Alaska Salmon Shark Assessment Project

Project Number:	01396
Restoration Category:	Research
Proposer:	Jeep Rice NMFS, Auke Bay Laboratory
Lead Trustee Agency:	NOAA
Cooperating Agencies:	Alaska Department of Fish and Game
Alaska Sea Life Center:	no
Duration:	Year 2 of 2 year project
Cost FY 01:	$85.0K
Geographic Area:	Prince William Sound
Injured Resource/Service:	Pacific salmon, Pacific herring, rockfish

ABSTRACT

Throughout the 1990's salmon shark observations and bycatch in Prince William Sound (PWS) and the northeastern Gulf of Alaska (GOA) increased dramatically. The second year of the Alaska Salmon Shark Assessment Project is designed to investigate seasonal salmon shark movements and diet in PWS and GOA to determine seasonal fidelity to diet and region. Utilization of state-of-the-art satellite telemetry transmitters will augment successful applications of the technology demonstrated in FY00. Data transmitted by satellite tags deployed on salmon sharks in July 2000 are providing much needed information about spatial and temporal movements beyond the summer sampling period, but more tags need to be deployed. Seasonal variations in salmon shark diet composition will be described from stomach sample analyses. The project will also synthesize historical salmon shark distribution and abundance in the north Pacific from literature and analysis of bycatch databases. This work will be performed to investigate whether evidence of salmon shark population trends are revealed. These inquiries are needed to assess the ecological role of a predominant shark species in the Gulf of Alaska, and the potential impact they could have on other important species; forage fish, sablefish (***Anoplopoma fimbria***), salmon (Oncorhynchus spp.), and marine mammals.

INTRODUCTION

The salmon shark, ***Lamna ditropis,*** is one of the predominant shark species in coastal Gulf of

Alaska (GOA), yet very little is known of their seasonal movements, regional fidelity, or diet composition. Large surface aggregations, often numbering in the thousands, have been observed in PWS bays and passages associated with returning adult chum salmon (***Onchorhynchus keta***) and pink salmon (***Onchorhynchus gorbuscha***) since the mid 1990's. Previously, salmon shark sightings and bycatch in commercial fishing gear were rare. Preliminary results of diet analyses indicate that the sharks consume a variety of prey, even during summer months when adult salmon are abundant (Table 1). As Fall approaches and salmon abundance declines, the sharks disperse and are rarely observed at the surface. However, satellite telemetry data and bycatch in the walleye pollock (***Theragra chalcogramma***) fishery in PWS confirm salmon sharks occur in PWS and the northeastern GOA during winter months. Salmon shark diet composition during times of the year when adult salmon are not abundant has not been documented. In regions of high abundance, salmon sharks have the potential to affect the recovery of oil spill damaged species including wild salmon, herring, and rockfish.

Lamna ditropis Prey Taxa	Frequency (%)	Biomass (%)
Salmonids (***Oncorhynchus***)	26	40
Sablefish (***Anoplopoma***)	26	36
Pollock, Cod (***Gadidae***)	5	4
Rockfish (***Sebastes***)	5	1
Herring (***Clupeidae***)	11	0.4
Spiny dogfish (***Squalus acanthias***)	5	7
Squid (***Teuthoidea***)	16	1
Halibut (***Pleuronectidae***)	5	11

Table 1. Summary of stomach contents from 18 salmon sharks caught in the PWS region during July and early August.

Data transmitted from satellite tags deployed in FY00 are yielding previously inaccessible information that are necessary to study salmon shark movements and ecology. Conventional tag-and-recapture programs studying sharks are dependent on fisheries for tag recoveries, and as indicators of movement and behavior have limited resolution. To date, of the 223 salmon sharks tagged with spaghetti tags in 1999 and 2000, only one has been recaptured. There is no directed commercial salmon shark fishing in Alaska and tag recoveries are low, either due to low incidental bycatch or low recovery as large sharks are rarely brought aboard. Utilization of satellite telemetry technologies provide state-of-the-art methods to acquire otherwise unattainable data on the movements, seasonal residency, regional fidelity, and ecology of these apex fish predators in PWS and GOA ecosystems. The data returned to date is intriguing, but the sample size is small and more tag deployments are needed.

Increases in salmon shark abundance in the northeastern GOA follows 10-15 years after an ocean climate regime shift and changes in trophic community structure. Is the trend in shark abundance due to population increase or range extension? Are the sharks more affected by climate regime

shift or trophic regime shift? Synthesis of historical salmon shark distribution and abundance data in the north Pacific from literature and bycatch databases will be performed to investigate whether evidence of salmon shark population trends are revealed.

