Southeast Alaska Sport Shrimp Harvest Survey, 2018–2023

by

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and

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Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as 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. state	use two-letter abbreviations (e.g., AK, WA)

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	$(F, t, \chi^2, \text{etc.})$
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

FISHERY DATA SERIES NO. 24-27

SOUTHEAST ALASKA SPORT SHRIMP HARVEST SURVEY, 2018–2023

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This document should be cited as follows:
Teske, D. J., and R. Peterson. 2024. Southeast Alaska sport shrimp harvest survey, 2018–2023. Alaska Department of Fish and Game, Fishery Data Series No. 24-27, Anchorage.

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ABSTRACT

The sport shrimp fishery in Southeast Alaska has a permit and reporting requirement, that requires permit holders to report location, effort, and harvest. From 2018 to 2023, a total of 1,234 permits were issued to residents and 17,890 to nonresidents, of which residents returned a total of 401 permits and nonresidents returned 10,235 permits; however, owing to the newness of the permitting requirement in 2018, reliable data were not obtained until 2019.

Resident effort ranged from 81 to 3,359 pots fished, with the lowest effort in 2021. Residents harvested an estimated 7,420, 1,065, 170, 536 and 317 pounds of whole shrimp in 2019, 2020, 2021, 2022, and 2023 respectively. The decreasing resident participation in this fishery was likely a result of residents' participation shifting to personal use or subsistence fisheries. Nonresident effort ranged from 3,883 to 9,326 pots fished, with the greatest effort in 2019. Nonresidents harvested an estimated 19,047, 6,753, 13,147, 12,868 and 15,256 pounds of whole shrimp in 2019, 2020, 2021, 2022, and 2023 respectively.

Keywords: Permit, noncommercial, sport, personal use, subsistence, spot shrimp, *Pandalus platyceros,* Coonstripe shrimp, *Pandalus hysinotis*, Southeast Alaska

INTRODUCTION

Effective 25 June 2018 the Board of Fisheries (board) required a shrimp permit for sport fishery users wishing to harvest shrimp in Southeast Alaska (SEAK; 5 AAC 47.020(16)). This permitting requirement was part of a shellfish proposal to address concerns of depressed shrimp populations throughout SEAK, particularly in Hoonah Sound, within Section 13-C (Alaska Department of Fish and Game [ADF&G] 2018). Permits are free and available online or at ADF&G offices in Douglas, Juneau, Yakutat, Haines, Sitka, Petersburg, Ketchikan, and Craig (Prince of Wales Island).

Prior to the permit requirement, the department did not have reliable, annual estimates of shrimp harvest in the SEAK sport fishery (ADF&G 2018). Hence, the purpose of this project was to estimate effort in pot days and harvest of whole shrimp biomass in the SEAK sport shrimp fishery. Permit holders have the option to report harvest in either quarts or pounds, as well as in tailed or whole weight, and therefore some level of estimation is necessary. Moreover, although mandatory reporting is part of the permitting requirement, ADF&G staff expect less than 100% participation, also making estimation necessary. Permit holders were not asked to identify the shrimp species removed; however, spot shrimp *Pandalus platyceros* and to a lesser extent coonstripe shrimp *P. hysinotis* were the 2 major target species.

ADF&G has the responsibility to sustainably manage the shrimp resource in SEAK. The permit and reporting requirement to participate in the sport shrimp fishery allows fisheries managers to estimate the total harvest and harvest by district in the Southeast Region. By collecting this data over multiple years, trends in effort, harvest, and harvest per unit effort (HPUE) can be monitored. These results, along with commercial, personal use, and subsistence harvest estimates, will be used by managers to estimate total removals of the shrimp resource and help ensure that harvest does not exceed the harvestable surplus.

OBJECTIVES

PRIMARY OBJECTIVE

The objective of the project was to:

1. Estimate effort (pot days) and harvest (whole shrimp biomass in pounds) by district and residency in the SEAK sport shrimp fishery such that estimates are within 10% of true values 95% of the time.

SECONDARY OBJECTIVE

In addition to the primary objectives, this project also sought to:

1. Count and measure carapace lengths of sport-harvested spot shrimp caught per quart of shrimp to obtain weight using a length-weight conversion.

METHODS

SURVEY DESIGN

All participants in the SEAK sport shrimp fishery were required to obtain a permit (Teske 2018; Teske and Peterson 2022) with one permit issued per individual. Permits could be obtained at ADF&G offices or online (https://www.adfg.alaska.gov/Store/). Permits were sequentially numbered, 4 pages in length, and required completion of identifying information such as the angler's name, address, sport fishing license number, driver's license number, and signature that were added to the top section of the permit at the issuing office by ADF&G staff or online if completing the electronic permit. Signatures were used to provide a count of the number of permits issued and the names and addresses of all participants in the fishery. The provided contact information was used to contact permit holders if they failed to return their permits. Permits were required to be returned to ADF&G offices or reported online by 15 January the following year with a final acceptance deadline of 31 March.

Anglers were required to be in possession of their permit while working shrimp gear and record the district, location, harvest (quarts or pounds, whole or tailed), and effort (number of pots pulled). Anglers were asked to provide both the commercial fishing district of their harvest using a map provided with the permit (Figure 1 and Figure 2), as well as a description of the location. The original map issued with the permit (Figure 1) was changed in November 2022 (Figure 2) as a result of feedback received from sport shrimp anglers, and therefore anglers that reported their harvest online during the 2022 project may have received 2 different maps. Advisory announcements and direct contact with anglers were used to educate users about the permit system and to reduce the number of people participating in the fishery without a permit.

Permit holders were encouraged to use the ADF&G online harvest reporting system, which allowed the user to enter each day's harvest through an easy-to-use web interface. The permit holder had the option of entering this information periodically throughout the fishing season or waiting until all fishing had been completed. The permit holder also had the option of hand-delivering the completed harvest reporting form to an ADF&G office or mailing it to the address printed on the permit. Reporting forms that come into the ADF&G offices were entered by Douglas staff into the Licensing Admin System (LAS), an internal data entry website.

Once the season had closed and all harvest reports received by the ADF&G office had been entered, a list of permit holders that did not report was created. Initially, an email was sent to all listed nonrespondents that provided a valid email address notifying them of their noncompliance. The email included a link that took them directly to the online reporting page.

Anglers who did not return their permit before the 15 January deadline received up to 3 reminders in the form of emails and phone calls. After the first reminder was sent and anglers were given an opportunity to submit their report, ADF&G updated its internal list of nonrespondents. The reminders included a blank reporting form as well as a web address to report by mail, by phone, or online. If necessary, a final reminder was sent in March. Permits received after the 31 March deadline were considered noncompliant.

Biologic data from sport caught shrimp fishery, which could be used to inform length-weight conversions, was not collected due to budgetary constraints (secondary objective 1). In the absence of this information, the following analysis relied on length-weight data collected by ADF&G Commercial Fishery Division staff (Max Schoenfeld, Fishery Biologist 2, ADF&G, Division of Commercial Fisheries, personal communication).

DATA REDUCTION

All the permit and harvest reporting data collected were stored in a MicrosoftSQL Server database. A variety of SQL queries were performed to verify data integrity:

1) Records must have a matching permit number for the respective year.
2) Records must have a unique report date, which is used to determine mailing status.
3) All harvest dates should be from the year of permit was issued or NULL, which is used to reflect that the date was missing on the harvest report.

Data were transmitted to the project biologist in an Excel file, where additional checks were performed to verify data integrity. Permits reporting the same information twice (i.e., duplicate harvest dates) were of particular concern. Duplicate records were generally resolved by identifying records with multiple reporting dates, determining if any of the recorded harvest dates appeared twice, and removing 1 from the dataset. Duplicate records with the same harvest dates but different reported effort and or harvest were generally thought to be a user error and assumed that the user had entered the wrong date and were corrected by assigning an arbitrary date. Permits reporting unrealistically high effort or harvest were also a concern. These records were approached from the assumption that these were data entry errors, with corrections made on a case-by-case basis. Finalized data were generated after resolving all issues with data. Two tab-delimited text files were generated:

1) YYYY SE Shrimp Permits Issued (i.e. 2018 SE Shrimp Permits Issued.txt): Contains all permit holder names, addresses, residency status, and other personal information.
2) YYYY SE Shrimp Permits Compliant (i.e. 2018 SE Shrimp Permits Compliant.txt): Contains all returned permits, with fields including permit number, if the permit fished, harvest date, district fished, location fished, effort expressed in terms of the number of pots fished, harvest expressed in terms of either quarts or pounds, a field indicating whether reported harvest was in terms of tails only or whole, reporting date, and residency status.

