1. Title: Western Alaska Salmon Revolt 2012: Teaching Notes

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3. Abstract
In June of 2012, more than 25 Alaska native residents along the Kuskokwim River were cited for fishing illegally for Chinook salmon. At least 30 nets and over 1,000 lbs of fish were seized by state and federal officials, and in some cases fishermens' nets were cut. These conflicts occurred after Alaska Department of Fish and Game (ADF&G) regional managers extended a closure of the Kuskokwim River subsistence fishery in an attempt to allow enough Chinook upstream to spawn, following multiple years of poor returns of Chinook salmon. This case study will develop and explore a socio-environmental model for the Kuskokwim River Chinook salmon fishery, with students working from the point of view of a newly graduated, newly hired fishery biologist responsible for managing the salmon fishery on the Kuskokwim River. Students will be asked to consider what they need to know, in addition to strictly biological information, in order to do their job well.

4. Intended courses:
FISH 433/633 Pacific Salmon Life Histories (3 cr.) – University of Alaska Fairbanks

5. Intended level:
Upper division undergraduate or graduate

6. SES Learning goals:
- ability to create a conceptual model, showing major components and linkages, for a socio-environmental system
- ability to locate, analyze and synthesize existing data in order to evaluate management decisions and stakeholder responses
- ability to develop methods, analyses and conclusions in interdisciplinary teams
- ability to comprehend and reconcile conflicting opinions and hypotheses

7. Learning objectives
- understand the socio-environmental system describing Kuskokwim River chinook salmon
- understand types of data used by ADFG in management of these fisheries
- understand objectives/importance of co-management in Kusko chinook
- understand and evaluate multiple hypotheses for declines in Kusko chinook populations
- understand limitations of a strictly biological understanding of this system

8. Introduction/background

In June of 2012, more than 25 Alaska native residents along the Kuskokwim River were cited for fishing illegally for Chinook salmon. At least 30 nets and over 1,000 lbs of fish were seized by state and federal officials, and in some cases fishermens' nets were cut. These conflicts occurred after Alaska Department of Fish and Game (ADF&G) regional managers extended a closure of the Kuskokwim River subsistence fishery in an attempt to allow enough Chinook upstream to spawn. A number of Kuskokwim River residents, at the urging of their elders, decided to defy these orders and continued to fish for Chinook salmon. In May 2013, Bethel magistrate Bruce Ward ruled that despite the fact that he agreed that subsistence fishing was a form of religious expression, in this case this expression was likely to harm the salmon run, and conservation of the run was paramount, so the charges were upheld.

Throughout the course of this case study, students will construct and explore a socio-environmental conceptual model in an attempt to understand *how we got to this point, despite earnest and dedicated efforts of both ADF&G and fishermen to achieve co-management of fisheries in this system*. Students will operate from the point of view of an individual, recently graduated with a M.S. in fisheries, who just landed a job with ADF&G as a regional salmon management biologist on the Kuskokwim River. The main question for them is, **what do they need to know to do their job well?**

Socio-environmental synthesis (SES) is an approach that seeks to analyze and merge multiple sources of information in order to construct models for understanding the various physical, biological, and social components of an environmental or resource issue, including interactions and feedbacks among components. This case will provide an opportunity for students to examine multiple facets of the story, learning how, for example, a strictly biological approach to this problem is not adequate to explain its outcomes. It will also expose them to sources of data, methods, and publications in fields outside of the focal discipline of the class (fisheries ecology).

This case was designed for an upper-division undergraduate or graduate course in fisheries, natural resource management, or environmental studies. It is assumed that students have a basic knowledge of salmon biology, fisheries management and population biology, as well as the ability to understand basic socioeconomic concepts. Many of the biological concepts developed in the case study will be taught alongside teaching the case study throughout the course.

9. Classroom Management

The case is intended to take approximately 30 contact min./week in a 3-credit (three contact hours/week) course over 12 weeks during the semester. Information needed to complete the case will be introduced sequentially throughout the course (following weekly schedule presented below).

N.B.—the modules for weeks 4 – 12 are ordered in a way that follows the information provided in the lecture aspect of UAF FISH F433/633 course; they may be re-ordered in a way that makes more sense to individual instructors.

Week 1.—Case study introduction
Learning objective 1: understand what is meant by a socio-environmental system

Activity 1: identify components of Kuskokwim Chinook SE system.

Lecture/information provision:
Instructor will introduce the case, beginning by showing the video of Alaska Troopers seizing fish from subsistence fishermen fishing after the closure. Class will then read the Alaska Dispatch news story from 5/21/13 (Medred 2013) about the trial (including slide show of testimony), which will summarize the case, raising biological, social, economic, and political facets for the students to explore further throughout the course.

