with pre-existing injuries to the fin. Note that only the top (dorsal) fin can be marked; any marks found in the lower fin will be ignored when the fish is sampled in port.

Male: Make a single cut through the gill-plate (operculum) on the fish's white side (see below, right). Make the cut using an upward stroke, making the cut parallel to the rear edge of the operculum. The cut should extend about 3/4 of the way up the plate, so that the "flap" that you create will remain attached to the plate.

Female

Male

Female: Make two parallel cuts in the top (dorsal) fin.

Male: Make one cut through the white-side gill plate (operculum).

Please mark 100% of your catch!

Your effort is greatly appreciated!

Current research activities

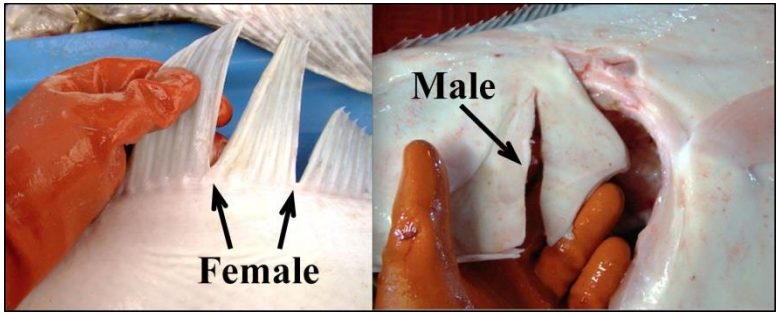
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**
- **Test the technique via voluntary fleet participation**



	2016		
Reg Area	Offloads	Samples	% marked
2A	-	-	-
2B	**130**	1,905	**13.1**
2C	-	-	-
3A	-	-	-
3B	-	-	-
4A	-	-	-
4B	-	-	-
4C	-	-	-
4D	-	-	-

Current research activities

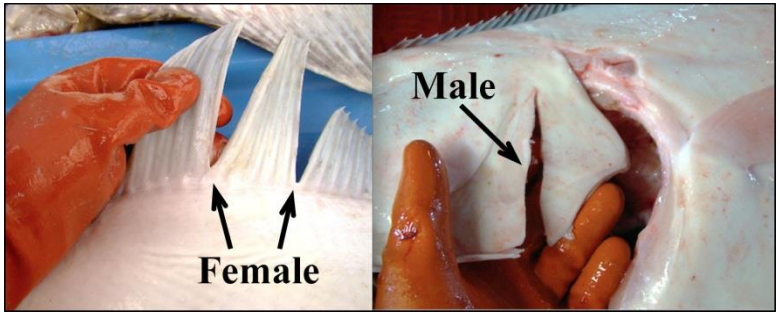
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**
- **Test the technique via voluntary fleet participation**



	2016		
Reg Area	Offloads	Samples	% marked
2A	-	-	-
2B	130	1,905	13.1
2C	-	-	-
3A	-	-	-
3B	-	-	-
4A	-	-	-
4B	-	-	-
4C	-	-	-
4D	-	-	-

	Samples	Accuracy
Vessel 1	47	1.00
Vessel 2	13	1.00
Vessel 3	9	1.00
Vessel 4	8	1.00
Vessel 5	3	1.00
Vessel 6	17	0.82
Vessel 7	12	0.75
Vessel 8	90	0.74
Vessel 9	33	0.73
Vessel 10	40	0.48

Some issues with accuracy that need to be corrected

Current research activities

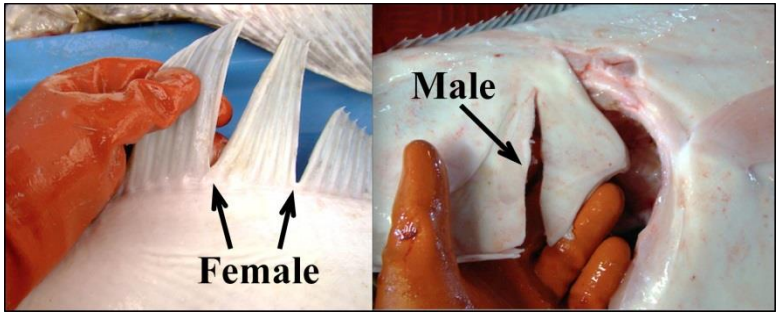
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**
- **Test the technique via voluntary fleet participation**