These computer files, along with the Excel file transmitted to the project biologist, as well as all analysis code used to produce this report, are archived on the ADF&G commercial fisheries github website: https://github.com/commfish/SF_PU_Shrimp.

CONVERSION FACTORS

The project objective was to estimate harvest of whole shrimp biomass removals; however, permit holders could report harvest in pounds or quarts, as well as harvest of whole or tailed shrimp. Three conversion factors were needed to convert these different methods of reporting into a common unit: (1) weight of whole shrimp in pounds per quart, (2) weight of tailed shrimp in pounds per quart, and (3) the ratio of tail to whole weight.

The first 2 conversion factors were computed using data collected by ADF&G Commercial Fishery Division in 2022 and 2023 (Max Schoenfeld, Fishery Biologist 2, ADF&G, Division of Commercial Fisheries, personal communication). Data collected were from multiple commercial fishing districts: 1, 2, 3, and 7 for both years, and 11, 12, and 13 in 2022 only (Figure 1), using commercial fishing gear and including the weight of shrimp per quart (tailed and whole) in grams, converted to pounds. The conversion factor for converting quarts of whole shrimp to pounds was calculated to be 1.11 lb/quart and the conversion factor for converting quarts of tailed shrimp to pounds was 1.44 lb/quart.

Use of these conversion factors makes a number of assumptions in that it assumes (1) commercial caught shrimp have the same size distribution as shrimp caught by sport gear, (2) the spatial location of the data collected during the study are assumed to be the same as those used by sport harvesters, (3) the shrimp caught in 2022 and 2023 have the same size distribution as the shrimp caught in other years, and (4) sport users always softly pack their harvest. Assumptions regarding gear and spatial differences of the data are arguably less worrisome than yearly differences in size distribution and how shrimp are packed by sport users. The size structure of shrimp populations throughout SEAK are known to vary annually; however, this assumption should somewhat be ameliorated because data were collected at the time of this project.

The third conversion factor, which was used to convert tailed to whole weight, was also collected by ADF&G commercial fishery division staff (David Harris, Retired Fishery Biologist, ADF&G, Division of Commercial Fisheries, personal communication). Data were collected from multiple commercial fishery districts, 3, 7, 12, and 13, (Figure 1) using commercial fishing gear and biological data including the number of shrimp per quart (tailed and whole) in grams, average carapace length, whole average tail weight, and average weight of individual spot shrimp. The conversion factor for converting tailed to whole weight was determined to be 2.02 tail/whole.

ANALYSIS

Participation, Effort and Harvest

Subscripts denoting residency status were omitted to simplify presentation of equations. The number of permits that fished, $\widehat{N}_f$, was estimated as:

$$\widehat{N}_f = N\widehat{w} \tag{1}$$

and similarly, the number of permits that did not fish, $\widehat{N}_z$, was estimated as:

$$\widehat{N}_z = N(1 - \widehat{w}) \tag{2}$$

where

$$\widehat{w} = \frac{n_f}{n} \tag{3}$$

and where

    N = number permits issued,

    $\hat{w}$ = estimated proportion of permits that fished from the responding permits,

    n_f = number of responding permits that fished, and

    n = number of responding permits.

Harvest and effort by area, $\hat{H}_a$, was estimated as:

$$\hat{H}_a = N\bar{h}_a \tag{4}$$

where

$$\bar{h}_a = \frac{\sum_{i=1}^{n} h_{a,i}}{n} \tag{5}$$

and where

    $\bar{h}_a$ = mean harvest or effort by area a for responding permits, and

    $h_{a,i}$ = reported harvest or effort by responding permit i in area a.

Total harvest and total effort, $\hat{H}$, was estimated as:

$$\hat{H} = N\bar{h} \tag{6}$$

where

$$\bar{h} = \frac{\sum_{i=1}^{n} \sum_{a=1}^{j} h_{a,i}}{n} \tag{7}$$

and where

    $\bar{h}$ = mean total harvest or effort for responding permits,

Variance of $\hat{N}_f$ and $\hat{N}_z$ was estimated as:

$$\text{var}(\hat{N}_f) = \text{var}(\hat{N}_z) = \text{var}(N\hat{w}) = N^2\text{var}(\hat{w}) \tag{8}$$

where

$$\text{var}(\hat{w}) = \frac{\hat{w}(1-\hat{w})}{n-1}\left(1 - \frac{n}{N}\right) \tag{9}$$

Variance of $\hat{H}$ and $\hat{H}_a$ was estimated as:

$$\text{var}(\hat{H}_a) = \text{var}(N\bar{h}_a) = N^2\text{var}(\bar{h}_a) \tag{10}$$

where

$$\text{var}(\bar{h}_a) = \frac{s_{\bar{h}_a}^2}{n}\left(1 - \frac{n}{N}\right) \tag{11}$$

and where

$$s_{\bar{h}_a}^2 = \frac{\sum_{i=1}^{n}(h_{a,i} - \bar{h}_a)^2}{n - 1} \tag{12}$$

Standard errors were calculated from the square root of the variance estimates.

Assumptions

The pooled data model described above assumed that responding (i.e., compliant) permits were representative of nonresponding (i.e., noncompliant) permits. If this assumption was violated, then nonresponse bias could be an issue. Given the potential for nonresponse bias due to the study design, the following measures were implemented to mitigate its impact:

1. mandatory reporting,
2. testing for evidence of nonresponse bias, and
3. applying a model that explicitly accounted for nonresponse bias if significant effects were detected.

Key terms used in this context were defined as follows:

- **Compliant:** Permits that responded before receiving a reminder letter.
- **Compliant noncompliant:** Permits that responded only after receiving a reminder letter.
- **Noncompliant:** Permits that never responded.

Harvest and effort were compared between compliant and compliant noncompliant permits to test for nonresponse bias. If either comparison was significant, nonresponse bias was present, and a model designed to explicitly address it investigated. Additional details about the test and the nonresponse bias model can be found in Appendix A.

Harvest per unit effort (HPUE)

For areas with adequate effort (i.e. > 0), HPUE was estimated as:

$$\widehat{HPUE}_a = \hat{H}_a / \hat{E}_a \tag{13}$$

where $\hat{H}_a$ is the estimated harvest in area a and $\hat{E}_a$ is the estimated effort in area a. The variance of HPUE was approximated using the delta method (Seber 1982).

$$\text{var}(\widehat{HPUE}_a) \approx \frac{\hat{H}_a^2}{\hat{E}_a^2}\left[\frac{\text{var}(\hat{H}_a)}{\hat{H}_a^2} + \frac{\text{var}(\hat{E}_a)}{\hat{E}_a^2}\right] \tag{14}$$

For areas without adequate effort (i.e., effort = 0), HPUE is not calculated, and SE(HPUE) is undefined for areas without adequate effort or harvest (i.e., effort = 0 and harvest = 0).

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RESULTS

A total of 1,160 permits were issued to residents and 14,347 were issued to nonresidents from 2018 to 2023 (Table 1). Although mandatory reporting was a condition of the permit, participation in the program varied by year. The lowest reported participation was 3% for both residents and nonresidents and corresponded with the first year of the project (2018). The highest participation was 82% for residents in 2020 and 78% for nonresidents in 2022. This increase in reporting participation suggests a growing awareness about the harvest reporting requirement.

Because no permits were categorized as compliant in 2018, the nonresponse bias test described in Appendix A could not be conducted for this year. The absence of this test combined with low participation and the fact that the reporting requirement did not go into effect until summer 2018, led to the authors' decision to exclude further reporting of statistics for the 2018 season.