Individual activity:
5-minute free-write: Imagine you are an ADFG regional manager – what kinds of information would you like to have to try to prevent this conflict from occurring again?

Discussion:
What is the role of biology in addressing this problem? What other disciplines or perspectives might be necessary?

Assigned media/readings:
You-tube video of net and catch seizure:
www.youtube.com/watch?v=dJ1-Sjlv75s

Medred, C. 2013. Cultures collide in Bethel courtroom with future of Kuskokwim kings hanging in the balance. Alaska Dispatch, 21 May 2013.
http://www.alaskadispatch.com/article/20130521/cultures-collide-bethel-court-future-kuskokwim-kings-hanging-balance

Week 2.—Building the model
Learning objective 2: understand how to construct a socio-environmental system model

Activity 2: begin to construct conceptual model

Lecture/information provision:
Instructor will briefly describe what is meant by a conceptual model for a socio-environmental system, showing them an example that is completely different from the one we'll create, so as to have minimal influence on the details of the ones they'll construct.

Instructor will give them the key components of the model to get them started. This will also facilitate the ability to teach these components as outlined in the weekly modules below:

Subsistence
Spawner quality
Freshwater rearing
Socioeconomic factors
Escapement-based management
Marine survival
Run timing
Bycatch

<u>Group/individual activity:</u>
The class will begin the process of constructing the conceptual model. First, the class will take 10 minutes to brainstorm model components, working in self-formed groups or as individuals. Afterwards, groups/individuals will report out, creating a master-list of components. Remaining class-time will be used for groups/individuals to begin to construct a conceptual model for the Kuskokwim River Chinook salmon fishery.

<u>Discussion:</u>
None structured, other than what arises via questions during the in-class activity.

<u>Homework activity:</u>
Working within their group or individually, construct a conceptual model (graphic). Due date: one week later.

Students will decide which of the pre-defined topics they would like to take on as their case study project. This must be submitted by the end of the following course.

<u>Assigned reading:</u>
Palmer, M. A. 2012. Socioenvironmental sustainability and actionable science. BioScience 62:5-6.

<u>Additional resources</u>:
Example SE models from other systems (Figs. 1 and 2).

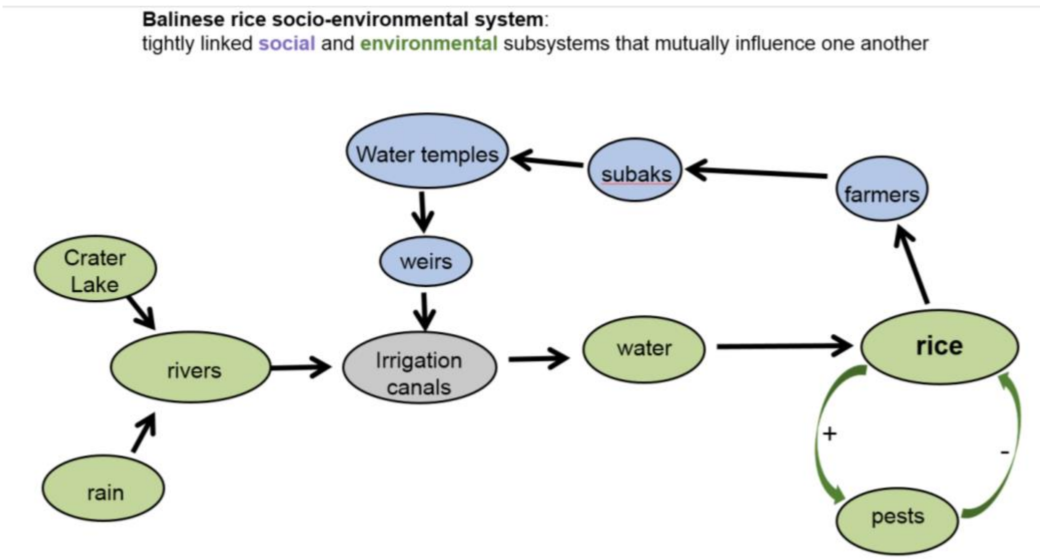

Figure 1. Balinese rice socio-environmental system model (from Cynthia Wei et al., SESYNC).