Coastwise

	2016			2017		
Reg Area	Offloads	Samples	% marked	Offloads	Samples	% marked
2A	-	-	-	36	70	6.2
2B	130	1,905	13.1	5	84	5.3
2C	-	-	-	16	116	9
3A	-	-	-	10	113	7.6
3B	-	-	-	9	292	20.3
4A	-	-	-	2	77	7.4
4B	-	-	-	2	95	10.7
4C	-	-	-	3	63	9.1
4D	-	-	-	1	19	3.7

Current research activities

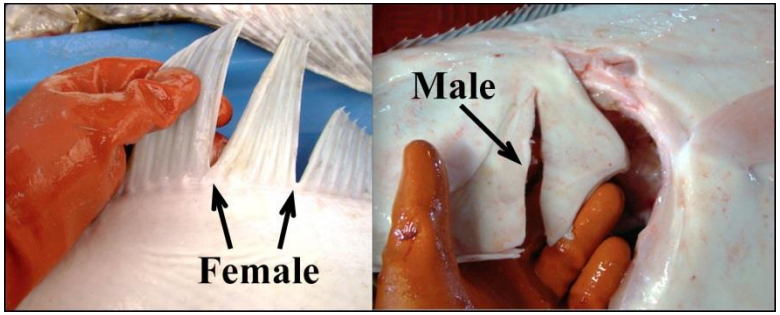
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**
- **Test the technique via voluntary fleet participation**



	2016			2017		
Reg Area	Offloads	Samples	% marked	Offloads	Samples	% marked
2A	-	-	-	36	70	6.2
2B	**130**	1,905	**13.1**	**5**	84	**5.3**
2C	-	-	-	16	116	9
3A	-	-	-	10	113	7.6
3B	-	-	-	9	292	20.3
4A	-	-	-	2	77	7.4
4B	-	-	-	2	95	10.7
4C	-	-	-	3	63	9.1
4D	-	-	-	1	19	3.7

Coastwise

Large decline in participation

Current research activities

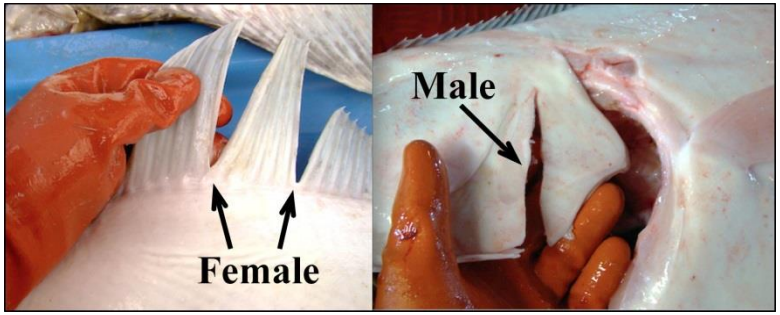
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

- **Develop a set of knife-cuts that crew could use to mark females and males**
- **Test the technique via voluntary fleet participation**



	2016			2017		
Reg Area	Offloads	Samples	% marked	Offloads	Samples	% marked
2A	-	-	-	36	70	6.2
2B	**130**	1,905	**13.1**	**5**	84	**5.3**
2C	-	-	-	16	116	9
3A	-	-	-	10	113	7.6
3B	-	-	-	9	292	20.3
4A	-	-	-	2	77	7.4
4B	-	-	-	2	95	10.7
4C	-	-	-	3	63	9.1
4D	-	-	-	1	19	3.7

Coastwise

Large decline in participation: ineffective incentive program

Some issues with accuracy that need to be corrected

Current research activities

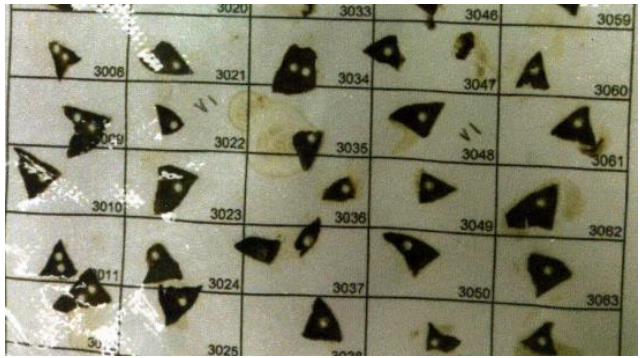
2. Reproduction: Identification of sex in the commercial landings