Participation and the number of compliant and compliant noncompliant permits greatly increased in 2019 enabling testing for nonresponse bias. Only one of the tests needed to be significant to indicate the presence of a nonresponse bias effect. The nonresponse bias tests indicated that the difference between resident compliant and compliant noncompliant permits was not significantly different (Appendix A2; effort, $W = 1,009$, $P = 0.167$; harvest, $W = 926$, $P = 0.062$) and therefore the pooled data model described in the Methods section was used. Tests indicated a significant difference for nonresident permits (Appendix A2; effort, $W = 19,039$, $P = 0.017$; harvest, $W = 21,308$, $P = 0.213$), suggesting the presence of nonresponse bias. The nonresponse bias model described in Appendix A was investigated for nonresident permits but was not adopted because there were only 48 compliant noncompliant permits, most of which were from District 1, and it was thought that this relatively small group of permits were less likely to represent the noncompliant permits as opposed to the pooled compliant and noncompliant compliant permits.

During 2020, the nonresponse bias tests indicated that there was not a significant difference between resident compliant and compliant noncompliant permits (Appendix A2; effort, $W = 443$, $P = 0.446$; harvest, $W = 423$, $P = 0.674$) and therefore the pooled data model described in the Methods section was used. However, tests indicated a significant difference for nonresident permits (Appendix A2; effort, $W = 252,383$, $P < 0.001$; harvest, $W = 257,875$, $P < 0.001$), suggesting the presence of nonresponse bias. The nonresponse bias model described in Appendix A was investigated and adopted, which meant the 514 compliant noncompliant permits could be used to draw inference about the 494 noncompliant permits.

The nonresponse bias tests for resident permits could not be conducted in 2021 due to no compliant noncompliant permits being returned. For the nonresident permits in 2021, tests indicated that the difference between nonresident compliant and compliant noncompliant permits were not significantly different (effort, $W = 17,426$, $P = 0.908$; harvest, $W = 18,664$, $P = 0.681$). These results led to the use of the pooled data model described in the Methods section for both residents and nonresidents in 2021.

In 2022, the nonresponse bias tests indicated that the difference between resident compliant and compliant noncompliant permits were not significantly different (Appendix A2; effort, $W = 72$, $P = 0.432$; harvest, $W = 89$, $P=0.980$). Nonresident compliant and compliant noncompliant permits were not significantly different (Appendix A2; effort, $W = 255,629$, $P = 0.677$; harvest, $W = 259,030$, $P = 0.428$) and these results led to the use of the pooled data model described in the Methods section for both residents and nonresidents in 2022.

The nonresponse bias tests for 2023 indicated that the difference between resident compliant and compliant noncompliant permits were not significantly different (Appendix A2; effort, $W = 50$, $P = 0.630$; harvest, $W = 47$, $P = 0.501$). Nonresident compliant and compliant noncompliant permits were not significantly different as well (Appendix A2; effort, $W = 86,655$, $P = 0.560$; harvest, $W = 91,176$, $P = 0.160$). These results led to the use of the pooled data model described in the Methods section for both residents and nonresidents in 2023.

Resident effort in pots fished ranged from an estimated low of 81 (SE = 22) in 2021 to a high of 3,359 (SE = 516) in 2019 (Table 2, Figure 4). Residents harvested an estimated 7,420 (SE = 1,460), 1,065 (SE = 132), 170 (SE = 41), 536 (SE = 114), and 317 (SE = 41) pounds of whole shrimp in 2019, 2020, 2021, 2022, and 2023 respectively. Nonresident effort ranged from a low of 3,883 (SE = 148) in 2020 to a high of 9,326 (SE = 460) pounds of whole shrimp in 2019. Nonresidents harvested an estimated 19,047 (SE = 1,016), 6,753 (SE = 252), 13,147 (SE = 512), 12,868 (SE = 699), and 15,526 (SE = 536) pounds of whole shrimp in 2019, 2020, 2021, 2022, and 2023 respectively. Effort and harvest were, in general, not concentrated in any single ADF&G commercial fishing district (Table 3).

DISCUSSION

Although estimates for 2018 could be produced, the late implementation of the permit program and low participation made the results unreliable. The permit program began on 25 June 2018, and of the 527 permits issued to residents, only 15 (3%) complied with the reporting requirement (Table 1). Similarly, of the 2,269 permits issued to nonresidents, only 69 (3%) were reported (Table 1). Notably, all reports were submitted only after reminder letters were sent, classifying these respondents as compliant noncompliant rather than compliant (Table 1). Due to the low participation and the small sample size in this initial year, the 2018 estimates are considered unreliable and should be interpreted with caution. As a result, the authors chose not to report effort and harvest statistics for 2018 and instead limited the analysis to participation.

In 2019, nonresident participation in the program significantly increased compared to 2018 as users most likely became more aware of the permit and harvest reporting requirements. There were 3,144 permits issued to nonresidents, and 1,039 of those permits completed harvest reports (Table 1). The number of permits issued was roughly a 39% increase compared to 2018 (Table 1), suggesting an increased awareness of the permit requirement. Furthermore, the percentage of respondents significantly increased during 2018 to 2019, from 3% to 33% (Table 1). This suggests the permittees became more aware of the harvest reporting requirement. This could have been due to better communication and outreach from the department, nonresidents reading the conditions of the permit more carefully, or charter operators educating their nonresident clients with shrimp permits of the harvest reporting requirement.

Compared to 2019, nonresident participation in the sport shrimp fishery drastically decreased in 2020. In 2020, 1,824 permits were issued to nonresidents, a 42% decrease from the 3,144 permits issued in 2019 (Table 1). A potential reason for the decrease in permits issued to nonresidents was the effects of the beginning of the COVID-19 pandemic, such as restrictions placed on travel to Alaska from out of state (Dunleavy et al. 2020). Despite a decrease in the number of permits issued to nonresidents in 2020, the percentage of respondents increased from 33% to 73% (Table 1), potentially due to the same reasons alluded to in the previous paragraph. In 2021, the number of permits issued to nonresidents was 3,567, a 96% increase compared to 2020 (Table 1). This increase in permits issued to nonresidents is likely due to fewer restrictions on interstate travel to

Alaska for nonresidents (Dunleavy 2021). In 2022, the number of permits issued to nonresidents stayed almost the same compared to 2021, at 3,543 permits (Table 1). The percentage of nonresident permit holders who submitted their harvest report in 2021 was relatively the same compared to 2020, decreasing slightly from 73% (2020) to 67% (2021; Table 1). The percentage of nonresident permit holders who submitted their harvest reports noticeably increased from 67% in 2021 to 78% in 2022. The relatively similar response rates from 2020 to 2022 could potentially be due to nonresidents' increased awareness of the harvest reporting requirement and persistent reminders from ADF&G staff informing permit holders of the harvest reporting requirement. In 2023, the exact same number of permits were issued to nonresidents at 3,543 compared to 2022 (Table 1). The percentage of nonresident permit holders who submitted their harvest report in 2023 was relatively the same decreasing slightly from 78% (2022) to 75% (2023; Table 1).

The nonresident estimates reported in Table 2 follow a similar trend year to year as shown in Table 1. From 2019 to 2020, all nonresident estimates decreased: percentage of permits fished (71% to 38%), effort in pots fished (9,326 to 3,883), harvest in pounds of whole shrimp (19,047 to 6,753), and HPUE (2.04 to 1.74; Table 2). Once again, similar to Table 1, from 2020 to 2021 all nonresident estimates increased: percentage of permits fished (38% to 44%), effort (3,883 to 6,167), harvest in pounds of whole shrimp (6,753 to 13,147), and HPUE (1.74 to 2.13; Table 2). A possible explanation for the drop in nonresident estimates in 2020 and subsequent increase in 2021 are the same reasons alluded to earlier, i.e., the COVID-19 pandemic interstate travel restrictions in 2020 (Dunleavy et al. 2020) and lessening of COVID-19 pandemic travel restrictions in 2021 (Dunleavy 2021). From 2021 to 2022, the estimates stayed relatively the same: percentage of permits fished (44% to 38%), effort (6,167 to 5,573), harvest in pounds of whole shrimp (13,147 to 12,868), and HPUE (2.13 to 2.31). From 2022 to 2023, the estimates increased slightly: percent of permits fished (28% to 50%), effort (5,573 to 6,716), harvest in pounds of whole shrimp (12,868 to 15,256) with HPUE slightly decreasing (2.31 to 2.27; Table 2).