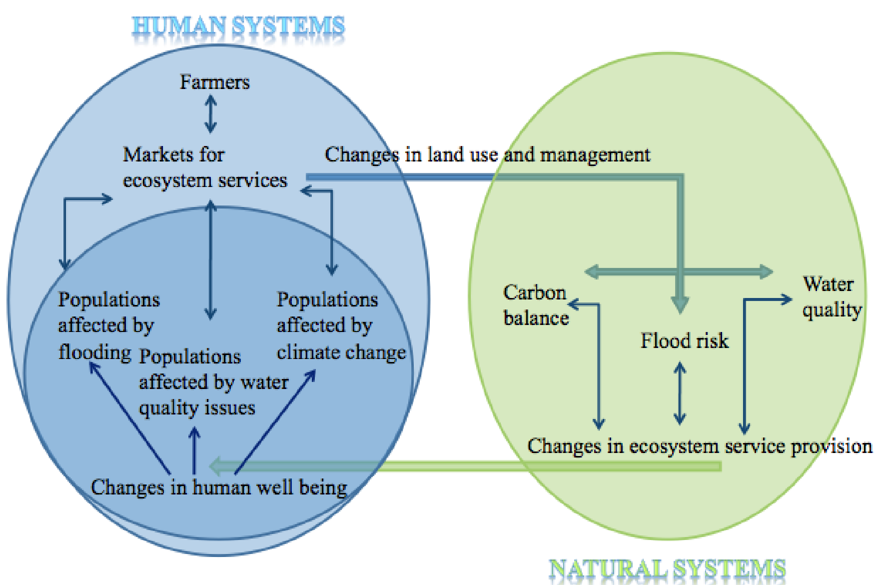

Figure 2. Example socio-environmental conceptual model (from Sylvia Secchi, Southern Illinois University).

Week 3.—Consensus model

Learning objective 3: learn different ways of viewing conceptual models; learn how to reconcile differing viewpoints, learn that tough choices are part of natural resource management

Activity 3: construct a consensus conceptual model for the Kuskowkim Chinook salmon fishery SE system

Lecture/information provision:
Instructor will provide students with an electronic document showing all of the submitted models.

Group/individual activity:
Each group will given 3 minutes to present their model, explaining why they chose the components and linkages that they did.

Discussion:
Class will arrive at a consensus model through instructor-led discussion. In cases where consensus is not achieved, instructor will be 'the decider'! Instructor should specify that the consensus model should at the minimum, contain the pre-defined components (subsistence fishing, etc.)

Resources:
Example Kuskokwim Chinook salmon fishery socio-environmental model (Figure 3).

