Briefing for PWSRCAC Board of Directors – September 2020

INFORMATION ITEM

Sponsor: Austin Love and the Scientific Advisory Committee

Project number and name or topic: 966 – The Recovery of a Subsistence Way of Life

1. **Description of agenda item:** This agenda item entails a summary presentation by the Alaska Department of Fish and Game – Division of Subsistence (ADF&G) about the results of a project they have conducted on behalf of the Council. The overall goal for this project was for ADF&G scientists to assess how the subsistence harvest of natural resources has changed over time in Exxon Valdez oil spill impacted communities and attempt to determine what is causing observed trends. This project did not entail the gathering of subsistence harvest data, instead it used data previously collected by ADF&G. Through this project a large amount of historic subsistence harvest data, information going back before 1989 and up until 2014, was organized and interpreted in a new way. The results have been summarized in a draft report prepared by ADF&G, which is included in this meeting packet. During their presentation, ADF&G will provide a summary of the key findings of their report and recommendations for future research that could benefit from Council support.

2. **Why is this item important to PWSRCAC:** This project is helping achieve a service mandated in the Council's contract with Alyeska. The contract states that the Council shall "Provide input into monitoring and assessing the environmental, social, and economic consequences of any oil related accidents." This project, focused on analyzing subsistence resource harvest data, is a way for the Council to monitor and assess the potential long-term social consequences of the Exxon Valdez oil spill and other factors (e.g., more pressure from recreational hunters, increased use of digital media, etc.) that may be currently affecting the collection and use of subsistence resources in the spill-affected region.

3. **Previous actions taken by the Board on this item:**

Meeting	Date	Action
Board	5/4/2017	Board approved the FY2018 budget as presented. The FY2018 budget included funding for the Subsistence Way of Life project.
Board	5/3/2018	Board approved the FY2019 budget, as amended. The FY2019 budget included funding for the Subsistence Way of Life project.

4. **Summary of policy, issues, support or opposition:** At this time only a draft report is available for Board review. However, this draft report incorporates edits and comments provided through reviews already conducted by the Scientific Advisory Committee as well as Council staff. The draft report is also currently undergoing review by Alaska Native stakeholders from the Exxon Valdez oil spill region with the goal to receive all comments and questions by September 30, 2020. With that input in hand, ADF&G will update the draft report as appropriate and a final version should be completed by November 30, 2020, for acceptance by the Council at the January 2021 Board meeting.

ADF&G is presenting the draft report now, as some of their key staff for this project are unable to make the January 2021 Board meeting because of other work priorities. This will allow Board members the opportunity to ask questions of ADF&G staff or

provide other input directly to them. Council staff also do not anticipate significant changes between this draft and the final version of the report. If significant changes are made to the final report, they will be presented to the Board by Council staff during the January 2021 Board meeting when acceptance of the final report will be requested.

5. **Committee Recommendation:** None at this time.

6. **Relationship to LRP and Budget:** Project 966 – Subsistence Way of Life was funded by the Council in FY2018 and FY2019 in the total approximate amount of $55,000.

7. **Action Requested of the Board of Directors:** None, this is an informational item only.

8. **Alternatives:** Not applicable.

9. **Attachments:** Draft report titled "Recovery of a Subsistence Way of Life: Assessments of Resource Harvests in Cordova, Chenega, Tatitlek, Port Graham, and Nanwalek, Alaska since the Exxon Valdez Oil Spill" by Jacqueline M. Keating, David Koster, and James M. Van Lanen of ADF&G.

Technical Paper No. 471

Recovery of a Subsistence Way of Life: Assessments of Resource Harvests in Cordova, Chenega, Tatitlek, Port Graham, and Nanwalek, Alaska since the *Exxon Valdez* Oil Spill—FINAL DRAFT

by
Jacqueline M. Keating
David Koster
and
James M. Van Lanen

August 2020

Alaska Department of Fish and Game

Division of Subsistence

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in Division of Subsistence reports. All others, including deviations from definitions listed below, are noted in the text at first mention, in the titles or footnotes of tables, and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols

alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly-accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly-accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures)	first three letters (Jan,...,Dec)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. states	two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance:	
population	Var
sample	var

TECHNICAL PAPER NO. 471

RECOVERY OF A SUBSISTENCE WAY OF LIFE: ASSESSMENTS OF RESOURCE HARVESTS IN CORDOVA, CHENEGA, TATITLEK, PORT GRAHAM, AND NANWALEK, ALASKA SINCE THE *EXXON VALDEZ* OIL SPILL—FINAL DRAFT

by
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The Division of Subsistence Technical Paper Series was established in 1979 and represents the most complete collection of information about customary and traditional uses of fish and wildlife resources in Alaska. The papers cover all regions of the state. Some papers were written in response to specific fish and game management issues. Others provide detailed, basic information on the subsistence uses of particular communities which pertain to a large number of scientific and policy questions.

Technical Paper series reports are available through the Alaska Resources Library and Information Services (ARLIS), the Alaska State Library, and on the Internet: http://www.adfg.alaska.gov/sf/publications/. This publication has undergone editorial and professional review.

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ABSTRACT

This project used household-level survey data to examine the economic, social, and cultural factors that have shaped subsistence harvest trends in communities affected by the 1989 *Exxon Valdez* oil spill (EVOS). The Division of Subsistence of the Alaska Department of Fish and Game has collected over four decades of subsistence harvest data in the coastal communities of Cordova, Chenega, Tatitlek, Nanwalek, and Port Graham. A household-level database was developed to include responses to all available survey questions, resulting in a total of 40 community-year records, over 2,100 household records, over 6,500 person records, over 24,000 income records, and over 1 million harvest detail records. Qualitative data in the form of survey responses and key informant interviews were also analyzed to assess changes and trends in subsistence resource use. These data show that harvest diversity (the number of types of resources harvested) had rebounded from low levels in the years directly following the spill, but there was an especially sharp drop in resource diversity between 2003 and 2014 that unexpectedly approached levels of the year of the oil spill. Additionally, the concentration of wild resource production by a relatively small number of households has increased steadily and is especially evident for key resources like sockeye salmon, where a small percentage of households are responsible for upwards of 90% of harvests in some communities. Overall per capita resource harvest levels were also notably lower in 2014 compared to 2003, post-spill averages since 1991, and pre-spill estimates. There is no apparent evidence that these key changes are directly related to certain EVOS effects such as changes in resource abundance, contamination, or perceived food safety. Analysis of the household database found no quantitative evidence that the drop in harvest levels and diversity from 2003 to 2014 was caused by a demographic shift in which a large number of household heads reached maturity in the post-spill years when subsistence uses were low; the analysis found that before the spill, households with older heads had higher and more diverse harvests than households with younger heads, and that harvest and diversity levels of households headed by younger and older adults had declined from 2003 to 2014. Based on key respondent and household survey responses, changes in subsistence harvest and use patterns were attributed to barriers to the intergenerational transfer of traditional knowledge, the influence of digital technology, and abrupt changes in local cash economies from oil spill payments that led to a dependence on, and perhaps preference for, commercial foods for many community members. As also noted in previous research, EVOS initiated or contributed to a complex set of environmental, economic, and sociocultural conditions which continue to shape subsistence harvests and uses in the study communities. Additional years of survey data are needed to determine if the sharp decline in resource diversity in 2014 was an anomaly, or part of a marked downward trend in subsistence resource use. Future surveys should directly address the role of digital technology in subsistence participation, specific cost barriers associated with subsistence participation, the role of commercial fishing in terms of equipment ownership and the ability to maintain equipment, and the role of overall trends in commercial fishing participation in subsistence harvest activities.

Key words: subsistence, way of life, *Exxon Valdez*, oil spill, EVOS, wild resources, sockeye salmon, household harvest, Cordova, Chenega, Tatitlek, Nanwalek, Port Graham

1. INTRODUCTION

Project Background

This project uses household-level data to examine the economic, social, and cultural contributions to subsistence harvest trends in communities affected by the 1989 *Exxon Valdez* oil spill (EVOS). EVOS severely altered the subsistence way of life in the coastal communities of Cordova, Chenega (formerly Chenga Bay), Tatitlek, Nanwalek, and Port Graham (Fall 1999). Following the spill in March of 1989, subsistence harvest levels dropped substantially compared to pre-spill years (Figure 1-1) (Fall and Zimpelman 2016). Although the range of resources used rebounded close to pre-spill averages within three to five years, harvest estimates for the most recent study year (2014) were notably lower for both resource volume and diversity across all five communities compared to pre-spill and post-spill averages (Figure 1-2). There is no singular explanation for these unexpectedly large declines, which warrants the exploration of multiple social and economic factors.

It is increasingly difficult to isolate EVOS effects from the concurrent sociocultural and socioeconomic changes that influence trends in subsistence use (Fall 2006:377–397; Fall and Zimpelman 2016:284–335). Surveys conducted by Alaska Department of Fish and Game (ADF&G) Division of Subsistence since 1990 have assessed whether and to what degree the traditional way of life was affected by EVOS. Results from surveys in 1999 (80%), 2003 (77%), and 2014 (80%) all found that a majority of the residents surveyed in Prince William Sound communities believed that their traditional ways of life had been affected (Fall 1999; 2006; Jones and Kostick 2016). Ongoing effects of EVOS's cultural disruption are evident in that most 2014 survey respondents continued to believe that the traditional way of life has not recovered since the oil spill (Figure 1-3) (Fall and Zimpelman 2016; Jones and Kostick 2016). One hypothesis that was explored in this project is that the cultural disruption's effect on subsistence harvest and use patterns might become more apparent as the generation that reached adulthood after the oil spill become a larger percentage of the communities' household heads and those who learned subsistence skills and values before the spill become less active hunters and fishers.

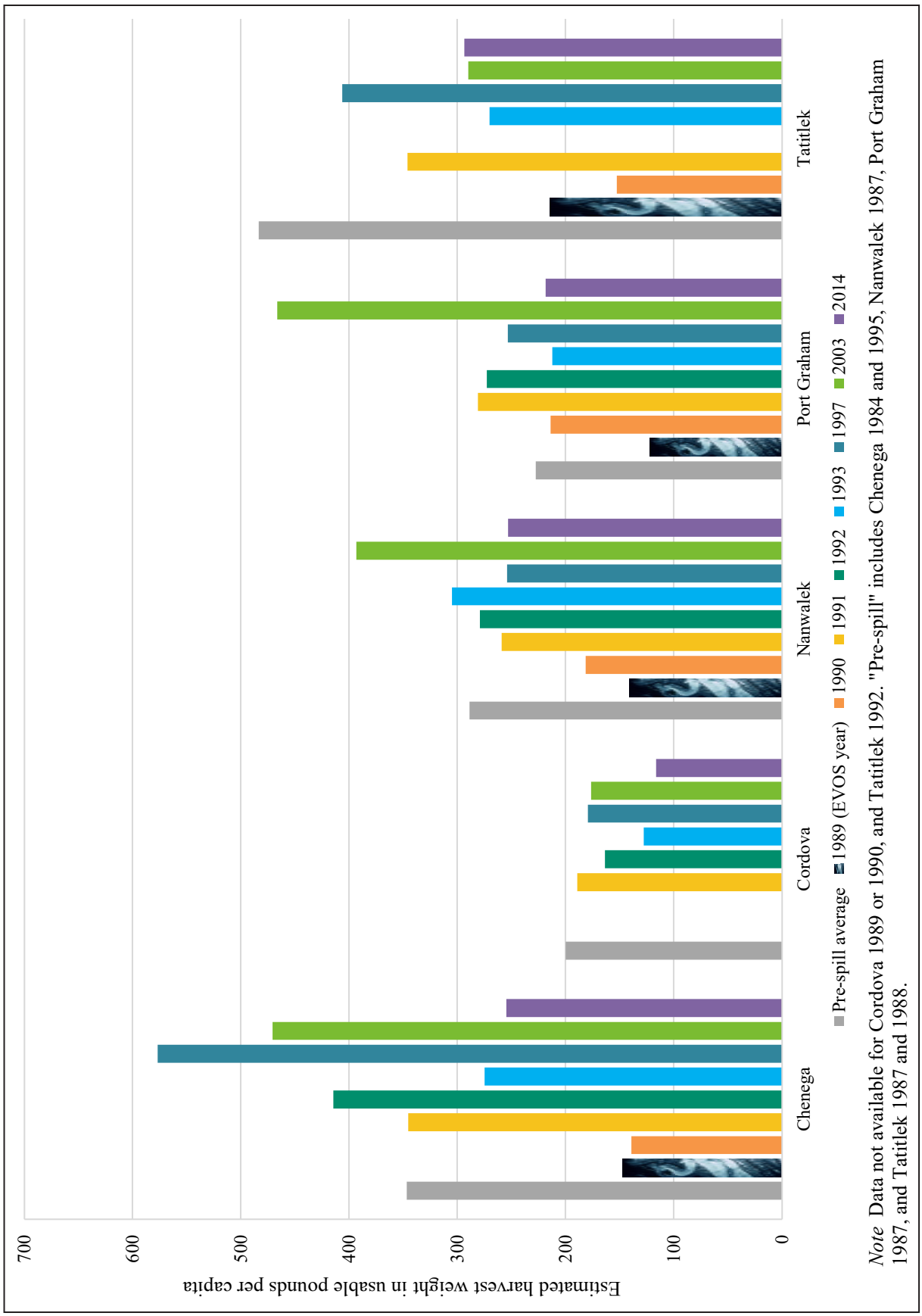
Projects assessing the status of subsistence uses in spill-area communities concluded that the lingering effects of EVOS are part of "the total environment of change" (Moerlein and Carothers 2012) for these communities (Fall and Zimpelman 2016:1–2, 334–335). This project combines household-level data analysis and qualitative data analysis to understand patterns and trends in subsistence resource use and harvest in EVOS communities across eight study years. Patterns are addressed through time to discern how long-term trends in factors like resource population status, community demographics, household composition, cash incomes, commercial fishing involvement, and other personal and cultural factors affect harvest levels and diversity, participation rates, and resource sharing. In combination, the study will provide an overview of "the total environment of change" facing the five study communities as a context for evaluating recovery and change since EVOS.

Study Objectives

The overall goal of this project was to contribute to the understanding of the economic, social, and cultural changes that have taken place in communities in the area affected by EVOS from the perspective of local communities. Enhancing this understanding will assist with planning for and responding to potential future oil spills and other environmental and technological disasters in Alaska.

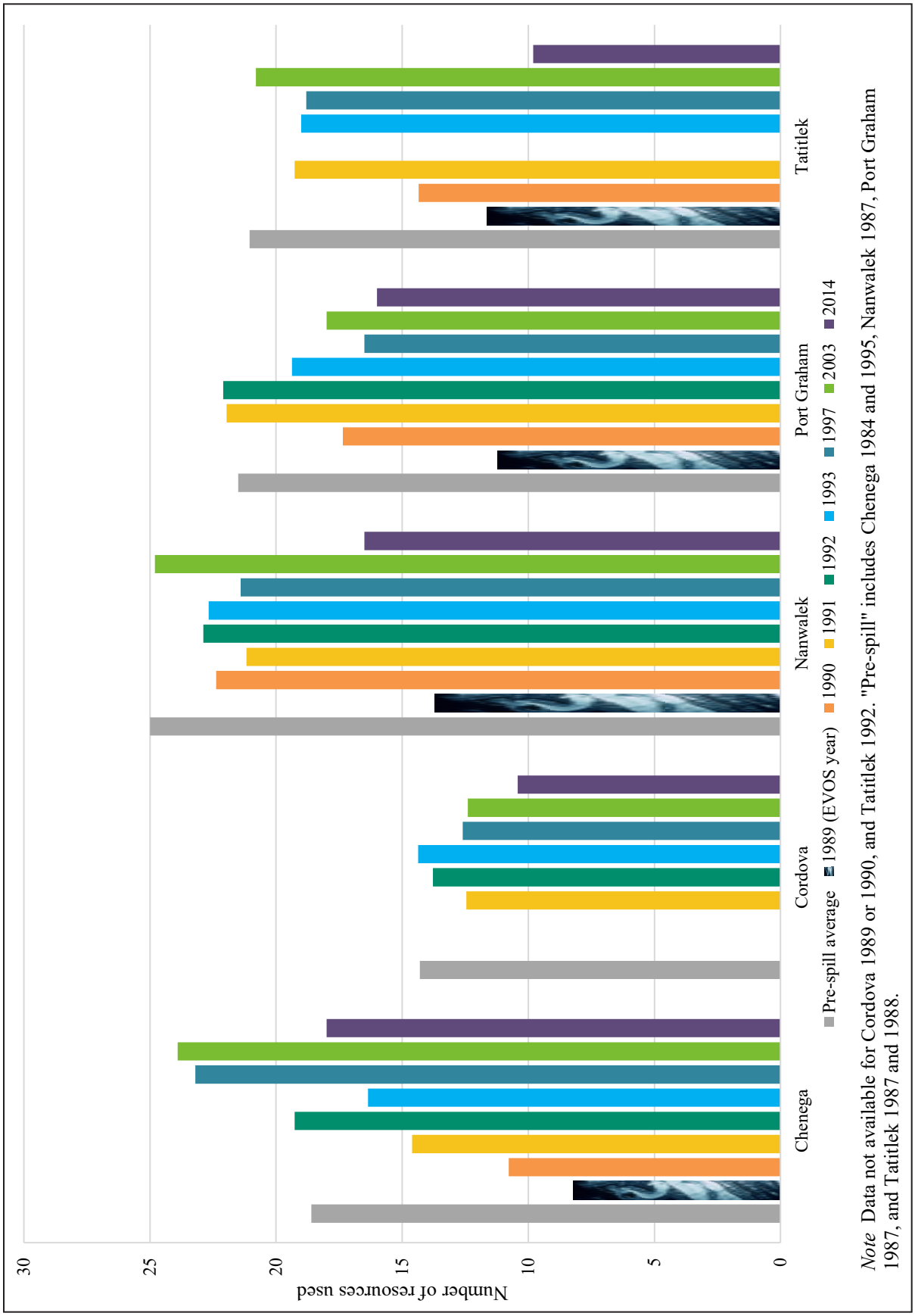
The project has the following objectives:

1. Prepare a household-level database, which includes responses to all available survey questions, including assessment questions, for each household in the five study communities of Chenega, Cordova, Nanwalek, Port Graham, and Tatitlek (discussed in Chapters 1 and 4).
2. Classify households in the dataset by type (Chapter 2).



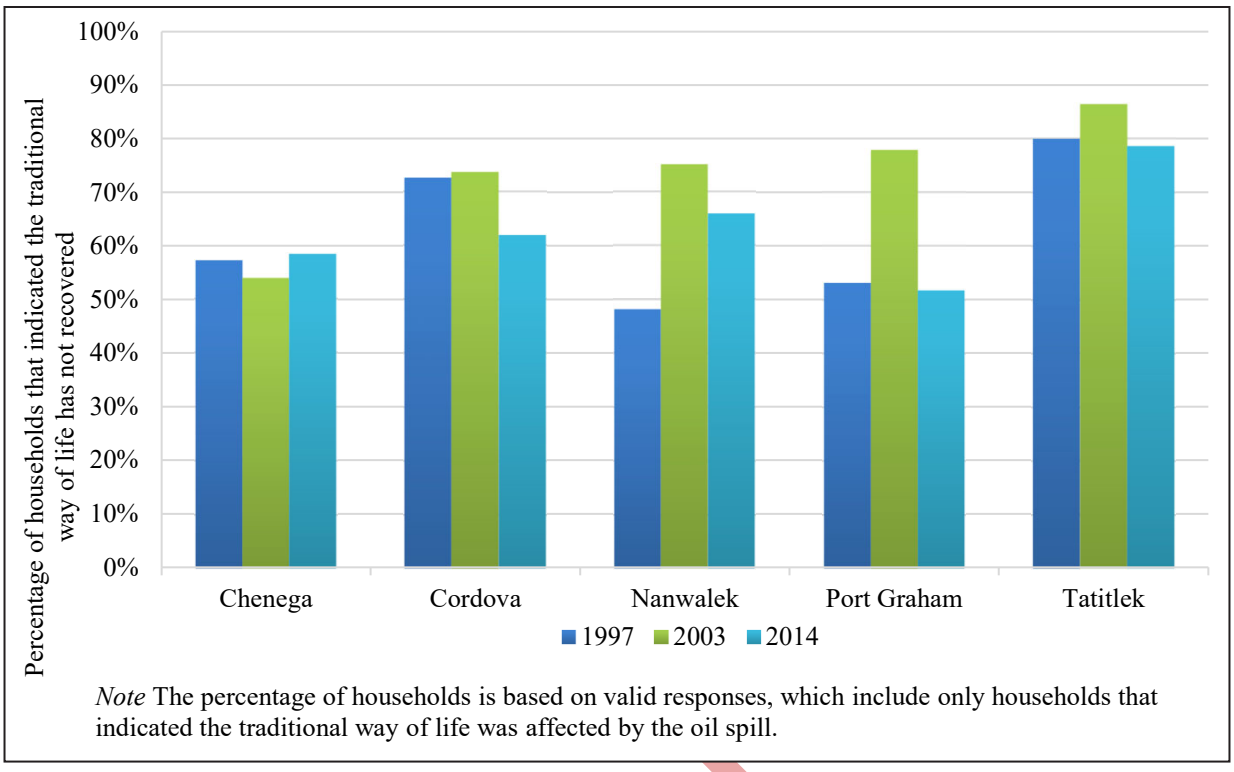
Note Data not available for Cordova 1989 or 1990, and Tatitlek 1992. "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 1-1.–Estimated harvests, pounds usable weight per person, Chenega, Cordova, Nanwalek, Port Graham, and Tatitlek, 1984–2014.



Note Data not available for Cordova 1989 or 1990, and Tatitlek 1992. "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 1-2.–Average number of resources used per household, Chenega, Cordova, Nanwalek, Port Graham, and Tatitlek, 1984–2014.



Note The percentage of households is based on valid responses, which include only households that indicated the traditional way of life was affected by the oil spill.

Figure 1-3.–Household assessments that the traditional way of life has not recovered from the effects of EVOS, study communities, 1997, 2003, and 2014.

3. Conduct an analysis to identify characteristics of productive and non-productive households, including associations with household size, household type (developmental cycle), ethnicity, involvement in commercial fishing, employment characteristics, earned cash income, other cash income, and other potential factors; and assess reasons for changes in harvests (Chapter 2).
4. For Cordova, compare and contrast resource harvest and use patterns of Alaska Native households and other households, including changes in characteristics over time (Chapter 2).
5. Conduct an analysis of changes and potential causes of changes and trends in resource harvests, including potential links to lingering EVOS effects (Chapters 2 and 3).
6. Identify hypotheses and conclusions in relevant ethnographic literature and other survey research alongside Division of Subsistence quantitative data (Chapters 1 and 3).
7. Prepare a technical paper with a detailed summary of study findings.

Community Backgrounds

Chenega, Tatitlek, and Cordova are located in Prince William Sound and are only accessible by boat or plane travel (Figure 1-4). The area has been traditionally inhabited by the Alutiiq in Prince William Sound and the Eyak of the Copper River Delta. Chenega (population of 61 in 2019) is on Evans Island in Crab Bay, approximately 42 miles southeast of the road-connected community of Whittier and 104 air miles southeast of Anchorage. The village was relocated from Chenega Island 20 years after the 1964 earthquake and tsunami. Many Chenega residents visit Anchorage regularly to obtain food supplies and other goods. Further information about the community's history is available in Stratton and Chisum (1986). Tatitlek (population 98 in 2019) is located in northern Prince William Sound, approximately 30 miles from Valdez,

where it borders the Chugach National Forest and an impassable area of the Chugach Mountains. The community Indian Reorganization Act (IRA) council provides governance and services to the community including maintenance of the water, sewer, solid waste, and electrical systems (Fall 2006).

Cordova (population 2,343 in 2019) was founded in 1906 to accommodate railway service for the copper mining industry and consisted of several traditional villages on Eyak lands. The population swelled in the 1970s and 1980s due to construction of the trans-Alaska pipeline and stable commercial fishing industry (for more information on the commercial fishery in Cordova, see: Fall 2006, Janson 1975, and Seitz and Fall 1995). Commercial fishing continues to be a significant part of life for Cordova residents. Population estimates produced by the ADF&G Division of Subsistence in 2014 found the population to be 16% Alaska Native and 84% non-Native (Fall and Zimpelman 2016).

Port Graham and Nanwalek are in the southeastern portion of the Lower Cook Inlet fisheries management area and are also only accessible by boat or small plane (Figure 1-5). The Kachemak Bay region was likely occupied around 10,000 years ago by the Ocean Bay II Tradition maritime culture (Csoba DeHass 2012; Stanek 2000). The Alutiiq, or Suqpiaq, ancestors of today's Nanwalek residents (population 208 in 2019) occupied the Gulf of Alaska and Lower Cook Inlet for hundreds of years prior to contact with explorers from England and Spain, and Russian fur traders (Workman and Workman 1988).[1] In Port Graham (population 180 in 2019), Alaska Native residents exclusively refer to themselves as Sugpiaq to be acknowledged as an independent Alaska Native group (Csoba DeHass 2007; 2009; 2012). For more background on Port Graham and Nanwalek, see Stanek (2000).

For the purpose of this project, Chenega, Tatitlek, Port Graham, and Nanwalek are examined together due to their small size, similar harvest patterns, and dependence on similar resources. The estimated population for the four communities combined has generally increased over time, reaching approximately 600 people by 2014 (Figure 1-6). Population estimates produced by ADF&G tend to be lower because of criteria used to identify year-round, permanent residents, which facilitates a more accurate estimate of resources harvested throughout the year in a community. The U.S. Census counts all people living in a household on April 1 of the census year, and the Alaska Department of Labor develops estimates based on Alaska permanent fund dividend applications and the decennial U.S. Census data. Therefore, seasonal residents that are reflected in U.S. Census and Alaska Department of Labor estimates are not included in ADF&G population estimates. The average age of household heads across study years, spanning 1984 to 2014, has remained generally consistent (Figure 1-7).

Regulatory Context

Cordova, Chenega, and Tatitlek are within the Prince William Sound fisheries management area while Nanwalek and Port Graham are in the Cook Inlet fisheries management area. State and federal regulations provide subsistence fishing opportunities for all five communities. Subsistence fishing for salmon, Tanner crab, and shrimp requires a permit from ADF&G. Residents of the five communities are also eligible for participation in the federally managed subsistence Pacific halibut fishery after obtaining a Subsistence Halibut Registration Certificate (SHARC).

State and federal regulations provide hunting opportunities under subsistence or general hunting regulations in Game Management Unit 6 (Cordova, Chenega, and Tatitlek) and Unit 15C (Port Graham and Nanwalek) for moose, mountain goat, deer, black bear, and small game (the predominately-used species in these communities). Residents of the study area communities are also eligible to participate in spring and summer subsistence hunting for migratory waterfowl and collection of eggs under the revised federal Migratory Bird Treaty Act. Alaska Native residents of the study communities may hunt marine mammals for subsistence uses under the provisions of the federal Marine Mammal Protection Act.

1. Walter Meganack, Sr., Elder and Chief, Port Graham, Alaska, 1982, personal communication.

Literature Review

Concentration of Wild Food Production and Patterns of Distribution

When assessing trends in subsistence for communities affected by EVOS, it is helpful to understand the broader factors that are generally associated with productive households in subsistence communities across Alaska. There has been a consistent demonstration of concentrated harvest production among a small percentage of households that share wild resources with the broader community. The seminal study on this pattern (Wolfe 1987) found that approximately 30% of households in Alaska Native communities produced approximately 70% of subsistence foods, which were widely shared within the community. Wolfe et al. (2010) repeated this analysis with data from 3,339 households in 67 rural communities and confirmed the initial pattern: the top 30% of harvesting households produced over 70% of the total harvest. These and other studies provide helpful insights for household characteristics associated with high productivity. The analysis of household-level data in this project was modeled in part on the analysis summarized in Wolfe et al. (2010).

Characteristics of Productive Households

"Super-households" (the top 30% of producers) tended to be mature, with multiple middle-aged adults and higher cash incomes than other households in their communities (Wolfe 1987). This was reaffirmed in 2010, where high-producing households tended to include multiple adult males and higher income as well as participation in commercial fishing, while lower subsistence production was associated with presence of female-headed households, elderly household heads, and lower cash incomes (Wolfe et al. 2010). Other studies have made similar findings on the relationship between high-producing households and economic factors. In an examination of demographic, economic, and harvest data for 98 communities, Wolfe and Walker (1987) found relationships between harvest levels and economic factors (cash income), demographic factors (percent Alaska Native), and community location. Magdanz et al. (2016) updated the Wolfe and Walker analysis with 179 study communities and developed a regression model that found similar associations between harvest levels, cash incomes, demography, and community location.

While these factors remain prevalent across studies, Wolfe et al. (2010:28) also discovered that household composition (number of adults contributing to harvest) only accounted for about 37% of the variation in household harvests and concluded that other factors, including individual skill levels, knowledge, and personal motivations, need to be considered to fully understand overall trends in subsistence resource use and harvest.

Understanding characteristics of high-producing households is especially important because super-households are significant providers for other community members. Baggio et al. (2016) used data from three northern Alaska communities (Venetie, Wainwright, and Kaktovik) to examine relationships between households based on subsistence harvests and distribution networks. The study concluded that "the loss of important social relations or the loss of key households has greater effects on community interconnectedness than the loss of core subsistence species" (Baggio et al. 2016:2). In other words, social relationships are key to subsistence community health and resilience. These social relationships appear to be equally crucial for communities affected by EVOS, especially in the years immediately following the spill. A pre-spill and post-spill household-level analysis of subsistence harvests in Chenega, Nanwalek, Port Graham, and Tatitlek found the general pattern of food distribution between higher and lower producing households remained consistent despite changes in the level and diversity of harvests (Fall et al. 2001). In comparing pre-spill data to data from 1989 through 1993, it was clear that while EVOS had the greatest effect on the highest producing households, those households continued to provide food for lower producers:

> While the spill created major local disruptions of food procurement and employment patterns, the spill did not transform the pattern of relationships in the subsistence sector. The traditional extended kinship networks adapted to the short-term crisis of food production and distribution at the local level without major dislocations in the underlying structure of production and distribution (Fall et al. 2001:287).

