

NOAA FISHERIES

A Management Strategy Evaluation for Pacific Hake Process, collaboration, and lessons

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Joint Technical Committee of the U.S. and Canada Pacific Hake/ Whiting Agreement

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Pacific Hake/Whiting

- Distributed from Baja California, Mexico to SE Alaska
- Supports trawl fisheries in British Columbia, West Coast of U.S., and a little in Mexico



Migration hypotheses



Figure 1.--Migratory patterns of Pacific whiting.

Variable distribution



sA values from the Joint US/Canada Acoustic survey

Variable recruitment



Figure e. Medians (solid circles) and means (X) of the posterior distribution for recruitment (billions of age-0) with 95% posterior credibility intervals (blue lines). The median of the posterior distribution for mean unfished equilibrium recruitment (R_0) is shown as the horizontal dashed line with a 95% posterior credibility interval shaded between the dotted lines.

Variable growth

	2013 —	0.02	0.13	0.28	0.36	0.47	0.51	0.63	0.71	0.73	0.83	1.00	1.08	1.23	1.12	1.07	1.05
	2012 —	0.02	0.13	0.22	0.35	0.41	0.49	0.65	0.68	0.78	0.94	0.97	0.96	0.95	0.99	1.00	0.94
	2011 —	0.02	0.08	0.24	0.32	0.38	0.51	0.60	0.67	0.86	0.95	0.96	1.07	1.06	1.01	1.06	0.94
	2010 —	0.02	0.11	0.23	0.26	0.43	0.54	0.67	0.87	1.13	1.08	0.99	0.92	0.88	1.14	0.72	0.90
	2009 —	0.02	0.07	0.24	0.34	0.47	0.64	0.68	0.70	0.75	0.83	0.77	0.84	1.03	0.86	0.95	1.01
	2008 —	0.02	0.14	0.24	0.41	0.57	0.65	0.70	0.69	0.72	0.73	0.76	0.82	0.89	0.82	0.87	0.84
	2007 —	0.02	0.05	0.23	0.38	0.54	0.55	0.61	0.63	0.65	0.71	0.77	0.76	0.81	0.87	0.80	0.87
	2006 —	0.02	0.13	0.38	0.46	0.53	0.57	0.59	0.60	0.66	0.70	0.73	0.72	0.78	0.66	0.64	0.96
	2005 —	0.02	0.12	0.26	0.43	0.51	0.54	0.57	0.63	0.65	0.70	0.80	0.81	0.81	0.76	1.14	0.97
	2004 —	0.02	0.11	0.26	0.44	0.48	0.53	0.65	0.71	0.66	0.71	0.81	0.86	0.77	0.97	0.86	0.90
	2003 —	0.03	0.10	0.26	0.44	0.52	0.59	0.76	0.69	0.75	0.82	0.77	0.89	0.93	0.79	0.84	1.00
	2002 —	0.03	0.08	0.36	0.46	0.61	0.82	0.76	0.85	0.98	0.93	0.92	1.00	0.99	0.92	1.13	1.06
	2001 —	0.03	0.05	0.29	0.48	0.65	0.66	0.75	0.86	0.86	0.88	0.96	0.98	1.01	1.05	0.99	0.98
	2000 —	0.03	0.19	0.32	0.47	0.58	0.66	0.72	0.73	0.75	0.84	0.82	0.88	0.86	0.94	0.87	0.93
	1999 —	0.03	0.14	0.25	0.35	0.43	0.53	0.56	0.57	0.61	0.70	0.67	0.80	0.76	0.88	0.73	0.82
	1998 —	0.03	0.08	0.21	0.35	0.50	0.52	0.54	0.64	0.61	0.68	0.81	0.72	0.81	0.77	0.75	0.77
	1997 —	0.03	0.09	0.36	0.43	0.49	0.55	0.55	0.58	0.59	0.61	0.63	0.86	0.59	0.71	0.66	0.87
	1996 —	0.03	0.10	0.29	0.40	0.47	0.53	0.57	0.65	0.60	0.64	0.60	0.75	0.68	0.81	1.49	0.75
	1995 —	0.04	0.11	0.27	0.34	0.49	0.54	0.65	0.62	0.66	0.76	0.67	0.74	0.80	0.91	0.68	0.80
<u> </u>	1994 —	0.04	0.12	0.30	0.36	0.45	0.45	0.53	0.57	0.62	0.56	0.63	0.48	0.65	0.73	0.70	0.75
ea	1993 —	0.04	0.13	0.25	0.34	0.40	0.45	0.49	0.50	0.49	0.55	0.51	1.26	1.02	0.61	0.60	0.69
\succ	1992 —	0.04	0.14	0.23	0.35	0.47	0.53	0.58	0.62	0.64	0.65	0.63	0.72	0.74	0.85	0.98	1.03
	1991 —	0.04	0.14	0.28	0.37	0.46	0.51	0.54	0.59	0.72	0.85	1.10	0.72	0.64	1.02	1.21	2.38
	1990 —	0.04	0.14	0.24	0.35	0.39	0.51	0.55	0.61	0.67	0.53	0.77	0.83	2.20	1.18	1.02	1.47
	1989 —	0.04	0.14	0.27	0.30	0.29	0.51	0.44	0.41	0.52	0.63	0.66	0.60	0.88	0.67	0.83	1.13
	1988 —	0.04	0.14	0.19	0.32	0.47	0.37	0.37	0.52	0.65	0.69	0.72	0.92	1.09	1.02	1.45	1.45
	1987 —	0.04	0.15	0.14	0.38	0.28	0.29	0.36	0.58	0.60	0.64	0.76	0.98	0.92	1.24	1.20	1.42
	1986 —	0.04	0.16	0.28	0.29	0.30	0.37	0.54	0.57	0.64	0.82	0.94	1.19	1.19	1.39	1.68	1.61
	1985 —	0.05	0.17	0.23	0.27	0.44	0.55	0.55	0.60	0.75	0.69	0.72	0.86	0.87	0.95	0.68	1.12
	1984 —	0.05	0.13	0.16	0.25	0.44	0.41	0.44	0.59	0.58	0.68	0.70	0.95	1.14	1.03	1.28	1.88
	1983 —	0.05	0.13	0.14	0.34	0.37	0.33	0.52	0.50	0.62	0.71	0.88	0.93	1.04	1.03	1.32	1.48
	1982 —	0.05	0.12	0.25	0.33	0.31	0.55	0.40	0.53	0.56	0.76	0.68	0.85	1.07	0.88	1.02	1.17
	1981 —	0.05	0.11	0.21	0.34	0.53	0.39	0.53	0.55	0.75	0.72	0.82	1.04	1.10	1.34	1.49	1.21
	1980 —	0.05	0.08	0.22	0.45	0.39	0.49	0.52	0.66	0.71	0.87	1.06	1.16	1.29	1.30	1.27	1.40
	1979 —	0.05	0.09	0.24	0.26	0.58	0.69	0.77	0.89	0.91	1.04	1.20	1.25	1.53	1.55	1.80	1.98
	1978 —	0.05	0.10	0.14	0.47	0.53	0.60	0.64	0.74	0.84	0.98	1.10	1.23	1.30	1.48	1.74	2.34
	1977 —	0.06	0.10	0.40	0.49	0.59	0.67	0.75	0.83	0.98	1.11	1.23	1.31	1.41	1.75	2.04	2.21
	1976 —	0.06	0.10	0.24	0.50	0.52	0.69	0.80	0.92	1.21	1.34	1.45	1.65	1.81	1.86	1.96	2.74
	1975 —	0.06	0.16	0.30	0.37	0.61	0.63	0.79	0.87	0.97	0.91	0.97	1.69	1.50	1.90	1.96	2.74
	mean —	0.03	0.09	0.25	0.37	0.48	0.54	0.59	0.66	0.72	0.79	0.86	0.93	0.97	1.07	1.01	1.02
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		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Weight-at-age by year