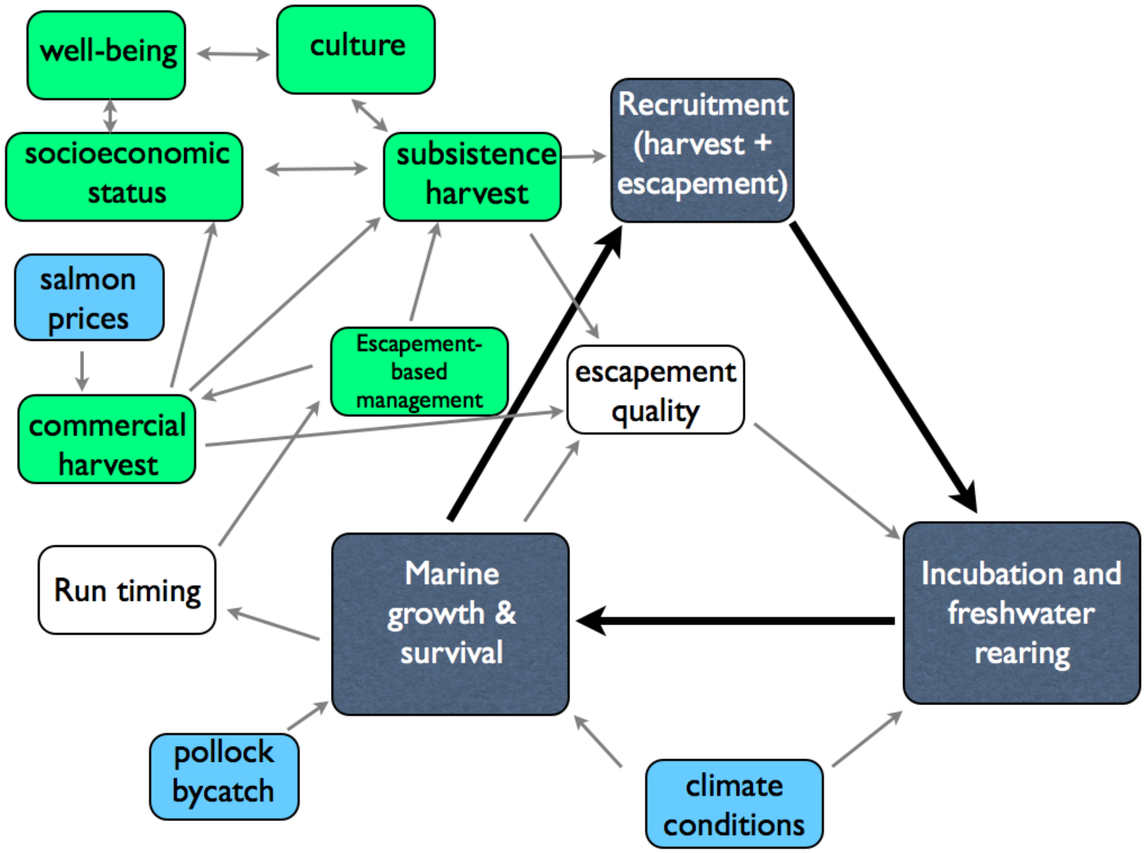

Figure 3. Potential socio-environmental model for the Kuskokwim Chinook salmon fishery. Dark blue boxes represent major stages in the salmon life cycle, and clear boxes represent smaller biological components. Green boxes represent local/regional human dimensions of the system, and bright blue boxes represent forcings beyond local/regional control.

Week 4.—Subsistence

Learning objective 4: learn about methods and importance of subsistence fishing in western Alaska

Activity 4: hear student-led presentation, reflect, and discuss

Lecture/information provision:
Student group/individual will provide a presentation (multi-media available; instructor will provide resources in form of publications, web sites, video, etc.). In cases where information directly about Kuskokwim Chinook salmon is lacking, information and examples from other regions and species may be used.

Individual activity:
5-minute free-write after presentation and Q&A period. Topics: how does learning about subsistence fishing change your view of what knowledge you need to know to do your job as a regional manager? How has your view of the 'salmon revolt' changed?

Discussion:
Instructor-led discussion of free-write topics.

Assigned media:
Wolfe, R. J. and J. Spaeder. 2009. People and salmon of the Yukon and Kuskokwim drainages and Norton Sound in Alaska: fishery harvests, culture change, and local knowledge systems. American Fisheries Society Symposium 70:349-379.

Felt Soul Media. 2008. Red Gold (DVD).
http://www.feltsoulmedia.com/thewire/redgoldfilm/

[This film is set in Bristol Bay, which is south of the Yukon-Kuskokwim area, but has some great footage of what the subsistence lifestyle is about (min. 30-36).]

Week 5.—Escapement (spawner) quality
Learning objective 5: learn about decline in body size and age of spawning Chinook salmon – causes and consequences

Activity 5: hear student-led presentation, reflect, and discuss

Lecture/information provision:
Student group/individual will provide a presentation about the decline in Kuskowkim Chinook salmon body size and age, and how this affects the fishery (instructor will provide resources in form of publications, web sites, video, etc.; students should use these as springboard for finding more sources). In cases where information directly about Kuskokwim Chinook salmon is lacking, information and examples from other regions and species may be used.

Individual activity:
5-minute free-write after presentation and Q&A period. Topics: What mechanisms do you think are likely contributing to observations of declining body size? How would this change the way you might manage the fishery in your new job?

Discussion:
Instructor-led discussion of free-write topics.

Assigned reading:
O'Neil, D. 2012. The fall of the Yukon kings. *In* S. Banarjhee (ed.), Arctic Voices: Resistance at the Tipping Point, pp.142-164. Seven Stories Press, New York.

[Note that this source is fairly biased against Alaska Department of Fish and Game, and gives little attention to the role of ocean conditions in influencing age and size at maturity in Chinook salmon from western Alaska. However it does give a good idea of the kinds of things fishermen have been observing on the river, and the importance of local knowledge in natural resource management.]

Week 6.—Freshwater rearing
Learning objective 6: learn about state of habitat and current issues in freshwater rearing of Kuskokwim Chinook salmon

Activity 6: hear student-led presentation, reflect, and discuss

<u>Lecture/information provision:</u>
Student group/individual will provide a presentation about issues in freshwater rearing of Kuskowkim Chinook salmon (instructor will provide resources in form of publications, web sites, video, etc.; students should use these as springboard for finding more sources). In cases where information directly about Kuskowkim Chinook salmon is lacking, information and examples from other regions and species may be used.

<u>Individual activity:</u>
5-minute free-write after presentation and Q&A period. Topics: What mechanisms might be causing declines in freshwater productivity of Kuskokwim Chinook salmon? What studies might you try to instigate in your new job?

<u>Discussion:</u>
Instructor-led discussion of free-write topics.