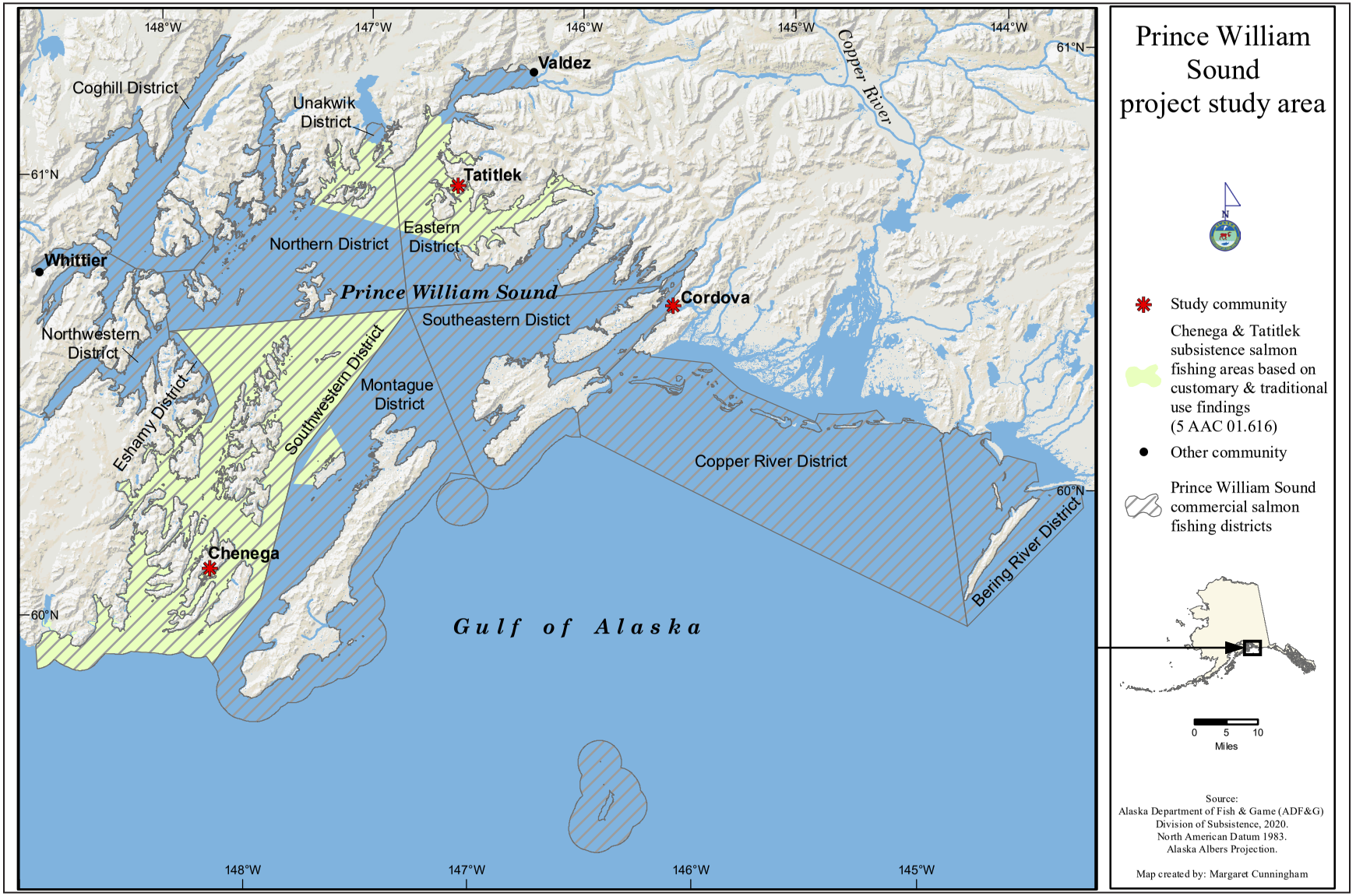


Figure 1-4.–Prince William Sound project study area and Prince William Sound Management Area fishing districts.

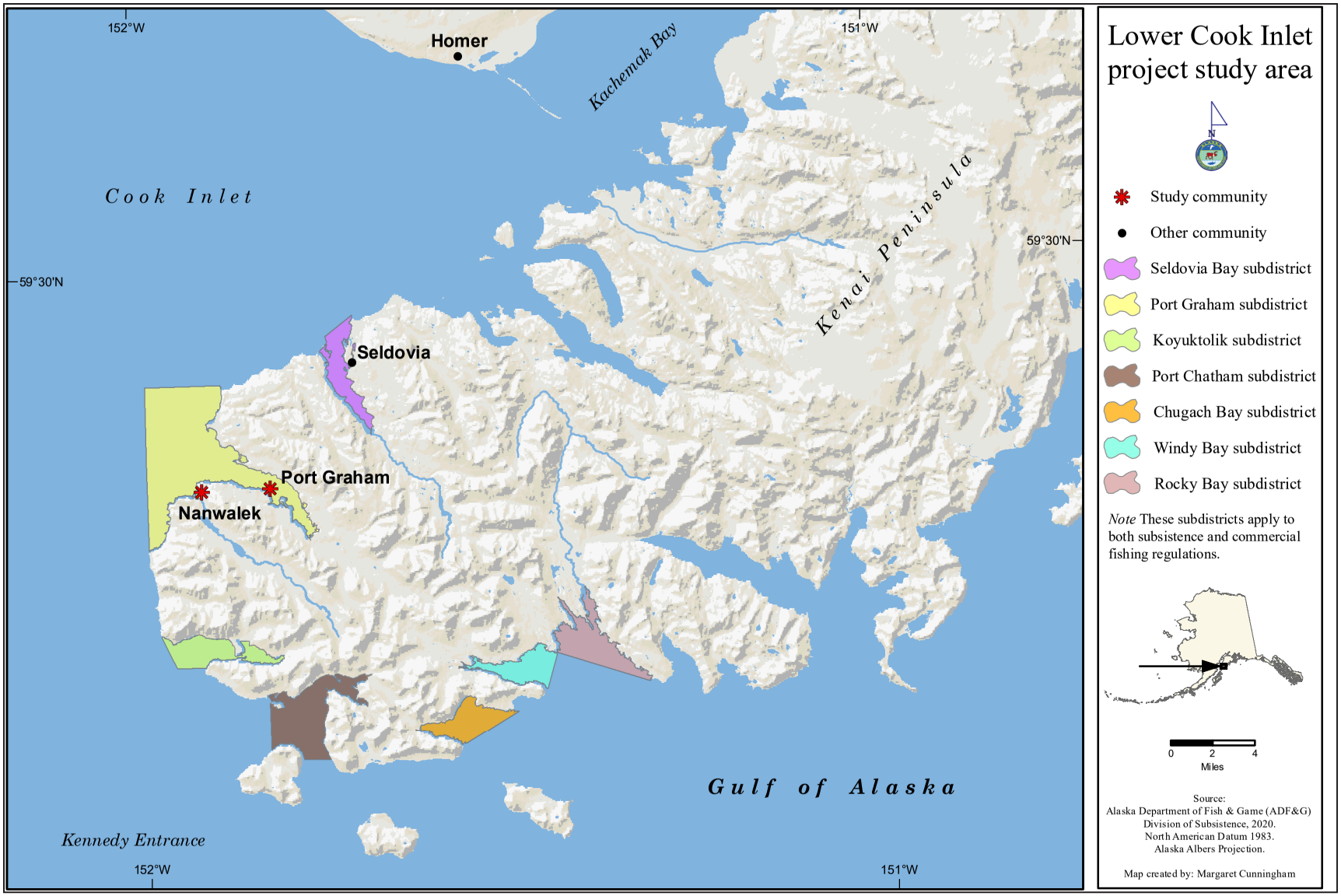
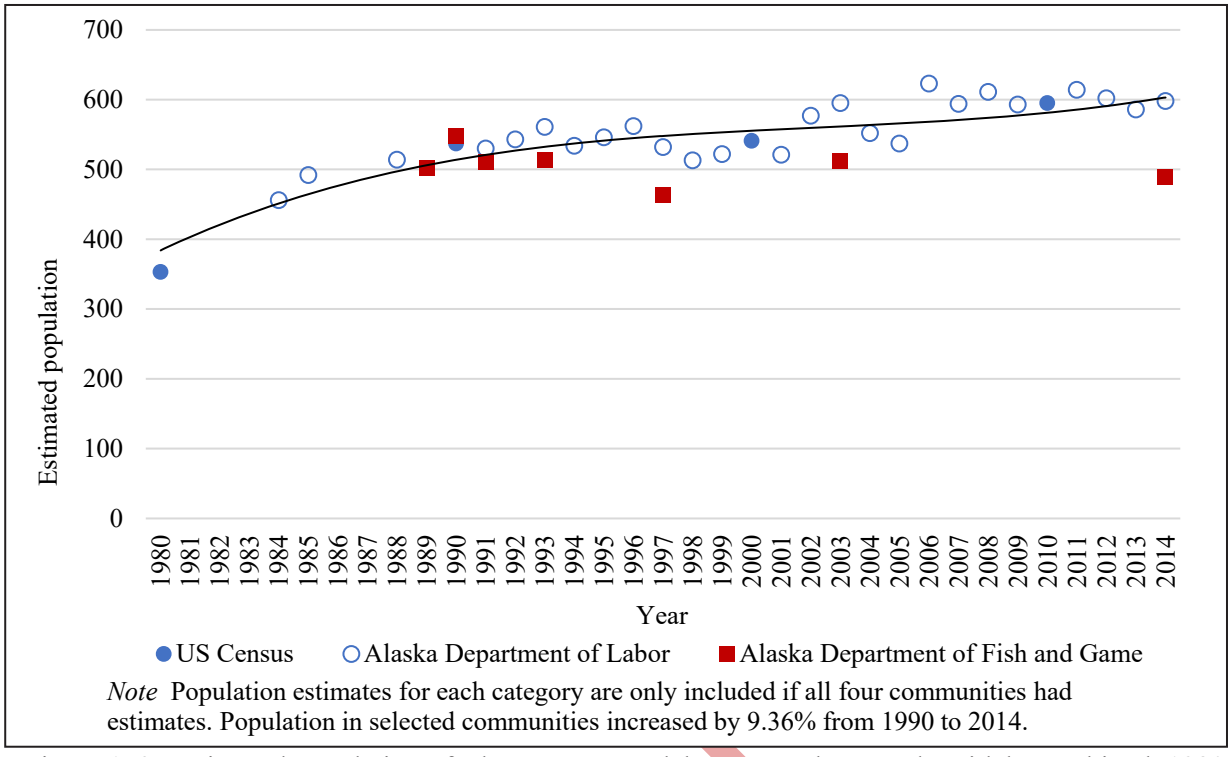
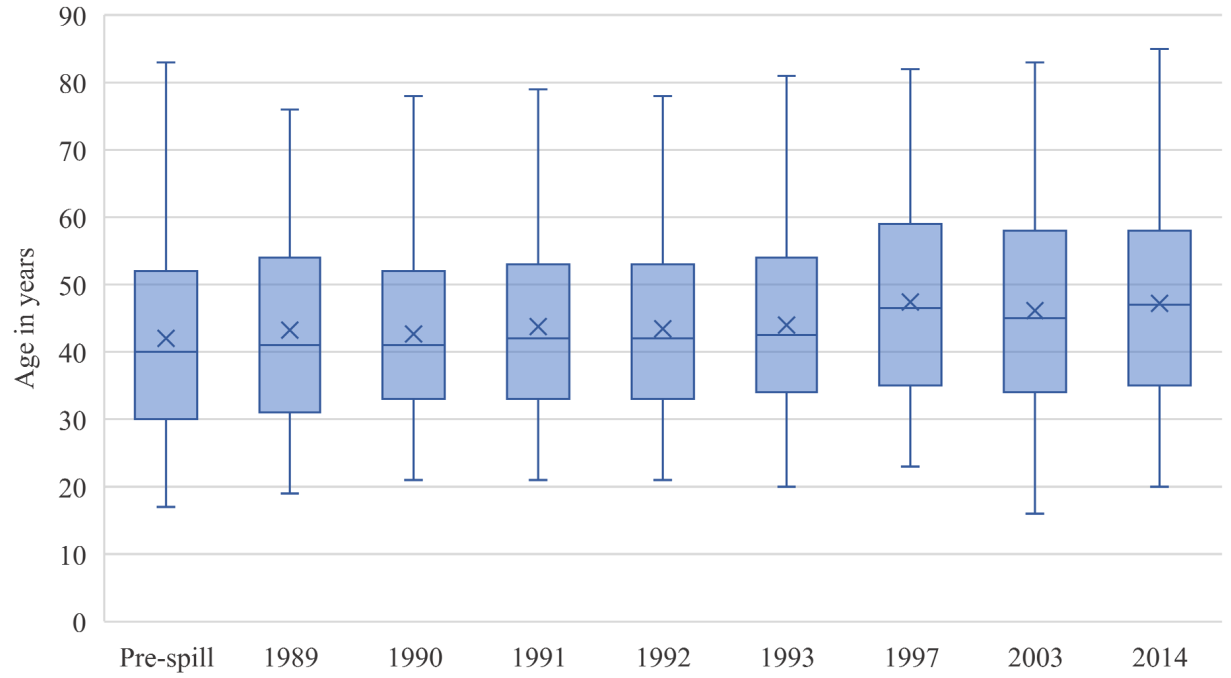


Figure 1-5.–Lower Cook Inlet project area and Lower Cook Inlet Management Area fishing subdistricts.



Note Population estimates for each category are only included if all four communities had estimates. Population in selected communities increased by 9.36% from 1990 to 2014.

Figure 1-6.–Estimated population of Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1980–2014.



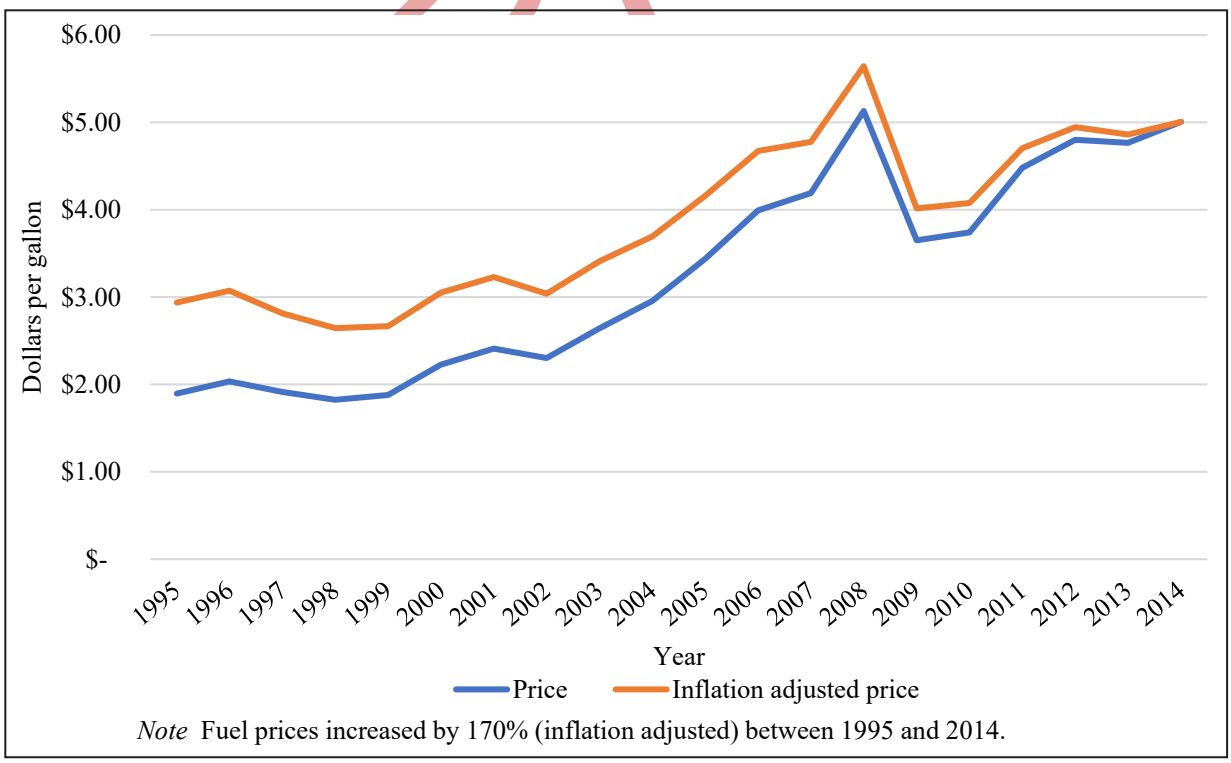
Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and

Figure 1-7.–Age of household heads, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1980–2014.

This is consistent with the relationships discussed by Baggio et al. (2016) and suggests that household characteristics, in addition to community-level patterns and the status of natural resource populations, are a key to understanding short and long-term changes in rural Alaska subsistence-based communities and ways of life. In other words, "kinship-based domestic groups appear central to subsistence food production and distribution" (Wolfe et al. 2010:1).

Evolving dependence on the cash economy is potentially an underlying cause of the documented changes in subsistence patterns in Alaska (Fall 2016). Alaska subsistence hunters, fishers, and gatherers have become almost wholly dependent on motorized technology (motorboats, snow machines, and ATVs) to participate in subsistence activities (Van Lanen 2018). Adapting to a mixed cash-subsistence type economic system presents a double-edged sword with significant benefits regarding food security, energy security, access to health care, education, and communication (BurnSilver et al. 2016; Kofinas et al. 2016; Kruse 1991; Langdon 1991; Wolfe 1986) but significant costs to traditions of self-reliance and related social well-being (Dombrowski 2014; Van Lanen 2018). Overall, the affordability of motorized transportation, gasoline, and upkeep is an evolving constraint for many rural subsistence households in Alaska (Brinkman et al. 2014; Van Lanen et al. 2018), especially with the rising cost of gas (Figure 1-8). Perhaps as a result, some households may leave traditional subsistence practices for various types of cash-based employment, which represents a substantial change from traditional structures where most households participated in the production, distribution, and consumption of subsistence foods (Wolfe et al. 2010).

EVOS-affected communities are no exception to these trends. Much of the commentary provided by community participants in EVOS studies over the last two decades suggests that involvement with the cash economy over the long-range may be detrimental to the maintenance of many longstanding aspects of traditional hunting, fishing, and gathering within subsistence socio-cultural systems. Additionally, EVOS made it more difficult to earn a profit in the commercial salmon fishery with the drastic drop in the price of salmon. At Nanwalek and Port Graham, by the time an enhancement project began restoration of sockeye salmon in the late-1990s, many fishermen had already divested themselves of their commercial interests (Stanek 1995). Other causes cited by local respondents for the decline in subsistence participation in Nanwalek and Port Graham include declines in elder influence and the expanding use of digital technology



Note Fuel prices increased by 170% (inflation adjusted) between 1995 and 2014.

Figure 1-8.–Price of a gallon of gasoline in Cordova, 1995–2014.

(Fall 2006). A recent study occurring in the neighboring Bristol Bay region also found that adoption of digital technology by younger generations was consistently cited as a significant cause of decline in both subsistence activities and wild food sharing (Hutchinson-Scarbrough et al. 2020). Resource abundance, changes in economic circumstances, costs of fuel and equipment, demographic change, and cultural change may all contribute to changing trends in subsistence resource harvest and use. The interplay of these social and economic factors requires further investigation for EVOS-affected communities.

Research Questions

Based on the trends and causes identified in the literature, the project addressed the following research questions:

1. How is total harvest concentrated among key harvesting households ("superhouseholds") in EVOS communities and has this concentration changed over time?
2. What are the characteristics of productive households and have they changed over time?
3. What is the role of commercial fishing in subsistence production and has it changed over time?
4. What are the ecological, economic, social, and cultural factors associated with the changes and trends (less resource harvest, less resource diversity, less sharing) documented in subsistence production? Specifically:
    a. Was use of certain resources in past surveys linked to the presence of an elder in a household? As an age cohort passes away, does use of certain resources, or general diversity, decline in these communities?
    b. What is the role of perceived changes in resource abundance and quality related to EVOS?
    c. Is loss of resource diversity linked to EVOS disrupting the transmission of skills and values from elders to youth?
    d. How has the cash economy affected subsistence activities?
    e. How has digital technology influenced EVOS community subsistence cultures?
5. What questions need to be further explored to adequately plan for and respond to potential future oil spills and other disasters in Alaska subsistence communities?

Research Methods

Ethical Principles for the Conduct of Research

The project was guided by the research principles outlined in the Alaska Federation of Natives Guidelines for Research[2] and by the National Science Foundation, Office of Polar Programs in its Principles for the Conduct of Research in the Arctic,[3] the Ethical Principles for the Conduct of Research in the North (Association of Canadian Universities for Northern Studies 2018), as well as the Alaska confidentiality statute (AS 16.05.815). These principles stress community approval of research designs, informed consent, anonymity or confidentiality of study participants, community review of draft study findings, and the provision of study findings to each study community upon completion of the research.

Project Planning and Approvals

This project was funded by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) for the purpose of contributing to the understanding of economic, social, and cultural changes in the area affected by the *Exxon Valdez* oil spill from a local community perspective. The original contract was signed

2. Alaska Federation of Natives. 2013. "Alaska Federation of Natives Guidelines for Research." Alaska Native Knowledge Network. http://www.ankn.uaf.edu/IKS/afnguide.html (accessed May 21, 2020).
3. National Science Foundation Interagency Social Science Task Force. 2012. "Principles for the Conduct of Research in the Arctic." https://www.nsf.gov/geo/opp/arctic/conduct.jsp (accessed May 21, 2020).

Table 1-1.–Project staff.

Task	Name	Organization
Project design and management	Jacqueline Keating Robin Dublin	ADF&G Division of Subsistence
Research coordination	Jim Fall	ADF&G Division of Subsistence
Project lead	Jacqueline Keating	ADF&G Division of Subsistence
Administrative and budget support	Pam Amundson	ADF&G Division of Subsistence
Data management lead	Dave Koster	ADF&G Division of Subsistence
Quantitative data analysis	Dave Koster	ADF&G Division of Subsistence
Qualitative data collection	Amy Wiita	ADF&G Division of Subsistence
Qualitative data analysis	James Van Lanen	ADF&G Division of Subsistence
Cartography	Margaret Cunningham Gayle Neufeld	ADF&G Division of Subsistence

in August of 2018 (966.19.01) and outlined study objectives. Due to changes in staff and the significant time needed for data processing, the original contract was updated in April of 2020 (966.20.01) and outlined steps to complete the final paper by August 14, 2020. The Chugach Regional Resources Commission (CRRC) represents the Alaska Native populations of the five study communities and review of findings from previous studies in EVOS communities by the CRRC board has provided valuable insights. The principal investigators met with the executive board of the CRRC to present draft study findings and obtain comments on July 7, 2020. A draft of the final report was also reviewed by the PWSRCAC on September 18, 2020. Division staff addressed questions and incorporated feedback into the final draft (Table 1-1).

Household Dataset

The primary data source for this project is results of systematic household surveys conducted by the Division of Subsistence. Household-level datasets covering the calendar years of 1993, 1997, 2003, and 2014 were organized, coded, and stored using consistent data formats. Older datasets for the five study communities going back as far as 1984 (Table 1-2) were also utilized. To address differences in the years household surveys were conducted, study years prior to 1989 were combined to present 'pre-spill' patterns among communities and provide the most complete pre-spill picture possible. Study results at the community level are reported in the online Community Subsistence Information System (CSIS).[4]

Data collected for each participating household in a standard division survey include household composition (gender, age, ethnicity); whether the household used, attempted to harvest, harvested, received, or gave away each resource available in the study area; harvest quantities; economic information including jobs and cash income (not collected for study year 1997); and assessments of harvests and uses of wild resources compared to other years. Since the 1997 study year, additional questions have been administered in spill-area communities to assist in evaluating the EVOS Trustee Council's recovery objective for subsistence.[5] These have included: influence of elders; transmission of subsistence skills to youth; food safety; recovery of natural resources; and recovery of the subsistence way of life. Finally, questions about food security,

4. ADF&G Division of Subsistence, Community Subsistence Information System (CSIS): http://www.adfg.alaska.gov/sb/CSIS.
5. The EVOS Trustee Council (EVOSTC) has adopted the following recovery objective for subsistence: "Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at pre-spill levels. In addition, there is recognition that people must be confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be reintegrated into community life." https://evostc.state.ak.us/status-of-restoration/subsistence/

Table 1-2.–Study years for which data are available.

	Population	Study years (years for which comprehensive harvest survey and other data are available)											
	2019	1984	1985	1987	1988	1989	1990	1991	1992	1993	1997	2003	2014
Chenega	61	X	X			X	X	X	X	X	X	X	X
Cordova	2,343		X		X			X	X	X	X	X	X
Nanwalek	280			X		X	X	X	X	X	X	X	X
Port Graham	180			X		X	X	X	X	X	X	X	X
Tatitlek	98			X	X	X	X	X		X	X	X	X

Note Study findings are summarized in the Community Subsistence Information System, at http://www.adfg.alaska.gov/sb/CSIS/

modeled on those administered nationwide by the U.S. Department of Agriculture, were administered for the 2014 study year (Fall and Zimpelman 2016; Jones and Kostick 2016).

Qualitative Data

Qualitative data were obtained for each study year in the form of key respondent interviews, community data review meetings, and comments during household surveys. In addition, key respondent interviews from salmon harvest surveys in Port Graham and Nanwalek for the 2016 and 2017 harvest years were also included.[6] Division researchers consult with tribal governments, community councils, and local research assistants to identify key respondents in study communities. Key respondent interviews provide additional context for the quantitative data and provide further information on the socioeconomic and demographic trends affecting life in EVOS effected communities. Respondents were informed that their names would not be included in any reports in order to maintain anonymity.

Data Analysis and Review

Data Preparation

Prior to analysis, a search of the division's digital archives was conducted to locate pertinent household and person-level data for all of the study communities. This search turned up an assortment of data formats and file organizations. Once located, data files were converted into SPSS[7] .SAV files using a variety of tools. Each column of data across the dataset was evaluated against available documentation to ensure correct interpretation of contents. Columns of data were then translated into the division's current standardized detail-level data organization. For cases where it was not possible to translate columns, new columns were created in the household database to accommodate the information.

Analysis procedures for each year and community were reconstructed in SPSS v21. These were based on standard division methods, methods obtained from available documentation, and methods derived by evaluation of differences between reconstructed estimates and published estimates. Once a community and year of data could be successfully validated against published materials, that dataset was uploaded into the household database stored in a Microsoft SQL Server database on internal department servers.

In total, the amount of data formatted, organized, and uploaded includes 40 community-year data sets, 2,100+ household records, 6,500+ person records, 24,000+ income records, and over 1 million harvest detail records. These represent a complete record of household responses to questions for all years covered in this report.

6. Amy Wiita, Ph.D, Subsistence Resource Specialist, "Port Graham and Nanwalek Subsistence Fishery Harvest Monitoring," project completion report to the Alaska Sustainable Salmon Fund, May 2019.
7. Product names are given because they are established standards for the State of Alaska or for scientific completeness: they do not constitute product endorsement.

Chenega, Nanwalek, Port Graham, and Tatitlek

The four small communities involved in the analysis covered by this report were evaluated separately from Cordova and as a combined region. A variety of strategies were employed to examine data over time, including t-tests, ANOVA, and multi-variate regression. To account for community size and sample proportion, harvest levels were expanded prior to combining to the regional level using the formula below.

$$X_{cyi} = \frac{N_{cy}}{n_{cy}} x_{cyi}$$

Where:

X_{cyi} = Expanded harvest for household i in community c for year y

N_{cy} = Total number of households in community c for year y,

n_{cy} = Sampled households in community c for year y,

x_{cyi} = Reported harvest in community c for year y, and household i.

Cordova

Cordova was not included in the regional analysis for two key reasons. The size of Cordova relative to the other communities would overwhelm any statistical analysis or findings for all four other communities involved in the study. Second, Cordova was sampled using a variety of stratified design strategies (Table 1-3). Inconsistent sampling design used in Cordova complicated in-depth analysis and inherent biases prevented meaningful annual comparisons at the household-level. Instead, t-tests were used to compare means of Alaska Native vs. non-Native households for characteristics of interest for Cordova.

Limitations

Two of the key study years, 1997 and 2003, had limited or no information regarding income and employment. During a research planning workshop for the 1997 study, some community representatives requested that the standard detailed questions on employment and income be deleted from the survey form, primarily due to concerns about potential misapplication of the data and to reduce the length of the interviews. Division staff advocated to retain the questions because of their utility for understanding socioeconomic trends in the study communities. A compromise was reached whereby a single question asking about total household income was asked (Fall and Utermohle 1999:11). However, this income question was dropped for the 2003 study. Although the full set of employment and income questions was restored for the 2014 research, the lack of reliable income and employment data for 1997 and 2003 prevented meaningful analysis of the relationship of cash income to harvest levels for later years of this study. Specifically, we were unable to determine whether there was an apparent correlation between the declines in diversity of harvests observed between 2003 and 2014 and household income or employment type.

Variations in collection of detailed harvest and participation information over time also prevented detailed analysis on timing, gear-types, assessments, and evaluation of changes in vegetation harvests. Where possible, limitations in available detail were handled by identifying commonalities and developing comparisons on those. Questions relating to assessments, or how respondents felt about availability and their household's ability to access resources, were addressed using available qualitative information.

Table 1-3.–Sampling for Cordova comprehensive subsistence surveys 1984–2014.

Year	Sample Type	Households	
		Sampled	Total
1985	Simple random sample	206	853
1988	High harvesting households	20	365
	Low harvesting households	71	494
	Trappers	10	13
1991[a]	Simple random sample	65	818
	MMS Panel[b]	36	55
1992	MMS Panel[b,c]	41	62 (784)
1993	Simple random sample	71	905
	MMS Panel[b]	33	41
1997	Non-Eyak Tribe	101	664
	Eyak Tribal members	51	166
2003	Non-Eyak Tribe	92	735
	Eyak Tribal members	56	175
2014	Simple random sample	184	950

Sources Alaska Department of Fish and Game, Division of Subsistence, household survey database, and Seitz and Fall, 1995 for 1991–1993.

a. Individual household stratfication could not be located. All available documentation indicates analysis was conducted on a single combined strata group. Later revisions in the CSIS used 784 total households to derive expansions.

b. MMS Panel is a panel of previous participants in the MMS Social Indicators project (Fall and Utermohle 1995).

c. The goal of this survey was to sample 62 panel households identified from the previous study. Estimates were derived using an expansion to all 784 households.

2. QUANTITATIVE ANALYSIS OF PATTERNS AND TRENDS

This chapter analyzes household-level data for Chenega, Tatitlek, Nanwalek, Port Graham, and Cordova from eight study years to address project objectives 2–5: (2) classify households in the EVOS community dataset by type; (3) conduct an analysis to identify characteristics of productive and non-productive households; (4) for Cordova, compare and contrast resource harvest and use patterns of Alaska Native households and other households; and (5) conduct an analysis of changes and potential causes of changes and trends in resource harvests, including potential links to lingering EVOS effects.

Concentration of Production

Specialization

This section begins to address project objective 2: Classify households in the dataset by type. This was first done through identifying households in the low, middle, and high thirds of producers. The next section explores household types further by looking at household composition and the relationship to household productivity. Examining household productivity by thirds in Chenega, Nanwalek, Port Graham, and Tatitlek revealed consistency with specialization patterns seen across rural Alaska communities, where the top third of harvesting households produce about 70% of a community's total harvest (Wolfe et al. 2010). Table 2-1 shows that the percentage of households harvesting roughly 70% of resources was roughly 30% for all communities in most years, other than the EVOS year (1989). This pattern changed in 2003 and 2014 when the percentage of households harvesting 70% of resources decreased to 24.5% and 22.3%. This suggests additional effort and successful harvests by fewer households, and decreased effort and harvests by the majority of households. This is also evident in Figure 2-1, which presents patterns of production for households in all four communities between 1984 and 2014. With lighter colored symbols representing older study years and darker symbols representing more recent years, the scatter distribution shows a slight increase in resource specialization by 2014, with a smaller percentage of households responsible for a larger percentage of the total harvest. Table 2-2 displays the Gini coefficients, which are used to gauge inequality in an economic system. A higher Gini indicates increased inequality. In this study, Gini coefficients were applied to total pounds of harvest by each household. This provides a single metric to evaluate specialization. While the overall regional Ginis do not indicate an increase in specialization over time, individual communities do appear to have increasing inequality in household harvests. This indicates that specialization in these communities is increasing.

It is helpful to examine each third of producing households to observe changes in production over time. Figure 2-2 and Table 2-3 display the percentage of total wild food harvest by thirds of producing households for Chenega, Nanwalek, Port Graham, and Tatitlek combined (for production by thirds for each community, see Appendix A). The contribution of the total harvest by the low third ranges between 1.3% and 5.5% of the total harvest. The middle third's contribution ranges from 17.8% to 24.0%. In contrast, contribution to the total harvest by the high third of harvesting households ranges from 70.9% to 83.9%, with a steady increase beginning in 1992. It is important to note that the percent of total harvest produced by the high third in 2014 (83.9%) is notably higher than what the high third produced in pre-spill years (76.9%), and very close to the year of EVOS (83.2%).