Since 2019, the number of sport shrimp permits issued to residents has decreased and stabilized to a consistently low level (Table 1). Similarly, the resident estimates of permits fished, effort, and harvest have seen a similar decrease from 2019 to a low baseline (Table 2). The decrease in resident participation in the sport shrimp fishery since 2019 was likely due to participation shifting to the personal use and subsistence shrimp fisheries where the methods and means are less restrictive and the daily bag, possession, and gear limits are greater compared to the sport fishery. This shift in participation may be a result of a web prompt to resident anglers attempting to obtain a sport permit in the online licensing system, which was introduced during the 2020 season.

Because this survey has only been in place for 6 years, and includes no compliant permit holders in 2018 and greatly diminished participation and effort in 2020, it is difficult to determine any long-term trends about shrimp anglers' effort, harvest, and HPUE at this time. As this survey continues and the dataset increases, ADF&G will be more capable of determining long-term trends about the SEAK sport shrimp fishery.

CONVERSION FACTORS

Permit holders have the option to report harvest in quarts or pounds, and either tailed or whole shrimp. Therefore, reported values need to be standardized. Conversion factors are used to standardize estimates to the unit of whole shrimp in pounds. In the original ROP, a conversion factor from Prince William Sound was used to convert quarts of whole shrimp to pounds of whole shrimp (Teske 2018, Teske and Peterson 2022). This conversion factor differed substantially from

those eventually used because it was for ADF&G commercial sampling gear from a different region.

Due to the issues with the original conversion factors, interim conversation factors were developed using data collected in SEAK (David Harris, Retired Fishery Biologist, ADF&G Division of Commercial Fisheries, personal communication). Estimates based on these interim conversion factors were presented to the 2022 board (Tydingco et al. 2021). Although these interim conversion factors were an improvement over the original values, they were still approximates. A study was planned to refine these factors, but results were not available for the 2022 board report. The estimates reported herein correct the previously reported values.

In 2022 and 2023, ADF&G Commercial Fishery Division staff conducted a study and collected data specifically for computing conversion factors for the SEAK sport, personal use, and subsistence shrimp fisheries (Max Schoenfeld, Fishery Biologist 2, ADF&G, Division of Commercial Fisheries, personal communication). The conversion factors calculated from this study are certainly better than the previous 2 iterations; however, it is important to note that the use of any conversion factor is not ideal, because conversion factors are based on a number of untestable assumptions (see the Conversion Factors section in the Methods for additional details).

RESIDENT HARVEST AND PARTICIPATION TRENDS

The low resident participation and harvest since 2019 is probably the result of residents shifting participation to a personal use or subsistence fishery due to regulations being more liberal. Improvements to the online permitting system now prompts residents to get personal use and subsistence permits instead of the sport permit.

COVID-19

The drop in nonresident participation, effort, and harvest in 2020 was likely a result of the early period of the COVID-19 pandemic. The number of permits issued declined from 3,144 in 2019 to 1,824 in 2020 and rebounded to 3,567 in 2021 (Table 1). Effort and harvest followed similar trends (Table 2, Figure 3). Although participation in the fishery in 2021, 2022, and 2023 saw a return to pre-pandemic levels, effort and harvest have not. This appears to be related to the decline in permits that reported fishing, which was 71% in 2019, 38% in 2020, 44% in 2021, 38% in 2022, and 50% in 2023 (Table 2).

ACKNOWLEDGMENTS

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TABLES

Table 1.–Number of permits issued; compliant, compliant noncompliant, noncompliant; and overall percentage of permits that responded in the Southeast Alaska (SEAK) sport shrimp fishery by residency, 2018–2023.

| Year | Residency | Permits | | | Total | Percent response |
		Compliant	Compliant noncompliant	Noncompliant		
2018	Resident	0	15	512	527	3%
	Nonresident	0	69	2,200	2,269	3%
2019	Resident	168	15	275	458	40%
	Nonresident	991	48	2,105	3,144	33%
2020	Resident	40	20	13	73	82%
	Nonresident	816	514	494	1,824	73%
2021	Resident	33	0	10	43	77%
	Nonresident	2,360	15	1,192	3,567	67%
2022	Resident	44	4	11	59	81%
	Nonresident	2,556	197	790	3,543	78%
2023	Resident	60	2	12	74	84%
	Nonresident	2,605	64	874	3,543	75%

Source: Kirk Brogdon (retired) and Ryan Snow, ADF&G Division of Sport Fish, Analyst Programmers, Anchorage, unpublished data.

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Table 2.–Estimated percent of permits that fished, effort (number of pots), harvest (lb), and harvest per unit effort (HPUE) of whole shrimp harvested in the SEAK sport shrimp fishery by residency, 2019–2023.

Year[a]	Residency	Percent fished		Effort		Harvest[b]		HPUE	
		Est	SE	Est	SE	Est	SE	Est	SE
2019	Resident	47%	3%	3,359	516	7,420	1,460	2.21	0.55
	Nonresident	71%	1%	9,326	460	19,047	1,016	2.04	0.15
2020	Resident	37%	3%	341	40	1,065	132	3.13	0.53
	Nonresident	38%	1%	3,883	148	6,753	252	1.74	0.09
2021	Resident	21%	3%	81	22	170	41	2.11	0.76
	Nonresident	44%	1%	6,167	203	13,147	512	2.13	0.11
2022	Resident	25%	3%	124	18	536	114	4.32	1.11
	Nonresident	38%	0%	5,573	144	12,868	699	2.31	0.14
2023	Resident	27%	2%	127	14	317	41	2.51	0.42
	Nonresident	50%	0%	6,716	167	15,256	536	2.27	0.10

Source: Kirk Brogdon (retired) and Ryan Snow, ADF&G Division of Sport Fish, Analyst Programmers, Anchorage, unpublished data.

[a] Estimates from 2018 are not shown because they were generated from a small sample and are likely unreliable.

[b] Conversion factors of 1.44 lb/qt (tails), 1.11 lb/qt (whole), and 2.02 tail/whole were used to convert reported harvest estimates in varying units to a common unit of lb/qt of whole shrimp. The lb/qt conversion factors were based on an ADF&G study (Max Schoenfeld, Fishery Biologist 2, ADF&G, Division of Commercial Fisheries, personal communication) and the tail/whole conversion factor was based on a separate ADF&G study (David Harris, Retired Fishery Biologist, ADF&G Division of Commercial Fisheries, personal communication).

Table 3.–Estimated effort (number of pots), harvest (lb), and harvest per unit effort (HPUE) of whole shrimp harvested in the SEAK sport shrimp fishery by residency and ADF&G Commercial Fishing District, 2018–2023.

Year[a]	District[b]	Resident						Nonresident					
		Effort		Harvest[c]		HPUE		Effort		Harvest[c]		HPUE	
		Est	SE	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE
	1	1,304	435	3,745	1,354	2.87	1.41	1,477	213	2,695	457	1.82	0.41
	2	420	175	720	291	1.71	0.99	1,462	278	3,292	613	2.25	0.60
	3	108	48	156	79	1.45	0.98	242	58	673	180	2.78	1.00
	5	23	17	0	0	0.00	–	248	60	527	154	2.13	0.81
	6	105	76	101	69	0.96	0.95	166	65	246	108	1.48	0.87
	7	218	105	723	438	3.32	2.57	690	148	1,735	279	2.51	0.68
	8	173	92	306	169	1.77	1.36	551	85	1,227	199	2.23	0.50
	9	233	159	269	146	1.15	1.01	336	46	635	114	1.89	0.43
	10	265	85	386	140	1.45	0.70	669	78	1,317	195	1.97	0.37
2019	11	58	45	175	136	3.04	3.34	121	38	178	67	1.47	0.72
	12	288	87	472	162	1.64	0.75	1,219	131	2,547	340	2.09	0.36
	13	33	13	53	23	1.62	0.96	799	84	2,027	249	2.54	0.41
	14	43	31	182	100	4.28	3.90	336	105	571	173	1.70	0.74
	15	90	44	133	96	1.48	1.29	735	135	902	174	1.23	0.33
	152	0	0	0	0	–	–	61	50	212	173	3.50	4.05
	154	0	0	0	0	–	–	179	73	189	73	1.06	0.60
	183	0	0	0	0	–	–	33	25	70	58	2.12	2.34
	189	0	0	0	0	–	–	3	2	3	3	1.11	1.28
	Total	3,359	516	7,420	1,460	2.21	0.55	9,326	460	19,047	1,016	2.04	0.15

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Table 3.–Page 2 of 5.