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

A) Development of genetic techniques

B) At-sea sex-marking

C) Routine collection of fin clips (matched to each otolith) in ports since 2017



Current research activities

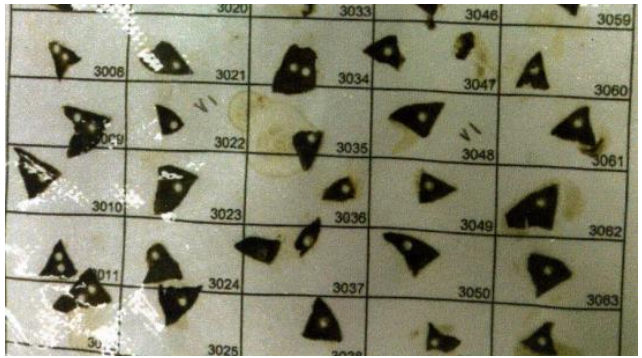
2. Reproduction: Identification of sex in the commercial landings

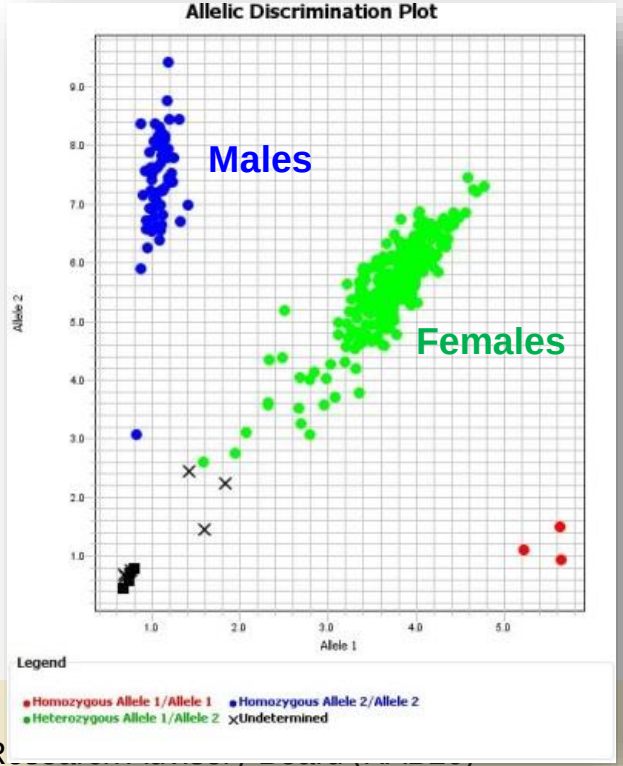
To generate sex-ratio data for use in assessment and policy analysis

A) Use of genetic techniques

B) At-sea sex-marking

C) Routine collection of fin clips (matched to each otolith) in ports since 2017





Current research activities

2. Reproduction: Identification of sex in the commercial landings

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

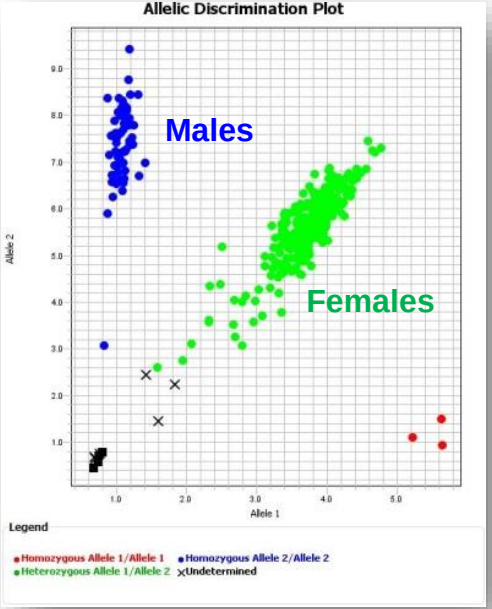
A) Use of genetic techniques

B) At-sea sex-marking

C) Routine collection of fin clips (matched to each otolith) in ports since 2017

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

2019 FULL STOCK ASSESSMENT



Current research activities

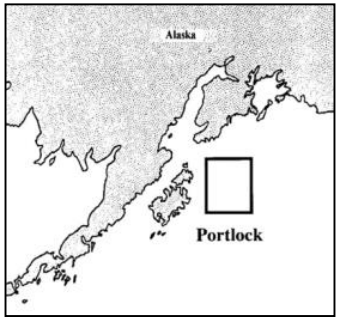
2. Reproduction: Full characterization of the annual reproductive cycle