Concentration of Harvest by Types of Wild Food

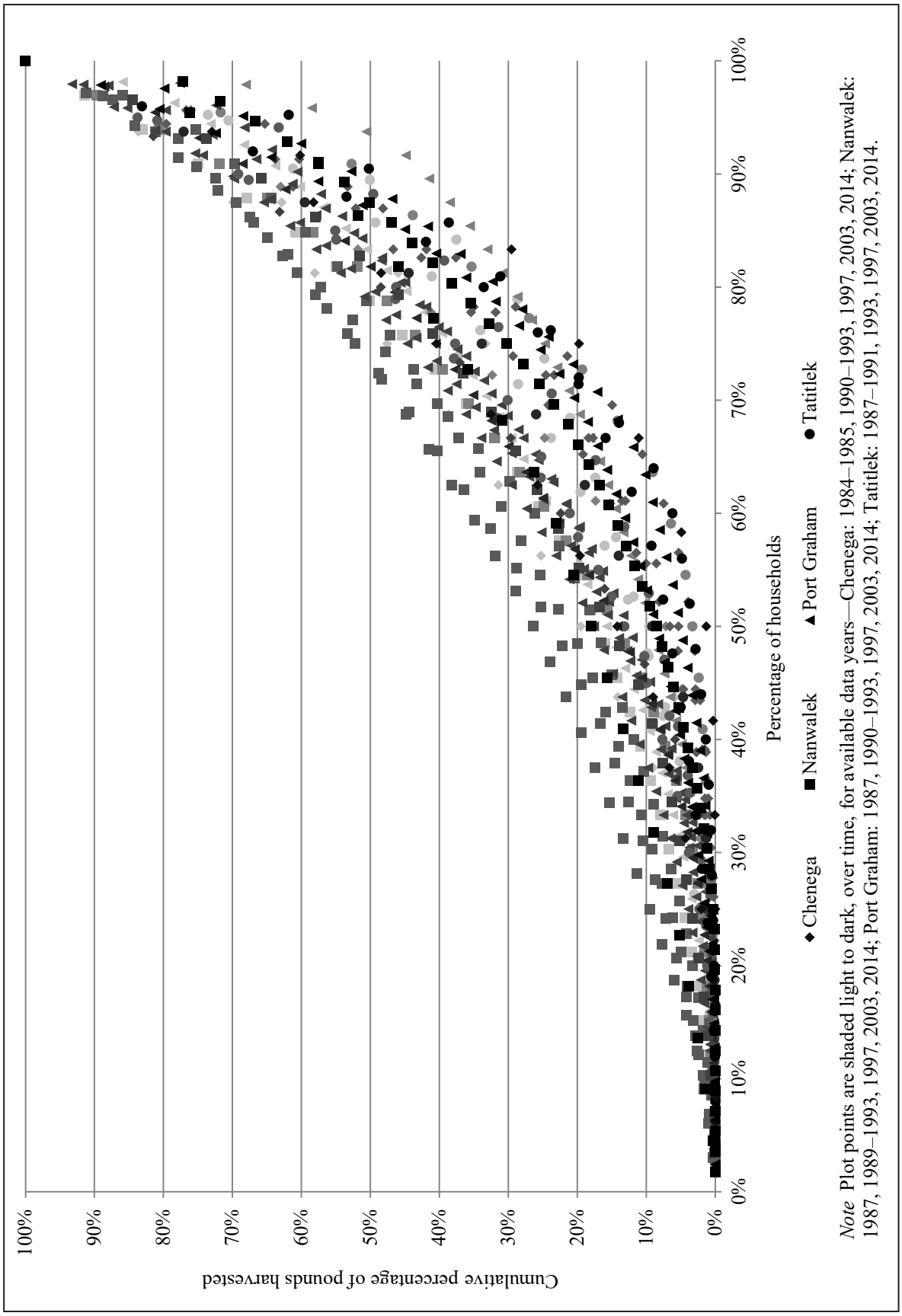
The degrees of harvest specialization in the study communities vary by resource. Figure 2-3 displays the percentage of harvest by thirds for Pacific cod, chitons, herring, and sockeye salmon, resources that were taken in relatively large quantities and used by a significant portion of households in pre-EVOS study years. Low (blue), middle (orange), and high (gray) thirds are determined by total household harvest of all resources. The contribution to total harvest of Pacific cod, chitons, herring, and sockeye salmon are summed. Yellow lines indicate the estimated annual harvest for each resource in pounds. While specialization is

Table 2-1.–Household specialization, Chenega, Nanwalek, Port Graham, Tatitlek, 1985–2015.

	All communities		Chenega		Nanwalek		Port Graham		Tatitlek	
	Percent of		Percent of		Percent of		Percent of		Percent of	
Study year	Harvest	Households	Harvest	Households	Harvest	Households	Harvest	Households	Harvest	Households
Pre-spill	70.0%	26.4%	68.4%	31.3%	71.3%	36.4%	70.5%	33.3%	71.4%	25.0%
1989	70.5%	22.3%	67.7%	27.8%	71.7%	36.4%	69.2%	18.8%	73.0%	22.7%
1990	70.2%	30.2%	64.6%	22.2%	70.2%	37.1%	69.0%	30.4%	68.6%	23.5%
1991	69.6%	32.2%	68.2%	22.2%	71.2%	44.8%	70.5%	34.7%	68.5%	31.6%
1992	69.8%	33.0%	71.1%	21.7%	71.0%	46.9%	70.5%	37.5%	–	–
1993	69.7%	30.7%	70.7%	26.1%	69.0%	39.4%	69.9%	31.4%	69.9%	30.0%
1997	70.0%	28.8%	70.4%	33.3%	71.1%	34.5%	70.0%	34.1%	66.2%	25.0%
2003	70.0%	24.5%	67.5%	31.3%	69.1%	31.8%	71.6%	23.4%	66.5%	20.0%
2014	70.4%	22.3%	70.5%	16.7%	69.8%	25.0%	72.0%	22.0%	68.8%	19.0%

Source ADF&G Division of Subsistence household surveys, 1985–2015.

Note This table depicts the percentage of the top households harvesting 70% of resources. The cumulative percentage of harvest closest to 70% is used to determine the percentage of households represented here. Cells containing '–' indicate no data collected or no data available. "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.



Note Plot points are shaded light to dark, over time, for available data years—Chenega: 1984–1985, 1990–1993, 1997, 2003, 2014; Nanwalek: 1987, 1989–1993, 1997, 2003, 2014; Port Graham: 1987, 1990–1993, 1997, 2003, 2014; Tatitlek: 1987–1991, 1993, 1997, 2003, 2014.

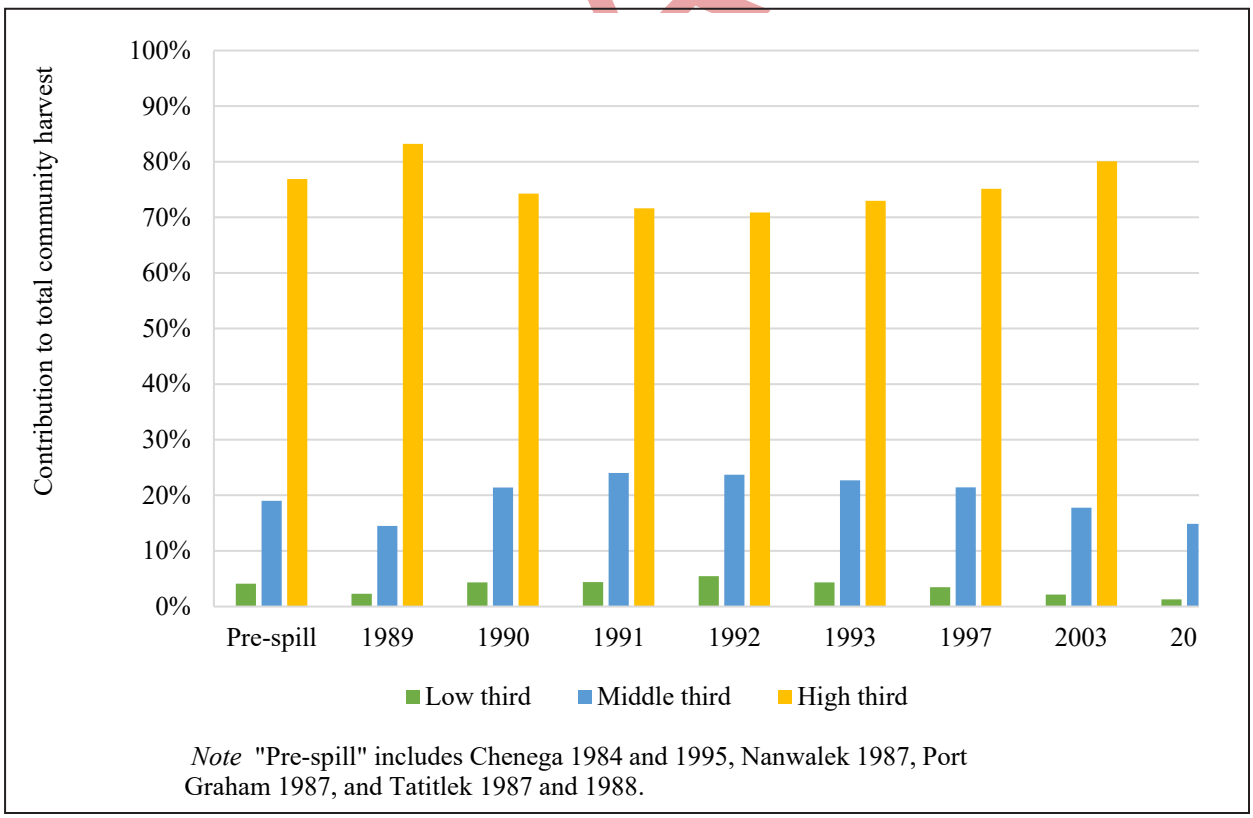
Figure 2-1.–Household specialization, Chenega, Nanwalek, Port Graham, Tatitlek, 1984–2014.

Table 2-2.–Gini coefficients over time, Chenega, Nanwalek, Port Graham, and Tatitlek, 1984–2014.

Year	All communities	Chenega	Nanwalek	Port Graham	Tatilek
Pre-spill	0.66	0.52	0.46	0.52	0.61
1989	0.65	0.57	0.49	0.68	0.69
1990	0.54	0.61	0.43	0.53	0.63
1991	0.54	0.64	0.37	0.50	0.52
1992	0.52	0.68	0.35	0.46	
1993	0.56	0.62	0.42	0.56	0.52
1997	0.55	0.51	0.50	0.51	0.57
2003	0.60	0.52	0.50	0.62	0.66
2014	0.59	0.70	0.63	0.68	0.67

Source ADF&G Division of Subsistence household surveys, 1985–2015.

Note Empty cells indicate no data collected or no data available. "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-2.–Contribution of bottom, middle, and top thirds of households to total community harvest, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1985–2014.

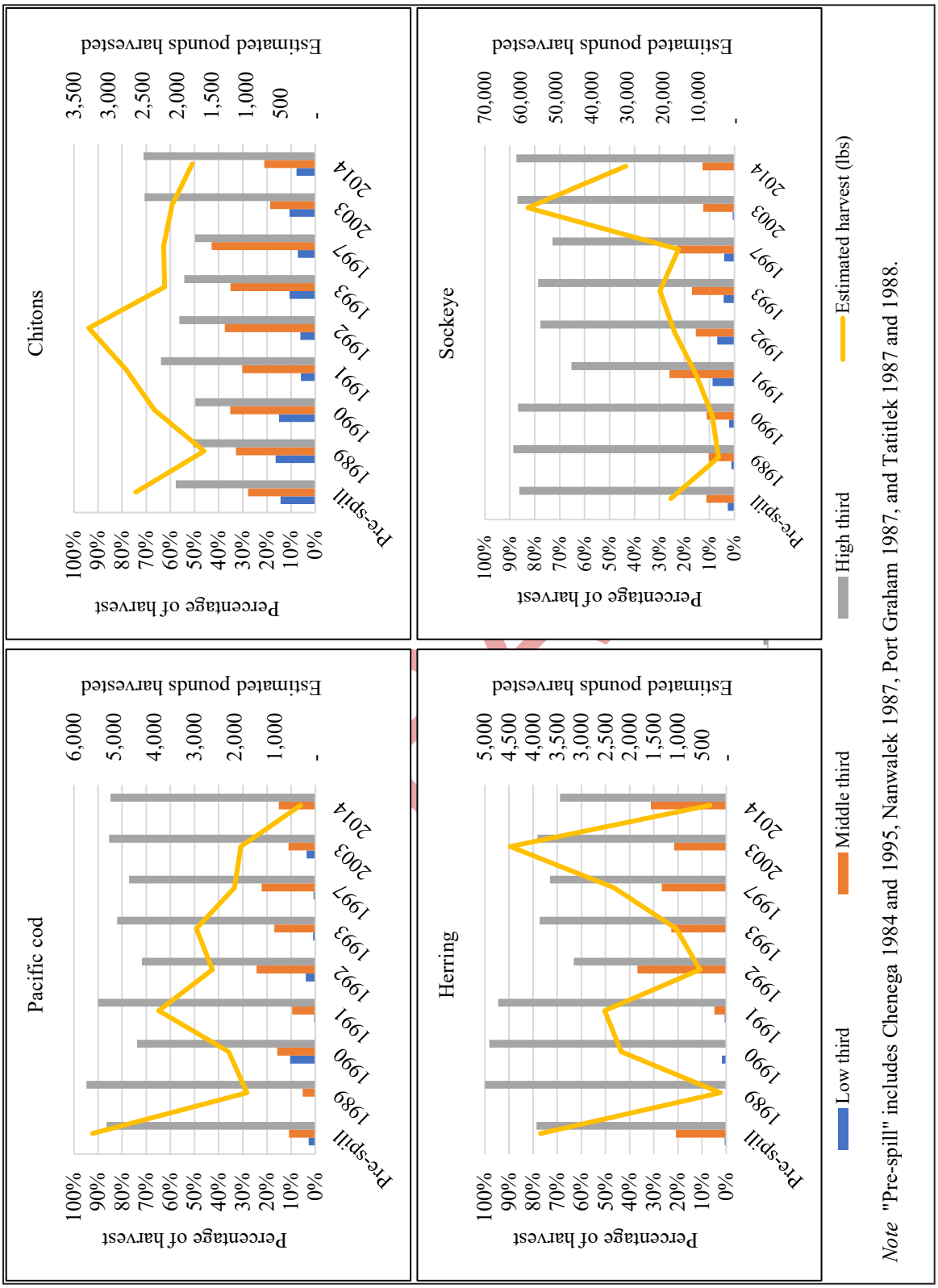
Table 2-3.–Contribution of bottom, middle, and top thirds of households to total community harvest, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1984–2014.

Year	N	Low third	Middle third	High third
Pre-spill	195	4.1%	19.0%	76.9%
1989	151	2.3%	14.5%	83.2%
1990	145	4.3%	21.4%	74.3%
1991	148	4.4%	24.0%	71.6%
1992	125	5.5%	23.7%	70.9%
1993	154	4.3%	22.7%	73.0%
1997	149	3.5%	21.4%	75.1%
2003	163	2.1%	17.8%	80.1%
2014	160	1.3%	14.9%	83.9%

Source ADFG Subsistence Division household surveys 1985–2015.

Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

N = Number of households.



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-3.–Concentration of resource harvests by thirds, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1984–2014.

present for all resources, the most accessible resource (chitons) shows a consistent contribution from the lower third of producing households, which produced up to 16.5% of the total harvest. Herring shows a more consistent contribution by the middle third of producing households, which produced at least 20% of the total herring harvest since 1992.

In contrast, Pacific cod and sockeye salmon consistently show an especially high concentration of production by the high third of households, upwards of 80% for most study years. For Pacific cod, the high third was responsible for 87% of the harvest in the study years before the oil spill and ranged between 72–90% in the years following. While the low and middle thirds combined still contributed about 15% of the total Pacific Cod harvest in 2003 and 2014, it is important to note the steady and dramatic decline in the volume of harvest beginning in 1993 with an estimate of 2,954 pounds harvested, and ending with 366 pounds harvested in 2014. For sockeye salmon, while the lower third reported contributions as high as 9%, the high third was responsible for at least 73% of the harvest in eight out of the nine study years. The top third of harvesting households were responsible for 85% of Pacific cod harvest in both 2003 and 2014, and 87% of sockeye salmon in both 2003 and 2014. With the sharp decline in the volume of Pacific cod harvested, it is possible that harvest of this species is now primarily incidental to activities that are more reliable and efficient (like salmon or halibut). Finally, yellow lines indicate a notable decline in the volume of all four resources between 2003 and 2014.

Some specialization trends within individual communities warrant further attention to understand the reasons some harvests have become more exclusive to the high third of harvesting households rather than redistributed along the specialization curve. Sockeye salmon harvest in Port Graham shows a significant trend towards harvest concentration starting in 1993, with the high third producing nearly the entirety (97%) of the sockeye salmon harvest by 2014 (Figure 2-4). While Port Graham and Nanwalek typically follow similar harvest trends each year, the extreme concentration of harvest in 2014 is not as evident in Nanwalek, where the high third harvested 81% of sockeye. Similarly, in Tatitlek since 1993, sockeye salmon have become almost exclusively harvested by the high third of households, which is a notable change from the lack of specialization in the years immediately before and after EVOS where the middle third of households produced between 39% and 46% of the total harvest (Figure 2-5).

Overall, findings of specialization were consistent with general trends documented across rural Alaska communities. However, the increasing trend towards a highly concentrated level of production that started in 1993 warrants further investigation. Possible explanations for increased specialization can be better understood by examining patterns of production and distribution, and characteristics of productive households, and how both have changed over time.

Patterns of Production and Distribution

This section addresses project objective 3: conduct an analysis to identify characteristics of productive and non-productive households, including associations with household type (developmental cycle), ethnicity, earned cash income, and involvement in commercial fishing among other factors; and objective 4: for Cordova, compare and contrast resource harvest and use patterns of Alaska Native households and other households, including changes in characteristics over time. First, general patterns of production and distribution are identified, followed by specific household and income characteristics associated with subsistence resource productivity including commercial fishing and Alaska Native households in Cordova.

The average estimated volume of resources harvested at the household level for the four small communities combined ranges from 506.5 pounds in 1989, the EVOS year, to 1,310.6 pounds in 2003 (Figure 2-6, Table 2-4). While the volume of resources remained mostly consistent in the years following EVOS, the average pounds harvested per household dropped from 1,310.6 in 2003 to 761.1 pounds in 2014, which is the lowest since 1989 and 1990, the two years following EVOS.

A similar pattern emerges when examining harvest diversity, or the average number of wild resources used and harvested per household within communities (Figure 2-7, Table 2-5). The average number of resources used ranged from 11.3 in the year of EVOS, to 21.8 in 1992. While the number of resources used steadily increased in the three years immediately following the oil spill, harvest diversity hovered around

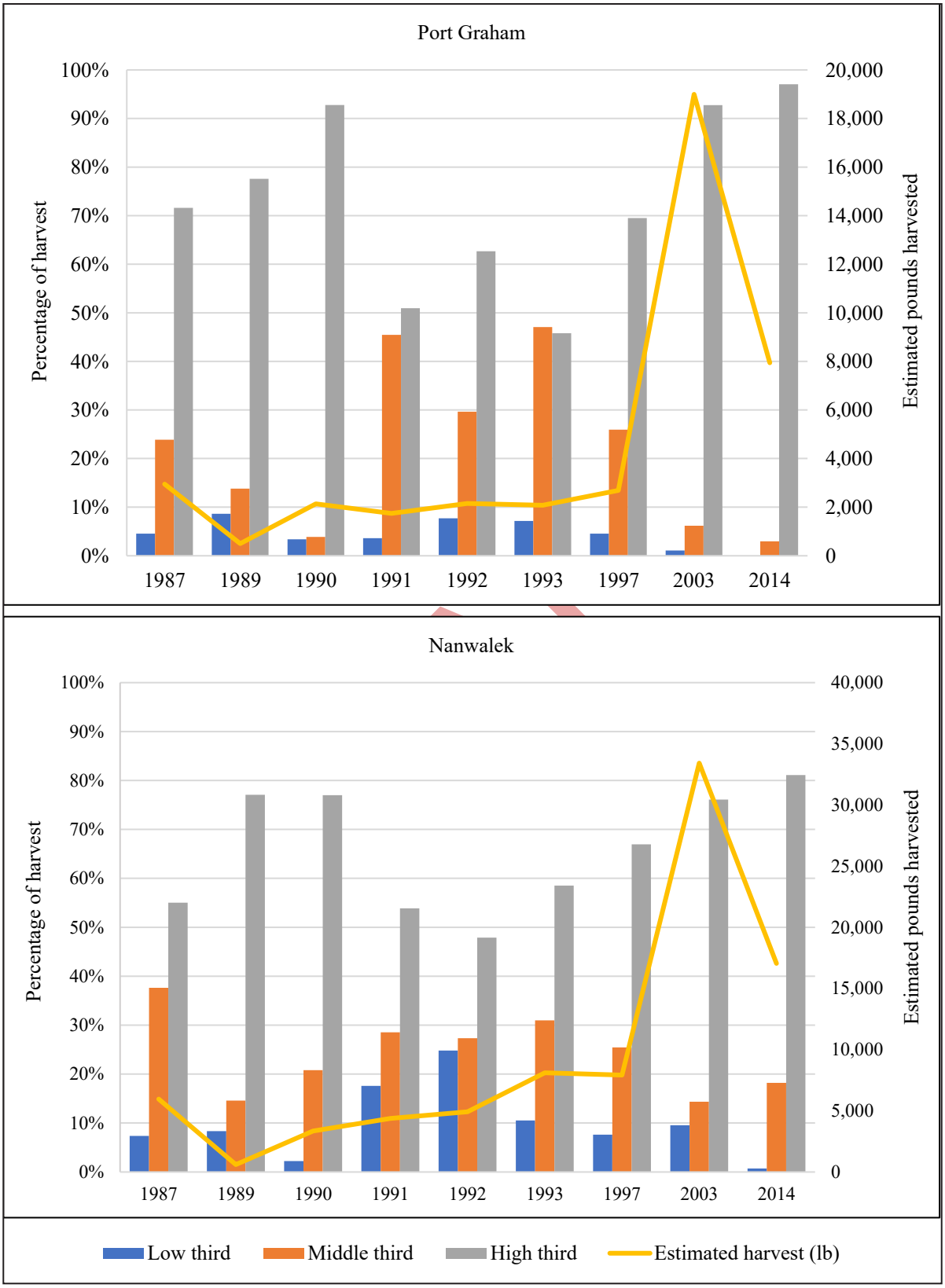


Figure 2-4.–Sockeye salmon harvest by thirds, Nanwalek and Port Graham, 1987, 1989–1993, 1997, 2003, and 2014.

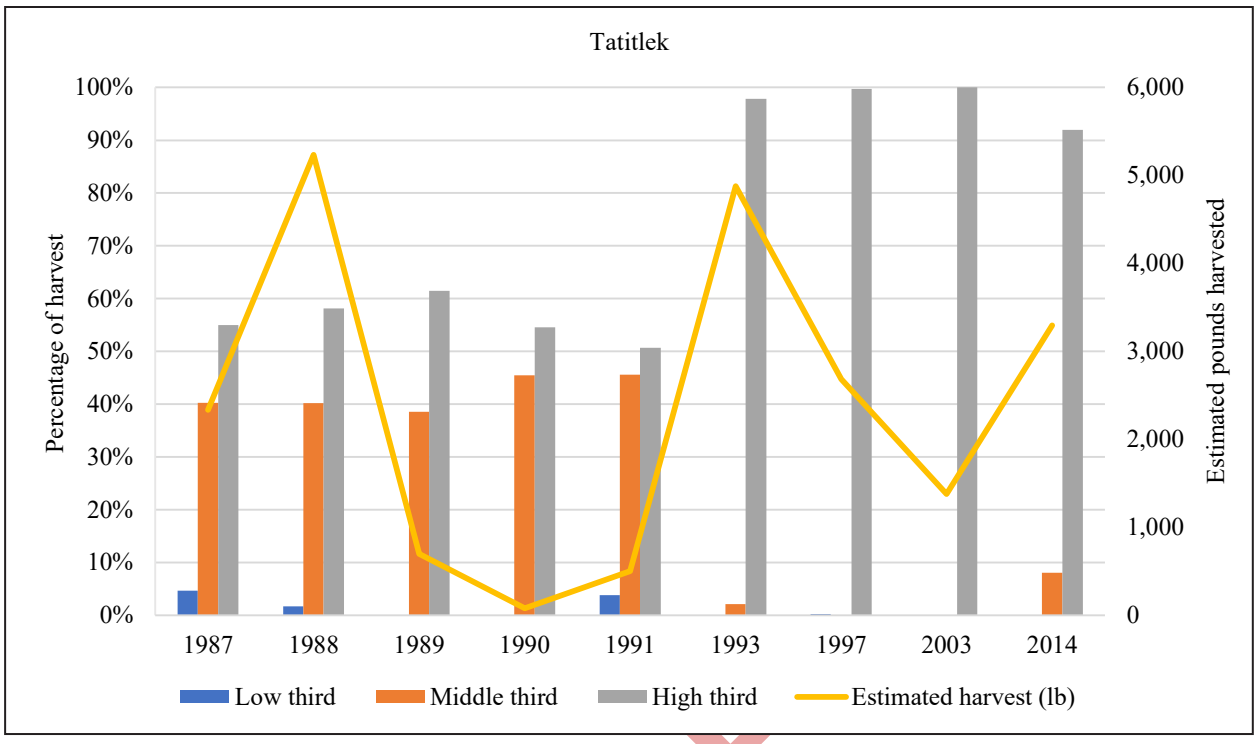
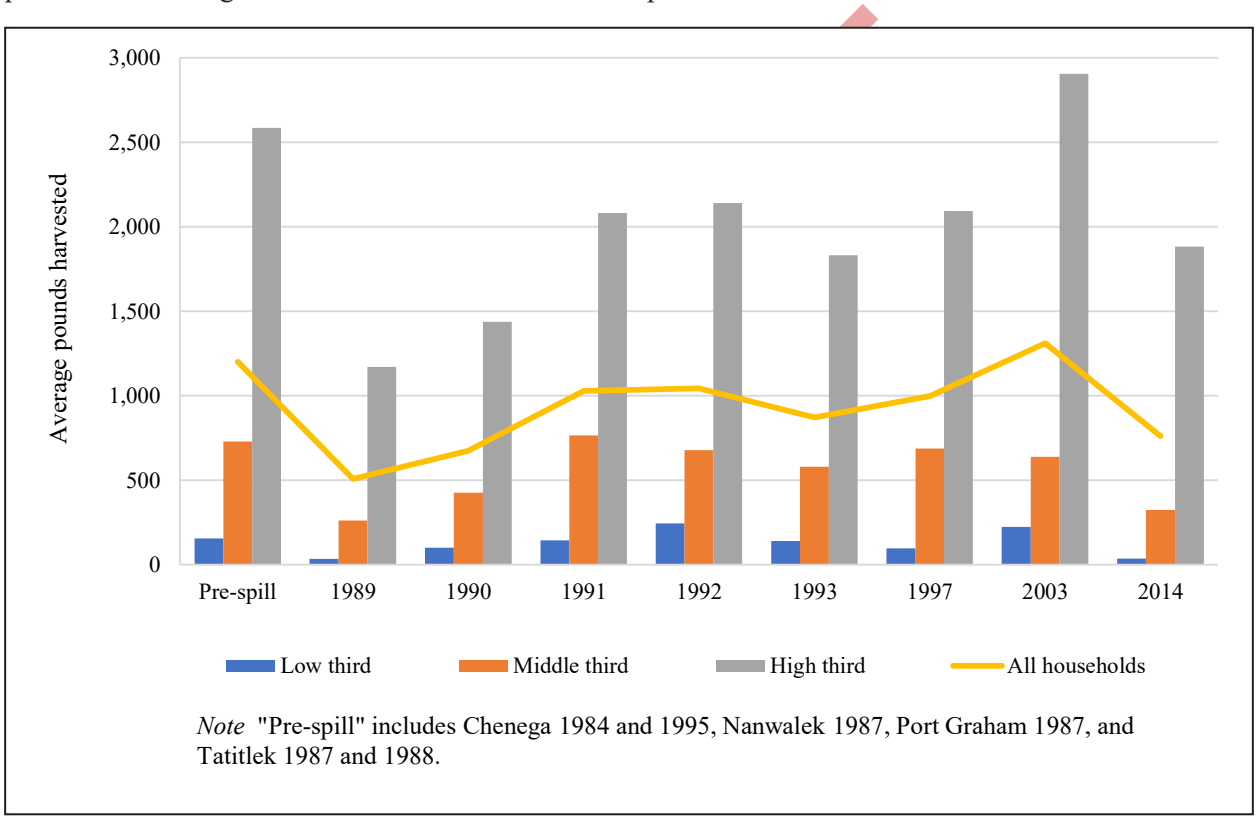


Figure 2-5.–Sockeye salmon harvest by thirds, Tatitlek 1987–1991, 1993, 1997, 2003, and 2014.

20 resources used for the following decade, until it dropped to an average of 13.3 resources used in 2014. Similarly, the average number of resources harvested dropped from hovering around 12 from 1991 to 2003, to just 8.0 resources in 2014. Aside from the year of the oil spill, this is the most minimal display of resource diversity among resource users and harvesters in all the study years.

Patterns of Production and Distribution by Thirds

For all four communities combined, the high third of harvesting households produced the greatest quantity and diversity of wild resources across study years, but with notable changes in both quantity and diversity. Households in the high third produced between an estimated 1,170.8 and 2,905.1 pounds, compared to 261.6 and 764.2 pounds for the middle third, and 34.0 and 244.1 pounds for the low third (Table 2-4). Between 2003 and 2014, the average volume of resources harvested by the high third fell from 2,905.1 to 1,882.2 pounds. Additionally, the high third consistently produced a greater diversity of resources, ranging from an average per household of 11.5 in the year of the spill to 21.7 in 1992 (Figure 2-8, Table 2-6). The middle third averaged a harvest of between 7.0 and 13.3 resources per household, and the low third produced an average of between 1.8 and 6.3 resources per household.



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-6.–Average pounds harvested per household by thirds, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

The high third gave away a greater range of resources than the low and middle thirds (Figure 2-9). The average number of resources given away by the high third ranged from 8.5 in the year of EVOS to 18.3 in 1992. In all but one study year, the high third of producers gave away an average of at least 10 resources. In comparison, the middle third of producers gave away 10 or fewer kinds of resources in all but one year, and the low third never gave away more than 6 kinds of resources. Between 2003 and 2014, the number of resources given away by the high third dropped from 17.8 to 11.1, almost approaching a level of resource diversity as low as the year of EVOS.

Table 2-4.–Average pounds harvested by thirds, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	Low third	Middle third	High third	All households
Pre-spill	154.8	728.4	2,584.6	1,199.3
1989	34.0	261.6	1,170.8	506.5
1990	100.3	426.5	1,436.3	673.7
1991	143.2	764.2	2,081.7	1,028.1
1992	244.1	678.6	2,139.9	1,044.0
1993	139.6	578.5	1,830.0	870.4
1997	96.9	687.0	2,092.0	999.4
2003	222.9	638.5	2,905.1	1,310.6
2014	35.6	323.8	1,882.2	761.1

Source ADF&G Division of Subsistence household surveys, 1985–2015.