Seasonally diverse salmon shark diet data are needed to assess the ecological role of salmon sharks in PWS and GOA ecosystems. One of the more cost-effective methods of assessing complex interactions of a food web is diet analysis from stomach contents. Cooperation has been established with commercial and sport fishermen and various agencies to acquire seasonally and regionally diverse salmon shark stomach samples in the GOA.

Understanding the ecology and impact of sharks on the predator/prey dynamics of PWS requires research on TWO shark species; salmon sharks (***Lamna ditropis***) and Pacific sleeper sharks (***Somniosus pacificus***). The evidence of increasing numbers occurs for both species. These species have different biologies, although little is known about the diet and migration of either species. Salmon sharks are caught in salmon fisheries; sleeper sharks are not. Sleeper sharks are caught often in long line gear; salmon sharks are not. Parallel but independent will be sleeper shark studies conducted by the NMFS, using emerging Stellar Sea Lion funds. Although the present evidence is meager, there is growing evidence of predation by sleeper sharks on marine mammals. This EVOS study will focus on salmon sharks, and at this time, is projected to be the last and only directed study on salmon sharks.

NEED FOR THE PROJECT

A. Statement of the Problem

The ecological role of sharks in PWS and their affects on the recovery of spill-injured resources in the region will vary with temporal and spatial patterns of movement. Salmon shark seasonal residency patterns, movements, and diet in PWS and the GOA have not been described. Large numbers of sharks coupled with high food consumption to support above ambient body temperatures indicates that shark predation may be dominant and directly limit other key species (salmon, herring, rockfish, sablefish). Salmon shark body temperature averages 26.5^0C (80^0F) (Goldman 1999 unpublished data) and may be the highest of any shark. Because of this and the cold waters they inhabit in the GOA, salmon sharks likely possess a high metabolism and high daily ration. Eighteen salmon shark stomachs collected in late July and early August, during peak pink salmon returns, contained as many sablefish as salmon and also contained herring and rockfish (Hulbert 1999 unpublished data). In regions of high abundance, salmon sharks have the potential to affect the recovery of oil spill injured species, including Pacific herring, Pacific salmon, and rockfish.

Salmon sharks inhabiting Alaskan waters have low fecundity, long life, and slow maturation. Once sharks reach a dominance level in the community they are likely to continue that dominance for a long time. Observations suggest salmon sharks may be a dominant predator in PWS now and for some time into the future, but we do not understand the significance of this role to other species and the ecosystem.

B. Rationale

This research will provide a valuable contribution to the understanding of shark ecology in the GOA and PWS and will document predator/prey interactions in the region. This information is needed to further the understanding of the ecological role of sharks in PWS and their effects on the recovery of spill injured resources in the region.

Pop-up archival transmitting (PAT) tags, and smart position-only transmitting (SPOT) tags were successfully demonstrated by the project in FY00 for monitoring the movements and diving behavior of salmon sharks. Data from satellite tags and opportunistic aerial observations will continue to be collected and analyzed in FY01 to describe salmon shark movements, migrations, regional fidelity, and critical feeding areas.

Shark stomachs will be collected during directed sampling efforts, opportunistically from commercial and sport fishermen, and from NMFS and ADF&G biologists. Efforts to collect and analyze seasonally diverse diet samples will be emphasized in an effort to describe prey switching when spawning aggregations of Pacific salmon are not present.

The project will also synthesize historical salmon shark distribution and abundance in the north Pacific from published literature and analysis of bycatch databases. This work is needed to investigate whether evidence of salmon shark population trends are revealed.

C. Location

Prince William Sound and Gulf of Alaska

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

A traditional and local knowledge component has been incorporated in this study. People from Cordova, Chenega, and Tatitlik have been and will continue to be asked to contribute their knowledge of shark temporal abundance and distribution. Community members may also be hired to recover PAT tags if they “pop-up” in PWS.

PROJECT DESIGN

A. Objectives and Hypotheses

The overall objectives of the project are to document salmon shark seasonal movements and fidelity to Prince William Sound, and to document seasonal variation in salmon shark diet. This information will be an important contribution to assessing the role of salmon sharks in the Prince William Sound ecosystem. All permits necessary for this work are in place.