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



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

2017 2018

30♀ / 30 ♂

Deliverables:

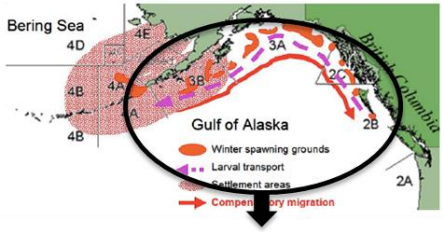
- Accurate staging of reproductive status
- Updated maturity-at-age estimates
- Estimates of skipped-spawning

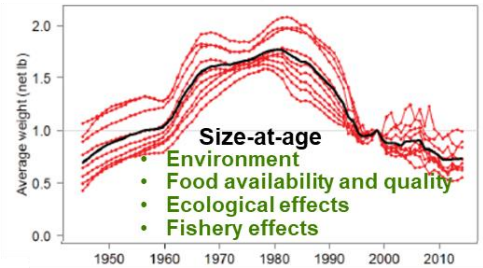
Current Research Activities

3. Growth

Projects:

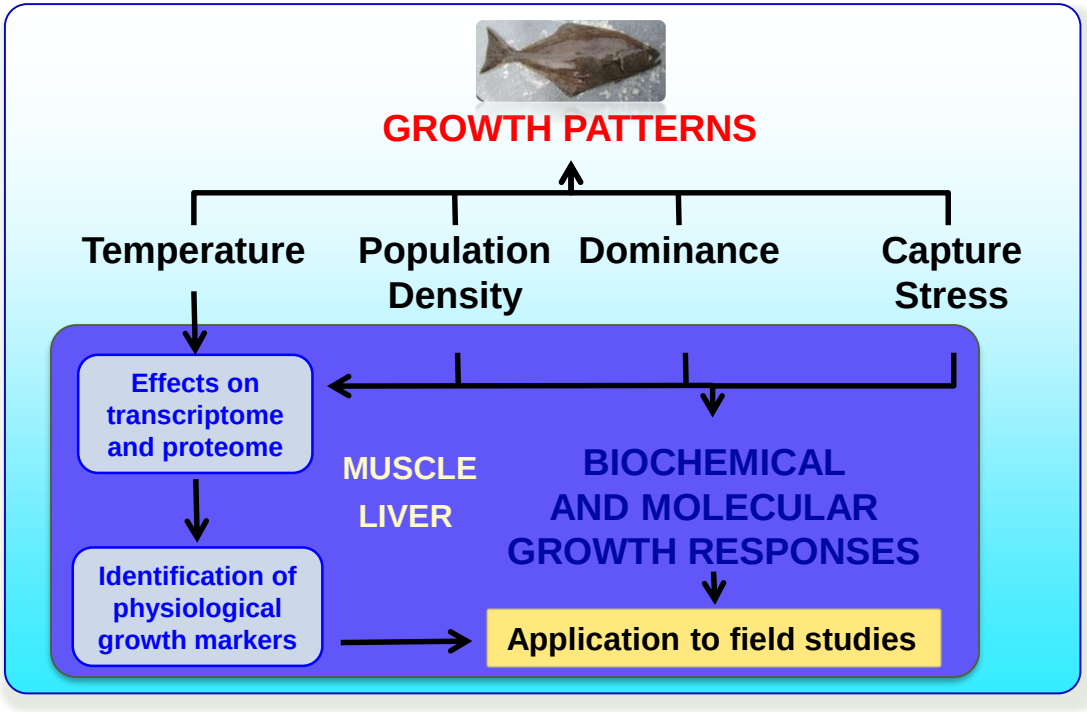
1. ***Identification and validation of physiological markers for growth***
2. ***Evaluation of growth patterns in the Pacific halibut population and possible effects of environmental variability***





Growth

1. Identification and validation of physiological markers for growth



IPHC / AFSC-NOAA (Newport, OR)

Dr. Josep Planas (PI)

Dr. Thomas Hurst

NPRB Grant 1704 (2017-2019)

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

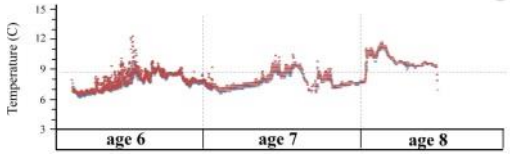
60-80 cm FL

Characterization of physiological growth markers in muscle samples from age-matched individuals