Note "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988

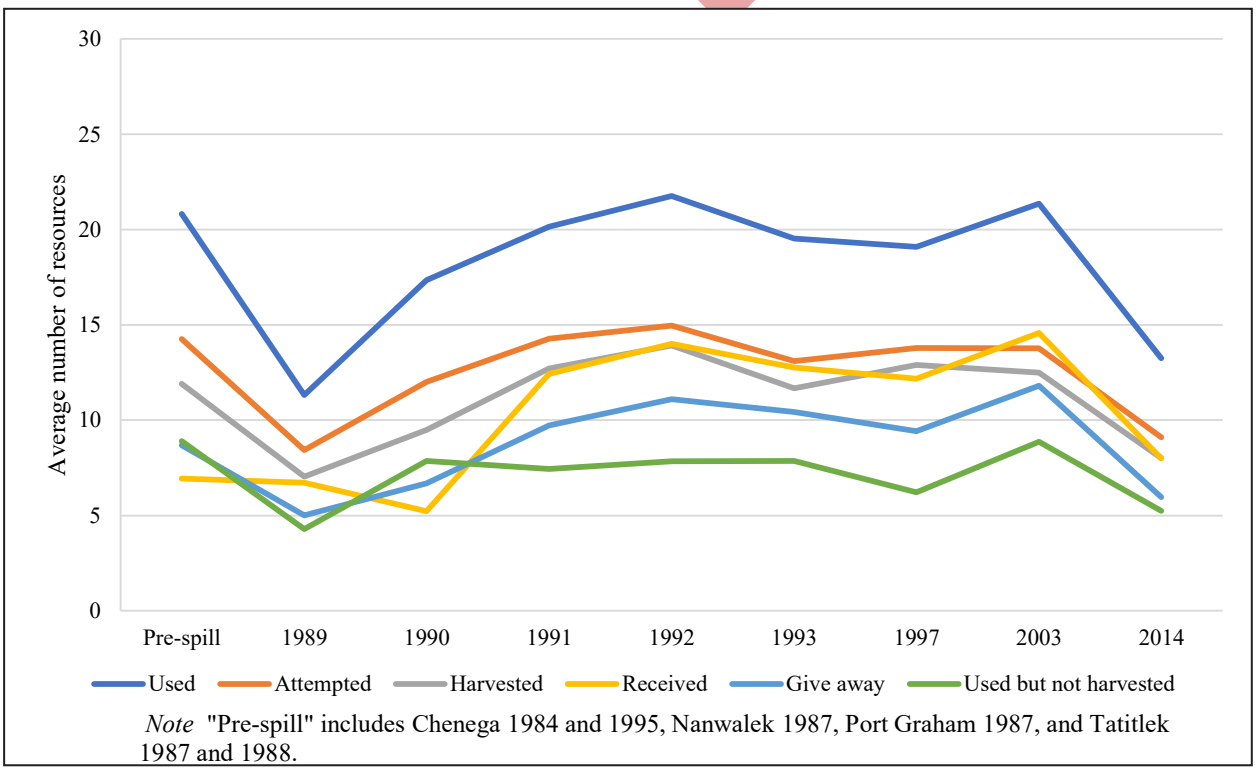


Figure 2-7.–Average number of resources harvested and used, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Table 2-5.–Average number of resources harvested and used, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	N	Used	Attempted	Harvested	Received	Give away	Used but not harvested
Pre-spill	195	20.8	14.3	11.9	6.9	8.7	8.9
1989	151	11.3	8.4	7.0	6.7	5.0	4.3
1990	145	17.3	12.0	9.5	5.2	6.7	7.9
1991	148	20.2	14.3	12.7	12.4	9.7	7.4
1992	125	21.8	15.0	13.9	14.0	11.1	7.8
1993	154	19.5	13.1	11.7	12.8	10.4	7.9
1997	149	19.1	13.8	12.9	12.2	9.4	6.2
2003	163	21.4	13.8	12.5	14.6	11.8	8.9
2014	160	13.3	9.1	8.0	8.0	6.0	5.2

Source ADF&G Division of Subsistence household surveys, 1984–1985, 1987–1993, 1997, 2014.

Note "Pre-spill" includes all data collected prior to 1989. Chignik Bay 1984 & 1985, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987, 1988.

Patterns of Production and Distribution by Household Type

There are clear relationships between household types and levels of subsistence resource productivity and distribution. This subsection examines households with and without young children, male and female single headed households, dual headed households, and households with elders (see Appendix B and Appendix C for detail). Figure 2-10 displays differences in pounds harvested by household type, and Figure 2-11 displays differences in harvest diversity by household type.

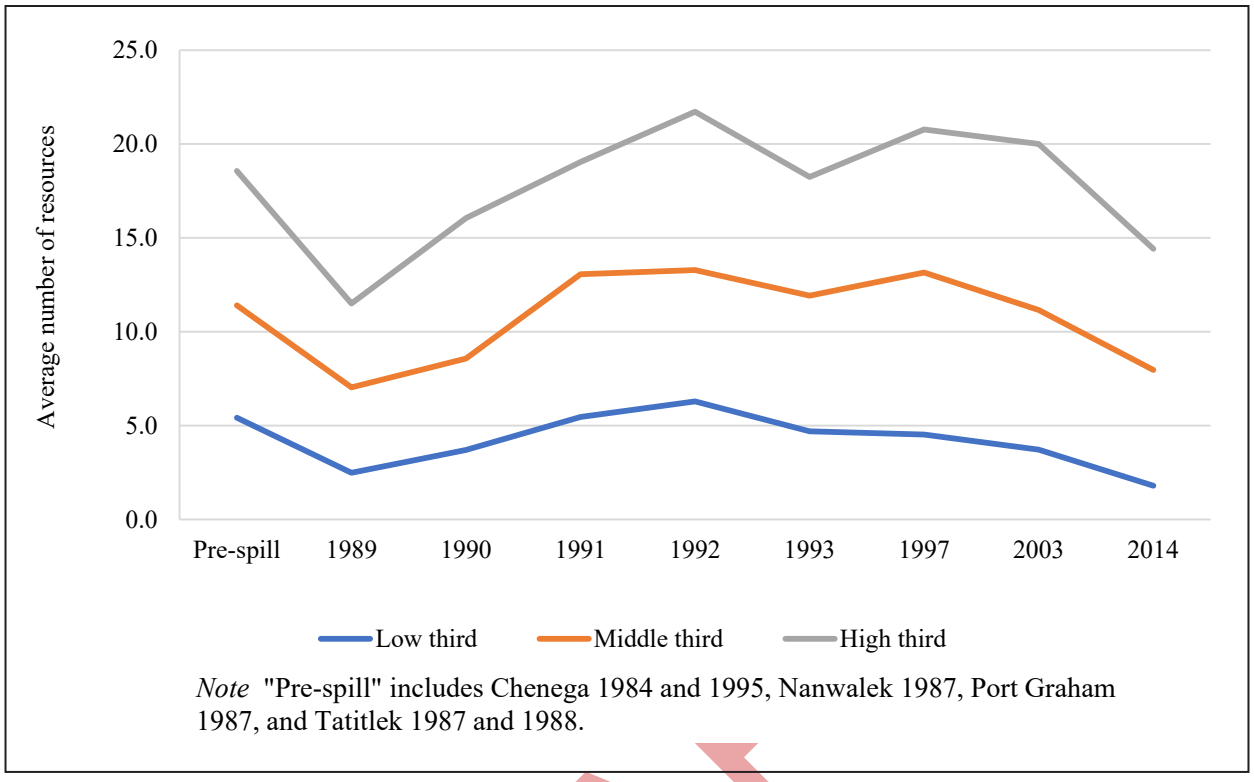
Households with children under 16 and household without children

Across all study years, a smaller percentage of households without children fell into the high third of producing households compared to households that had children under the age of 16 (Figure 2-12). Households were ranked by harvest volume then split into three equally sized groups referred to in this report as low, middle, and high thirds. The percentage represents the contribution to the total harvest of each respective category (households without children, or households with children under 16). In general, the volume of harvests by households without children was evenly split between thirds, with no third of households producing more than 50% of the total harvest in a study year.For example, production in the high third of households ranged from 17.7% to 34.8% of the total harvest (Table 2-8). This indicates a wide range of level of involvement in subsistence harvests for households without chidren: while they were not the lowest producers, they also did not consistently make up an overwhelming proportion of top harvesters. In contrast, households with children under 16 were generally more likely to fall into the high third of producers, never contributing less than 37% of the total harvest in the high third across study years (Table 2-9).

While households with and without young children generally used a similar range of resources, households without children had a slightly less diverse harvest. Households with no children harvested between 6.1 and 12.1 types of resources (Table 2-8), while households with children harvested between 7.8 and 15.4 resources (Table 2-9). Both household types show a significant drop in resource diversity between 2003 and 2014 (11.2 to 6.1 resources on average for households without children and 14.9 to 10.7 for households with children). Finally, households with and without children received a comparable range of resources, although diversity of resources for both household types dropped between 2003 and 2014 (15.3 to 8.1 resources on average received by households with no children and 13.2 to 7.9 resources received by households with children).

Single household heads with children under 16

Households composed of single female heads with children under 16 were generally more likely to be lower producers than other household types. The contribution to total harvest by single mothers in the low third of producers ranged from 0% to 71% across study years, in half of the study years falling between 35–55% in the lower third (Table 2-10). The only year with an especially high concentration of production



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

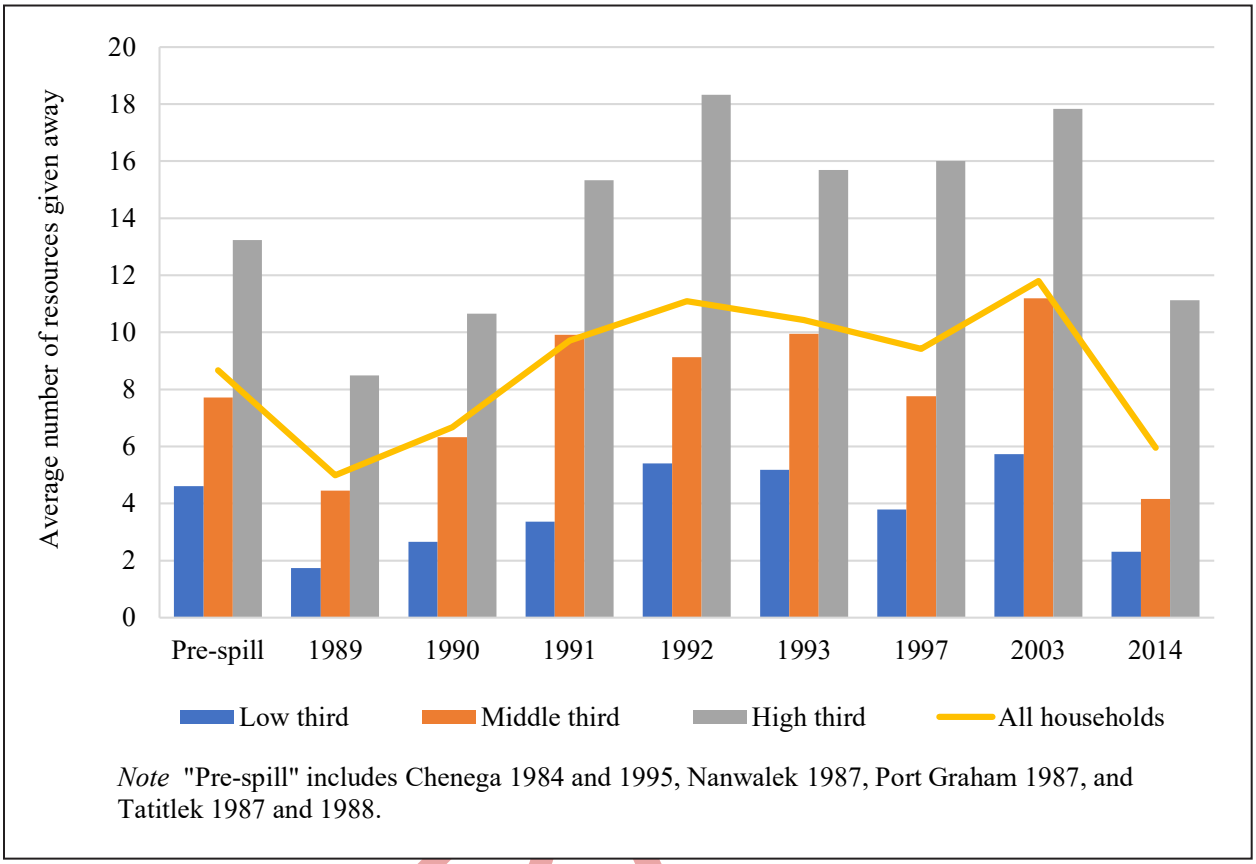
Figure 2-8.–Average number of resources harvested, by thirds, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Table 2-6.–Average number of resources harvested, by thirds, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

	Attempted			Harvested		
Year	Low third	Middle third	High third	Low third	Middle third	High third
Pre-spill	7.2	14.0	21.2	5.4	11.4	18.6
1989	3.5	8.6	13.1	2.5	7.0	11.5
1990	4.8	11.6	19.4	3.7	8.6	16.0
1991	6.8	14.7	20.8	5.5	13.1	19.0
1992	7.3	14.0	23.1	6.3	13.3	21.7
1993	5.9	13.8	19.5	4.7	11.9	18.2
1997	5.1	14.0	21.9	4.5	13.2	20.8
2003	5.2	12.2	21.3	3.7	11.2	20.0
2014	2.4	9.4	15.7	1.8	8.0	14.4

Source ADF&G Division of Subsistence household surveys 1985–2015.
Note "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-9.–Average number of resources given away, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.



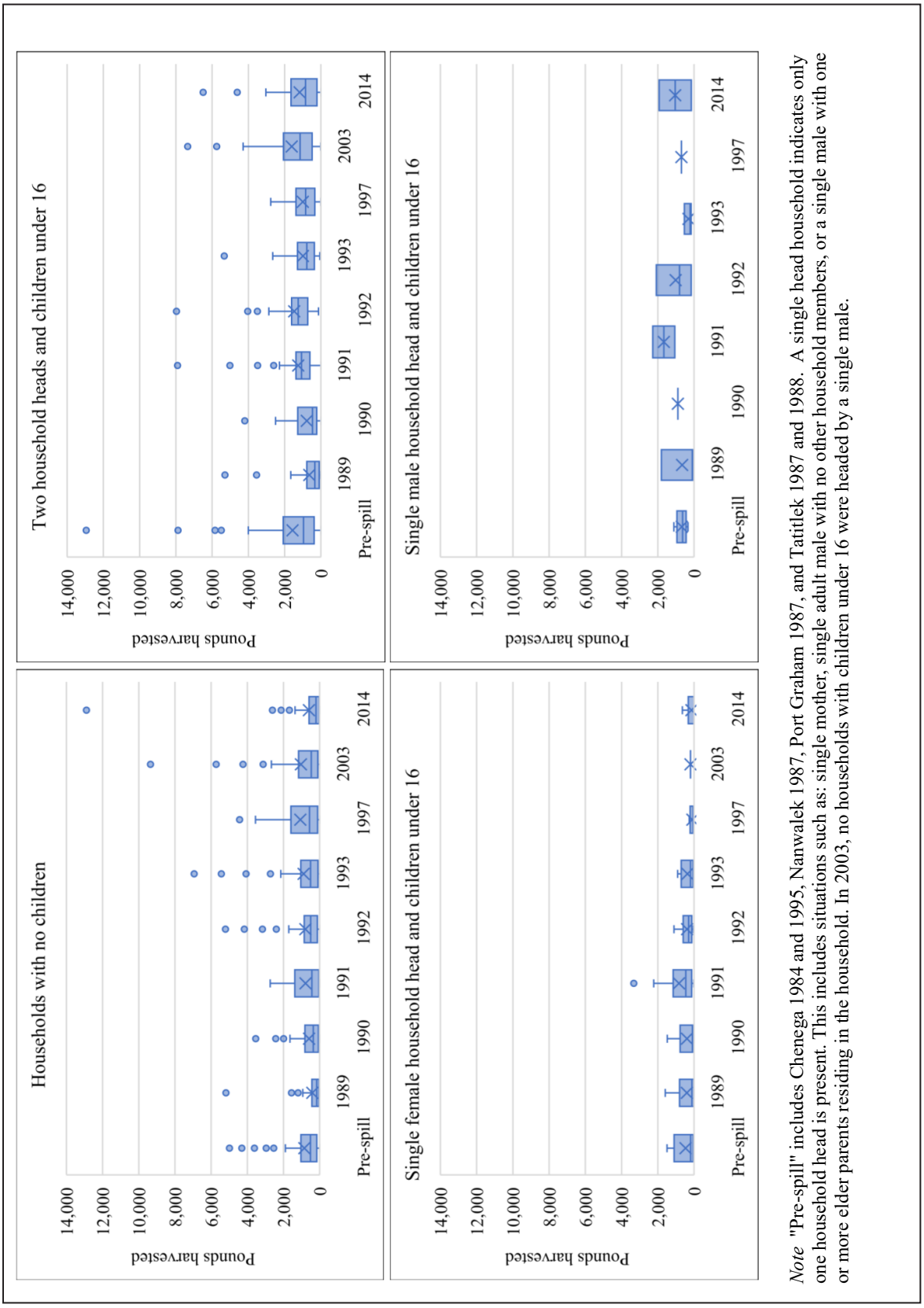
Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Table 2-7.–Average number of resources given away, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	Low third	Middle third	High third	All households
Pre-spill	4.6	7.7	13.2	8.7
1989	1.7	4.5	8.5	5.0
1990	2.7	6.3	10.7	6.7
1991	3.4	9.9	15.3	9.7
1992	5.4	9.1	18.3	11.1
1993	5.2	10.0	15.7	10.4
1997	3.8	7.8	16.0	9.4
2003	5.7	11.2	17.8	11.8
2014	2.3	4.2	11.1	6.0

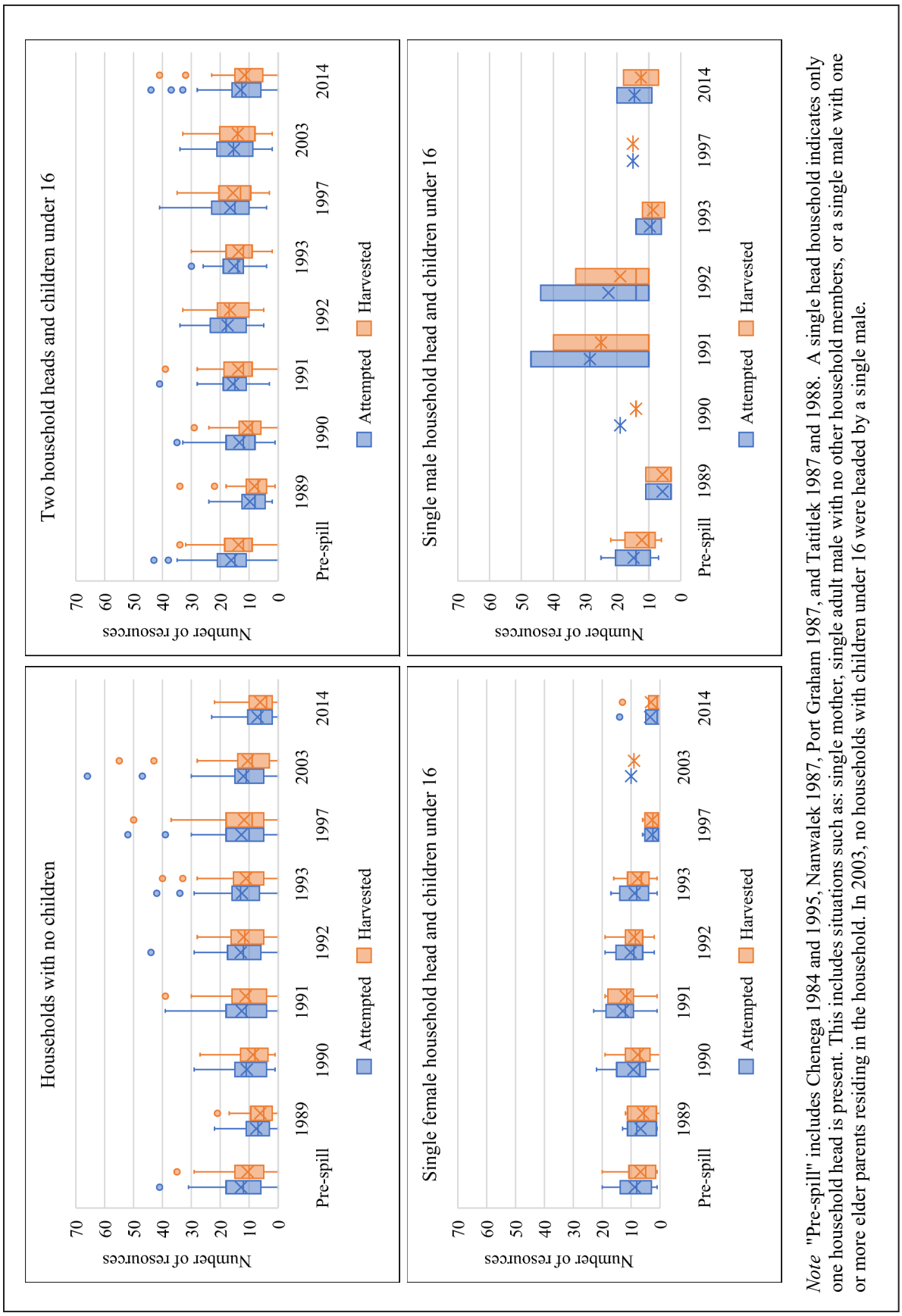
Source ADF&G Division of Subsistence household surveys, 1985–2015.

Note "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988. A single head household indicates only one household head is present. This includes situations such as: single mother, single adult male with no other household members, or a single male with one or more elder parents residing in the household. In 2003, no households with children under 16 were headed by a single male.

Figure 2-10.–Household harvest, in pounds, by household type, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1984–2014.



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988. A single head household indicates only one household head is present. This includes situations such as: single mother, single adult male with no other household members, or a single male with one or more elder parents residing in the household. In 2003, no households with children under 16 were headed by a single male.

Figure 2-11.–Resource diversity by household type, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1984–2014.

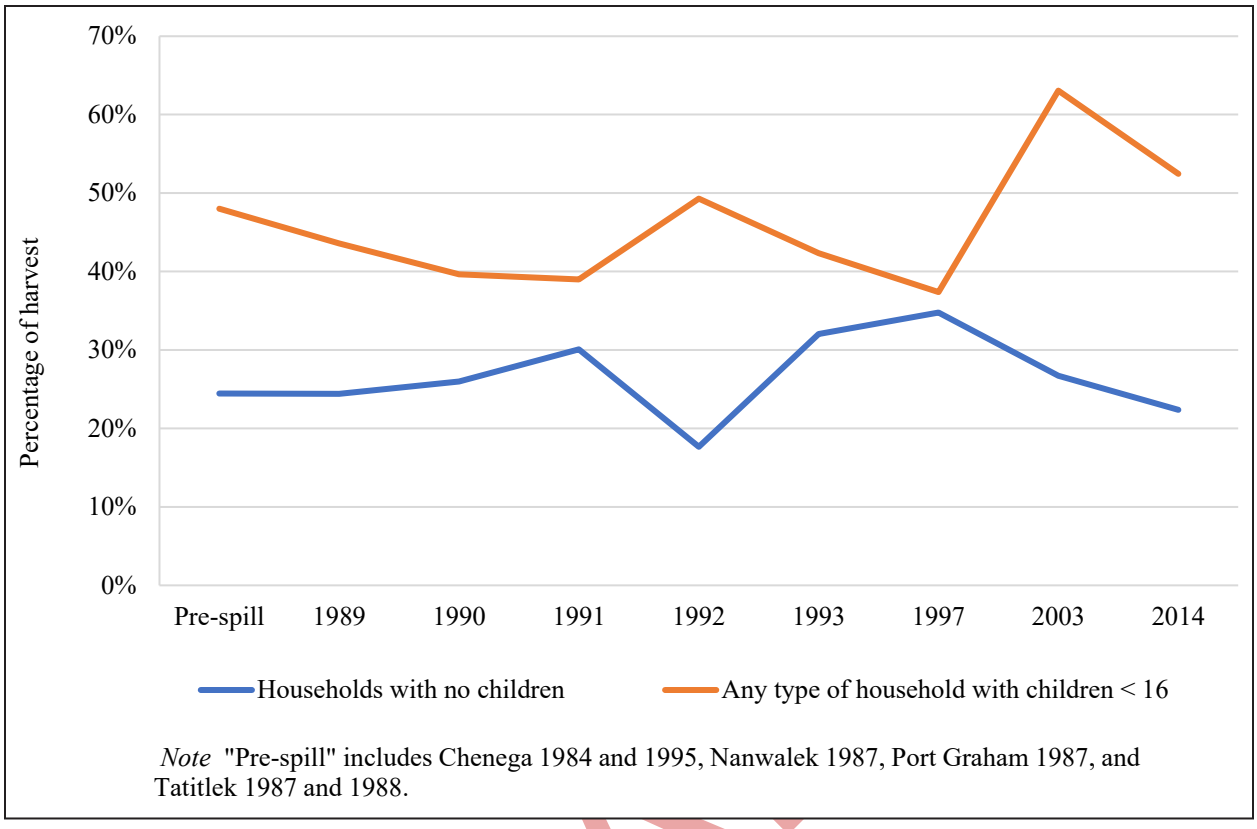


Figure 2-12.–Percentage of harvest by high third of households with no children vs. high third of households with children under 16, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

by single-mother households in the lower third was 2014 with 71.4%, which was a steep increase from 0% in 2003, and 28.2% in 1997.

Households composed of single fathers with children under 16 were higher producers than single mothers. The percentage of single male households with children in the low third of producers never exceeded 35% (Table 2-11). Instead, single male headed householdsconsistently fell in the high third, producing from 32–100% of the resources used across study years and 50% or higher in half of those same years.

Single male household heads with children used a greater diversity of resources than single female headed households. Male households used between 9.2 and 33.0 resources on average, exceeding 15 resources in all years except one (Table 2-11). Female households used an average of between 8.3 and 19.9 resources, exceeding an average of 13 resources in only two study years (Table 2-10). In the most apparent difference, male households harvested twice the number of resources, ranging from 5.5 in the year of EVOS, to 25.0 in 1991. The number of resources harvested only fell below 10 in two study years. In contrast, female headed households harvested between 2.6 and 12.0 resources, and only harvested more than 10 resources in one study year. However, male households generally received a smaller number of resources, ranging from 1.0 to 11.9 compared to 6.7 to 14.7 resources for female headed households. Therefore, while single female headed households with children harvested fewer resources, they still received and used a wide range, although there has been a steady downward trend in the number of resources received since 1992.

Dual household head with children under 16

Households with dual household heads and children under 16 were generally more like households with single male heads in that the greatest percentage of these households fell into the high third of producers.

Table 2-8.–Contribution of households with no children, by number of households, thirds, and number of resources used, harvested, and received, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	N	Low third	Middle third	High third	Resources used	Resources harvested	Resources received
Pre-spill	84	40.9%	34.6%	24.4%	19.8	10.5	7.0
1989	72	38.5%	37.1%	24.4%	10.7	6.2	6.6
1990	55	39.3%	34.7%	26.0%	16.4	8.5	5.3
1991	65	46.8%	23.1%	30.1%	19.3	11.2	12.2
1992	56	40.2%	42.1%	17.7%	20.5	12.1	12.5
1993	79	38.5%	29.4%	32.0%	19.5	11.0	12.5
1997	84	38.1%	27.1%	34.8%	17.8	11.8	10.9
2003	105	34.6%	38.7%	26.7%	21.4	11.2	15.3
2014	94	39.3%	38.3%	22.4%	12.0	6.1	8.1

Source ADF&G Division of Subsistence household surveys, 1984–1985, 1987–1993, 1997, 2014.

Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Table 2-9.–Contribution of households with children under 16, by number of households, thirds, and number of resources used, harvested, and received, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Pre-spill	N	Low third	Middle third	High third	Resources used	Resources harvested	Resources received
Pre-spill	111	23.5%	28.5%	48.0%	21.6	13.0	6.9
1989	79	28.3%	28.2%	43.6%	11.9	7.8	6.8
1990	90	27.7%	32.7%	39.6%	17.9	10.1	5.2
1991	83	20.9%	40.1%	39.0%	20.8	13.9	12.6
1992	69	18.8%	31.9%	49.3%	22.8	15.4	15.2
1993	75	22.8%	34.8%	42.3%	19.5	12.4	13.0
1997	65	20.0%	42.6%	37.4%	20.8	14.3	13.8
2003	58	14.1%	22.9%	63.1%	21.2	14.9	13.2
2014	66	26.7%	20.9%	52.4%	15.0	10.7	7.9

Source ADF&G Division of Subsistence household surveys, 1984–1985, 1987–1993, 1997, 2014.

Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Table 2-10.–Contribution of households headed by a single female with children under 16, by number of households, thirds and number of resources used, harvested, and received, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	N	Low third	Middle third	High third	Resources used	Resources harvested	Resources received
Pre-spill	10	53.8%	23.9%	22.3%	18.2	6.4	7.1
1989	10	49.1%	12.5%	38.4%	10.1	6.0	7.1
1990	11	53.3%	10.8%	35.9%	19.9	8.0	6.7
1991	13	37.4%	40.4%	22.1%	19.9	12.0	13.3
1992	12	38.5%	40.4%	21.1%	18.7	8.9	14.7
1993	12	50.9%	9.1%	40.0%	15.8	7.5	11.9
1997	6	28.2%	47.9%	23.9%	13.0	2.6	11.5
2003	1	0.0%	0.0%	100.0%	13.0	9.0	9.0
2014	8	71.4%	0.0%	28.6%	8.3	3.1	7.2

Source ADF&G Division of Subsistence household surveys, 1984–1985, 1987–1993, 1997, 2014.

Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Table 2-11.–Contribution of households headed by a single male with children under 16, by number of households, thirds and number of resources used, harvested, and received, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	N	Low third	Middle third	High third	Resources used	Resources harvested	Resources received
Pre-spill	6	0.0%	36.8%	63.2%	18.0	12.3	5.3
1989	4	34.3%	34.3%	31.5%	9.2	5.5	4.7
1990	1	0.0%	0.0%	100.0%	19.0	14.0	6.0
1991	2	0.0%	50.0%	50.0%	33.0	25.0	11.5
1992	4	31.9%	34.1%	34.1%	23.8	19.2	11.9
1993	4	0.0%	66.7%	33.3%	17.0	8.7	10.3
1997	1	0.0%	0.0%	100.0%	16.0	15.0	1.0
2003	—	—	—	—	—	—	—
2014	3	0.0%	50.0%	50.0%	15.0	12.5	2.0

Source ADF&G Division of Subsistence household surveys, 1984–1985, 1987–1993, 1997, 2014.

"—" indicates no data available

Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and

Table 2-12.–Contribution of households, with two household heads, with children under 16, by number of households, thirds and number of resources used, harvested, and received, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	N	Low third	Middle third	High third	Resources used	Resources harvested	Resources received
Pre-spill	96	21.8%	28.5%	49.8%	22.2	13.7	6.9
1989	66	24.8%	30.2%	45.0%	12.3	8.2	6.9
1990	78	24.4%	36.3%	39.2%	17.6	10.3	4.9
1991	68	18.5%	39.7%	41.8%	20.6	13.8	12.5
1992	54	13.5%	29.9%	56.7%	23.6	16.6	15.5
1993	60	18.4%	38.2%	43.4%	20.4	13.6	13.3
1997	58	19.6%	43.2%	37.2%	21.7	15.5	14.4
2003	57	14.4%	23.4%	62.2%	21.4	15.0	13.3
2014	55	21.5%	22.4%	56.1%	16.0	11.7	8.3

Source ADF&G Division of Subsistence household surveys, 1984–1985, 1987–1993, 1997, 2014.

Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

However, the concentration of production in the high third was less extreme for dual-headed households compared to single male headed households. While at least 37% of dual household heads with children fell into the high third of production, the percentage of the harvest produced by this household type in the high third never exceeded 62% (Table 2-12). This household group used a diverse range of resources, ranging from an average of 12.3 the year of EVOS to 23.6 in 1992. In all but one study year, dual-headed households with children used an average of at least 16 different resources. Again, there was a sharp decline between 2003 and 2014 from 21.4 to 16.0 resources used. Dual-headed households harvested between 8.2 and 16.6 resources and received between 4.9 and 15.5 resources.

Households with elders

Finally, differences in diversity in resource use, harvest, and receiving were examined by comparing all household types combined with households that had one or more elder above the age of 60. The number of types of resources used was similar between household types (Figure 2-13, Table 2-13). Households with elders used slightly more resources than all households combined in pre-spill years, 1992, 2003, and 2014. All household types, combined, harvested more resources than elder households in every year except for 2014, when the number of resources harvested dropped to the lowest since the year following EVOS. Elder households received a greater number of resources in every study year except for 1997. While the sharp decline in number of resources received by elder households is evident between 2003 and 2014, this decline is evident for all household types. Furthermore, elders still received more kinds of resources than all households despite the decrease in number. Therefore, there do not appear to be any remarkable changes in the relative patterns of resource use and sharing for elder households compared to all households combined in the decades following EVOS.

Additional Characteristics of Productive Households

Income and Commercial Fishing

It was not possible to reliably compare income levels with patterns of productivity due to a combination of missing income information for 1997 and 2003 and the distorted incomes reported in 1991–1993 due to EVOS employment. However, commercial fishing appears to have a positive relationship with a household's productivity. When examining differences in the number of resources used, noncommercial fishing households consistently use slightly fewer in most study years (Figure 2-14).

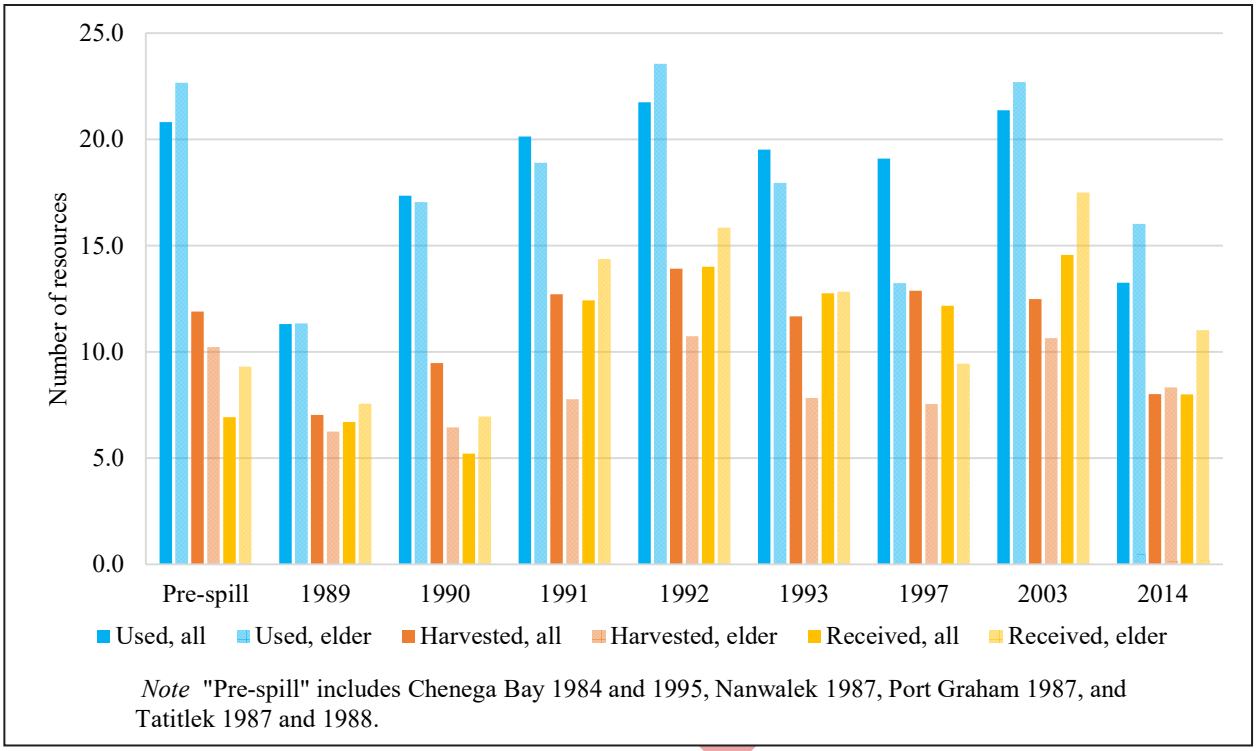


Figure 2-13.–Number of resources used, harvested, and received by all households, and households with elders older than 60, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Table 2-13.–Number of resources used, harvested, and received by all households, and households with elders older than 60, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

Year	Used, all	Used, elder	Harvested, all	Harvested, elder	Received, all	Received, elder
Pre-spill	20.8	22.7	11.9	10.2	6.9	9.3
1989	11.3	11.3	7.0	6.3	6.7	7.6
1990	17.3	17.0	9.5	6.5	5.2	7.0
1991	20.2	18.9	12.7	7.8	12.4	14.4
1992	21.8	23.6	13.9	10.7	14.0	15.8
1993	19.5	18.0	11.7	7.8	12.8	12.8
1997	19.1	13.2	12.9	7.5	12.2	9.4
2003	21.4	22.7	12.5	10.6	14.6	17.5
2014	13.3	16.0	8.0	8.3	8.0	11.0

Source ADF&G Division of Subsistence household surveys, 1985–2015.

Note "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

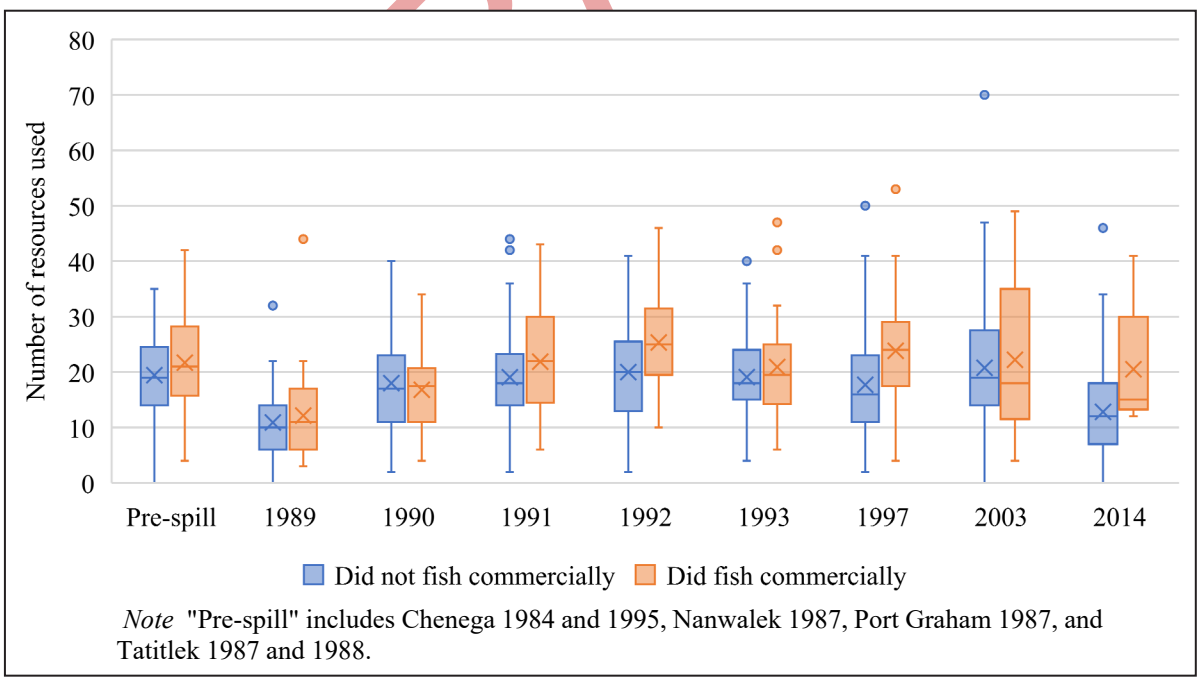
That difference between commercial fishing households and noncommercial fishing households is more pronounced when comparing the number of resources households attempted to harvest (Figure 2-15). The noticeable gap in the diversity of harvest between commercial fishing and noncommercial fishing households appears to have started increasing in about 1992. However, because the sample sizes reflect small populations many of the differences are not statistically significant. The R^2 value in the relationship between the number of resources attempted and percent of commercial fishing participation is 0.169. When 1989 is taken out, that increases to 0.344, which shows a moderate correlation.

When looking at the average pounds harvested, again the difference between commercial fishing and noncommercial fishing households is notable (Figure 2-16). The 2003 data are possibly irregular given only nine households reported participation in a commercial fishery. The group participating in commercial fishing appears to have similar characteristics to historical patterns all the way back to pre-spill surveys.

These figures demonstrate that households participating in commercial fisheries are overall more productive, a pattern that is present before the oil spill and after recovery. The oil spill year and those immediately after do not show statistically significant differences in productivity. However, this is likely the result of typically productive households not being able to participate in commercial fishing and the overall downturn in subsistence production during those years (see Appendix D for detail). Despite a decline in commercial fishing, the consistency in this pattern suggests that commercial fishing not only plays an essential role in mixed economies and subsistence production, but that its role may be increasingly important. Division of Subsistence harvest estimates include fish retained from commercial harvests. As fewer households participate in subsistence harvesting, the role of commercial fishing households in providing for the community grows, even if there are fewer commercial fishing households.

Native and non-Native Households in Cordova

To assess whether demography (percent Alaska Native) is associated with the productivity of households in EVOS communities, household surveys in Cordova utilized the larger community size to stratify the



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-14.–Comparison of number of resources used in households participating in a commercial fishery vs. households not participating in a commercial fishery, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

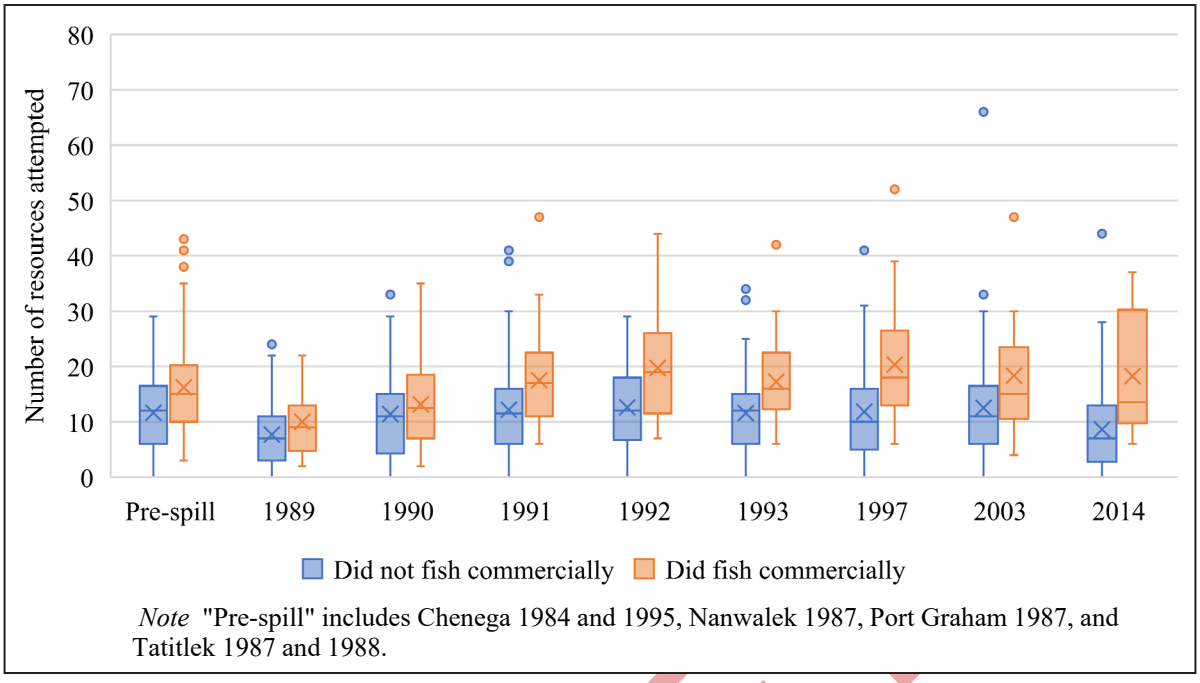


Figure 2-15.–Comparison of number of resources households participating in a commercial fishery attempted to harvest vs. households not participating in a commercial fishery, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

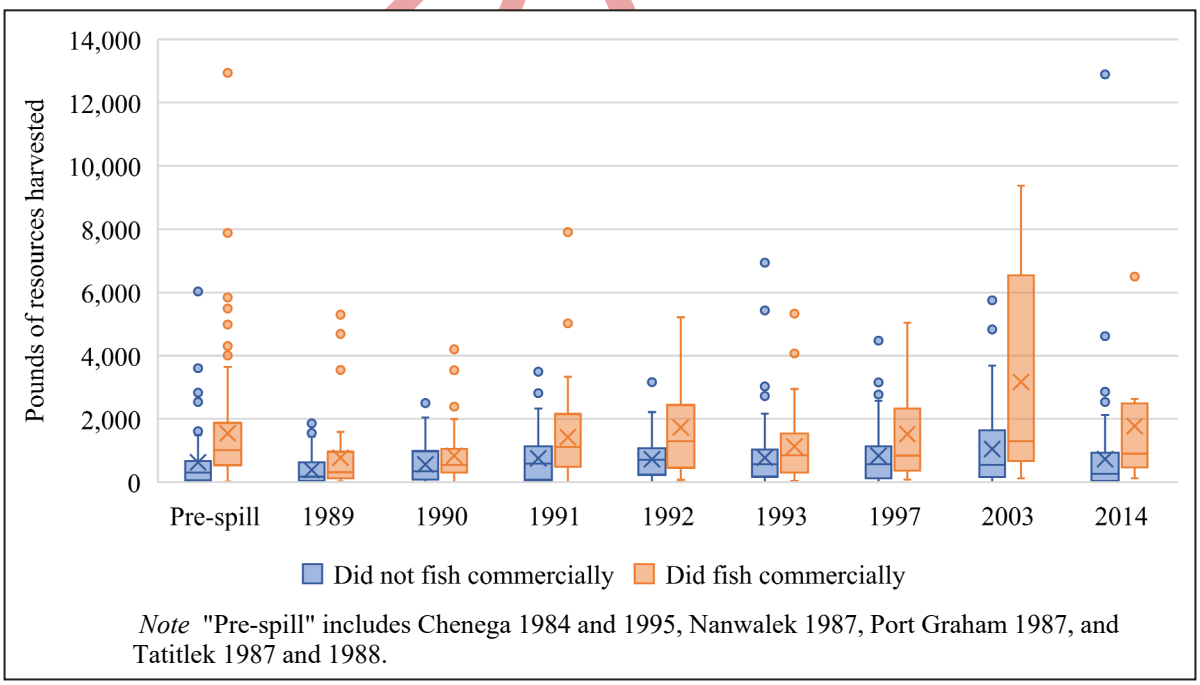


Figure 2-16.–Comparison of pounds of resources harvested by households participating in a commercial fishery vs. households not participating in a commercial fishery, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

household sample by Alaska Native and non-Native households. The stratification method for each study year is described in Appendix E.

Figure 2-17 displays the number of resources used by Alaska Native (orange) and non-Native (blue) households in Cordova, and the number of resources harvested by Alaska Native (yellow) and non-Native (gray) households across eight study years. In all but one year, Native households used a greater number of resources (between 11.8 and 18.9 on average) than non-Native households (between 9.8 and 16.0). In all but two years (1985 and 1988), Native households also harvested a greater number of resources. The differences in the number of resources used, attempted, harvested, received, given away, and used but did not harvest are statistically significant in some years but not most (Table 2-14). However, a high level of variability in the sample is most likely the reason that t-tests did not yield more significant results and these differences are likely still meaningful. It also appears that sharing patterns among Alaska Native households tend to be higher with increasing activity through 2003, until a drop from 7.9 resources given away on average per household in 2003 to 4.9 in 2014. Similar to Chenega, Tatitlek, Nanwalek, and Port Graham, the continuous decline in the number of resources used that began in the early 1990s is evident for both Alaska Native and non-Native households in Cordova.

In conclusion, notable decreases in resource use and harvest diversity are apparent across all household types in Chenega, Tatitlek, Port Graham, and Nanwalek, including various household compositions and commercial fishing households, and in Cordova across both Alaska Native and non-Native households. Potential causes of this downward trend including differences in species availability and age are examined in detail in the following section.

Trends in Resource Use and Harvest

This section addresses objective 5: Conduct an analysis of changes and potential causes of changes and trends in resource harvests, including potential links to lingering EVOS effects. Data show a notable decrease in harvest diversity, after it rebounded in the years immediately following the oil spill, especially between 2003 and 2014 (Figure 2-7, Table 2-5). To explore additional factors that might contribute to this decrease in resource diversity, this section examines the trends for specific species and the relationships

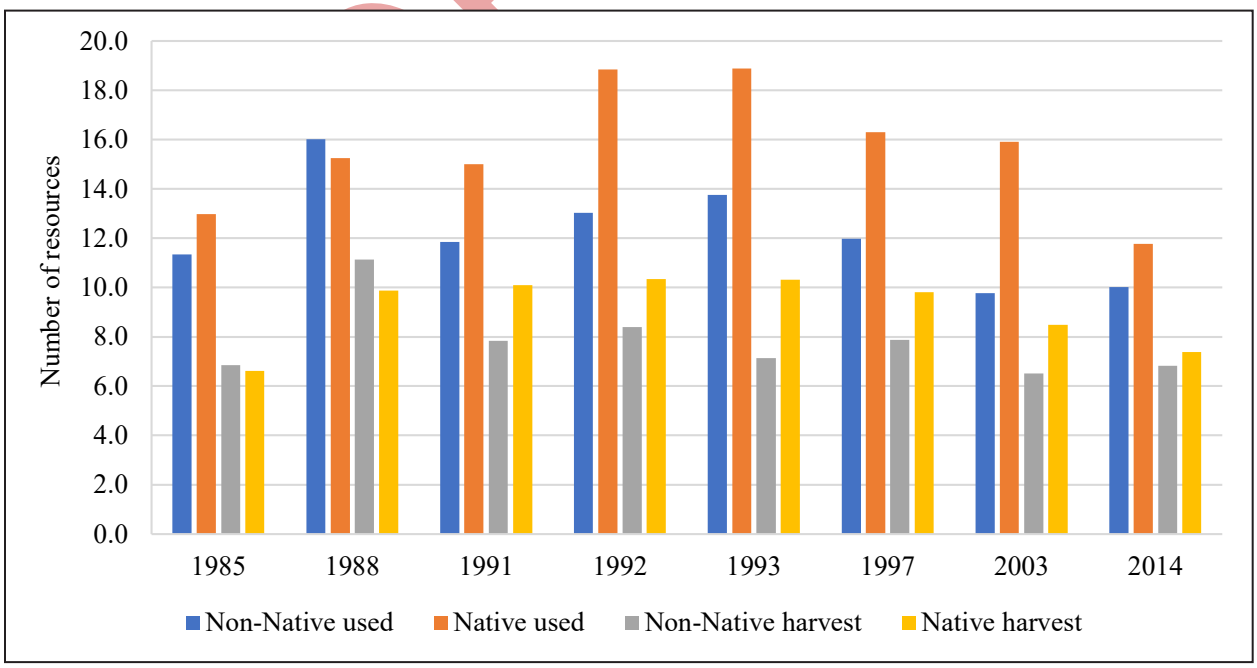


Figure 2-17.–Number of resources used and harvested by non-Native and Native households, Cordova.

Table 2-14.–Harvest, use, and income characteristics, Cordova, 1985, 1988, 1991, 1993. 1997, 2003, and 2014.

	1985			1988			1991			1992		
	Non-Native households	Native households	Sig.	Non-Native households	Native households	Sig.	Non-Native households	Native households	Sig.	Non-Native households	Native households	Sig.
Used	11.3	13.0	0.155	16.0	15.3	0.755	11.8	15.0	0.060	13.0	18.8	0.129
Attempted	9.6	8.5	0.326	13.1	12.3	0.760	9.7	12.1	0.191	10.2	12.7	0.514
Harvested	6.9	6.6	0.797	11.1	9.9	0.599	7.8	10.1	0.172	8.4	10.3	0.411
Received	3.0	4.0	**0.028**	3.5	3.2	0.693	5.2	6.8	0.225	6.7	11.0	0.123
Gave away	3.1	4.1	0.136	5.8	5.4	0.767	2.7	4.7	**0.002**	4.6	6.3	0.324
Used but didn't harvest	4.5	6.4	**0.003**	4.9	5.4	0.686	4.0	4.9	0.331	4.6	8.5	0.074
Percapita	193.6	180.2	0.777	285.5	224.9	0.382	204.3	268.7	0.325	209.3	210.8	0.988
Pounds harvested	431.7	448.1	0.853	729.1	594.9	0.479	505.6	727.3	0.103	574.1	465.4	0.567
Other income	$1,048	$1,173	0.318	$4,342	$4,862	0.691	$6,074	$9,605	0.073	$6,055	$11,376	0.45
Wage income	—	—	—	$66,723	$65,884	0.935	$56,125	$57,885	0.881	$56,894	$26,445	**0.002**
All income	$1,048	$1,173	0.318	$66,355	$66,628	0.980	$61,479	$59,596	0.876	$61,323	$33,414	**0.003**

Table 2-14.–Continued.

	1993			1997			2003			2014		
	Non-Native households	Native households	Sig.	Non-Native households	Native households	Sig.	Non-Native households	Native households	Sig.	Non-Native households	Native households	Sig.
Used	13.8	18.9	**0.010**	12.0	16.3	**0.008**	9.8	15.9	**0.000**	10.0	11.8	0.092
Attempted	9.5	12.1	0.179	9.9	12.0	0.186	7.2	9.4	0.133	7.5	8.2	0.524
Harvested	7.1	10.3	0.051	7.9	9.8	0.148	6.5	8.5	0.134	6.8	7.4	0.569
Received	8.5	11.2	0.165	5.8	9.2	**0.002**	4.3	9.7	**0.000**	4.4	6.3	**0.018**
Gave away	4.4	4.9	0.685	4.2	7.9	**0.000**	3.3	7.9	**0.000**	3.2	4.9	**0.027**
Used but didn't harvest	6.6	8.6	0.274	4.1	6.5	**0.003**	3.2	7.4	**0.000**	3.2	4.4	0.079
Percapita	145.5	158.1	0.802	163.5	379.2	**0.002**	170.9	299.4	**0.048**	116.2	169.5	0.056
Pounds harvested	383.7	493.5	0.502	452.7	887.6	**0.002**	406.0	656.3	0.058	301.0	375.2	0.378
Other income	$8,781	$14,033	0.161	—	—	—	—	—	—	$12,365	$7,798	0.120
Wage income	$50,503	$37,198	0.248	—	—	—	—	—	—	$97,338	$88,223	0.522
All income	$57,562	$46,582	0.306	$53,837	$63,103	0.201	—	—	—	$102,800	$87,814	0.271

Source ADF&G Division of Subsistence household surveys, 1985–2015.

Note Bold cells indicate a statistically significant difference at $p < .05$.

between productivity and resource use with household head age in the communities of Chenega, Tatitlek, Nanwalek, and Port Graham.

Resource Use

Figure 2-18 shows the percent of households using resources in the four small communities combined. Resources are organized by the percentages of households using them and plotted in this box and whisker plot. In the box and whisker depiction of pre-spill data, 50% of all reported resources were used by between 6% and 48% of households. This range of resources is illustrated with the blue box. Another 25% of resources reported used in that year were used by between 48% and 92% of households. This is represented by the whisker stretching from the top of the box to the line at 92%. The lower whisker represents 25% of resources used by the fewer than 6% of households. The X symbol indicates the average percentage of household use of a resource. A higher average indicates more resources being used by a higher percentage of households. Looking at the box and whisker for any one year, 50% of all resources used fall inside the box. A shorter box indicates a narrower range of percent of households using the middle 50% of resources. This is one metric to evaluate the decline in diet breadth: Beginning in 1989, the dots above the whisker line represent resources used by a large percentage of households. These outlier resources are generally outside of the broader community pattern of the of resources used overall. Outlier resources are determined by calculating the difference between the percentage at the top of the blue bar and the percentage at the bottom of the blue bar. This value is known as the inter-quartile range (IQR). Any resource used by a percentage of households that is 1.5 times the IQR is flagged as an outlier. The next metric that illustrates the decline in diet breadth is the median, represented by the blue line cutting across the middle of the box. The median represents the percentage of households using the resource that falls in the middle of the list when organized by percentage of use. This value drops from about 18% to 6% in 1989. While the value of the median fluctuates over time, it does not appear to return to pre-spill levels. This is also true for 1991 where there was an increase in the number of resources for a higher percentage of households. The figure suggests that marginal and opportunistic resources are used significantly less in later years, with the decline in diet breadth beginning with EVOS, followed by a modest recovery that leveled off beginning in 1991. The steep drop in the number of resources used between 2003 and 2014 is readily apparent.

Figure 2-19 highlights a broader decline in use based on individual wild resources. While use of sockeye salmon harvests is historically consistent after rebounding from EVOS, use of other resources is either down significantly (herring and halibut) or simply fits the pattern of less use (harbor seals and deer).

It was important to explore whether the age of household heads was related to these downward trends in resource diversity to see if household heads who were children during EVOS have different levels of resource use that could be associated with EVOS effects. Figure 2-20 shows the range of number of resources used by household head age groups in 2003 and 2014. Age groups are based on household heads who were younger than 16 during EVOS (blue) and those who were adults (orange). In 2003, the group of younger households used an average of 11.5 resources, while the older group used an average of 21.5 resources. The differences in number of resources used between age groups was not statistically significant ($t(108) = 0.062$, $p > 0.05$), but this was likely due to a relatively small population of household heads under the age of 32 as compared to the population of the older group. Therefore, the difference in number of resources used between age groups remains notable. In 2014, the group of younger households used an average of 9.3 resources, while the older group used an average of 15.2 resources. There was a statistically significant difference between household heads over the age of 40 and those 40 and younger ($t(128) = 0.000$, $p < 0.05$).