Primary Hypotheses

H1: Salmon sharks inhabit Prince William Sound and the Gulf of Alaska during winter months

H2: Salmon sharks are highly migratory and exhibit seasonal fidelity to Prince William Sound

H3: Salmon shark diet composition changes from summer to winter months

Project Objectives

1. Determine seasonal migration patterns by deploying SPOT and PAT tags on summer caught salmon sharks.

2. Determine seasonal diet from stomach analyses of salmon sharks collected in the summer (at time of tagging deployment), and in stomachs acquired from non-salmon fisheries at other times of the year.

3. Determine if there is evidence of historical trends in distribution and abundance by synthesizing literature and bycatch data bases.

B. Methods

1. Methods for determination of seasonal migration.
Migration movement will be tracked by the use of two types of tags: SPOT and PAT. Data from both types of tags use the ARGOS satellites to retrieve data; hence the initial costs of the tags are considerable, but data retrieval is cheap (no charters to track sharks for example). Why two types of tags? SPOT tags will continuously report position when the tagged shark fin breaks the surface. This tag will give high resolution tracking, particularly during the summer months when animals are at the surface more often. Knowing location of sharks in the winter is problematic, as the fin does not break the surface often. In contrast, the PAT tag is an archival tag yielding more biological information, recording time at depth and temperature data, but accurate position data is only given once- when the tag releases from the shark at a pre-programed date and time, floats to the surface, and begins transmitting. By having multiple tags programmed for different release dates, migration and fidelity can be determined. A combination of tags has the highest probability of success.

Collection of animals: Summer charter of a purse seiner will be used. This technique has been highly successful in the past.

Tag deployments.

- SPOT tags (Smart Position Only Tags) are bolted to the sharks dorsal fin and transmit high resolution movement data to ARGOS satellites when the tag breaks the waters surface. The tags are providing information on salmon shark regional fidelity, seasonal PWS residency, and large and small scale spatial and temporal movements.

  Three SPOT tags will be deployed in FY01 to supplement the 3 active tags which were deployed in FY00.

- PAT (Pop-up Archival Transmitting) tags are attached to the base of the sharks dorsal fin with a stainless steel dart. The tag releases from the animal on a predetermined date and time, and transmits archived data and position. The tags provide large-scale geographic movement data, time spent at depth, and seasonal PWS and GOA residency information.

  Nine PAT tags will be deployed. Three tags will be programmed to pop-up on each of three dates: October 1, 2001; February 1, 2002; and July 1, 2002. Note: The shorter the time period, the greater the chance of success; the longer the time period, less chance of success, but more meaningful information. We plan a scan of dates to give us the best chance of success and return of information.

  Note: Satellite tag data is transmitted to Argos system satellites which collect and retransmit the data to Argos centers for processing. The processed data is then sent via e-mail to the NMFS Auke Bay Laboratory for analysis.

Miscellaneous field sampling objectives:

Captured sharks will be sexed and measured for length, and weight (or estimated from length/girth measurements). After measurement, if a shark is to be released, tissue samples will be collected for stable isotope tracers, fatty acids, and genetic analyses. The shark will then be double tagged with numbered spaghetti tags and released. If a shark is killed, vertebrae and stomach will be collected and frozen for subsequent laboratory analysis. Maturity state will be recorded and urogenital tract collected and preserved in 10% formalin solution or frozen: presence or absence of eggs or embryos in females, and male clasper length will be recorded. Permits allowing this are in place.

2. Methods for determining seasonal variation in salmon shark diet.

Stomachs will be collected during the shark tagging charter during July 2001. Our goal is to collect 20 specimens representing a range of size during the charter. Another key objective is to collect another 20 voluntary and opportunistic stomachs samples during other times of the year from commercial and sport fishermen, and from researchers conducting surveys in Alaska waters. Salmon shark stomach collection efforts will emphasize a diverse seasonal range whenever possible. Stomach contents analyses methods will follow “Standardized diet compositions and trophic levels of sharks” (Cortes 1999).

3. Methods for determining whether there are historical trends in distribution and abundance. Evidence of historical salmon shark distribution and abundance in the north Pacific will be investigated by reviewing published salmon shark bycatch records in the literature and from analysis of bycatch databases. Special attention will be given to historical high seas gillnet fishery data. NorPac and RaceBase databases will be analyzed as well.

C. Cooperating Agencies and Volunteers

Alaska Department of Fish and Game port samplers will collect salmon shark stomachs and tissue samples.

University of Alaska Fairbanks (Evelyn Brown) will provide opportunistic PWS aerial salmon shark observations.

Cordova Air will provide opportunistic PWS aerial salmon shark observations.