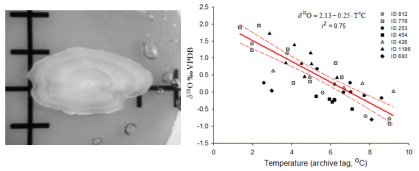
- Effects of environmental variability: influence of thermal history on growth patterns

- **U32 tagged fish with archival tags that record temperature**
- **Relate temperature history to otolith chemistry (O_2 isotopes); and then to growth**

Tag



Temperature time-series



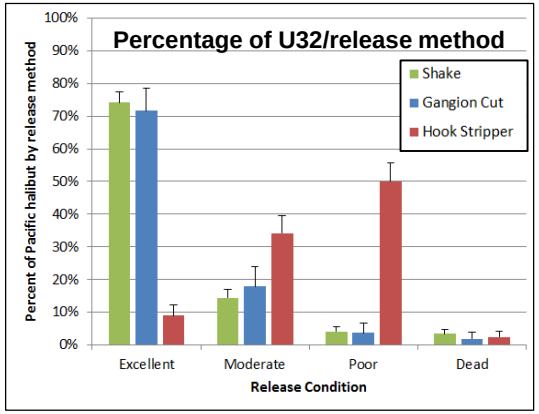
Otolith as temperature-recorder

DMRs and Survival Assessment

1. *Directed longline fishery*: NOAA FISHERIES Saltonstall – Kennedy Grant NA17NMF4270240 ALASKA PACIFIC UNIVERSITY

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
- Fat content
- Blood stress

– ***Capture conditions***

- Time

- Water temperature loggers

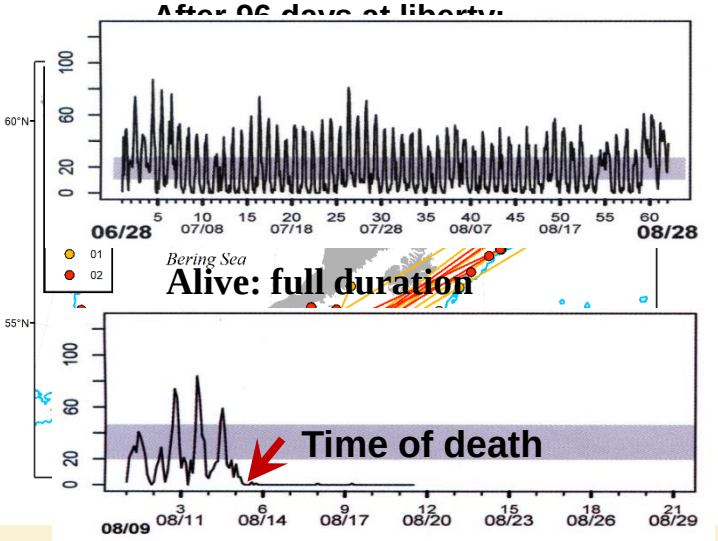
- Fish temperature

DMRs and Survival Assessment

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

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

Results: 4% mortality



DMRs and Survival Assessment

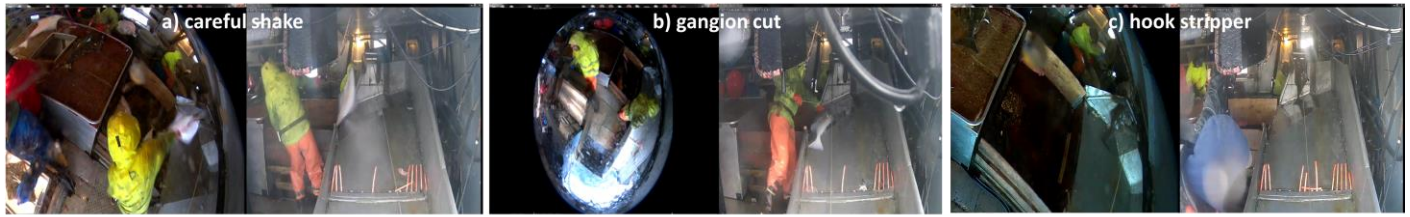
C. Applicability of electronic monitoring (EM) in DMR estimation