Year[a]	District[b]	Resident						Nonresident					
		Effort		Harvest[c]		HPUE		Effort		Harvest[c]		HPUE	
		Est	SE	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE
2020	1	89	23	249	72	2.80	1.09	747	47	1,869	131	2.50	0.24
	2	29	9	91	27	3.12	1.34	576	69	894	112	1.55	0.27
	3	73	28	205	81	2.81	1.54	158	25	304	14	1.93	0.32
	5	12	5	50	21	4.07	2.43	120	39	95	28	0.79	0.35
	6	0	0	0	0	–	–	374	66	348	55	0.93	0.22
	7	24	10	106	45	4.36	2.60	180	34	361	44	2.01	0.45
	8	18	8	53	22	2.91	1.74	567	73	771	78	1.36	0.22
	9	0	0	0	0	–	–	188	26	492	145	2.62	0.86
	10	0	0	0	0	–	–	139	25	258	16	1.86	0.35
	11	6	3	28	12	4.65	2.78	39	7	75	10	1.94	0.45
	12	55	16	223	66	4.07	1.68	234	30	521	51	2.23	0.36
	13	28	7	51	18	1.82	0.79	153	40	179	30	1.17	0.36
	14	1	1	2	1	1.45	0.87	213	22	333	11	1.56	0.17
	15	5	2	7	3	1.52	0.90	73	0	114	0	1.56	0.00
	16	0	0	0	0	–	–	3	0	5	0	1.64	0.00
	152	0	0	0	0	–	–	5	0	31	0	6.27	0.00
	154	0	0	0	0	–	–	1	0	5	0	5.00	0.00
	181	0	0	0	0	–	–	3	0	6	0	1.85	0.00
	183	0	0	0	0	–	–	109	16	93	10	0.85	0.15
	185	0	0	0	0	–	–	1	0	0	0	0.00	–
	189	0	0	0	0	–	–	1	0	0	0	0.00	–
	Total	341	40	1,065	132	3.13	0.53	3,883	148	6,753	252	1.74	0.09

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Table 3.–Page 3 of 5.

Year[a]	District[b]	Resident						Nonresident					
		Effort		Harvest[c]		HPUE		Effort		Harvest[c]		HPUE	
		Est	SE	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE
	1	39	12	123	39	3.15	1.41	955	70	1,869	178	1.96	0.23
	2	0	0	0	0	–	–	556	51	1,149	125	2.07	0.29
	3	0	0	0	0	–	–	201	28	477	72	2.37	0.49
	5	0	0	0	0	–	–	291	52	1,218	247	4.18	1.13
	6	13	6	5	3	0.40	0.28	431	62	796	123	1.85	0.39
	7	0	0	0	0	–	–	499	55	1,734	156	3.48	0.49
	8	26	13	21	10	0.81	0.55	581	52	1,370	127	2.36	0.30
	9	0	0	0	0	–	–	375	43	949	115	2.53	0.42
	10	0	0	0	0	–	–	536	54	803	111	1.50	0.25
	11	3	1	21	7	8.00	3.81	144	31	461	121	3.20	1.09
2021	12	0	0	0	0	–	–	563	69	765	108	1.36	0.25
	13	0	0	0	0	–	–	342	28	623	60	1.82	0.23
	14	0	0	0	0	–	–	336	43	460	63	1.37	0.26
	15	0	0	0	0	–	–	242	68	286	87	1.18	0.49
	16	0	0	0	0	–	–	20	8	59	24	3.04	1.72
	152	0	0	0	0	–	–	45	15	66	25	1.45	0.74
	156	0	0	0	0	–	–	3	2	5	3	1.67	1.36
	181	0	0	0	0	–	–	9	5	31	18	3.39	2.77
	183	0	0	0	0	–	–	35	11	27	9	0.80	0.35
	191	0	0	0	0	–	–	2	1	0	0	0.00	–
	Total	81	22	170	41	2.11	0.76	6,167	203	13,147	512	2.13	0.11

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Table 3.–Page 4 of 5.

Year[a]	District[b]	Resident						Nonresident					
		Effort		Harvest[c]		HPUE		Effort		Harvest[c]		HPUE	
		Est	SE	Est	SE	Est	SE	Est	SE	Est	SE	Est	SE
	1	9	2	31	13	3.62	1.80	921	60	2,125	167	2.31	0.24
	2	15	6	236	102	16.00	9.77	826	66	1,429	116	1.73	0.20
	3	0	0	0	0	–	–	221	27	435	56	1.97	0.35
	5	0	0	0	0	–	–	272	34	854	117	3.15	0.58
	6	0	0	0	0	–	–	493	67	807	118	1.64	0.33
	7	15	5	119	48	8.06	4.16	387	33	1,434	160	3.70	0.52
	8	12	5	31	14	2.55	1.56	497	48	969	79	1.95	0.25
	9	0	0	0	0	–	–	268	18	673	48	2.51	0.25
	10	7	3	11	5	1.48	0.90	273	24	1,848	615	6.77	2.33
2022	11	0	0	0	0	–	–	54	7	219	54	4.06	1.13
	12	0	0	0	0	–	–	322	17	652	47	2.03	0.18
	13	43	14	70	25	1.62	0.79	341	22	469	28	1.37	0.12
	14	12	5	6	3	0.50	0.31	232	29	329	54	1.42	0.29
	15	11	5	32	14	2.91	1.78	377	41	493	52	1.31	0.20
	16	0	0	0	0	–	–	24	5	22	5	0.90	0.28
	152	0	0	0	0	–	–	13	4	31	10	2.38	1.03
	154	0	0	0	0	–	–	23	8	32	11	1.39	0.65
	183	0	0	0	0	–	–	28	9	48	16	1.68	0.81
	Total	124	18	536	114	4.32	1.11	5,573	144	12,868	699	2.31	0.14

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Table 3.–Page 5 of 5.

Year[a]	District[b]	Resident Effort Est	Resident Effort SE	Resident Harvest[c] Est	Resident Harvest[c] SE	Resident HPUE Est	Resident HPUE SE	Nonresident Effort Est	Nonresident Effort SE	Nonresident Harvest[c] Est	Nonresident Harvest[c] SE	Nonresident HPUE Est	Nonresident HPUE SE
	1	43	8	55	10	1.28	0.34	779	47	1,488	106	1.91	0.18
	2	6	2	30	12	4.99	2.84	919	56	1,943	124	2.12	0.19
	3	5	2	28	11	5.82	3.31	455	32	911	75	2.00	0.22
	5	0	0	0	0	–	–	232	32	882	199	3.80	1.00
	6	0	0	0	0	–	–	616	69	1,691	239	2.74	0.50
	7	0	0	0	0	–	–	575	50	1,662	116	2.89	0.32
	8	0	0	0	0	–	–	554	44	924	74	1.67	0.19
	9	0	0	0	0	–	–	327	23	935	84	2.86	0.33
	10	0	0	0	0	–	–	400	29	1,103	212	2.76	0.57
	11	1	0	0	0	0.00	–	73	9	256	60	3.50	0.93
2023	12	8	3	58	22	6.98	3.62	454	27	856	55	1.89	0.16
	13	32	8	56	14	1.73	0.61	400	29	690	46	1.73	0.17
	14	24	8	76	29	3.20	1.58	210	19	1,002	274	4.78	1.38
	15	5	2	3	1	0.56	0.32	617	94	701	92	1.14	0.23
	16	2	1	12	5	5.00	2.85	16	5	70	22	4.36	1.86
	152	0	0	0	0	–	–	41	8	85	18	2.07	0.62
	154	0	0	0	0	–	–	28	11	28	12	1.02	0.58
	156	0	0	0	0	–	–	1	1	1	1	1.11	0.78
	157	0	0	0	0	–	–	4	2	3	1	0.67	0.47
	183	0	0	0	0	–	–	15	4	26	6	1.78	0.62
	185	0	0	0	0	–	–	1	1	0	0	0.00	–
	Total	127	14	317	41	2.51	0.42	6,716	167	15,256	536	2.27	0.10

Note: Areas without adequate effort (i.e., = 0), HPUE is undefined and denoted by an en dash. Areas without adequate effort or harvest (i.e., effort, = 0 or harvest = 0), SE(HPUE) is undefined and denoted by an en dash.

[a] Estimates from 2018 are not shown because they were generated from a small sample and were likely unreliable.

[b] Districts not included within a year have an estimated harvest of 0.