Variable maturity



Variable fishery catches



Variable economics



2014 Assessment Results

• Increasing due to estimated recent strong recruitment



Assessment of Pacific Hake

- Do not specifically model growth
 Use empirical weight-at-age
- Fishery and survey age-compositions
- Biennial acoustic survey index
 unless convinced otherwise
- Estimate recruitment with a variance of 1.4
- Model a single coast-wide stock
- Estimate annual deviations in selectivity
- Assess annually
- Use Stock Synthesis (SS) assessment software

Management of Pacific Hake

- International Agreement for Pacific Hake/Whiting
 - Written in early 2003
 - Implemented in 2006 (really in 2012)
 - US/Canadian scientists and managers acted in the spirit of the treaty for many years
 - Four committees
 - 1. JMC: Joint Management Committee
 - 2. SRG: Scientific Review Group
 - 3. AP: Advisory panel
 - 4. JTC: Joint Technical Committee

Assessment process

- Collaboration between U.S. and Canadian scientists
 JTC
- Public meetings held in early December to discuss the data and in January to discuss preliminary assessment results

– JTC and AP

- A review of the stock assessment over a week in February
 - JTC and SRG and some AP
- Final assessment results and advice is presented in March
 - JTC, SRG, AP, and JMC

Management process

- JMC decides on a coast-wide TAC at the March meeting
 - Agreement defines an F_{SPR=40%} harvest rate with a 40:10 adjustment (blue line)
 - But, JMC has flexibility



- Agreement defines proportional split between US and Canada
- US Pacific Fishery Management Council defines splits between US sectors after allocation to tribal and research quota
- Decision making is at the coast-wide level, then each country decides what to do with their portion

Call for a Management Strategy Evaluation (Year 1)

- A MSC condition
 - investigate the performance of the harvest control rule
- Initial trepidation from stakeholders and managers
- We quickly realized there are many more questions of interest
 - Annual vs. biennial survey

Initial MSE

- Used SS as an operating model (OM) and estimation model (EM)
- Decided to look at
 - Harvest Strategy defined in The Agreement

– Annual vs. Biennial surveys

• Reported results one year later



 Start with the assessment model

 MCMC samples show variability



- Start with the assessment model
- MCMC samples show variability
- The future is highly uncertain