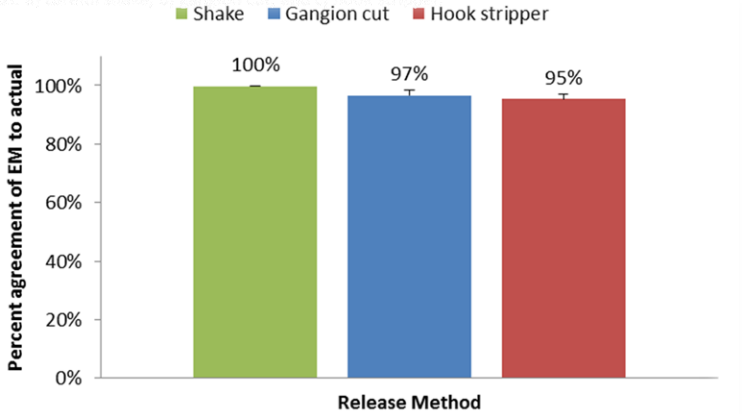
- **Deployed EM system on a longline vessel**
- **Video recorded fish handling events during capture**
- **This will allow us to determine injury profile by release method**

DMRs and Survival Assessment

C. Applicability of EM in DMR estimation

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





DMRs and Survival Assessment

2. *Guided recreational fishery: Estimation of DMRs*

– **To be 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**

Recreational charter

Captured Pacific halibut

Hook injury assessment

Tagging with sPATs

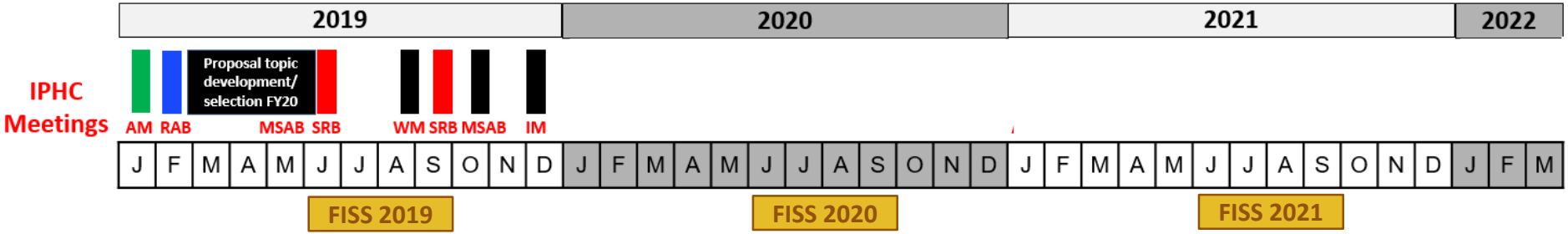
NFWF National Fish and Wildlife Foundation

UAF University of Alaska Fairbanks | Alaska Pacific University | Alaska Charter Association

Description of IPHC research activities

1. **Overview of IPHC 5-year Biological and Ecosystem Sciences Research Plan (2017-2021)**
2. **Core research streams: Updates for key ongoing research activities (Project leaders)**
   - **Migration***: Migratory behaviour and distribution of Pacific halibut* (L. Sadorus, T. Loher)
   - **Reproduction***:*
     - *Reproductive assessment of the Pacific halibut population* (J. Planas)
     - *Sex-marking at sea and application of genetics to determine the sex ratio of the commercial landings validation of sex identification* (T. Loher)
   - **Growth***: Factors affecting somatic growth in juvenile Pacific halibut* (J. Planas)
   - ***Discard mortality rates:*** *Discard mortality rates and post-release survival in the Pacific halibut fisheries* (C. Dykstra)
3. **IPHC new research projects selected for 2019 (J. Planas)**