[c] Conversion factors of 1.44 lb/qt (tails), 1.11 lb/qt (whole), and 2.02 tail/whole were used to convert reported harvest estimates in varying units to a common unit of lb/qt of whole shrimp (Max Schoenfeld, Fishery Biologist 2, ADF&G, Division of Commercial Fisheries, personal communication; David Harris, Retired Fishery Biologist, ADF&G Division of Commercial Fisheries, personal communication).
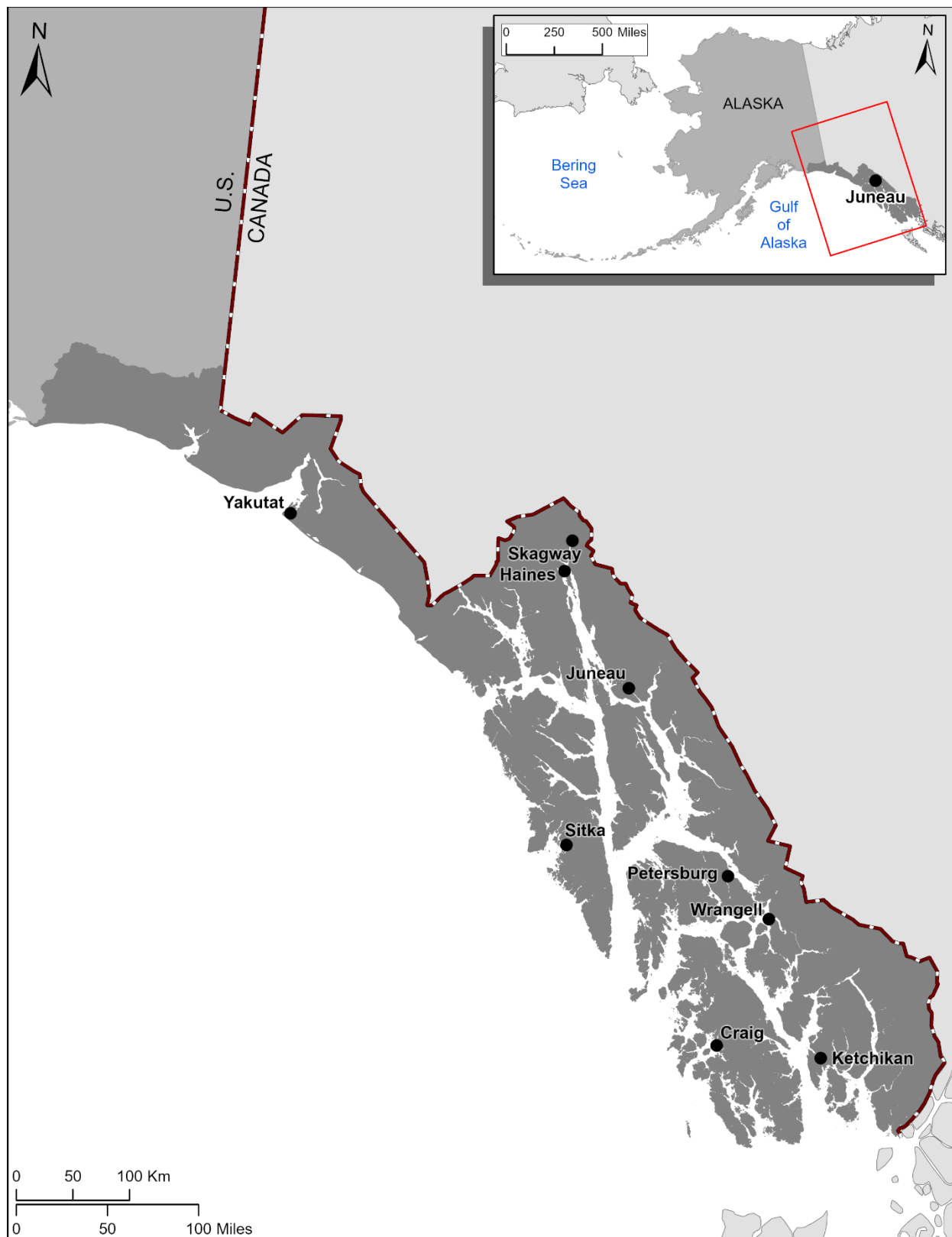
FIGURES

Figure 1.–Map depicting Southeast Alaska's location in relation to the entire state.
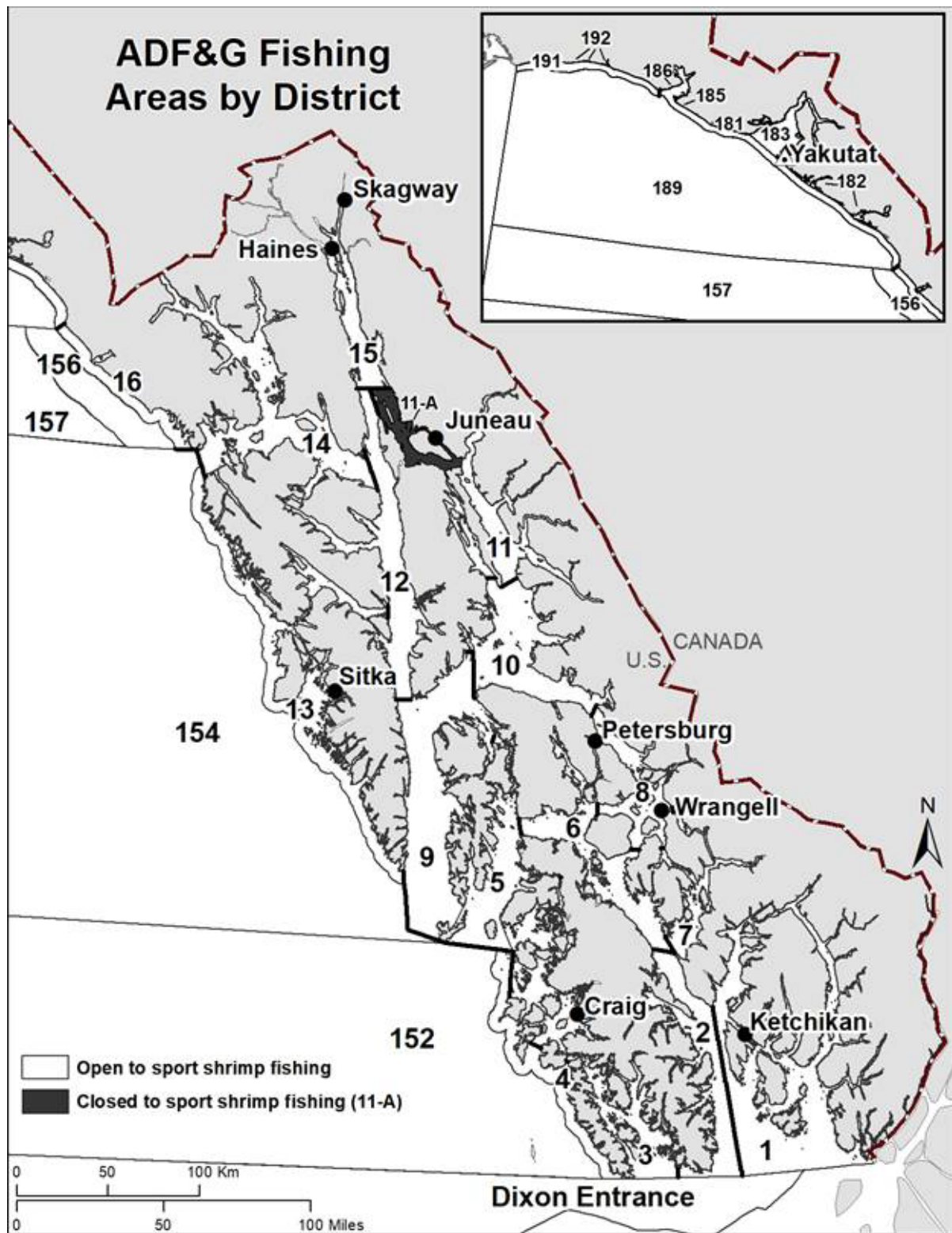
Figure 2.–Map of Southeast Alaska ADF&G commercial fishing districts issued with the sport shrimp permit from 2018 to November 2022.