<u>Assigned reading:</u>
Ruggerone, G. T., J. L. Nielsen, and B. A. Agler. 2009. Linking marine and freshwater growth in western Alaska Chinook salmon. Journal of Fish Biology 75:1287-1301.

[There currently is very little published on freshwater rearing habitat of Chinook salmon in western Alaska; this paper lays out rationale for why freshwater growth might be important to survival]

Week 7.—Socio-economic factors
Learning objective 7: learn about cultural, social, and economic factors affecting salmon use (including access) in the Kuskokwim River

Activity 7: hear student-led presentation, reflect, and discuss

<u>Lecture/information provision:</u>
Student group/individual will provide a presentation about socio-economic factors affecting residents along the Kuskokwim River (instructor will provide resources in form of publications, web sites, video, etc.; students should use these as springboard for finding more sources). In cases where information directly about the Kuskokwim is lacking, information and examples from other regions and species may be used.

<u>Individual activity:</u>

5-minute free-write after presentation and Q&A period. Topics: How has learning about the socio-economics of the lower Kuskokwim changed the way you might go about your job? What additional information would you like to have?

<u>Discussion:</u>
Instructor-led discussion of free-write topics.

<u>Assigned reading:</u>
Howe, E. L. and S. Martin. 2009. Demographic change, economic conditions, and subsistence salmon harvest in Alaska's Arctic-Yukon-Kuskokwim region. American Fisheries Society Symposium 70:433-461.

Week 8.—Escapement-based management
Learning objective 8: learn about how escapement-based management is implemented in the Kuskokwim

Activity 8: hear student-led presentation, reflect, and discuss

<u>Lecture/information provision:</u>
Student group/individual will provide a presentation about escapement-based management in the Kuskokwim River (instructor will provide resources in form of publications, web sites, video, etc.; students should use these as springboard for finding more sources). In cases where information directly about the Kuskokwim is lacking, information and examples from other regions and species may be used.

<u>Individual activity:</u>
5-minute free-write after presentation and Q&A period. Topics: If direction came from the commissioner to lower escapement goals for Chinook in the Kuskokwim, would you go along with this or would you try to influence the department to take a different direction?

<u>Discussion:</u>
Instructor-led discussion of free-write topics. Additional topics: what are the sources of distrust around escapement-based management? What are the sources of uncertainty in the information needed for escapement-based management?

<u>Assigned reading:</u>
Hamazaki, T. 2008. Fishery closure "windows" scheduling as a means of changing Chinook salmon subsistence fishery pattern: is it an effective management tool? Fisheries 33:495-501.

Week 9.—Marine survival
Learning objective 9: learn about factors affecting marine survival of Kuskokwim Chinook salmon

Activity 9: hear student-led presentation, reflect, and discuss

Lecture/information provision:
Student group/individual will provide a presentation about marine survival of Kuskokwim River Chinook salmon (instructor will provide resources in form of publications, web sites, video, etc.; students should use these as springboard for finding more sources). In cases where information directly about the Kuskokwim is lacking, information and examples from other regions and species may be used.

Individual activity:
5-minute free-write after presentation and Q&A period. Topics: what studies would you like to see done to increase knowledge of marine survival of Kuskowkim Chinook salmon? How would increased knowledge of marine survival help you do your job as the Kuskowkim management biologist?

Discussion:
Instructor-led discussion of free-write topics.

Assigned reading:
Miller, J. A., D. J. Teel, A. Baptista, and C. A. Morgan. 2013. Disentangling bottom-up and top-down effects on survival during early ocean residence in a population of Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 70:617-629.

[From the Columbia River, but some principles should apply generally, keeping in mind that Chinook salmon coming out of the Columbia River don't interact directly with sea-ice the way that Kuskowkim Chinook salmon might]

Week 10.—Run timing
Learning objective 10: learn how changes in phenology (migration timing) might affect the Kusko Chinook SE system (biological, social, economic, management)

Activity 10: hear student-led presentation, reflect, and discuss

Lecture/information provision:
Student group/individual will provide a presentation about phenology in the Kuskokwim River (instructor will provide resources in form of publications, web sites, video, etc.; students should use these as springboard for finding more sources). In cases where information directly about the Kuskokwim is lacking, information and examples from other regions and species may be used.

Individual activity:
5-minute free-write after presentation and Q&A period. What are some mechanisms by which changes in phenology might affect the way you would implement escapement-based management?

Discussion:

Instructor-led discussion of free-write topics.

Assigned reading:
Mundy, P. R. and D. F. Evenson. 2011. Environmental controls of phenology of high-latitude Chinook salmon populations of the Yukon River, North America, with application to fishery management. ICES Journal of Marine Science 68:1155-1164.