 Performance statistics related to short- or long-term reference period



- Performance statistics related to short- or long-term reference period
- Not a forecast

 a tool for
 comparing
 strategies



Year 1 Findings

- We reported
 - Stock status
 - Fishery yield
 - Annual variability in yield
- Realized that the OM was simplistic and too similar to the EM

- Constant selectivity, informative fisheries data

No clearly defined objectives to measure the performance against

Year 2

- Still used SS, but with additional complexity in OM
- Looked at past management behavior
- Solicited more stakeholder and manager input
- Began defining clear objectives

Management behavior

• In our MSE from year 1, we found that very large (unlikely) catches were taken



- Looking at past management response to assessments, it appears that there is an asymptote
 - Plus, stakeholders suggested a catch cap

Year 2 findings

Simulation Tested Catch Caps

	Long term (
<u>Specifications</u>				
Catch range (1000 mt)	-	< 500	< 375	180 - 375
Metrics related to depletion				
Median average depletion	39%	42%	45%	35%
Probability B < B _{10%}	6%	5%	5%	19%
Metrics related to catch				
Median of average catch (1000 mt)	199	203	216	233
Median of Average Annual Variability (AAV) in catch	52%	41%	34%	19%
Probability that catch = 0	13%	12%	10%	0%

Trade-offs

- Some objectives cannot be met
 - Instead, we think of developing harvest strategies that minimize or maximize objectives



Depletion

Defining objectives

- We need to define objectives:
 - That can be minimized or maximized
 - Are a product of collaboration and agreed upon
 - Are consistent with The Agreement
- The JMC defined some management principles as a start to defining objectives

Management Principles

- P.1 Manage the Pacific Whiting resource utilizing the best available science in a precautionary and sustainable manner.
- P.2 Maintain a healthy stock status across a range of recruitment events and consider total allowable catch levels that spread the harvest of strong cohorts over multiple years.
- P.3 Manage the fishery resource in a manner that aims to provide the best long-term benefits to the Parties.
- P.4 Manage the fishery to ensure that each country has the opportunity to receive the intended benefits contemplated in the treaty.
- P.5 These management principles are dynamic and shall be reviewed annually by the JMC and the AP to ensure they remain valid.

Further defining objectives

Stock Status							
Question	Metrics	Current OM	Spatial OM				
1) What is the desired status of the stock	The average stock status over a defined time period	Yes	Yes				
(i.e., abundance)?	The probability that the stock is above, below, or within a defined range	Yes	Yes				
	The diversity of age classes	Yes	Yes				
	The proportion of older fish to total numbers or biomass	Yes	Yes				
2) What is the desired age structure?	The amount of fish above a certain age are available in each country	No	Yes				
	The harvest rate of specific age classes	Yes	Yes				
	The age at which the median cumulative harvest occurred.	Yes	Yes				
3) What is the desired proportion/availability of biomass or numbers in each country?	The proportion of spawning, exploitable, or other biomass in each country.	No	Yes				

Further defining objectives

Yield:

The Agreement and the Management Principles do not specifically state any objectives related to yield other than possibly sustainability and intended benefits.

Question	Metrics	Current	Spatial OM
(1) What is the desired level of catch	The average TAC over a specified time	Yes	Yes
+) what is the desired level of catch	The average TAC in each country	No	Yes
5) What is the maximum allowable change	The average annual variability (AAV) of the TAC over a time period	Yes	Yes
in TAC from year to year?	That AAV of the TAC in each country	No	Yes
	The proportion of times that the TAC was set below a threshold	Yes	Yes
6) What is the minimum acceptable IAC?	The proportion of times that the TAC was set below a threshold in each country	No	Yes
7) What is the availability of fish in each country after allocation?	The proportion of times that a specified percentage of exploitable biomass is less than the TAC for each country	No	Yes

After 2 years

- Biggest concerns
 - Availability of fish to each country
 - Avoiding a low stock status
 - Avoiding a low TAC
 - Understanding the purpose of a MSE

Has the MSE affected management

- Not directly, but has been useful in
 - Understanding risks
 - Thinking about and defining objectives
 - Supporting arguments for a lower TAC than The Agreement defines

Lessons learned

- Input from all interested parties is very important
- Defining objectives is also important and can be difficult
- It takes time to understand the power and usefulness of an MSE tool
- Collaboration is very helpful

Another lesson learned

- I learned that MSE is a larger process than I originally thought
 - Solicit input,
 - define objectives,
 - build models,
 - choose scenarios,
 - define harvest strategies,
 - test harvest strategies,
 - report results,
 - repeat?



Closed-loop simulation



An important lesson

- MSE is a difficult concept
 - Fear that it will replace the assessment
 - Want the assessment to do what an MSE does
 - Assessment can provide short-term projections
 - MSE more appropriate for long-term statistics
 - Difficulty understanding an OM
 - We try not to use the word "truth"
 - Have not found a good analogy
- Beginning to understand that goal is to identify management procedures that are robust over a wide range of potential scenarios

Summary

- Conversations within the hake MSE world are not much different than MSAB
- We are hoping to collaborate more to develop strategies, OM's, explanations, analogies, ...



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