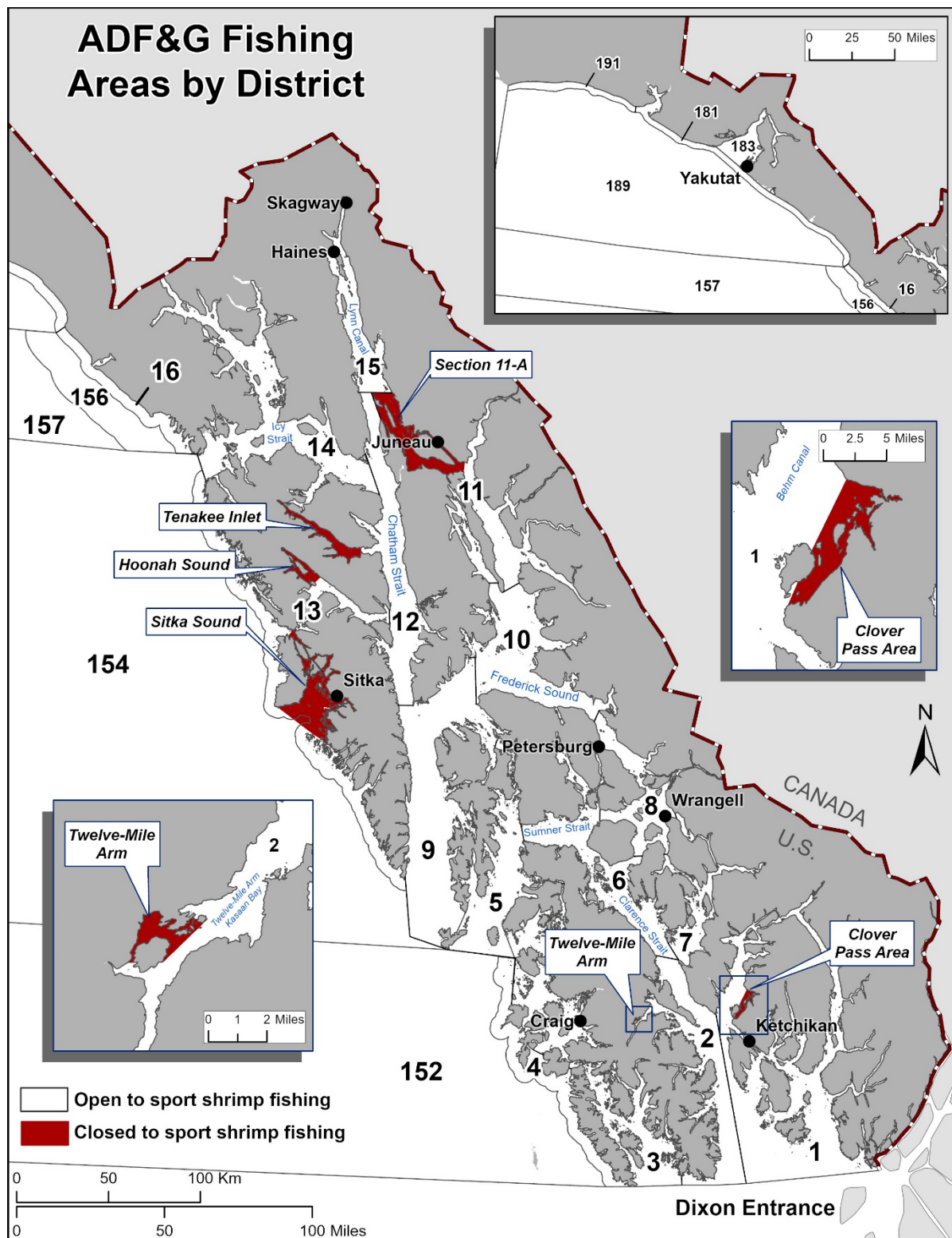Figure 3.–Map of Southeast Alaska ADF&G commercial fishing districts issued with the sport fish permit, from November 2022 to the date this report was published.
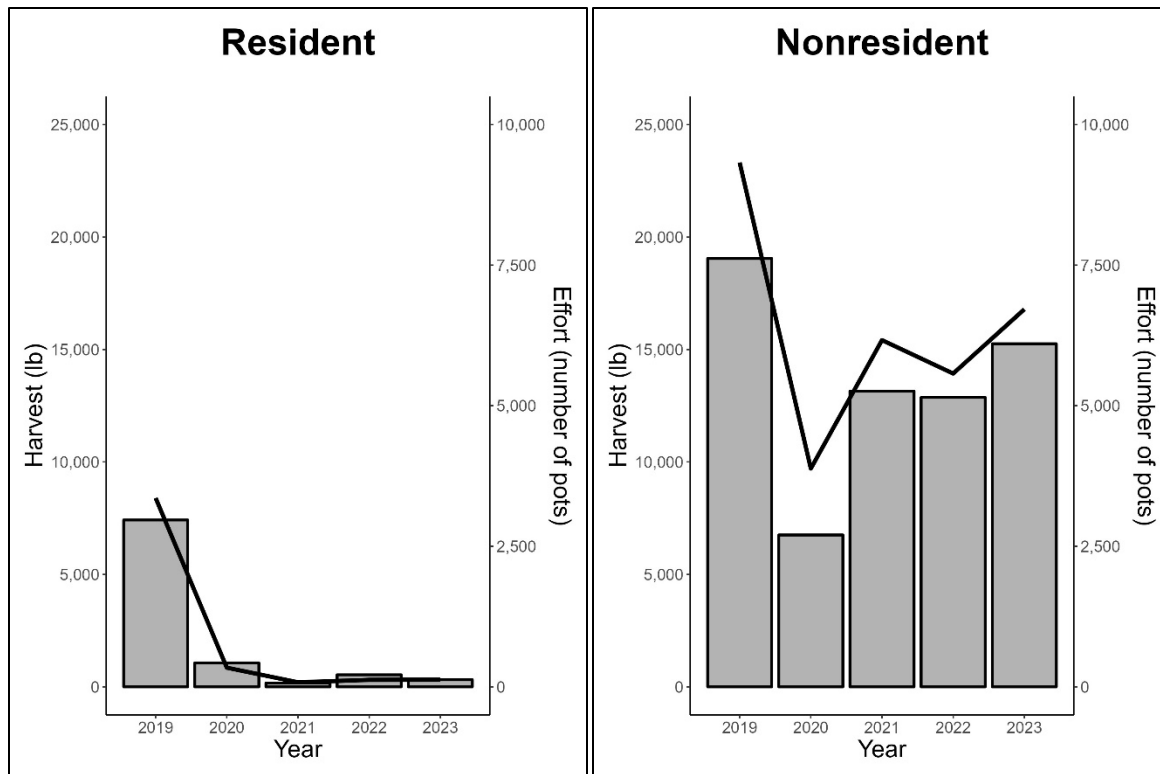
Figure 4.–Estimated effort (black line) and harvest of whole shrimp in pounds harvested in the SEAK sport shrimp fishery by residency, 2019–2023.

Note: Estimates from 2018 are not shown because they were generated from a small sample and likely unreliable.

APPENDIX A

NONRESPONSE BIAS

The model described in the Methods section assumes responding (i.e., compliant) permits are representative of permits that did not respond (i.e., noncompliant). Nonresponse bias is a potential issue if this assumption is not true. Logbook or catch-card study designs are prone to issues of nonresponse bias (Essig and Holliday 1993; Pollock 1994). Given the likelihood of nonresponse bias due to the study design, we (1) attempted to mitigate nonresponse bias by requiring all permits to be returned, (2) tested for evidence of nonresponse bias (methods and results described herein), and (3) considered use of a different model (also described herein) if a significant nonresponse bias effect was detected. Note the following terms will be used:

- compliant: permits that respond prior to receiving a reminder letter
- compliant noncompliant: permits that respond after receiving a reminder letter
- noncompliant: permits that never respond

NONRESPONSE BIAS TEST

Nonresponse bias was tested for by comparing the harvest and effort of compliant and compliant noncompliant permits. We used a 2-sample Wilcoxon Rank Sum Test to test for differences between compliant and compliant noncompliant permits because harvest and effort are non-normally distributed. If either test was significant, we concluded there was evidence of a nonresponse bias effect. If there was evidence of a nonresponse bias, we investigated use of the following model to resolve the issue.