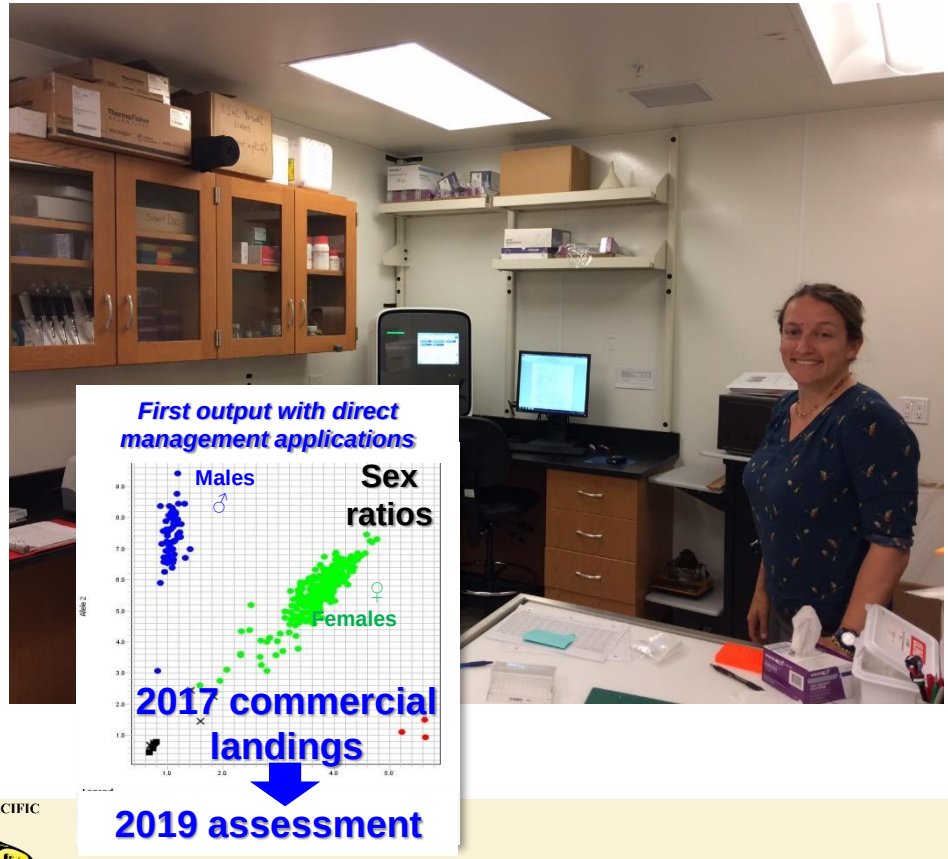
Research topic development and selection process



New research projects selected for 2019

	Project name	*Project description*	*Management implications*
1	**Up-to-date genetic analysis of population structure**	Collection of genetic samples from spawning fish in Reg. Area 4B and revisit genetic analyses	Adult distribution, regional management
2	**Dispersal and recruitment success of juvenile Pacific halibut**	Application of genetics and otolith chemical analyses to understand juvenile distribution and recruitment success	Juvenile distribution and recruitment
3	**Investigations on chalky Pacific halibut**	Collection of information from stakeholders on the incidence of chalky flesh and understanding possible causes leading to its development	Landed value
4	**Whale detection techniques**	Use of acoustic towed array hydrophones for whale detection. Participation in project led by ALFA and funded by BREP-NOAA	Whale depredation
5	**Bycatch reduction techniques**	Use of LEDs in trawl gear to facilitate escape responses of Pacific halibut. Participation in project led by PSMFC and funded by BREP-NOAA	Bycatch reduction

New biological laboratory at IPHC

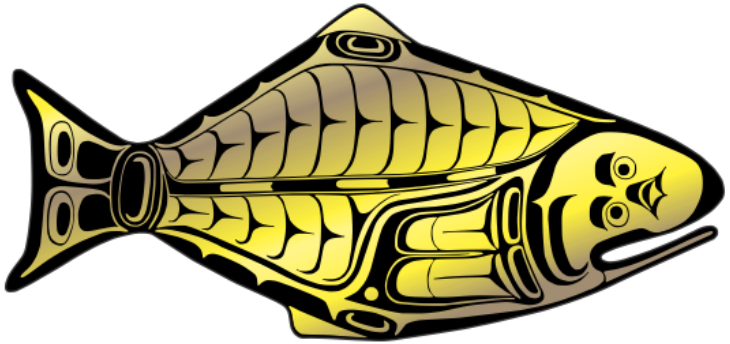


- **Lab technician: Anna Simeon (full time; 2 yr appointment; salary co-financed by NPRB grant)**
- **Lab equipment:**
  - **PCR machine**
  - **Spectrophotometer**
  - **Microplate reader**
- **Current lab capabilities:**
  - **Nucleic acid extraction and quantification**
  - **Genotyping**
  - **Gene expression** → **Growth/reproduction**
  - **Blood metabolite and hormone determinations**
  - **Staff and student training**

Sex ratios/ genetics/ migration

Discard survival/ reproduction

INTERNATIONAL PACIFIC



HALIBUT COMMISSION