To explore whether the difference in resource use diversity between age groups was a result of the oil spill, Figure 2-21 incorporates study years prior to EVOS. Age cohorts match those of the 2003 and 2014 datasets: resource use by households with the oldest household head aged 32 and younger (blue) is compared to use by those older than 32 (orange), and resource use by those 41 and younger (gray) is compared with use by those older than 41 (yellow). Again, there is a statistically significant difference ($t(122) = 0.005$, $p < 0.05$) for household heads under the age of 32 compared with older households, where younger households used an average of 17.3 resources and older households used and average of 22.7 resources. The difference

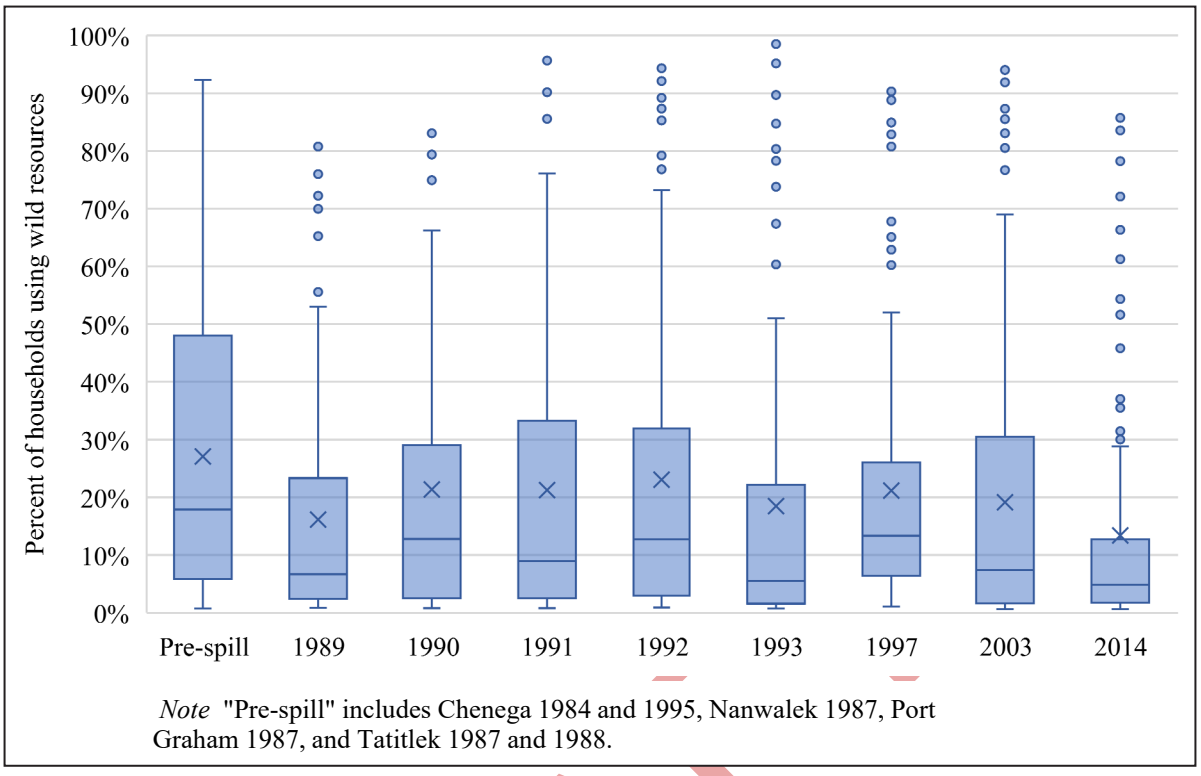


Figure 2-18.–Percent of households using wild resources, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

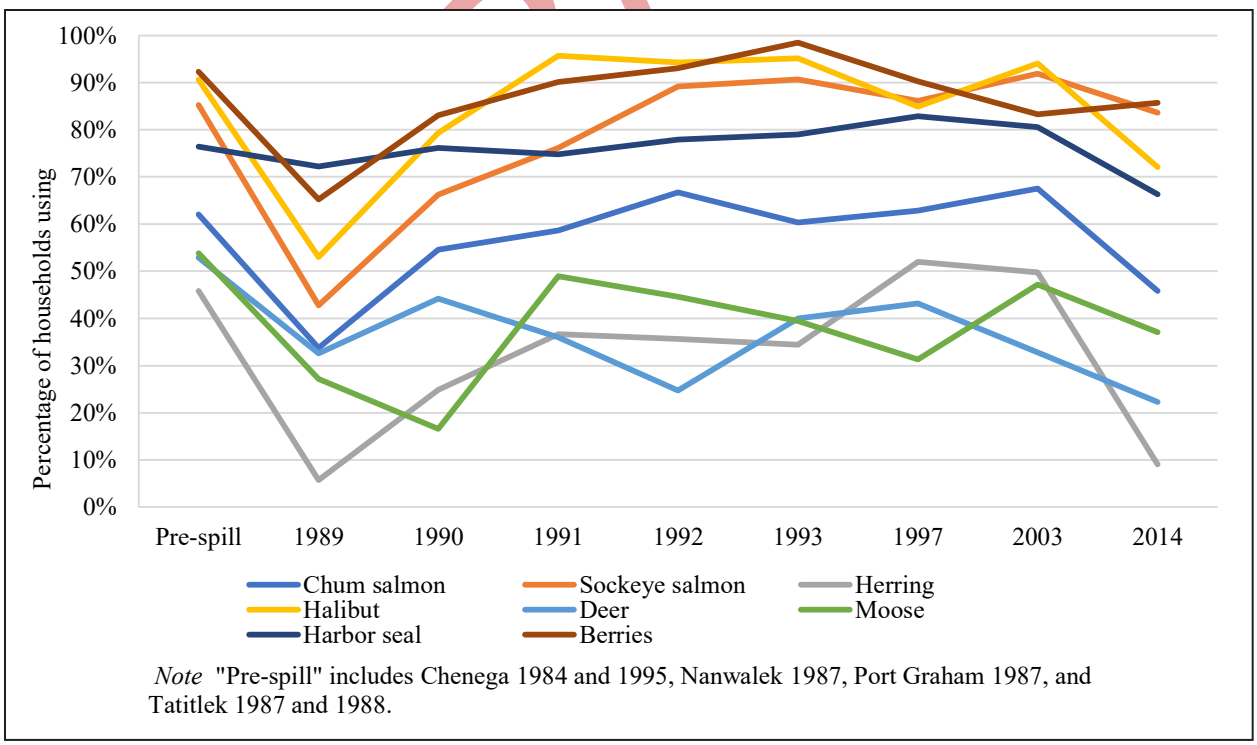


Figure 2-19.–Household use of selected resources over time, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

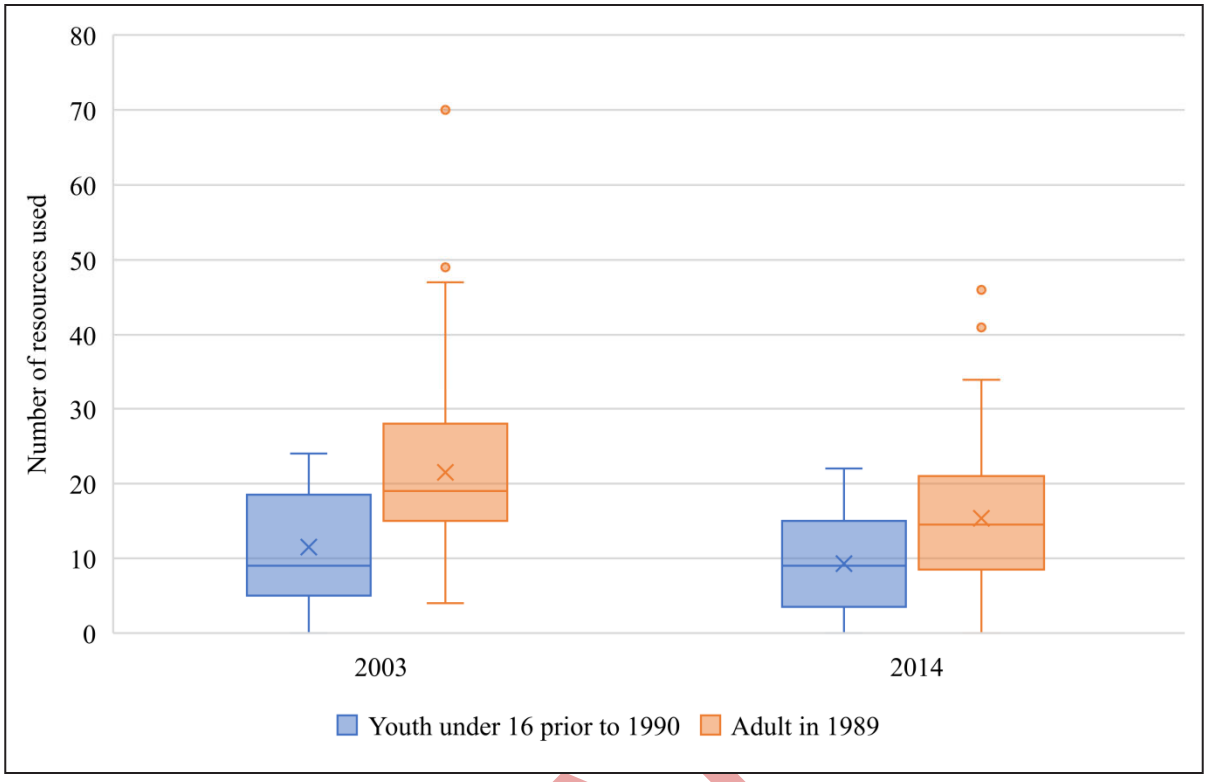


Figure 2-20.–Number of wild resources used, by age group, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 2003 and 2014.

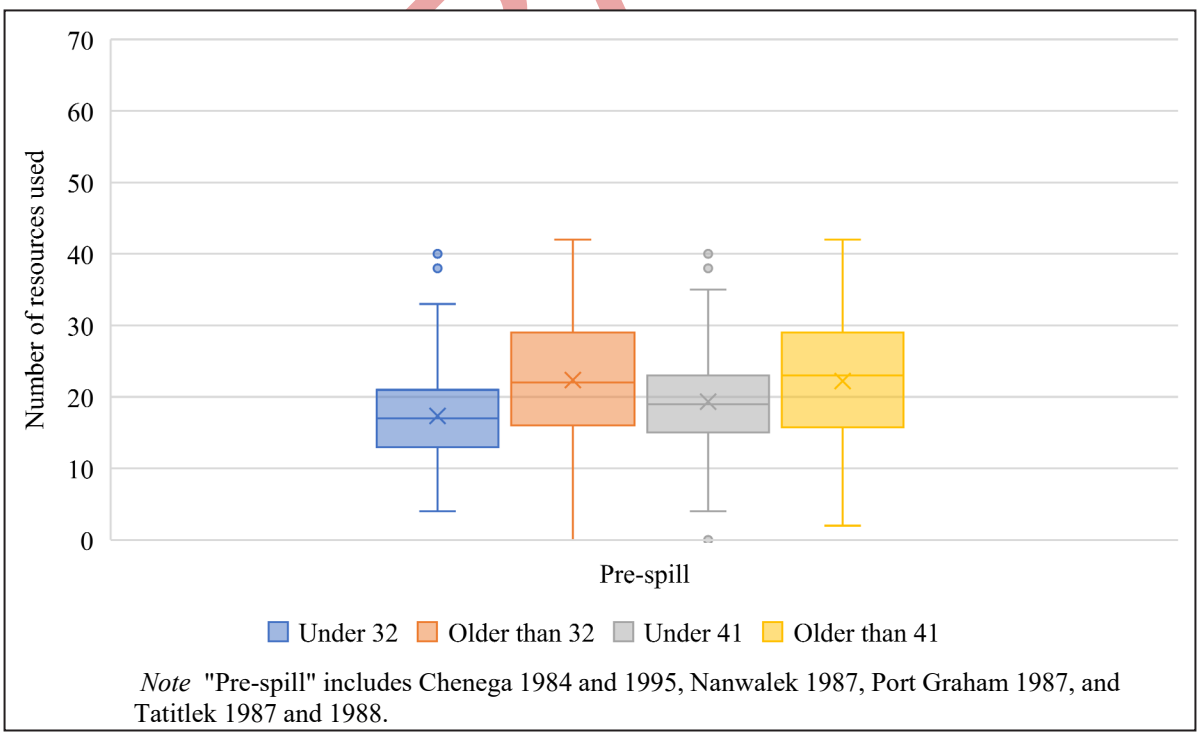


Figure 2-21.–Number of wild resources used, by age cohorts matching the 2003 and 2014 age groups, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill.

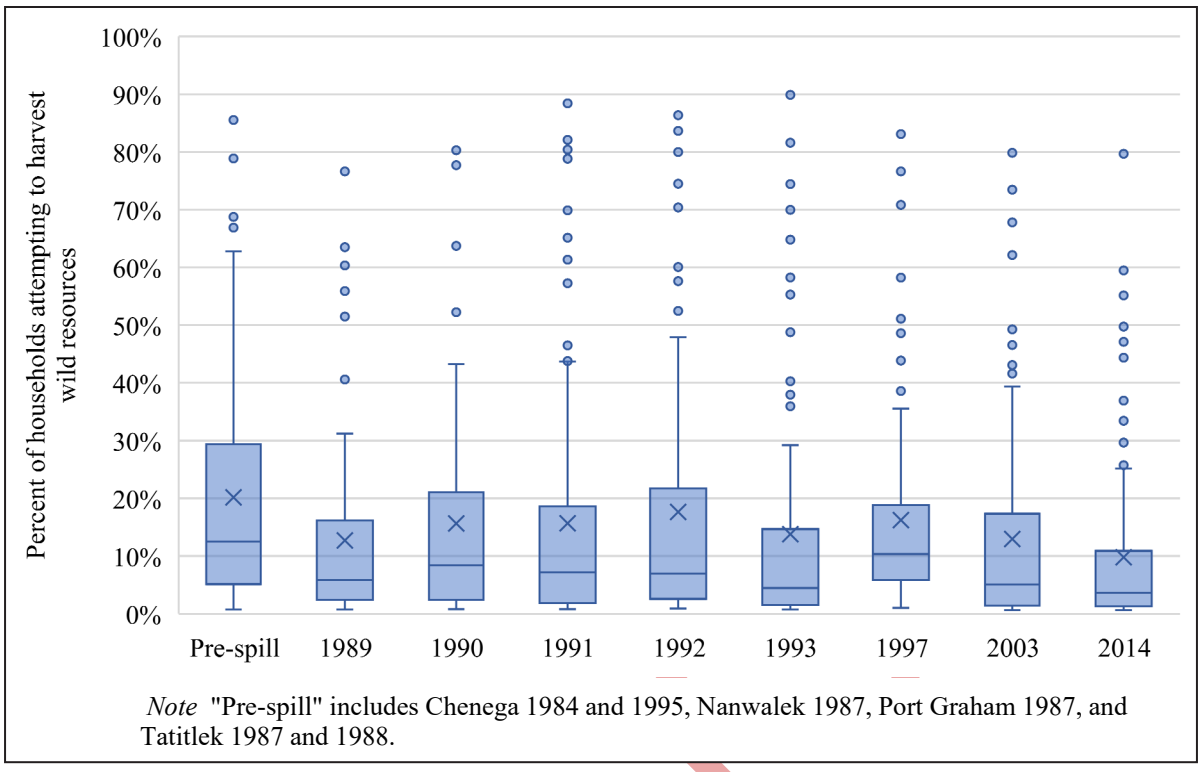


Figure 2-22.–Percent of households attempting to harvest wild resources, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

in resource use between household heads under the age of 41 compared to older households is also statistically significant ($t(122) = 0.001$, $p < 0.05$), where younger households used an average of 19.3 resources and older households used and average of 22.2 resources. This suggests that the relationship between age and resource use diversity was evident before EVOS.

Resource Harvest

Figure 2-22 shows the percent of households attempting to harvest resources. Like Figure 2-18, 50% of all resources households attempted to harvest fall inside the box, and a shorter box indicates fewer households attempted to harvest 50% of resources. The dots, as outliers, represent resources with a high percentage of attempts, but fall outside the broader community pattern. Blue lines cutting across the middle of each box represent the median, or how many households attempted to harvest the resource that would fall in the middle of the list when organized by attempt. The X indicates the average percentage of hosueholds that attempted to harvest a resource. The top of the blue box, representing roughly the top 75% of resources households attempted to harvest, drops in 1989 and does not return to pre-spill levels. The median, represented by the blue line, also drops and remains below pre-spill levels. Both of these illustrate that that fewer households attempted to harvest about half of the resources, and dots indicate a smaller set of resources that were consistently targeted over time. This displays a steep decline in the number of resources households attempted to harvest between 2003 and 2014. Overall, it again appears that diet breadth dropped in 1989 and never recovered to pre-spill levels.

Figure 2-23 shows the range of number of resources attempted to harvest by age group in 2003 and 2014. Age groups are based on household heads who were younger than 16 during EVOS (blue) and those who were adults (orange). Results for number of resources households attempted to harvest generally match those of resources used, although we did not find a statistically significant relationship for this comparison. In 2003, the group of younger households attempted to harvest an average of 11.5 resources, while the older

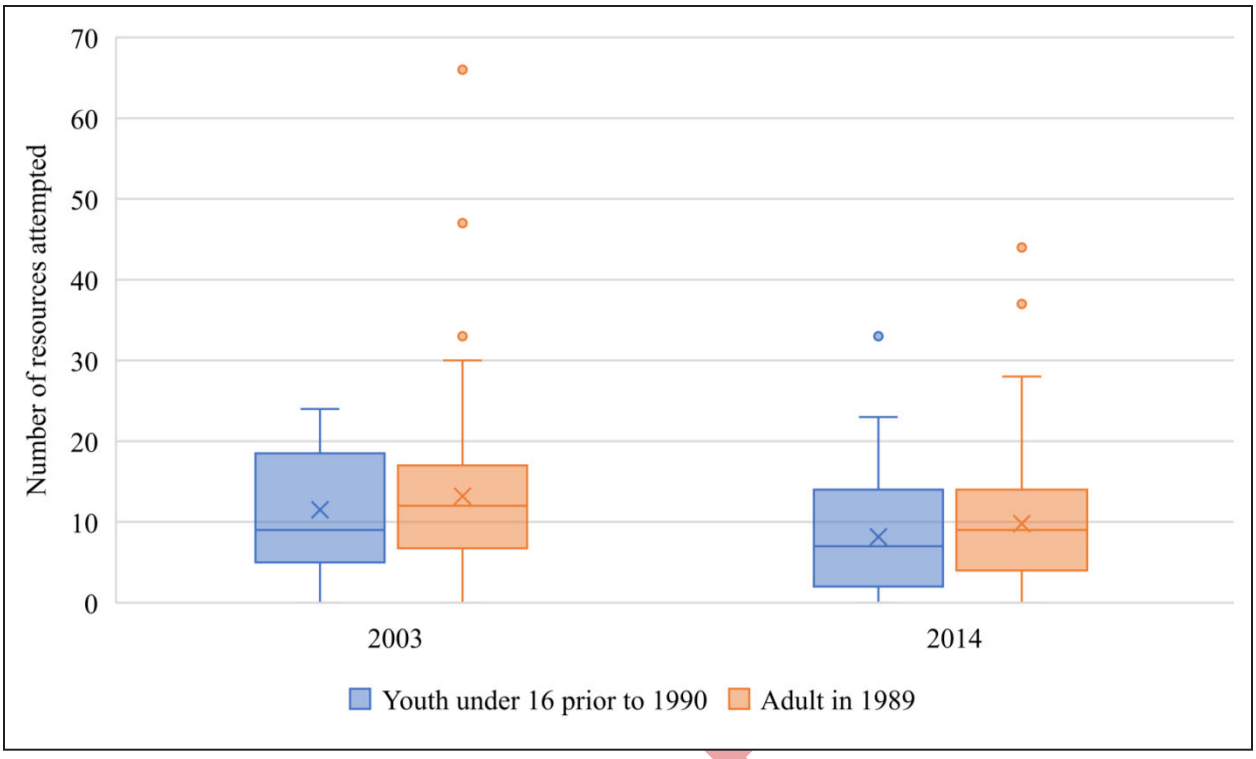
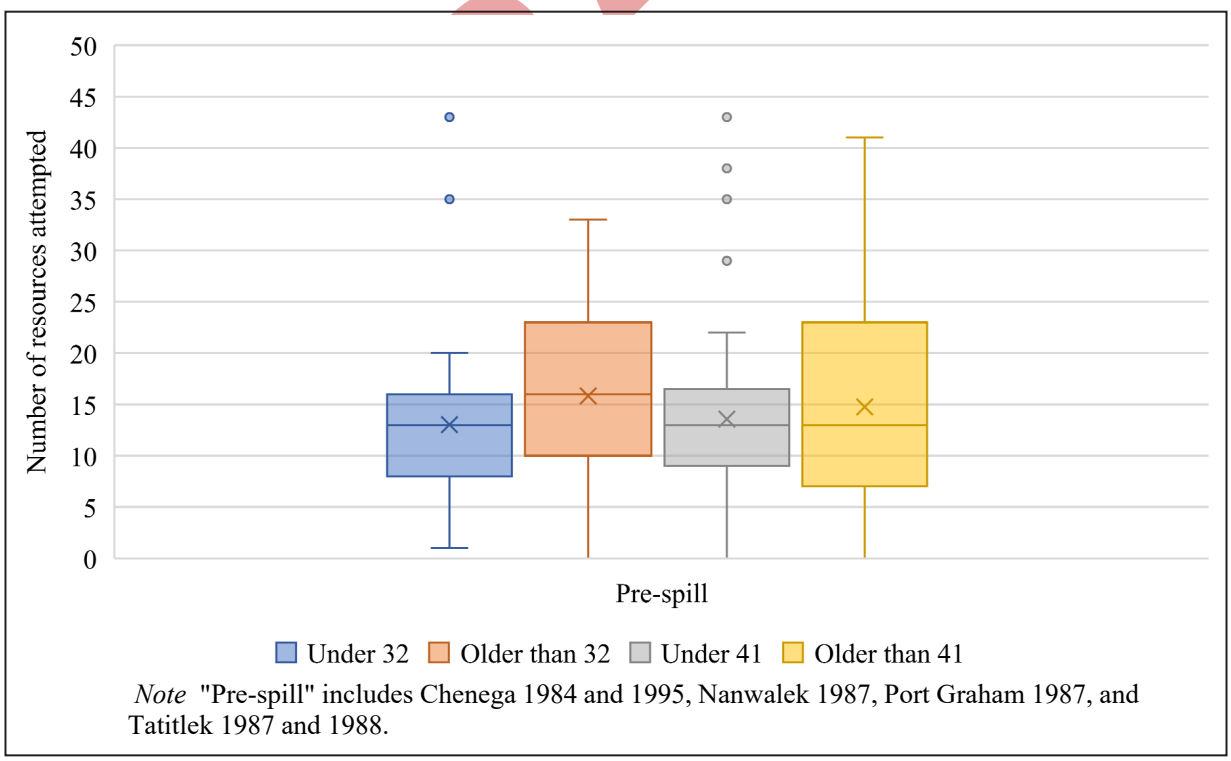


Figure 2-23.–Number of resources attempted by age group, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 2003 and 2014.



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-24.–Number of wild resources attempted, by age cohorts matching the 2003 and 2014 age groups, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill.

group attempted to harvest an average of 13.2 resources. While older households did attempt to harvest a more diverse set of resources, the differences were not significant ($t(108)=0.584$, $p > 0.05$). Similarly, in 2014, the group of younger household heads attempted to harvest an average of 7.4 resources, while the group of older households attempted to harvest an average of slightly fewer than 10 resources. Again, while the younger group tried for fewer resources on average, the differences were not significant ($t(128)=0.083$, $p > 0.05$).

To explore whether the difference in harvest diversity between age group was a result of the oil spill, Figure 2-24 compares the number of resources younger and older age cohorts attempted to harvest in study years prior to the oil spill. Age cohorts match those of the 2003 and 2014 datasets: households with the oldest household head aged 32 and younger (blue) are compared to those older than 32 (orange), and those 41 and younger (gray) are compared with those older than 41 (yellow). The average number of resources those 32 and under attempted to harvest before 1989 was 12.7, versus 15.5 resources by older households ($t(63) = 0.061$, $p > 0.05$). Similarly, the average resources those 41 and under attempted to harvest before 1989 was 13.6 versus 15.9 resources for older households ($t(122) = 0.122$, $p > 0.05$). Like findings for the 2003 and 2014 survey years, the differences in both age groups were not statistically significant. This demonstrates a similar pattern of greater diversity in resources attempted among older household heads both before and after the 1989 oil spill.

Participation in subsistence activities

Figure 2-25 depicts the total percentage of youth (under 16), adults, and elders (over 60) who reported participating in subsistence activities for Chenega, Tatitlek, Port Graham, and Nanwalek combined and shows a significant drop in percentage among all age groups between 2003 and 2014 for participation in subsistence activities, excluding harvest of plants and berries, especially by youth. When plants and berries are included with subsistence activities, data also show a drop in participation between 2003 and 2014, albeit less steep than when plants and berries harvest are not included.

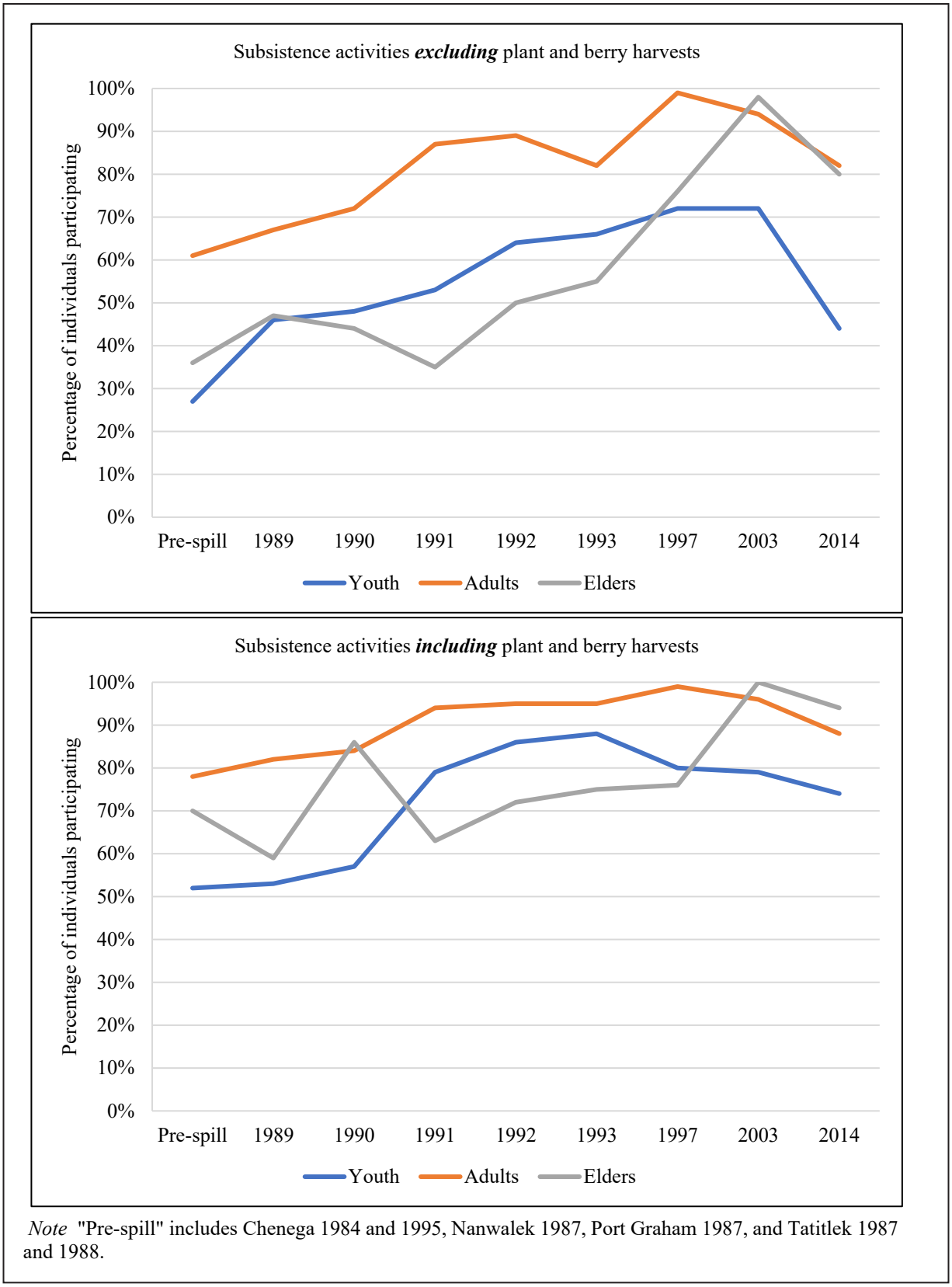
One of the patterns that appears to emerge from the various age comparisons above is that a reduction of use in some of the more marginal resources began to occur well before the most current dataset shows. Younger households, even in the years prior to EVOS, showed less diverse attempts to harvest certain resources, and in turn less diverse overall harvests, than older households.

Discussion and Conclusion

This chapter addressed four project objectives: classify households in the EVOS community dataset by type; conduct an analysis to identify characteristics of productive and non-productive households; for Cordova compare and contrast resource harvest and use patterns of Alaska Native households and other households; and conduct an analysis of changes and potential causes of changes and trends in resource harvests, including potential links to lingering EVOS effects.

How is total harvest concentrated in EVOS Communities and has it changed over time?

Consistent with the specialization documented in rural communities across Alaska (Wolfe 1987; Wolfe et al. 2010), wild resource harvests in Chenega, Nanwalek, Port Graham, and Tatitlek show a concentration of wild resource production where the top third of producing households contributes at least 70% of the total community harvest. It is important to note that the concentration of production remained consistent in the years immediately following EVOS, despite significantly lower levels of harvest. Since 1992, the percentage of total harvest produced by the high third has been increasing, ultimately reaching nearly 84% of the total harvest for all four communities combined in 2014. The sharp shift to extremely concentrated harvests by the high third of producing households for resources like sockeye salmon in Port Graham and Tatitlek is especially significant. While the exact causes are unknown, one possible explanation is that communities concentrate harvest efforts to produce larger quantities of the most consistent species (like salmon), which require more effort and resources (like boats and fuel) to harvest. However, additional study years are needed to determine the extent of this increased specialization trend. Meanwhile, possible explanations



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Figure 2-25.–Participation of youth, adults, and elders in subsistence activities, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.

for increased specialization can be better understood by examining patterns of production and distribution, characteristics of productive households, and how both have changed over time.

What are the characteristics of productive households and have they changed over time?

Several findings in this analysis of characteristics associated with productive households are consistent with findings from Wolfe et al. (2010). First, the high third of producing households likely overproduced to provide for other households and consistently gave away the greatest number of resources. However, both harvest diversity and the number of resources given away dropped sharply between 2003 and 2014, nearing similar levels to the year of EVOS. Second, single male household heads with children had the highest percentage of harvests falling in the high third of producers, followed by dual household heads with children. This is consistent with Wolfe's findings, where working age males (above the age of 15) were strongly associated with high levels of productivity. While households of single mothers with children less than 16 years of age were not the highest producers, they were not as heavily concentrated in the lower third as in the communities described by Wolfe et al. (2010), where 73.6% fell into the low third of producing households. Third, households with elders generally produced a smaller number of resources and received a greater number of resources than all households in most study years. These general patterns remained consistent despite changes in the level and diversity of resource use and harvest.

What is the role of commercial fishing in subsistence production and has it changed over time?

Commercial fishing was expected to be associated with high productivity due to associated levels of income as well as access to equipment. While commercial fishing did have a significant association with productivity, results suggest that ownership of essential equipment and the ability to capitalize on proximity to subsistence resources during free time may be the factors most associated with high production. The decline in overall commercial fishing participation corresponds with the decline in overall diet breadth. If commercial fishing is a proxy for cash income, this points to a situation where declines in diet breadth are driven by economic factors. Despite the decline, it is also possible that fishing is still a reliable source of income that has likely done a better job at keeping up with inflation. This suggests the need for a more in-depth study of the role of local participation in commercial fisheries in subsistence production, specifically the role of owning equipment rather than solely considering cash income.

What are the ecological, economic, social, and cultural factors associated with the changes and trends (less resource harvest, less resource diversity, less sharing) documented in subsistence production?

When assessing the potential causes of changes in harvest and use trends, the pattern of higher levels of both resource use and attempted harvest among older age cohorts is prevalent before and after the oil spill. For number of resources used, while the differences for age cohorts in 2003 was not statistically significant, the difference remains notable and is consistent with the finding that households prior to 1989 did have significant differences in these age groups. For the number of resources attempted, the cohort of younger households attempted to harvest similar numbers of resources in 2003 as the older cohort in 2003, but the numbers for the same cohort dropped in 2014. This suggests that household head age does play a role in harvest diversity, but changes in harvest patterns cannot solely be attributed to demographic shifts. While demographic shifts likely factor into the drop in harvest diversity seen between 2003 and 2014, it is not the sole driver of changes in harvest diversity. Thus, broader economic, social, or resource-based explanations should be considered.

In conclusion, the characteristics associated with high productivity of subsistence resources in EVOS-affected communities are generally consistent before and after the oil spill. While the volume and diversity of resources harvested and shared in the years immediately following the spill decreased, general patterns of sharing and productivity remained consistent. The most striking finding from the available dataset is the steep decline in resource diversity in use, harvest, and sharing between 2003 and 2014. Additional study years are essential for understanding whether the 2014 harvest was an anomaly, or part of a notable down-

ward trend. In the meantime, qualitative data provide vital insight into the ecological and socioeconomic factors that likely contributed to the 2014 decline, where resource use and diversity neared spill year levels. Chapter 3 will explore observed changes in resource abundance and diet breadth, local perceptions of barriers to intergenerational knowledge transfer, the influence of digital technology and the effect of a cash economy on subsistence traditions.

3. CHANGES AND TRENDS IN HARVEST PATTERNS: RESULTS OF QUALITATIVE DATA ANALYSIS

This chapter addresses project objectives 5 and 6: Conduct an analysis of changes and potential causes of changes and trends in resource harvests, including potential links to lingering EVOS effects, and identify hypotheses and conclusions in relevant ethnographic literature and other survey research and explore with Division of Subsistence quantitative data. Qualitative data from household harvest surveys across all study years, key respondent interviews conducted during the 2014 study year, and additional key respondent interviews from subsistence salmon surveys in Nanwalek and Port Graham in 2016 and 2018 were analyzed to understand changes and trends in wild resource use and harvest in EVOS communities more fully. Potential causes for the apparent decline in subsistence resource diet breadth include both ecological and socioeconomic factors. These factors are explored specifically through observed changes in resource abundance and diet breadth, and proposed broader social contributions including problems with the intergenerational transfer of knowledge, the influence of digital technology, and the effect of a cash economy on subsistence traditions.

Resource Abundance

Both quantitative and qualitative data convey a decline in resource availability by 2014. Quantitative harvest data demonstrate a virtual recovery in the volume of resources harvested starting in 1992, until the dramatic drop in 2014 that approached EVOS year levels. This trend is also reflected in qualitative data obtained during 2014 household surveys, when residents of Prince William Sound and Kachemak Bay communities reported declines in the abundance and availability of several subsistence resources. With the exceptions of a post-EVOS crash in herring and clam populations, 2014 interview participants generally believed that overharvest and environmental conditions were the primary reasons for the decline in resource availability, rather than EVOS-related effects.