Virginia Institute of Marine Science (Ken Goldman) will provide salmon shark stomachs.

SCHEDULE

A. Measurable Project Tasks (Milestones) for FY 01 (October 1, 2001-September 30, 2002)

April 15, 2001:	Complete FY00 Annual report
July 2001:	Conduct field research, deploy tags.
August 2001-September 2001	Organize and analyze data from FY01 field season. Analyze stomachs collected during summer
May 2001-July 2002	Retrieve and analyze satellite data as available. (3 SPOT tags deployed last year should reappear by May
August-September 2002	Analyze satellite tag data, complete reports/manuscripts

C. Completion Date

October, 2002	Final Report (Date of final report allows for analysis of satellite tag data transmissions from SPOT tags which are likely to transmit during summer months when the sharks are active in surface waters. and the last PAT tags, set for summer 2002 release.)

D. Budget Summary

Budget Category:	FY01
Personnel	$28.2
Travel	$ 2.2
Contractual	$22.2
Commodities	$26.6
Equipment	$ 0.0
Subtotal	$79.2
General Administration	$ 5.8
Project Total	$85.0

PUBLICATIONS AND REPORTS

An EVOS annual report in April 2001 will describe the results and accomplishments of the research to date.

A final report detailing results and accomplishments of the research will be accompanied by: A draft salmon shark seasonal diet manuscript; a draft salmon shark spatial and temporal movement manuscript; and report detailing the results of salmon shark historical distribution and abundance synthesis.

NORMAL AGENCY MANAGEMENT

NOAA/NMFS has statutory stewardship for most living marine resources; however, if the oil spill had not occurred, NOAA would not be conducting this project. NOAA/NMFS proposes to make a significant contribution (as stated in the proposed budget) to the operation of this project, making it truly cooperative.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The information gathered in this study may be useful to understanding the lack of recovery of some non-recovering species (harbor seals, Pacific herring).

PRINCIPAL INVESTIGATOR

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OTHER KEY PERSONNEL

Lee Hulbert, NMFS, Auke Bay Laboratory

Scott Meyer, ADF&G, Homer AK

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FFY 1999	Proposed FFY 2000
Personnel	$0.0	$28.2
Travel	$0.0	$2.2
Contractual	$0.0	$22.2
Commodities	$0.0	$26.6
Equipment	$0.0	$0.0
Subtotal	$0.0	$79.2
General Administration	$0.0	$5.8
Project Total	$0.0	$85.0
Full-time Equivalents (FTE)	0.0	0.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FFY 2002	Estimated FFY 2003
$50.0	$0.0

Dollar amounts are shown in thousands of dollars.

Comments: This project investigates salmon shark seasonal residency, movements, and trophic interactions in the eastern Gulf of Alaska (GOA) and Prince William Sound (PWS). State-of-the-art satellite tags will be employed to describe salmon shark movements and migrations, and critical feeding areas and depths.

National Marine Fisheries Service will donate 3 PAT tags and salary (Jeep Rice, approx. 1 month @ $12.1K/mo). NMFS is pursuing investigations of Pacific sleeper shark predation on marine mammals with seperate agency funds.

2001

Project Number: 01396
Project Title: Alaska Salmon Shark Assessment Project
Agency: NOAA

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	I
	Name	Position Description					
	L. Hulbert		GS9	6.0	4,700		
	J. Rice		GS14	0.0	12,100		
		Subtotal		6.0	16,800	0	
						Personnel Total	

Travel Costs:		Ticket Price	Round Trips	Total Days	Daily Per Diem	I
	Description					
	Juneau to Cordova (Lee Hulbert)	374	1	2	225	
	Juneau to Cordova (Scott Johnson)	374	1	2	225	
	Homer to Cordova (Scott Myers, ADFG invitational travel)	100	1	2	150	
					Travel Total	

2001

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Contractual Costs:	
Description	I
vessel charter (10 days at $1,650/day, 7/10-7/19) fuel charges for vessel shipping ARGOS platform satellite rental time ($350/tagx3 PAT tags plus 3 SPOT tag charges= $1.5K-5.0K) seine net repair	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	

Commodities Costs:	
Description	I
Wildlife Computers PAT tag ($3,500 per tag x 6 tags) Wildlife Computers SPOT tag ($1,860 per tag x 3 tags)	
Commodities Total	

2001

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	I
Description			
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	

Existing Equipment Usage:	Number of Units	
Description		
purse seine	1	
scale	1	
PAT tags	3	

2001

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001