Week 11.—Bycatch
Learning objective 11: learn about issues surrounding by-catch of Kuskokwim Chinook salmon

Activity 11: hear student-led presentation, reflect, and discuss

Lecture/information provision:
Student group/individual will provide a presentation about bycatch of Chinook salmon, focusing on the North Bering Sea walleye pollock fishery.

Individual activity:
5-minute free-write after presentation and Q&A period. Topics: what are the sources of distrust around the pollock fishery? What are the sources of uncertainty in the information needed for assessing the effects of the pollock fishery? What are the socio-economic factors surrounding this issue?

Discussion:
Instructor-led discussion of free-write topics. Question: if you were at a regional management meeting with subsistence fishermen (in your new position), what would you tell them about the pollock fishery?

Assigned reading:
Gisclair, B. R. 2009. Salmon bycatch management in the Bering Sea walleye pollock fishery: threats and opportunities for western Alaska. American Fisheries Society Symposium 70:799-816.

Week 12.—Synthesis
Learning objective 12: process what it is like to grapple with complex socio-environmental issues

Activity 12: discuss revised conceptual model for Kuskokwim Chinook SE System, reflect on what was learned from case study

Lecture/information provision:
Nothing formal.

Individual activity:

5-minute free-write after presentation and Q&A period. Topics: How has this case study changed your idea about what it means to be a regional salmon manager? What are the pros and cons of socio-environmental systems as a discipline or world view?

Discussion:
Instructor-led discussion of synthesis – focusing on how students would revise the SE system model they came up with at the beginning of the class, and how they might use what was learned from the case study in their education and future (or present) job.

10. Blocks of Analysis

Background

Chinook salmon natural history

Chinook salmon *Oncorhynchus tshawtyscha* are the oldest and largest of the anadromous Pacific salmon species. At the higher latitudes, such as those in western Alaska, Chinook salmon return from the Pacific Ocean as mature adults in June-July, spawning in large rivers and tributaries in late summer. The fertilized eggs incubate in the gravel through the winter, with young Chinook salmon emerging the following spring. Typically, Chinook salmon from western Alaska will spend a full year in freshwater, undergoing smolt transformation the following spring and out-migrating to sea during break-up of the river ice in late spring. These Chinook salmon will then spend 1-5 years at sea, foraging opportunistically. Chinook salmon tend to be more piscivorous (fish eating) than other Pacific salmon species other than coho salmon, although they will also feed on zooplankton, particularly at smaller sizes. Age-at-maturity is influenced by genetics, growth, and sex, with faster growing individuals likely to mature earlier, and males likely to mature earlier than females. Maturing individuals will begin homeward migration, returning to their natal rivers to spawn one time before dying, when the cycle begins anew. Quinn (2005) provides an excellent review of many facets of Pacific salmon life history.

Factors influencing abundance of Chinook salmon

Many hypotheses exist for why Chinook salmon have declined in western Alaska, ranging from natural climate variation to anthropogenic climate change and overharvest in commercial and subsistence fisheries as well as bycatch in the walleye pollock fisheries in the Bering Sea (AYK SSI 2006, 2013). No potential cause is well understood, and much conflict has arisen from this misunderstanding. Very little is known about freshwater habitat requirements of Chinook salmon in the Kuskokwim River, although the river itself is subject to very little human development; there are no major dams, diversions, or hydropower projects. Most of the variation in run size (number of adults returning upriver) is thought to be attributed to environmental variation during their marine phase of rearing, although the effects of climate change on incubation and freshwater rearing habitats has not been investigated to any large extent. The North Pacific Ocean has experienced several ‘regime shifts’ where major changes in sea surface temperature, circulation and sea level pressure have affected marine survival of Pacific salmon; a major change occurred in the winter of 1976/1977, where conditions shifted from favoring salmon from southern British Columbia, Washington, Oregon and

California to favoring Alaskan stocks (e.g., Mantua et al. 1997, Peterson and Schwing 2003). How these regime shifts have affected Chinook salmon from western Alaska is not well understood, but these shifts likely have influenced what people perceive as "normal" compared to "declining" run sizes, and this probably plays a role in the expectations of fishermen and subsequent conflicts observed recently.