Instead of citing EVOS, community residents consistently stated that nonlocal sport fishing and commercial sport fishing charters have heavily affected Chinook salmon and nonsalmon fish populations, especially halibut and rockfish. In addition to the quantity of resources, residents also consistently reported that the average size of halibut had declined as a result of these activities (Jones and Kostick 2016). Similarly, residents consistently stated that nonlocal residents' hunting has been negative for Prince William Sound and Kachemak Bay black bear populations, which are an important traditional subsistence resource in the region. In 2014, study respondents reported observations that local black bear populations had declined drastically as a result of nonlocal hunters pursuing black bears from boats along the shores of Prince William Sound, Cook Inlet, and Kachemak Bay. As one Nanwalek hunter said, "Bears are in trouble. They have been overharvested. We got all them guides coming from across the bay [Homer] that have been doing a lot of hunting" (Jones and Kostick 2016). Similarly, Chenega residents complained that better road access to Whittier since 1998 has provided spring bear hunters with easier boat access to Chenega. Residents noted that in many bays that were never hunted historically, 4–6 boats at a time can be observed looking for black bears in recent years.[1] In 2018, a Nanwalek hunter reported disgust that nonlocal black bear hunters often only pursue bears for their fur and relayed a recent observation: "The sad part was all they wanted was the fur...In fact there was some people who saw the carcass. They saw one up at the lake…[a] full carcass not one piece of the meat was taken off, just the hide was gone (AKSSF KRI NW4 2018). Another Nanwalek resident in 2018 said:

> We are how many years screaming about bears? "You guys are depleting our bears!" And for how many years we didn't see a bear. Now they are coming back

1. Joshua Ream, ADF&G Subsistence Resource Specialist, Chenega field notes, April 10, 2015.

> again, and all these hunters are coming out of the woodwork again. Come on, let them live a little bit, have more babies. (AKSSF KRI NW3 2018)

Respondents had similar concerns about other species. Residents of the Kachemak Bay study communities expressed concerns about increasing interest in mountain goat hunting by nonlocal sport hunters, while residents of Prince William Sound study communities expressed concern about nonlocal hunters overharvesting Sitka black-tailed deer. Prince William Sound residents also reported that record breaking snowfalls during the winter of 2011–2012 caused a crash in the Sitka black-tailed deer population and stated that the population is only slowly recovering.[2] Prince William Sound and Kachemak Bay communities engage in moose hunting for subsistence, but residents did not report concerns about changing moose abundance in the region. However, local residents have reported that both spruce grouse and ptarmigan are relatively scarce and thus are not often hunted for subsistence any longer (Jones and Kostick 2016).

Above all other resource categories, sustainability of marine invertebrate populations has caused the greatest ongoing concern among Kachemak Bay study community members. Because they are highly accessible intertidal foods, resources including various mollusks, octopus, snails, clams, cockles, crab, sea urchins, sea cucumbers, and chitons, are traditionally extremely important foods for EVOS region residents. Yet in 2014, community members reported observations of generalized declines in intertidal marine invertebrate resource availability. As one Nanwalek resident said, "Shellfish has been declining, now we need to travel further away to get what we need" (Jones and Kostick 2016). Beginning in the mid-1990s, Nanwalek and Port Graham residents also began to observe declines in the abundance and size of individual chitons (called "bidarkis" by residents). Both black (small) and red chitons are important traditional foods. Red chitons became especially rare and the average size of black (small) chitons diminished (Jones and Kostick 2016; Salomon et al. 2011).

Many Nanwalek and Port Graham residents openly blamed community overharvest of chitons as the primary cause for declines (Salomon et al. 2011). A Nanwalek elder said that the major declines in chiton abundance "have been more recent with more and more people going out for them." The elder also said that chiton harvests occurring in a concentrated area close to the community have only furthered the problem. "Some people don't have boats so they can't go too far, but they have freezers to store bidarkis in," said the elder. "They don't even give 'em a chance to get bigger," he continued, expressing his concern for the small size of the average chitons now harvested by the community (Jones and Kostick 2016). A 2014 Port Graham study respondent reported that the communities traditionally relied more on crabs and clams when they were available but that since these species are rarely available today, residents have increased their harvest of chitons. Similarly, a Nanwalek elder said that octopus harvests have also increased in response to the lesser availability of other shellfish.[3] Safety concerns are also reported for shellfish. These fears are predominantly centered around the risk associated with paralytic shellfish poisoning (PSP). While few people avoid eating shellfish because of this concern, they are cognizant of the risk.[4]

Noting concerns similar to the smaller average size of chitons, residents also said that harvest of very small clams is the norm today with harvest of large-sized clams now very rare. Multiple respondents asserted that sea otter predation is a major cause of the decline of clam populations in Kachemak Bay. "[Clams] have been wiped out pretty well," said a Nanwalek elder. Several respondents explained that during the mid-twentieth century, sea otter populations in Prince William Sound and Kachemak Bay began to recover immensely from past exploitation. Sea otters feed on many of the same marine invertebrates that are important to residents as subsistence foods. When the local sea otter population was depleted due to the fur trade, shellfish populations flourished in the region. Sea otter recovery meant burgeoning populations and increasing effects on marine invertebrates. However, residents do not view sea otters as the sole cause for marine invertebrate declines (Jones and Kostick 2016).

Subsistence hunters in Prince William Sound and Kachemak Bay communities also feel that marine mammals have declined. Hunters reported that it generally takes more time and effort to harvest seals and sea lions mainly because of having to travel further from the communities to be successful. Concerns mostly pertained to harbor seal scarcity rather than to sea lion populations, which were reported to have remained

stable. Nanwalek and Port Graham hunters assigned declines in harbor seal abundance to the depletion of groundfish stocks by sport fisheries operating in Kachemak Bay. Community members explained that seals feed heavily on groundfish and thus have been unable to maintain their populations because of an increased scarcity of prey. "Too many people fishing in the bay, trolling. At Yukon Island the charter boat or tourist boat that goes around that island is impacting the [seal] rookery there," said a Nanwalek elder (Jones and Kostick 2016).

While respondents generally agreed that the abundance of resources like Chinook salmon, halibut, rockfish, and numerous marine invertebrates had noticeably declined by 2014, few directly blamed EVOS for these changes. Instead, most respondents referenced overharvest by both nonlocal users targeting larger resources (like halibut and black bears) and local harvesters targeting easily accessible ones (like chitons). Concurrent with the perceived changes in resource availability is the tangible change in diet breadth. Surveys and interviews also shed light on the socioeconomic influences on the drop in diversity of resource harvest and use.

Changes in Harvest Composition and Subsistence Diet Breadth

Diet breadth is often measured by the average number of resources used per household in a study year. Quantitative harvest data revealed a striking drop in the number of resources used between 2003 and 2014, from a household average of 21.4 types to 13.3 types. In pre-spill years, households used an average of 21 kinds of resources. Diet breadth can also be measured by the number of specific resources used by 50% or more of community households. This measurement also reflects the drastic drop between 2003 and 2014. In Nanwalek, for example, 19 types of resources were used by 50% or more of Nanwalek households in 2003, compared to just 7 types in 2014 (Jones and Kostick 2016). In 2014, there were also no cases of an equal or greater percentage of Nanwalek households using any of the 25 most-used resources as reported in 2003. Instead, the drop in percentage of households using was substantial for many resources: halibut went from 90% using to 68%, octopus from 91% to 54%, Pacific tomcod from 64% to 16%, and black bear from 64% to 18%. On average, there was a drop of 31 percentage points when comparing values for these 25 resources across the two study years (Fall and Zimpelman 2016; Jones and Kostick 2016).

In 2014, survey respondents were asked to indicate reasons for changes in levels of resource use. The reasons most cited for less use of wild resources by Nanwalek residents overall were lack of effort (46%), working/no time (34%), less sharing (26%), other reasons (23% each), and lack of resources available (20%). Working/no time was the primary reason cited for less use of salmon (28% of households), the most harvested of all subsistence resource categories used by Nanwalek households, while 17% of households cited regulations as the reason for less use of salmon. Working/no time was also the primary reason cited for less use of seaweed (44% of households), vegetation, and marine mammals (each by 38% of households), and nonsalmon fish (28%). Less sharing was the primary reason cited for less use of large game (56%), followed by resource availability (22%) (Jones and Kostick 2016).

Qualitative data obtained through comprehensive and subsistence salmon harvest surveys provide additional context to the lack of effort, working/no time, and less sharing categories. In the 2014 and 2018 research particularly, community perspectives on these categories became increasingly pronounced and suggest that social and economic variables play a highly significant role in the apparent decline in subsistence diet breadth in the Prince William Sound and Kachemak Bay communities effected by EVOS. The remainder of this chapter discusses these socioeconomic variables through a focus on a perceived decline of intergenerational knowledge transfer, digital technology, and a cash economy.

Perceived Declines in the Intergenerational Transfer of Traditional Subsistence Knowledge, Skills, and Lifestyles

The first common explanation for the sharp decline in diet breadth, offered by key respondents and explored through household surveys, is a lack of intergenerational knowledge transfer related to the knowledge and skills of the traditional subsistence way of life. Notably, an established condition for subsistence recovery under EVOS is whether "the cultural values provided by gathering, preparing, and sharing food" have been "reintegrated into community life" (Exxon Valdez Oil Spill Trustee Council 1994). The 1999, 2003, and

2014 surveys included questions to assess youth involvement in subsistence activities. The first question asked if young adults are learning subsistence skills, and if not, why not. Across the three separate study years, the majority of survey respondents from Tatitlek, Chenega, Nanwalek, and Port Graham reported that the younger generations are not learning enough subsistence skills (Fall 2006; Fall and Utermohle 1999; Jones and Kostick 2016). Those who said that young adults were not learning the skills pointed to a general lack of interest as the primary explanation. A lack of teachers and changes in the traditional community way of life are the other primary reasons given for failure to learn subsistence skills by young adults across the study years. Additionally, having "no time" and having "too much else to do" are also frequent explanations given for intergenerational declines in subsistence participation (Fall 2006; Fall and Utermohle 1999; Jones and Kostick 2016). When community residents did report that young adults were learning enough hunting, fishing, and processing skills, this was primarily attributed to the influence of elders and other family members, as well as experiential practical involvement in subsistence activities, and participation in spirit camps and Alaska Native programs (Fall 2006; Fall and Utermohle 1999; Jones and Kostick 2016).

Elders play an important role in village life as leaders and teachers of traditional knowledge. The influence of elders is recognized as a measure of whether traditional practices and ways of life persist. Importantly, it has been noted that the EVOS event caused an interruption in the intergenerational transmission of knowledge regarding subsistence skills.[5] The second question addressing the status of the subsistence way of life asked if the role of elders in teaching subsistence skills and values in the community had changed over time. In 1998 most community residents reported that elders' influence had stayed the same, but in 2003 and 2014, most respondents began to report that elder influence has decreased (Fall 2006; Fall and Utermohle 1999; Jones and Kostick 2016). Demographic explanations provided by residents include the small size of the communities and a lack of replacement of community elders who have passed (Fall 2006; Jones and Kostick 2016). The distribution of ages in the population of all communities combined is reported in Appendix F, although individual communities exhibit different trends in age distribution. For example, a 2014 Port Graham study interviewee said:

> All the demographics has changed a lot. I mean we're getting younger and younger every year. There are more young children being born…. there are less elders in the community… a lot of elders passed away… (PG KRI2 2014)

Similarly, a primary reason given for the decrease in elder influence during the 2003 and 2014 surveys was that many elders had died or moved away, and that elders who were still alive were less active in subsistence activities and teaching subsistence (Fall 2006).

Overall, community residents often commented that the motivation to regularly participate in subsistence activities has declined intergenerationally. For example, in 2018, a Port Graham interviewee said:

> You know when I look at the younger generation, high schooler students and stuff, there's only a good handful of them that are actually going to go up there and do [subsistence fishing].The other ones just have no interest and no care in it. (AKSSF KRI PG7 2018)

When asked if the younger generations are helping as much as they used to, another Port Graham resident stated, "They don't like to do nothing" (AKSSF KRI PG8 2018). In the 2014 study, elders from Nanwalek told researchers that younger community members were not putting in enough time and effort to hunt marine mammals for the community, and that they wanted younger community members to hunt seals for the community because seals were traditionally harvested by younger hunters and shared with elders (Jones and Kostick 2016).[6] Similarly, in Cordova, survey comments included a request that persons obtain seals for elders because of a desire for braided seal gut, a traditional food that was said to have fallen out of use because the art of producing it had not been retained.[7] In 2018, a Port Graham interviewee stated that most

5. ADF&G Division of Subsistence household surveys, comments, Cordova, 2015.
6. Nanwalek Community Review Meeting notes, November 5, 2015, on file at ADF&G Division of Subsistence, Anchorage.
7. ADF&G Division of Subsistence household surveys, comments, Cordova, 2015.

youth today only fish "for fun, not for food" and that they lack the motivation to process what they harvest. "They just have fun doing it and then they just let [the fish] sit in their yard because they are too lazy to clean it. Or they expect somebody else to do it for them" (AKSSF KRI PG4 2018). Throughout the study years it has become common for older community members to recommend that younger persons are not only taught subsistence skills, but also that they become motivated to harvest subsistence foods to share them with community members in need.[8] In this regard, another Port Graham interviewee during 2018 stated:

> The ratio of people who go out and do stuff and the people that don't, it should add up so the people that go out and get all the stuff, then they should come back and provide for those that don't have anything, or those who are always needing food and stuff like that so it should be without a doubt those people that always overharvest, or even just harvest, they should be going back to the root of subsistence where they get the resources and spread it out throughout the village. (AKSSF KRI PG5 2018)

Many respondents feel that a lack of skill and knowledge related to subsistence is not alone responsible for the changes in participation and resource use. Instead, many attribute this change to a broader shift in cultural values like sharing and providing for the broader community. This can be better understood by exploring the perceived influence of digital technology and a cash economy.

The Influence of Digital Technology

A common explanation for the decline in the influence of elders discussed above was that cultural values had shifted and young people are not paying attention to elders because they are too busy doing other things. Specifically, respondents regularly referenced youth's reliance on digital technology in the form of social networking and video games. In both 2003 and 2014, study participants who believed that young adults were not learning enough subsistence skills regularly blamed their lack of interest on the adoption of digital technology (Fall 2006; Jones and Kostick 2016). For example, in 2003, several participants in the Tatitlek and Chenega surveys shared comments specifically related to young people's lack of involvement in subsistence activities due to technology:

- They have lack of incentive to learn—too many video movies;
- Too much technology and Game Boys, watching more TV;
- Too much TV and video games (Fall 2006:28).

Due to the prevalence of this theme, a new category of "technology and modernization" was added for coding qualitative survey responses in 2014, and it was frequently cited as an explanation by 2014 study participants. In a 2015 follow up interview, speaking of youth involvement in subsistence activities during the current decade, a Nanwalek elder with longstanding prestige as an important knowledge holder in the community stated, "Most of them, you know, they have all this high-tech stuff coming in, they're attached to them [digital devices] and too much different kinds of drugs and alcohol moving in to the villages." The respondent was then asked if he believed that the frequent use of smartphones had changed the traditional dynamics of the community: "Very much, even all the way to the adults, all the way to elders, I would say. Things from the outside, that'll do it." The perceived role of digital technology is comparable to respondents' frequent reference to another prevalent factor affecting traditional subsistence culture: the influence of a cash economy.

Involvement with the Cash Economy and its Effect on Subsistence Traditions

While it was not possible to directly compare household income with subsistence productivity in this study quantitatively, commercial fishing has an apparent and positive relationship with household productivity

8. ADF&G Division of Subsistence household surveys, comments, Cordova, 2015.

due to both cash income and the availability of necessary gear. This section further explores the perceived effect of a cash economy on subsistence traditions, specifically in terms of the influx of commercial foods, the ability to independently purchase boats and gear, and the resulting inability to afford rising gas prices. A primary theme from EVOS study participants has been that availability of cash among some households has allowed otherwise expensive commercial foods to be readily available, limiting the economic need to utilize local food sources. For example, in 2014, a Chenega respondent commented that due to the increasing availability of store-bought foods and cash to purchase these items, some residents now associate subsistence foods with poverty.[9] Multiple community residents have noted that availability of store-bought foods has affected the perceptions of younger community members. A 2014 Nanwalek study interviewee said "They are too much into different stuff. Their livelihood has changed completely. They turn down the Native food. They'd rather live on the warm-up food [microwave] or whatever there is easy access to."

In the 2014 study, multiple elders in Nanwalek mentioned the unprecedented influx in income resulting from the financial compensation received by community members as a result of EVOS. Elders asserted that this new level of access to cash negatively affected the community's social environment because individual families were able to purchase motorized equipment and other advanced technology, leading to a situation where participation in resource harvests became increasingly individualized and nuclear, and thus done increasingly less in the traditional communal fashion. As one elder explained:

> The oil spill in one way was worse for subsistence and traditional community culture because it gave everyone money, and this gave them the ability for each individual to have their own boat motor. Lots of people ended up doing subsistence only for themselves and overall, people shared lots less together. (Jones and Kostick 2016)

Similarly, in 2018, a Port Graham interviewee stated:

> [The] Exxon oil spill, you know, we had a bump up in the economy, so there was skiffs and stuff bought, so you will probably see a spike in the…permits that were fished then, [but] it's gone down since then. Even though you have permits issued, not all permits issued are fished now. (AKSSF KRI PG2 2018)

The respondent went on to say that this decline in active subsistence fishing has to do with an evolving unaffordability of transport fuel and other equipment. This became a common theme. As another 2018 Port Graham respondent stated:

> [There are] fewer jobs. It's harder for a family of people that have skiffs who end up needing to sell it just to pay their bills or make ends meet, whatever their intentions of getting rid of their boat knowing that they need it. Or they are moving out and they need to sell it. Or they have a skiff and there's parts broken, and they can't afford to fix it because there's no jobs available for them to make the money. They need to have their stuff keep running for them to subsist. (AKSSF KRI PG4 2018)

A 2014 survey respondent in Cordova said that it is "too expensive to go out to get fish and deer and other subsistence resources [when there is] no gas or means to go out and get it" (CSC 2014). Another Cordova respondent said that fuel available to the community has frequently been priced at over $5 per gallon and said that increase in overall transport costs "is becoming an impossible burden" for many Cordova households to be able to participate in wild resource harvesting activities (CKRI2 2014). A Port Graham interviewee in 2018 said, "Given the crisis for gas, the people who have the skiffs and the income to buy into nets and boats and outboards and gas is not what it used to be" (AKSSF KRI PG2 2018). Another Port Graham interviewee stated:

> It seems like less subsistence fishing because they don't have the transportation, they don't have a boat, they don't have a vehicle to go out on the road, so I think

9. Joshua Ream, ADF&G Subsistence Resource Specialist, Chenega field notes, April 10, 2015.

> they pretty much just hope and pray and dwell on the sharing by other people who are able to go and get the subsistence that they need. (AKSSF KRI PG4 2018).

A concern related to unaffordability of fuel and equipment is that localized depletion of some resources requires that fishers, hunters, and gatherers travel further to obtain them (Van Lanen et al. 2018). In 2003, Tatitlek residents noted that because of the time and costs required to travel longer distances, it had become increasingly difficult to get youth involved in subsistence activities and to teach them skills. Concerns about the costs associated with distance were more prevalent in 2014 and 2018. For example, in 2014, a Nanwalek study participant said, "Shellfish has been declining, now we need to travel further away to get what we need" (Jones and Kostick 2016), and in 2018, a Nanwalek interviewee said, "Fuel prices are so high and prevent people from traveling farther to get resources" (AKSSF KRI NW9 2018). When a 2014 Port Graham survey respondent was asked about the availability of halibut to the community, the respondent answered, "In the bay there is definitely less. Out in the ocean we don't have any trouble finding them," and continued stating:

> It definitely takes a lot longer to be able to harvest resources…the fact [is] that it takes so long to harvest what you usually get in a shorter amount of time, and so it is costing a lot more fuel to get whatever you do get…we joke all summer long about how the king salmon we are catching end up costing you $700–$800 depending on the price of fuel.(PG KRI2 2014)

Meanwhile, EVOS community residents also voiced concerns about the high costs of store-bought foods in the communities.[10] A 2014 Cordova study interviewee observed that the number of permanent residents in Cordova has declined likely due to a steeper increase in the overall cost of living in the community compared to places like Anchorage. A Nanwalek elder said that if store-bought food was not available "they gonna be in trouble: they wouldn't know how to subsist." The elder continued:

> We have to tell our younger generation to be aware of what is coming up in the future, to watch carefully what they are doing, and watch carefully what is happening in the world…Gas has been going up. It's way over $6 a gallon, but these kids and people, how can they afford it? And we wonder where they are getting all that money? It's easy to figure that out. Too much hand-outs [from welfare subsidies, food stamps, etc.] So, if that stops, that might take care of everything, we might go back to our own tradition. (NW KRI1 2014)

In 2014 and 2018, Port Graham and Nanwalek residents voiced concern over a related phenomenon where former community residents who have moved out of the communities to obtain jobs in Anchorage return to the Kachemak Bay areas surrounding the communities to harvest subsistence resources because their urban based incomes provide them the capacity to do so. Interviewees said that when these people harvest resources in the area they normally return to Anchorage with their harvests and leave little or none to actual residents. "A new thing that's impacting our resources is that a family that's gone to live in the city, they come home and fish for a week and get all kinds of stuff and take it home," said a Port Graham respondent (AKSSF KRI PG6 2018). Similarly, Nanwalek study participants reported that shellfish depletion, particularly chitons, was being driven by a demand for this resource from urban relatives (Jones and Kostick 2016). Port Graham interviewees in 2018 expressed that urban attitudes about hunting coupled with related ideals about cash and profit have led to wasteful harvests of resources in the area. A Port Graham resident said that such bear hunters are not only hunting just for the skin, but also for "the gall bladder, which is worth thousands of dollars, or the bear pecker. That's just wanton waste, greed" (AKSSF KRI PG6 2018). Another study participant continued, "If I were to get [a bear] that [meat] would have spread around to whoever wanted to have the bear meat, not so it's just going to waste up on the mountainside and then someone having a wallet full of cash" (AKSSF KRI PG5 2018).

10. Joshua Ream, ADF&G Subsistence Resource Specialist, Chenega field notes, April 10, 2015.

In 2018, Nanwalek residents voiced concern that monetary incentives were corrupting a program sponsored by the local government that compensated younger hunters and fishers for subsistence harvests that were shared with elders who can no longer participate. A Nanwalek study participant provided an extended narrative explaining that the deeper negative implications of such a program for maintaining subsistence traditions are being overlooked:

> The fact is that those elders who aren't able to go out and subsist anymore, the community has a program that helps to put away food for them…It keeps the tradition alive in the subsistence livelihood. The problem I have with it is it's being done by the youth of the community and they're being paid for that service. And that's counterintuitive to what subsistence is, which is the understanding that if I don't do this I'm not going to survive. These kids are being taught, well if I do this for the elders, I'll get paid for it. So that when an elder asks them to do something for them outside of their workday, that same youth isn't going to be as willing, but rather that youth is going to say well how much are you going to pay me? So, it puts monetary value on subsistence and survival. From the standpoint of this generation of kids it's a dangerous place. In my opinion, it's a dangerous lesson to teach the kids. Because the reality is if they don't continue to live this lifestyle of subsistence then they're obviously going to become more dependent on the government. And that just means they're going to be spending their whole lives at the unemployment line, at the welfare line, buying groceries from the store. And all of these natural resources, all of these foods that are surrounding—surrounding them, surrounding us—don't get utilized. I don't want to say the subsistence livelihood would die, but that's the reality, there'd be few people practicing subsistence lifestyles and more people practicing a western society lifestyle, going to the store to buy their groceries. (AKSSF KRI NW7 2018)

The Nanwalek respondent also said:

> Paying kids to harvest subsistence foods for elders is—don't get me wrong—it's not a bad thing, but it's also detrimental to an elder. To where that elder becomes dependent and relies upon those harvests from the youth, but they no longer go out on their own. So, it could also kind of speed up the [aging] process of an elder, who's already had, essentially has one foot in the grave already. It could just kill their will to continue to practice that strong lifestyle of subsistence. (AKSSF KRI NW7 2018)

In a 2018 interview, an elder in Port Graham and his grandson had a pointed conversation on the larger topic of how money has influenced socioeconomic evolution and people's perspectives in the community. The elder said to researchers:

> We're losing [our subsistence traditions] in a faster pace [and] losing our spirituality…This community is selling itself to the government to get more grants…we are losing it by doing that kind of stuff, by not living [our traditions]…. We've become a welfare system. Welfare Indians, or whatever you want to call us. We just stand there with our hands out and the government gives us money… [We] gotta get back to helping one another. Even liking one another. That's the way it should be. Right now, this ain't a community. Its individual households. No interaction. To have a community you need that interaction or you're not a community in a cultural sense. (AKSSF KRI PG6 2018)

The respondent's grandson replied:

> I understand what he's talking about. There isn't that kinda drive in my generation, the younger generation where you don't see the enthusiasm when it comes down to it. Talking to my friends they say, "Oh yeah I want to go after this job and then I'll

> make some money," and then when it does happen it's not like towards the village anymore [it is in Anchorage]. I think there's a cultural disconnect where there's not too many people, not too many of my friends that want to come back here and help run this place or help maintain it. It's all, "I wanna go out of town." I just think that there needs to be something to bring that kind of pride and stuff back into the village, to see more people, not even just in my generation, but those a little bit older than me, where you just don't see people wanting to get out and do anything. It's just all stay in their house and hope for some free money. You don't see like the older generation used to do; they'd work for something and then they earn their money and then that's how they got their gas and their materials or whatever equipment they needed to go out there and just an overall lazier generation coming up in the future…There's hardly anybody in the village that even goes hunting….I think back to when it was survival of the community relying on these things, and back then it was more or less based on real survival needs for everyone to eat, but I think we are facing a different type of survival where it is a cultural survival of the village that we're facing. (AKSSF KRI PG5 2018)

Speaking to his grandfather the grandson said:

> Listening back to your stories, how you said your happiest times was the times where it was hardest; the struggle is what brings everyone together because you rely on everyone and therefore you build a strong bond between each other, and maybe that's what we need for us to get back together, is a struggle like that. (AKSSF KRI PG5 2018)

The grandfather respondent replied:

> When everyday was a struggle it put food on the table for the people, and every day you accomplished it, you had an accomplishment, you felt good about it, "I fed my family. I fed my community." Those days are gone. We got two stores here. We got all these microwave foods....(AKSSF KRI PG6 2018)

While quantitative data could not produce a direct correlation between income and subsistence productivity, qualitative data provide strong support for the significant effect of a cash economy on subsistence traditions, practices, and values.

Discussion and Conclusion

The documented declines in harvest diversity and use are noteworthy signals of a changing pattern of subsistence uses by the EVOS communities. Based on the available study years, in terms of total pounds harvested per household in 2014 as compared to similar cohorts in 1987, there is no solid indicator that 'younger' households are becoming less productive relative to older households. Qualitative data offer several explanations for the sharp drop in diet breadth, which are based heavily on socioeconomic factors rather than environmental ones.

What is the role of perceived changes in resource abundance?

Qualitative survey and interview data related to resource abundance reflects the drop exhibited in quantitative data. By 2014, the documented decline in reported resource diversity is also evident in qualitative reports of decreased resource abundance including Chinook salmon, halibut, rockfish, and numerous marine invertebrates. Overwhelmingly, respondents blamed the decreased resource abundance on a combination of outside pressures (like charter boats and sport hunters) and localized pressure on readily accessible resources (like marine invertebrates), rather than attributing the decline directly to EVOS effects. Respondents also brought attention to the smaller size of resources, many alluding to harvesters not allowing resources like chitons (or "bidarkis") to reach their proper size.

Was use of certain resources in past surveys linked to the presence of an older person in a household? Is loss of resource diversity linked to the disruption by EVOS of the transmission of skills and values from elders to youth?

In examining social dynamics, the noted decrease in knowledge transfer from older to younger generations was a prevalent theme in later study years. This included a perceived diminished role of elders (often due to elders passing away without anyone replacing them), youth's lack of interest in traditional skills (often attributed to the influx of digital technology), and a broader shift in cultural values where younger generations are perceived to lack traditional values (such as providing for the broader community). While some programs exist to support traditional harvest and sharing for elders, like the subsistence harvest program in Nanwalek, some respondents were concerned that offering monetary compensation for traditional activities diminished the associated cultural values. Additionally, respondents were more likely to blame the influx of cash from EVOS payments in the early 1990s for making people accustomed to commercial foods and enabling them to purchase their own equipment, as opposed to loss of resource diversity directly linked to EVOS effects on natural resources. Numerous respondents worried that the influx of cash had damaging effects on traditional subsistence values: younger generations suddenly preferred nonsubsistence foods and grew up in a time where individual households temporarily had the resources to obtain individual boats and other technological resources rather than engaging in communal acts of resource production that were based on sharing of harvest technologies.

How has the cash economy impacted subsistence activities?

Respondents highlighted the fact that many households eventually lacked the consistent income needed to maintain equipment and purchase fuel for harvesting resources. The problem was compounded by the resulting pressure on localized resources, which quickly became depleted. Many respondents felt that the combination of external and localized harvest pressures made it harder to reach abundant resources, which became exclusively accessible to the small percentage of households that still had the necessary equipment and income. Comments documented on this subject may help explain the dramatic shift towards a very small percentage of households harvesting the majority of resources in 2014, and the sharp shift from diverse resource use to reliance on a few select, more reliable resources such as salmon.

Conclusion

Only additional study years can determine whether 2014 was an anomaly, or part of an significant trend in subsistence resource use in EVOS communities. However, evidence of harvest diversity declines in tandem with the ethnographic commentary support the idea that there is a generally occurring shift away from some key traits of the traditional subsistence way of life known by earlier generations. The ethnographic record for contemporary hunter-gatherers globally points to an overall trend of adopting commercial foods and other modern conveniences at the expense of traditional sustenance and community engagement, where as soon as people begin a pathway towards dependency on industrial goods similar patterns as those discussed by EVOS study respondents emerge (Dallos 2011; Eibl-Eibesfeldt and Hitchcock 1991; Griffin 1991; Hitchcock et al. 2011; Lye 2004; Ready and Power 2018; Wenzel 2013). As such, analysis from cultural anthropology research would frame this situation as a slow erosion of fundamental aspects of traditional subsistence life resulting from people's time and energy being redirected towards involvement with economic and technological modernity, irrespective of EVOS effects. While direct information for the study communities pertaining to technology and the cost of subsistence activities does not yet exist, existing qualitative results do suggest that socioeconomic and technological factors are important and require further inquiry as to their effects. While lingering EVOS effects likely contribute in some way to the broader social changes affecting participation in subsistence activities, existing qualitative data do not indicate that EVOS effects, such as changes in resource abundance, contamination or perceived food safety, are the driving factor in current subsistence trends.

4. CONCLUSION

Summary of Findings

This project used household level survey data to examine the economic, social, and cultural factors that have shaped subsistence harvest trends in communities affected by the 1989 *Exxon Valdez* oil spill (EVOS). In fulfillment of project objective 1, data from over four decades of research conducted by the Division of Subsistence in the coastal communities of Cordova, Chenega, Tatitlek, Nanwalek, and Port Graham were formatted, organized, and uploaded into a unique database that included responses to all available survey questions. The database offered a complete picture of household responses to questions for all years covered in this report. In total, these data represent 40 community-year records, over 2,100 household records, over 6,500 person records, over 24,000 income records, and over 1 million harvest detail records. Qualitative data in the form of survey responses and key informant interviews were also analyzed. In combination, household-level quantitative data and corresponding qualitative data addressed five study objectives and five research questions (RQs). See page 15 for a description of RQs. Key findings are summarized below.

Objective 2: Classify households in the dataset by type (Chapter 2).