NONRESPONSE BIAS MODEL

The number of permits issued (N) by residency status will be divided into 2 groups (separate equations for residents and nonresidents omitted to simplify presentation of equations):

$$N = N_c + N_d \tag{A1}$$

where

N_c = number of compliant permits, and

N_d = number of noncompliant and compliant noncompliant permits.

Note that compliant permits can be further divided into permits that fished and did not fish:

$$N_c = N_{cf} + N_{cz} \tag{A2}$$

and similarly, noncompliant and compliant noncompliant permits can be separated into the same categories:

$$N_d = \widehat{N}_{df} + \widehat{N}_{dz} \tag{A3}$$

where,

N_{cf} = number of compliant permits that fished,

N_{cz} = number of compliant permits that did not fish,

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$\widehat{N}_{df}$ = estimated number of noncompliant and compliant noncompliant permits that fished, and

$\widehat{N}_{dz}$ = estimated number of noncompliant and compliant noncompliant permits that did not fish.

We are interested in the number of permits that fished, $\widehat{N}_f$, calculated as:

$$\widehat{N}_f = N_{cf} + \widehat{N}_{df} \tag{A4}$$

and similarly, the number of permits that did not fish, $\widehat{N}_z$, calculated as:

$$\widehat{N}_z = N_{cz} + \widehat{N}_{dz} \tag{A5}$$

where

$$\widehat{N}_{df} = N_d \widehat{w}_d \tag{A6}$$

and where

$$\widehat{N}_{dz} = N_d (1 - \widehat{w}_d) \tag{A7}$$

where

$$\widehat{w}_d = \frac{n_{df}}{n_d} \tag{A8}$$

and finally, where

$\widehat{w}_d$ = estimated proportion of noncompliant permits that fished,

n_{df} = number of compliant noncompliant permits that fished, and

n_d = number of compliant noncompliant permits.

Total harvest or effort, $\widehat{H}$, and total harvest or effort by area, $\widehat{H}_a$, will be estimated as (note separate equations for each omitted for simplicity):

$$\widehat{H} = H_c + \widehat{H}_d \tag{A9}$$

where

H_c = harvest or effort of compliant permits,

$\widehat{H}_d$ = estimated harvest or effort of noncompliant permits,

and where,

$$\widehat{H}_d = N_d \bar{h}_d \tag{A10}$$

where

$\bar{h}_d$ = the mean harvest or effort for compliant noncompliant permits,

and where

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$$\bar{h}_d = \frac{\left(\sum_{i=1}^{n_d} h_{d,i}\right)}{n_d} \tag{A11}$$

where

$h_{d,i}$ = reported harvest or effort by responding compliant permit j that reported fishing, and

variance of $\hat{H}$ and $\hat{H}_a$ will be calculated as (note separate equations for each omitted for simplicity):

$$\text{var}(\hat{H}) = \text{var}(H_c + \hat{H}_d) = \text{var}(H_c) + \text{var}(\hat{H}_d) = 0 + \text{var}(\hat{H}_d) = \text{var}(\hat{H}_d) \tag{A12}$$

and variance of $\hat{H}_d$ as:

$$\text{var}(\hat{H}_d) = \text{var}(N_d \bar{h}_d) = N_d^2 \text{var}(\bar{h}_d) \tag{A13}$$

and variance of $\bar{h}_d$ as:

$$\text{var}(\bar{h}_d) = \frac{s_{\bar{h}_d}^2}{n_d}\left(1 - \frac{n_d}{N_d}\right) \tag{A14}$$

where $s_{\bar{h}_d}^2$ is the sample variance of the mean reported harvest for compliant noncompliant permits:

$$s_{\bar{h}_d}^2 = \frac{\sum_{i=1}^{n_d}\left(h_{d,i} - \bar{h}_d\right)^2}{n_d - 1} \tag{A15}$$

Variance of $\hat{N}_f$ will be calculated as:

$$\text{var}(\hat{N}_f) = \text{var}(N_{cf} + \hat{N}_{df}) = \text{var}(N_{cf}) + \text{var}(\hat{N}_{df}) = 0 + \text{var}(\hat{N}_{df}) \tag{A16}$$

and variance of $\hat{N}_{df}$ as:

$$\text{var}(\hat{N}_{df}) = \text{var}(N_d \hat{w}_d) = N_d^2 \text{var}(\hat{w}_d) \tag{A17}$$

and variance of $\hat{w}_d$ as:

$$\text{var}(\hat{w}_d) = \frac{\hat{w}_d(1 - \hat{w}_d)}{n_d - 1}(1 - \frac{n_d}{N_d}) \tag{A18}$$

Lastly, the proportion of permits that fished, will be calculated as:

$$\hat{w} = \frac{\hat{N}_f}{N} \tag{A19}$$

Variance of $\hat{w}$ will be calculated as:

$$\text{var}(\hat{w}) = \frac{1}{N^2}\text{var}(\hat{w}_d) \tag{A20}$$

Standard errors were calculated from the square root of the variance estimates.

Appendix A2.–Number of permits, average effort or harvest ($\bar{h}$), and, where applicable, the test statistic (W) and *P*-value from the Wilcoxon Rank Sum Test used to detect nonresponse bias by residency, response variable, and permit compliancy status, 2018–2023.

Year	Residency	Variable	Permit compliancy status	Number of permits	$\bar{h}$	W	*P*-value
2018	Resident	Effort	Compliant	0	–		
			Compliant Noncompliant	15	2.9	–	–
		Harvest	Compliant	0	–		
			Compliant Noncompliant	15	6.8	–	–
	Nonresident	Effort	Compliant	0	–		
			Compliant Noncompliant	69	1.6	–	–
		Harvest	Compliant	0	–		
			Compliant Noncompliant	69	3.1	–	–
2019	Resident	Effort	Compliant	168	7.1		
			Compliant Noncompliant	15	9.7	1,009	0.167
		Harvest	Compliant	168	16.0		
			Compliant Noncompliant	15	20.8	926	0.062
	Nonresident	Effort	Compliant	991	2.8		
			Compliant Noncompliant	48	5.9	19,039	0.017
		Harvest	Compliant	991	5.9		
			Compliant Noncompliant	48	11.5	21,308	0.213

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Year	Residency	Variable	Permit compliancy status	Number of permits	$\bar{h}$	W	P-value
2020	Resident	Effort	Compliant	40	5.6	443	0.446
			Compliant Noncompliant	20	2.8		
		Harvest	Compliant	40	18.1	423	0.674
			Compliant Noncompliant	20	8.0		
	Nonresident	Effort	Compliant	816	2.7	252,383	<0.001
			Compliant Noncompliant	514	1.6		
		Harvest	Compliant	816	5.9	257,875	<0.001
			Compliant Noncompliant	514	2.0		
2021	Resident	Effort	Compliant	33	1.9	–	–
			Compliant Noncompliant	0	–		
		Harvest	Compliant	33	4.0	–	–
			Compliant Noncompliant	0	–		
	Nonresident	Effort	Compliant	2,360	1.7	17,426	0.908
			Compliant Noncompliant	15	1.8		
		Harvest	Compliant	2,360	3.7	18,664	0.681
			Compliant Noncompliant	15	1.9		

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Year	Residency	Variable	Permit compliancy status	Number of permits	$\bar{h}$	W	P-value
2022	Resident	Effort	Compliant	44	2.2		
			Compliant Noncompliant	4	1.5	72	0.432
		Harvest	Compliant	44	9.9		
			Compliant Noncompliant	4	1.5	89	0.980
	Nonresident	Effort	Compliant	2,556	1.6		
			Compliant Noncompliant	197	1.3	255,629	0.677
		Harvest	Compliant	2,556	3.7		
			Compliant Noncompliant	197	3.1	259,030	0.428
2023	Resident	Effort	Compliant	60	1.7		
			Compliant Noncompliant	2	1.5	50	0.630
		Harvest	Compliant	60	4.3		
			Compliant Noncompliant	2	5.0	47	0.501
	Nonresident	Effort	Compliant	2,605	1.9		
			Compliant Noncompliant	64	2.2	86,655	0.560
		Harvest	Compliant	2,605	4.3		
			Compliant Noncompliant	64	2.6	91,176	0.160

Note: En dashes represent results for cases with insufficient data (i.e., number of permits = 0) where the nonresponse bias test could not be calculated.