<u>Kuskokwim Chinook salmon SE model components</u>

Subsistence

Subsistence fishing is catching fish for personal consumption, sharing, or barter, but not for cash sale. It is difficult to overemphasize the importance of subsistence to the residents of western Alaska. Sources of monetary income are limited in western Alaska and the cost of living is high (see *Socioeconomic factors*), so subsistence hunting and fishing comprises a necessary source of food. The value of subsistence goes beyond material benefit; many Yupik residents see subsistence as an important expression of their spiritual relationship to their environment and a way of protecting their community from the pervasive threats of alcoholism and suicide (Rogers 2013). Practicing a traditional lifestyle, centered around subsistence activities, is also associated with greater physical and mental health (Mills 2003, Bursamin et al. 2013). Approximately 50% of all Chinook salmon harvested for subsistence in Alaska comes from the Kuskokwim (Ikuta et al. 2013), although it is just one of many wild foods harvested in the region. Some people, particularly from communities further upriver, feel that the dependence on Chinook salmon has been overemphasized, and that Kuskokwim residents should curtail their harvest of Chinook salmon during low return years and focus on other subsistence resources instead (e.g., Leary 2012).

Escapement (spawner) quality

Body size is an important aspect of salmon throughout their life cycle. The last 40 years have seen trends of decreasing size of adult Pacific salmon, including Kuskokwim Chinook salmon (Bigler et al. 1996, Helle et al. 2007). While there is still considerable controversy over the causes of these declines in western Alaska (O'Neil 2012), one possible cause is size-selective fishing. The mesh size of gill nets influences the catchability of different sized fish (Bromaghin 2005), and nets used in commercial and subsistence fishing might selectively harvest the larger, older fish, particularly females. As larger females have more eggs (Skaugstad and McCracken 1991), this effect might be contributing to the decreased population productivity, and over time could lead to evolution of the population toward younger maturity and smaller adult size (Hard et al. 2009). However, the role of changing ocean conditions in influencing size and age at return has not been well studied.

Freshwater rearing

There has been very little research conducted on freshwater rearing of Chinook salmon in the Kuskokwim River. In the neighboring Yukon River, it has been reported that juvenile Chinook salmon may move considerable distances (>500 km) downstream from where they were spawned to seek rearing habitats during their year in fresh water (Daum and Flannery 2011). There is currently little development along the Kuskokwim River that might adversely impact Chinook salmon rearing. Freshwater growth may affect early marine survival, however, as smaller smolts are likely to experience increased predation early in their marine life (Ruggerone et al. 2009).

Socio-economic factors

Western Alaska is a cash poor region, and the cost of living is high. After adjusting for cost of living differences, per capita income of rural villages is ~1/5 of that in Alaska's 'urban' regions such as Anchorage and Fairbanks, and about 1/3 of that in Bethel, the commercial center of western Alaska (Wolfe and Spaeder 2009). Given this disparity in cash income, subsistence hunting and fishing plays a large role in sustaining populations in the region. Sharing subsistence harvest is an important component of community life; this allows people who are unable to hunt or fish themselves to still have wild food.

Subsistence activities and transportation now depend on gasoline for boats and snow machines, so cash is now necessary to conduct subsistence (Howe and Martin 2009). However, full-time employment also restricts subsistence activities, which can lead to economic and social difficulties. Rates of suicide and alcoholism tend to be higher in rural villages compared to state-wide averages (Hull-Jilly and Casto 2011).

Outside of Bethel, a great majority (> 80%) of residents identify as Alaska Native. The Kuskokwim River crosses lands historically occupied by members of both Athabaskan and Yup'ik linguistic groups (Langdon 2002).

Escapement-based management

The state of Alaska has a Sustainable Salmon Fisheries Policy (5 ACC 39.222) mandating that the state manage its salmon resources for 'maximum sustainable yield', whereby harvest should occur at a rate that maximizes benefits to fishermen but does not reduce productivity (number of returning adults per number spawning adults) of the spawning stock. The policy also calls for the setting of 'escapement goals', which are the number of returning salmon that managers must let escape the fishery and return to their natal river for spawning. Alaska also has a Policy for Statewide Salmon Goals (5 ACC 39.223) defining various kinds of escapement goals. The most developed of these goals are 'Biological Escapement Goals', which are established when ADF&G can reliably estimate the number of fish escaping, as well as the total number of returning adults ('recruits'), which include both escapement as well as those adults taken in harvest. These escapement goals require considerable data on spawner-recruit relationships over a wide range of spawner stock sizes; such data are hard to come by in large riverine systems such as the Kuskokwim River. In more data-limited situations, managers can define Sustainable Escapement Goals (SEGs) and Sustainable Escapement Thresholds (SETs), which are derived from estimates of the number of spawners required to keep the population sustaining for 5-10 years, or from becoming jeopardized, respectively.