Classifying households in the dataset by type enabled researchers to address RQ1: How is total harvest concentrated in EVOS communities and has it changed over time? When examining the total production of wild resources by thirds of the communities' populations, the high third of producing households in Chenega, Nanwalek, Port Graham, and Tatitlek contributed at least 70% of the total harvest. This is consistent with specialization documented in large-scale analyses of rural subsistence communities across Alaska (Wolfe 1987; Wolfe et al. 2010). This concentrated distribution of production in the high third did not change in the year of the oil spill, even though the volume of harvest dropped drastically. However, the percentage produced by the high third of households has changed, with a continuous increase since 1992. By 2014 (the latest year in the dataset), the high third was producing nearly 84% of the total harvest. An examination of specific resources reveled an even greater shift. In Port Graham and Tatitlek, the high third of households harvested over 90% of sockeye salmon. It is possible that communities have concentrated harvest efforts on larger quantities of the most consistent species (like salmon), which require more effort and resources such as boats and fuel to harvest.

Objective 3: Conduct an analysis to identify characteristics of productive and non-productive households, including associations with household size, household type (developmental cycle), ethnicity, involvement in commercial fishing, employment characteristics, earned cash income, other cash income, and assessments of reasons for changes in harvests, among other factors (Chapter 2).

The first component of this objective was answering RQ2: What are the characteristics of productive households and have they changed over time? Consistent with findings from Wolfe et al. (2010), single male household heads with children were the most likely to fall into the high third of households, followed by dual household heads with children. Households of single mothers with children were not the highest producers, but they were not as heavily concentrated in the lower third as the communities described in Wolfe et al. (2010), where 73.6% fell into the low third of producing households. Finally, households with elders were generally associated with lower levels of productivity, but higher levels of resource use and receiving. These general patterns of production and use remained consistent over time, despite other changes. Most notably, the level and diversity of resource use and harvest declined across all household types, ultimately dropping again, between 2003 and 2014, to levels comparable to the year of EVOS.

Commercial fishing participation was expected to be associated with higher levels of household productivity. R3 asked: What is the role of commercial fishing in subsistence production and has it changed over time? Commercial fishing households were compared to non-commercial fishing households for the number of resources used, number of resources attempted, and average pounds harvested. Many of the differences were not statistically significant, but that can likely be attributed to small populations, so the differences remain notable. This is especially true for the average pounds harvested. Overall commercial fishing participation

declined over the study years, which corresponds with the overall decline in diet breadth. It is possible that commercial fishing remains a reliable source of income, but results also suggest the critical role of owning equipment to have the ability to capitalize on access to subsistence resources.

Objective 4: For Cordova, compare and contrast resource harvest and use patterns of Alaska Native households and other households, including changes in characteristics over time (Chapter 2).

This objective further addresses R2: What are the characteristics of productive households and have they changed over time? Alaska Native households are often associated with higher levels of productivity, and Cordova was the only community large enough to select a stratified sample of Native and non-Native households. As expected, Native households almost always used and harvested a greater number of resources. Again, while most differences were not statistically significant, a high level of variability in the sample is most likely the reason and differences are still meaningful. Similar to Chenega, Tatitlek, Nanwalek, and Port Graham, the continuous decline in the number of resources used beginning in the early 1990s is evident for both Alaska Native and non-Native households in Cordova.

Objective 5: Conduct an analysis of changes and potential causes of changes and trends in resource harvests, including potential links to lingering EVOS effects (chapters 2 and 3).

The analysis of changes and trends was guided by RQ4: What are the ecological, economic, social, and cultural factors associated with the changes and trends documented in subsistence production? Household head age was examined to see if older household heads who had been adults before the oil spill used and harvested a greater diversity of resources. An analysis of the same age cohorts before the oil spill showed similar differences between older and younger households, suggesting that household head age does play a role in harvest diversity, but changes in harvest patterns after EVOS cannot solely be attributed to demographic shifts.

Objective 6: Identify hypotheses and conclusions in relevant ethnographic literature and other survey research and explore with Division of Subsistence quantitative data (chapters 1 and 3).

RQ4 (What are the ecological, economic, social, and cultural factors associated with the changes and trends documented in subsistence production?) was further examined with qualitative data in Chapter 3. Little support could be found for lingering environmental EVOS effects being the primary driver in the downward trends of resource diversity. Instead, respondents blamed a combination of outside pressures (like charter boats and sport hunters) and localized pressure on easily accessible resources (like marine invertebrates). In addition, many respondents cited barriers to knowledge transfer from older to younger generations. These barriers included a perceived diminished role of elders as they passed away without being replaced, youth's lack of interest in traditional skills, distractions associated with digital technology, and broader value shifts away from traditional cultural values like providing for the community. Another common theme in responses was the negative impact of monetary compensation in the years following EVOS. Numerous respondents expressed that the abrupt influx of cash made people accustomed to commercial foods and enabled a shift from community production to individual ownership of equipment that could not be maintained. The problem of lacking resources to maintain equipment was compounded by the resulting pressure on local and easily accessible resources (which quickly become depleted) and the reliance on dependable resources that only a small percentage of households have the ability to harvest. These responses may help explain the degree of shift towards a very small percentage of households harvesting the majority of resources in 2014, and away from diverse resource use to reliance on a few select, more reliable resources such as salmon.

Discussion

The overall goal of this project was to contribute to the understanding of the broad set of environmental, economic, and sociocultural changes that have taken place in EVOS-effected communities from a local perspective, and to use findings to assist with planning for responding to future environmental or technological disasters in Alaska. There are two key findings: the overwhelming evidence of harvest diversity decline where overall per capita resource harvest levels were notably lower in 2014 compared to 2003, post-spill averages since 1991, and pre-spill estimates and the increase in specialization that is especially evident for

key resources like sockeye salmon. In this comprehensive analysis of "the total environment of change" (Moerlein and Carothers 2012), lingering environmental factors from EVOS appear to have limited influence in the minds of community residents, since there is no apparent evidence that these key changes are directly related to changes in resource abundance that can be linked to EVOS. While qualitative data create an image of sweeping cultural changes, findings from quantitative household-level analysis depict the persistence of trends documented throughout Alaska subsistence communities: concentrated harvest, consistent resource sharing despite varying harvest levels, higher resource diversity in elder households, and higher levels of subsistence harvest and sharing in commercial fishing households. This is consistent with findings from previous research (Fall and Zimpelman 2016) where EVOS contributed to a complex set of conditions, which continue to shape subsistence harvests and uses in the study communities. The practical question then becomes: how can communities address cultural changes that negatively impact subsistence practices and harvest diversity, and what should be the response to potential future disasters that may affect them?

Enhanced youth education about traditional knowledge and subsistence skills has often been cited by EVOS community study participants as a necessary pathway forward to maintaining the subsistence way of life (Fall 2006; Jones and Kostick 2016).[1] Community members assert that this education should not only be centered around youth involvement in subsistence activities, but also elder influence and actively teaching a sharing ethos as essential components of traditional subsistence life. Respondents reported that all three of these characteristics have diminished since the oil spill because of socioeconomic and technological changes. Other subsistence research in Alaska has suggested that individual agents who are motivated to make creative, strategic choices towards pursuit of subsistence activities despite the apparent physical and economic constraints will be the likely drivers of adaptive resilience for Alaska's rural subsistence cultures in the twenty-first century (Hutchinson-Scarbrough et al. 2020; Van Lanen 2018; Van Lanen et al. 2018). In addition, community residents frequently blamed EVOS employment and settlement payments for the rapid shift to commercial foods and individualized harvest methods that could not be sustained. When considering potential compensation for subsistence communities that are vulnerable to environmental or technological disasters in the future, more innovative measures that support traditional lifestyles should be considered. Possibilities include facilitating temporary hunting and fishing opportunities in other locations to sustain subsistence resources and community grants to support subsistence education and community harvest methods. Finally, several critical questions remain that can only be answered with continued, focused research.

Implications for Future Research

Evaluation of Study Methods

First, a brief discussion of study methods is warranted. The first objective of this project was to prepare a household level database that included responses to all available survey questions for each household in the five study communities of Chenega, Cordova, Nanwalek, Port Graham, and Tatitlek.

While the majority of survey questions were consistent across the years, the level of detail for harvests varied too much to conduct any analysis on changes in gear type or seasonality. Variation in questions for cash income also proved problematic. While employment and other income questions were largely unchanged, when asked, they were omitted for 2003, and involved only a single question in 1997. These changes were made at the request of representatives of the study communities. Analysis conducted on available data suggest a possible link between cash income and production. As additional years of study data are collected, collecting reliable and consistent information on income is a critical point for evaluating factors driving change.

Another key limitation to quantitative analysis involved a wide-ranging set of assessment questions. Each study year employed differing sets of assessments to meet specific project objectives. The variability and uniqueness in questions and coding of responses prevented both quantitative comparison and effective

1. Joshua Ream, ADF&G Subsistence Resource Specialist, Chenega field notes, April 10, 2015.

standardization into the household-level database. While this information can be synthesized using ethnographic interviews, there is no mechanism to develop meaningful correlations of study-year specific harvest and use patterns to other factors, such as changes in climate, unusual weather conditions, or economic conditions. In the latest year of the survey, simple questions were asked regarding need and whether households were able to get enough with standardized codes for reasons needs were not met. Future studies should continue to include these questions.

In addition, this study benefited from the integration of both quantitative and qualitative analysis. It is standard practice for the Division of Subsistence to include key informant interviews in most studies. Several themes related to the impact of cultural and demographic changes on subsistence practices were almost exclusively supported by qualitative data. This reinforces the importance of using a mixed-methods approach when studying changes and trends in Alaska subsistence communities.

Future Research Needs

Several clear research needs emerge from this project. Understanding whether the comparable to EVOS-year decline in resource diversity in 2014 was an anomaly or part of an noteworthy trend in subsistence resource use in EVOS communities will require additional years of study in Cordova, Chenega, Tatitlek, Nanwalek, and Port Graham. Comprehensive subsistence household harvest surveys are needed to understand the direction of resource use, diet breadth, and harvest specialization in these communities. Operating under standard Division of Subsistence procedures, these surveys would include assessments of resource use and availability, resource mapping, and key respondent interviews. These new data will help to determine if a trend towards a narrower range of subsistence uses is taking place and contribute to the ongoing understanding of possible cultural, economic, and environmental causes of such a change.

Within this broader research need, several more focused questions arise. Existing qualitative results suggest that socioeconomic and technological factors have a significant influence on participation in subsistence activities, but direct information pertaining to technology and the cost of subsistence activities does not yet exist for these communities. Future surveys could include questions that directly address the role of digital technology and the specific cost barriers associated with subsistence participation in alignment with established socioeconomic and fisheries involvement indices for community well-being (Himes-Cornell and Kasperski 2016). In addition, the role of commercial fishing in household production needs to be further examined. Rather than focusing solely on commercial fishing as a means for income, project findings suggest that commercial fishing household productivity may be more closely related to equipment ownership, the ability to maintain equipment, and the ability to access more abundant and dependable subsistence resources. At the same time, commercial fishing participation is declining, and there are cultural and social implications of this decline (Carothers 2008; Carothers et al. 2010; Clay and Olson 2008; Himes-Cornell and Hoelting 2015; Langdon 2008). These need to be specifically examined in EVOS-affected communities. If this trend is one of the key drivers in increased specialization and decreased diet diversity, barriers to commercial fishing involvement and strategies for resiliency warrant urgent attention.

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APPENDIX A:
HOUSEHOLD SPECIALIZATION

Appendix Table A1.– Contribution of low, middle, and high thirds of households to total community harvest, Chenega, Nanwalek, Port Graham, and Tatitlek, 1984–2014.

	Chenega				Nanwalek				Port Graham				Tatitlek			
Year	N[a]	Low Third	Mid Third	High Third	N	Low Third	Mid Third	High Third	N	Low Third	Mid Third	High Third	N[b]	Low Third	Mid Third	High Third
Pre-spill[c]	33	2.9%	24.9%	72.2%	40	6.7%	25.3%	68.1%	63	5.3%	24.2%	70.5%	59	3.2%	15.9%	80.9%
1989	21	0.8%	23.9%	75.3%	41	3.3%	28.7%	68.0%	61	2.6%	15.5%	81.9%	28	0.9%	8.2%	90.9%
1990	21	0.3%	17.4%	82.3%	41	7.6%	26.7%	65.7%	55	4.5%	21.5%	73.9%	28	2.2%	15.1%	82.7%
1991	22	0.7%	17.7%	81.6%	41	10.5%	29.8%	59.7%	58	3.3%	26.2%	70.5%	27	1.5%	23.8%	74.7%
1992	26	0.6%	9.9%	89.4%	41	13.3%	28.1%	58.5%	58	6.5%	27.4%	66.1%	–	–	–	–
1993	28	1.1%	18.1%	80.8%	37	9.1%	28.0%	62.9%	61	3.5%	24.3%	72.2%	28	3.8%	21.4%	74.8%
1997	21	0.7%	28.9%	70.4%	38	5.2%	23.7%	71.1%	63	4.0%	25.9%	70.0%	27	1.3%	17.6%	81.1%
2003	20	4.3%	21.4%	74.3%	51	9.0%	17.2%	73.8%	65	2.9%	14.1%	83.0%	27	0.6%	8.3%	91.1%
2014	17	0.0%	11.1%	88.9%	58	1.6%	18.2%	80.2%	58	1.2%	10.7%	88.1%	27	1.9%	14.0%	84.1%

Source ADF&G Division of Subsistence household surveys, 1985–2015.

N = Number of households in the community.

– = No data collected.

a. Includes the total number of households identified in Chenega in 1984 and 1985 combined.

b. Includes the total number of households identified in Tatitlek 1987 and 1988 combined.

c. "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

APPENDIX B: CONTRIBUTION OF THIRDS OF HOUSEHOLDS BY HOUSEHOLD TYPE

Appendix Table B1.– Contribution of low, middle, and high thirds of households to total community harvest, by household type, Chenega, Nanwalek, Port Graham, and Tatitlek, 1984–2014.

		Communities combined			
Study year	Household type	N	Low third	Mid third	High third
Pre-spill[a]	Households with no children	84	40.9%	34.6%	24.4%
	Single female head with children < 16	10	53.8%	23.9%	22.3%
	Single male head with children < 16	6	0.0%	36.8%	63.2%
	Dual head HH with children < 16	96	21.8%	28.5%	49.8%
	Any type of household with children < 16	111	23.5%	28.5%	48.0%
1989	Households with no children	72	38.5%	37.1%	24.4%
	Single female head with children < 16	10	49.1%	12.5%	38.4%
	Single male head with children < 16	4	34.3%	34.3%	31.5%
	Dual head HH with children < 16	66	24.8%	30.2%	45.0%
	Any type of household with children < 16	79	28.3%	28.2%	43.6%
1990	Households with no children	55	39.3%	34.7%	26.0%
	Single female head with children < 16	11	53.3%	10.8%	35.9%
	Single male head with children < 16	1	0.0%	0.0%	100.0%
	Dual head HH with children < 16	78	24.4%	36.3%	39.2%
	Any type of household with children < 16	90	27.7%	32.7%	39.6%
1991	Households with no children	65	46.8%	23.1%	30.1%
	Single female head with children < 16	13	37.4%	40.4%	22.1%
	Single male head with children < 16	2	0.0%	50.0%	50.0%
	Dual head HH with children < 16	68	18.5%	39.7%	41.8%
	Any type of household with children < 16	83	20.9%	40.1%	39.0%
1992	Households with no children	56	40.2%	42.1%	17.7%
	Single female head with children < 16	12	38.5%	40.4%	21.1%
	Single male head with children < 16	4	31.9%	34.1%	34.1%
	Dual head HH with children < 16	54	13.5%	29.9%	56.7%
	Any type of household with children < 16	69	18.8%	31.9%	49.3%
1993	Households with no children	79	38.5%	29.4%	32.0%
	Single female head with children < 16	12	50.9%	9.1%	40.0%
	Single male head with children < 16	4	0.0%	66.7%	33.3%
	Dual head HH with children < 16	60	18.4%	38.2%	43.4%
	Any type of household with children < 16	75	22.8%	34.8%	42.3%
1997	Households with no children	84	38.1%	27.1%	34.8%
	Single female head with children < 16	6	28.2%	47.9%	23.9%
	Single male head with children < 16	1	0.0%	0.0%	100.0%
	Dual head HH with children < 16	58	19.6%	43.2%	37.2%
	Any type of household with children < 16	65	20.0%	42.6%	37.4%
2003	Households with no children	105	34.6%	38.7%	26.7%
	Single female head with children < 16	1	0.0%	0.0%	100.0%
	Single male head with children < 16	—	—	—	—
	Dual head HH with children < 16	57	14.4%	23.4%	62.2%
	Any type of household with children < 16	58	14.1%	22.9%	63.1%

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Appendix Table B1.–Page 2 of 2.

Study year	Household type	Communities combined N	Low third	Mid third	High third
2014	Households with no children	94	39.3%	38.3%	22.4%
	Single female head with children < 16	8	71.4%	0.0%	28.6%
	Single male head with children < 16	3	0.0%	50.0%	50.0%
	Dual head HH with children < 16	55	21.5%	22.4%	56.1%
	Any type of household with children < 16	66	26.7%	20.9%	52.4%

Source ADF&G Division of Subsistence household surveys, 1985–2015.

a. "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Note — indicates no data.

Note N is the estimated number of households falling into each category.

APPENDIX C:
HARVEST AND USE BY HOUSEHOLD TYPE©A

Appendix Table C1.– Harvest and use by household type, Chenega, Nanwalek, Port Graham, and Tatitlek, combined, 1984–2014.

Study year	Household type	N	Used	Attempted	Harvested	Gave away	Received	Used but did not harvest
Pre-spill[a]	Households with no children	84	19.8	12.7	10.5	7.4	7.0	9.3
	Single female head with children < 16	10	18.2	8.3	6.4	4.2	7.1	11.8
	Single male head with children < 16	6	18.0	14.8	12.3	5.9	5.3	5.7
	Dual head HH with children < 16	96	22.2	16.2	13.7	10.4	7.0	8.5
	Any type of household with children < 16	111	21.6	15.5	13.0	9.6	6.9	8.6
1989	Households with no children	72	10.7	7.6	6.2	4.6	6.6	4.5
	Single female head with children < 16	10	10.1	6.9	6.0	2.7	7.1	4.1
	Single male head with children < 16	4	9.2	5.5	5.5	3.2	4.7	3.7
	Dual head HH with children < 16	66	12.3	9.8	8.2	5.9	6.9	4.1
	Any type of household with children < 16	79	11.9	9.2	7.8	5.4	6.8	4.1
1990	Households with no children	55	16.4	10.6	8.5	6.1	5.3	7.9
	Single female head with children < 16	11	19.9	9.6	8.0	5.1	6.7	11.9
	Single male head with children < 16	1	19.0	19.0	14.0	1.0	6.0	5.0
	Dual head HH with children < 16	78	17.6	13.2	10.3	7.4	4.9	7.3
	Any type of household with children < 16	90	17.9	12.9	10.1	7.0	5.2	7.8
1991	Households with no children	65	19.3	12.5	11.2	8.4	12.2	8.1
	Single female head with children < 16	13	19.9	13.1	12.0	7.5	13.3	7.8
	Single male head with children < 16	2	33.0	28.5	25.0	19.0	11.5	8.0
	Dual head HH with children < 16	68	20.6	15.7	13.8	11.1	12.5	6.8
	Any type of household with children < 16	83	20.8	15.6	13.9	10.7	12.6	7.0
1992	Households with no children	56	20.5	13.1	12.1	9.3	12.5	8.4
	Single female head with children < 16	12	18.7	10.2	8.9	8.7	14.7	9.7
	Single male head with children < 16	4	23.8	22.9	19.2	10.2	11.9	4.6
	Dual head HH with children < 16	54	23.6	17.5	16.6	13.6	15.5	7.0
	Any type of household with children < 16	69	22.8	16.5	15.4	12.5	15.2	7.4

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Appendix Table C1.–Page 2 of 2.

Study Year	Household type	N	Used	Attempted	Harvested	Gave away	Received	Used but did not harvest
1993	Households with no children	79	19.5	12.4	11.0	9.8	12.5	8.6
	Single female head with children < 16	12	15.8	8.7	7.5	9.0	11.9	8.2
	Single male head with children < 16	4	17.0	9.7	8.7	3.3	10.3	8.3
	Dual head HH with children < 16	60	20.4	15.1	13.6	12.0	13.3	6.8
	Any type of household with children < 16	75	19.5	13.8	12.4	11.1	13.0	7.1
1997	Households with no children	84	17.8	12.8	11.8	8.5	10.9	6.0
	Single female head with children < 16	6	13.0	2.6	2.6	6.3	11.5	10.3
	Single male head with children < 16	1	16.0	15.0	15.0	9.0	1.0	1.0
	Dual head HH with children < 16	58	21.7	16.4	15.5	11.2	14.4	6.2
	Any type of household with children < 16	65	20.8	15.1	14.3	10.7	13.8	6.5
2003	Households with no children	105	21.4	12.6	11.2	10.3	15.3	10.2
	Single female head with children < 16	1	13.0	10.0	9.0	7.0	9.0	4.0
	Single male head with children < 16	—	—	—	—	—	—	—
	Dual head HH with children < 16	57	21.4	16.1	15.0	14.7	13.3	6.4
	Any type of household with children < 16	58	21.2	15.9	14.9	14.5	13.2	6.4
2014	Households with no children	94	12.0	7.0	6.1	4.3	8.1	5.9
	Single female head with children < 16	8	8.3	3.4	3.1	1.9	7.2	5.1
	Single male head with children < 16	3	15.0	14.5	12.5	10.5	2.0	2.5
	Dual head HH with children < 16	55	16.0	13.2	11.7	9.1	8.3	4.2
	Any type of household with children < 16	66	15.0	12.0	10.7	8.3	7.9	4.3

Source ADF&G Division of Subsistence household surveys, 1985–2015.

a. "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

APPENDIX D:
COMMERCIAL FISHING PATTERNS

Appendix Table D1.– Comparison of patterns among households participating in commercial fisheries and those who did not, Chenega Bay, Nanwalek, Port Graham, and Tatitlek, combined 1984–2014.

Year		Households not commercial fishing	Households commercial fishing	Sig.
Pre-spill[a]	Number of households	65	94	—
	Average number of resources			
	Used	19.4	21.7	0.085
	Attempted	11.6	16.2	0.001
	Harvested	9.4	13.7	0.000
	Given away	5.6	10.5	0.000
	Received	6.7	6.9	0.772
	Average pounds harvested	625.0	1545.5	0.000
1989	Number of households	83	38	—
	Average number of resources			
	Used	10.9	12.2	0.317
	Attempted	7.7	10.0	0.057
	Harvested	6.4	8.5	0.045
	Given away	4.7	5.7	0.303
	Received	6.6	7.0	0.608
	Average pounds harvested	384.9	772.8	0.064
1990	Number of households	68	48	—
	Average number of resources			
	Used	18.0	16.8	0.435
	Attempted	11.4	13.2	0.227
	Harvested	9.2	10.2	0.432
	Given away	6.3	7.3	0.370
	Received	5.8	4.6	0.081
	Average pounds harvested	559.3	836.3	0.042
1991	Number of households	70	45	—
	Average number of resources			
	Used	19.1	21.9	0.094
	Attempted	12.2	17.5	0.001
	Harvested	11.1	15.1	0.012
	Given away	7.9	12.4	0.002
	Received	12.4	12.5	0.907
	Average pounds harvested	754.1	1422.2	0.005

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Appendix Table D1.–Page 2 of 3.

Year		Households not commercial fishing	Households commercial fishing	Sig.
1992	Number of households	70	33	—
	Average number of resources			
	Used	20.0	25.3	0.004
	Attempted	12.6	19.7	0.000
	Harvested	11.8	18.2	0.001
	Given away	8.7	16.0	0.000
	Received	13.1	16.0	0.081
	Average pounds harvested	725.9	1729.8	0.003
1993	Number of households	91	36	—
	Average number of resources			
	Used	19.1	20.9	0.216
	Attempted	11.6	17.3	0.000
	Harvested	10.5	15.0	0.002
	Given away	9.9	11.9	0.185
	Received	13.1	11.9	0.388
	Average pounds harvested	772.7	1126.9	0.096
1997	Number of households	79	25	—
	Average number of resources			
	Used	17.7	23.8	0.006
	Attempted	11.8	20.3	0.000
	Harvested	11.2	18.5	0.001
	Given away	8.2	13.9	0.002
	Received	11.6	14.4	0.123
	Average pounds harvested	834.1	1516.7	0.035
2003	Number of households	101	9	—
	Average number of resources			
	Used	20.8	22.2	0.687
	Attempted	12.5	18.3	0.095
	Harvested	11.0	17.6	0.042
	Given away	11.3	14.8	0.255
	Received	14.7	12.4	0.48
	Average pounds harvested	1045.4	3170.3	0.100

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Appendix Table D1.–Page 3 of 3.

Year		Households not commercial fishing	Households commercial fishing	Sig.
2014	Number of households	122	8	—
	Average number of resources			
	Used	12.8	20.5	0.012
	Attempted	8.6	18.3	0.048
	Harvested	7.6	16.6	0.001
	Given away	5.6	12.5	0.117
	Received	8.0	8.4	0.875
	Average pounds harvested	726.1	1770.0	0.046

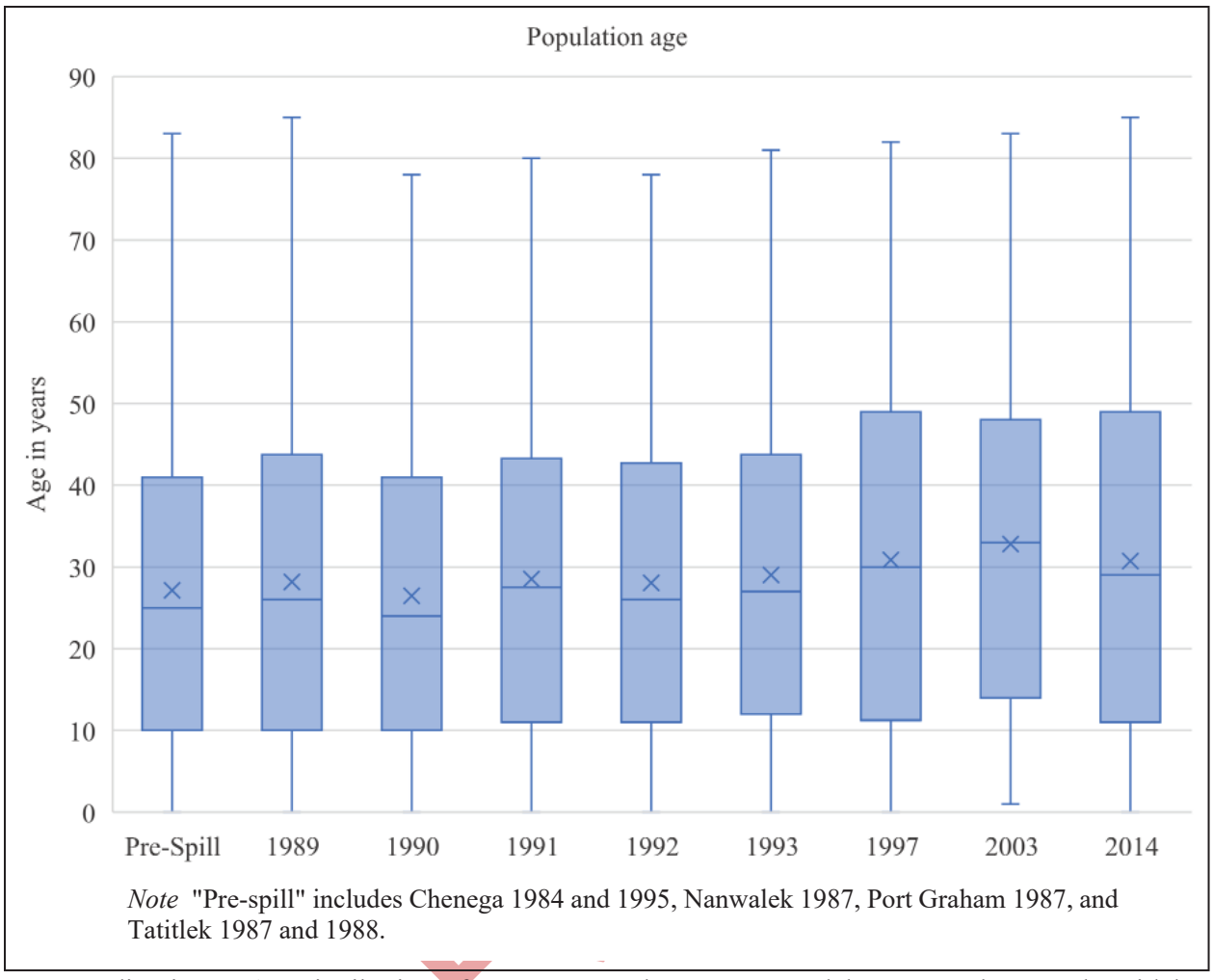
a. "Pre-spill" includes Chenega Bay 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

APPENDIX E:
CORDOVA SAMPLING METHODS

Appendix Table E1.– Description of sampling methods for Cordova comprehensive surveys 1985–2014.

Year	Sampling description
1985	Based on case study interviews, it was decided to seek an 18-20 percent household sample. A list of residences was compiled using city plat maps and with assistance from city government staff, and Coast Guard and FAA personnel. Multiple dwelling units were identified. A random sample was selected from this listing. It is estimated the survey covered 24.2 percent of all occupied units.
1988	A stratified random sample was used. A listing of all households was compiled using ADF&G records, the phone book, and key respondents. These were divided into three strata: trapping households(=high harvesters), medium level harvesters (based on harvests documented by department records or holding a limited entry permit), and other households.
1991	The total sample was a combination of a panel from previous MMS research (the Social Indicators Project) and a random sample. The random sample was selected by applying a table of random numbers to housing stock previously enumerated by the City of Cordova Planning Department. Fifty-four households could not be contacted, and 40 households declined to participate.
1992	The goal was to interview a panel of up to 62 households that had been interviewed the previous year as part of a randomly selected sample. Of the 62 households, 7 had moved from Cordova, nine declined to be interviewed, and five could not be contacted.
1993	The goal was to interview 100 Cordova households in two strata. The first stratum was a panel of up to 41 households interviewed in the two previous project years (1991 and 1992); and the second was a set of randomly selected households for the balance of the sample of 100. Of the 41 panel members, 33 were interviewed. Also 71 newly randomly selected households were interviewed, for a total of 104. There were 23 refuslas and 28 "no contacts".
1997	A stratified random sample was used. A total of 166 Eyak tribal members were identified and 51 were interviewed. Another 101 non-Eyak members were randomly selected and interviewed. Within the Eyak stratum, six households declined to participate and 15 were unavailable. Within the non-Eyak stratum, 17 households declined and 14 were unavailable.
2003	A stratified random sample was used. A total of 175 Eyak tribal members were identified and 50 were interviewed. Another 100 non-Eyak members were randomly selected and interviewed from the remaining 735 households. Within the Eyak stratum, six households declined to participate and 8 were unavailable. Within the non-Eyak stratum, 21 households declined and 27 were unavailable.
2014	A simple random sample was used. A total of 1489 occupied households were identified. 187 households were interviewed. Another 46 declined to be interviewed and 257 could not be contacted. A total of 490 households were attempted.

APPENDIX F:
DISTRIBUTION OF AGES ACROSS STUDY COMMUNITIES



Note "Pre-spill" includes Chenega 1984 and 1995, Nanwalek 1987, Port Graham 1987, and Tatitlek 1987 and 1988.

Appendix Figure F1.– Distribution of ages across Chenega, Nanwalek, Port Graham, and Tatitlek, combined, pre-spill, 1989–1993, 1997, 2003, and 2014.