Although the chum salmon commercial fishery on the Kuskokwim River has been subject to closures due to chum and Chinook salmon escapement concerns (Hamazaki 2008), restrictions on the subsistence fishery have been very minimal, and there are no subsistence catch limits (Hamazaki 2008, Howe and Martin 2009). Managers have tried to influence the number of fish available to upriver fishermen and upriver spawning habitats by regulating the subsistence fishing schedule on the lower river; this had minimal effect as people merely adjusted their effort within the modified schedule (Hamazaki 2008). Downriver fishermen prefer to fish early in the season, as it increases the proportion of their catch that is the desired Chinook salmon rather than other species, and it increases their chances of catching upriver-migrating Chinook salmon, which are desired due to their high oil content (Hamazaki 2008); this makes managing for escapement to upriver spawning areas challenging.

Marine survival

Very little is known about marine survival of Kuskokwim Chinook salmon populations. Recent statewide declines in Chinook salmon have suggested that common ocean conditions play an important role, but how regional climate change might be affecting incubation and freshwater rearing is not well understood either. The 'critical size/critical period hypothesis' (Beamish and Mahnken 2001) is paradigmatic in the field of salmon ocean ecology. It posits that mortality is greatest for salmon at sea during two phases of their marine life: 1) early weeks just after entry into seawater, and 2) going into their first winter at sea. Both periods of high mortality are size dependent, with larger individuals less susceptible to predation during the first period, and starvation during the second. Recent work on Chinook salmon from the San Francisco estuary supports the idea that early marine mortality is size dependent (Woodson et al. 2013), suggesting that food availability and sea surface temperatures in the nearshore environment in spring and early summer might play a large role in influencing the population dynamics of Kuskokwim River Chinook salmon.

Run timing

The calendar dates when adult salmon return to the Kuskokwim River (or pass various key locations within the river) play an important role in management and stakeholder dynamics in the system. As described previously (*Escapement-based management*), lower-river fishermen often target the early migrating fish, which tend to be destined for upriver spawning areas. Salmon that migrate further upstream have higher oil content, making their flesh more desirable to consumers (Hamazaki 2008), but the perception that lower-river fishermen are targeting upriver fish can lead to conflict between stakeholders. Run timing also plays a big role in in-season management of harvest and escapement of salmon populations: if a large number of fish return to the river early, this could be indicative of a very large run, or a medium or small-sized run that is simply early. Mistaking an early run for a large run could limit a manager's ability to meet escapement goals, while the opposite could mean lost harvest opportunities (M. Adkison, University of Alaska Fairbanks, pers. comm.). Any information allowing managers to predict run timing would be very useful. Mundy and Evenson (2011) were able to predict when Yukon River Chinook salmon would enter the lower Yukon River based on sea surface and air temperatures. Such a relationship has not been developed for the Kuskokwim River, but would be useful in the face of climate change.

Bycatch

Concern over bycatch of Chinook salmon (as well as chum salmon) became acute in 2007, when the Bering Sea/Aleutian Islands pollock trawl fishery took over 121,000

Chinook salmon (Gisclair 2009). Bycatch in the pollock fishery had been increasing since 2004, coinciding with a general time of poor Chinook salmon returns in western Alaska. Genetic stock identification indicates that most of these Chinook salmon are from coastal western Alaska stocks (Guthrie et al. 2013). Skeptics of the idea that bycatch is playing a large role in declining Chinook salmon stocks point out that the pollock fleet is more likely to catch high numbers of Chinook salmon during years of high salmon abundance. They also suggest that many of these individuals were likely to die of other causes before maturing, so bycatch numbers should be translated into 'adult equivalents' before attempting to determine the role of bycatch in the population dynamics of Chinook salmon. Opinions regarding the pollock fishery are complicated by the existence of the federal Community Development Quota (CDQ) program, which allocates a percentage of the total allowable pollock catch to six nonprofit corporations in coastal western Alaska, providing an influx of money into the cash-poor region, and giving rise to the slogan (of the Kuskokwim region's CDQ group, Coastal Villages Region Fund, but often used sardonically) that "pollock provides" (Jensen 2012). NOAA spends considerable resources implementing onboard observer and genetic stock identification programs to determine how many salmon are caught in the pollock fishery, and which salmon stocks are most affected.

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12. Assessment

Student presentations will be evaluated based on the following criteria: 1) how well they covered the topic (40%); 2) clarity of oral expression (30%), and 3) clarity and usefulness of audio/visual aids (30%).

Self-assessment: students will be asked to reflect on their participation in the case study and will submit short, written answers the following questions: 1) What was your contribution to group activities? 2) How much work did you put in on the project? 3) What was your unique contribution to the project?

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