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CALIFORNIA RECREATIONAL ABALONE FISHERY CATCH AND EFFORT ESTIMATES FOR 2002 FROM A COMBINED REPORT CARD AND TELEPHONE SURVEY

PETER E. KALVASS

California Department of Fish and Game
19160 S. Harbor Dr.
Fort Bragg, CA 95437

JOHN J. GEIBEL

(Retired)

California Department of Fish and Game
350 Harbor Blvd
Belmont, CA 94002

Total catch and effort were estimated for the 2002 California recreational abalone fishery, using a combination of returned report card data complimented by a telephone survey to estimate the contribution of unreturned report cards. There were 35,146 cards purchased for fishing year 2002. Abalone catch and effort were estimated at 264,130 (95% CI $\pm 16,823$) abalone and 100,473 (95% CI $\pm 6,822$) picker days. Catch per unit of effort averaged 2.63 abalone per picker day and 8.54 abalone per picker year. Report cards revealed that the Fort Ross area in Sonoma County and Van Damme State Park in Mendocino County provided the most abalone for pickers in 2002. Sonoma and Mendocino counties contributed almost 25% of abalone card purchasers, with 6 northern California counties accounting for over 50% of the purchasers. Telephone survey data revealed the mean number of abalone trips in 2002 as 3.1, with the mean age of pickers as 44 years. Approximately 58% of the telephone surveyed pickers accurately recalled their number of effort days and abalone taken. On average, pickers who returned their abalone report cards picked more days and took more abalone than those who did not return their cards.

INTRODUCTION

Telephone surveys have become widely used in recreational fisheries catch and effort investigations since the early 1990s. The National Marine Fisheries Service's Marine Recreational Fishery Statistics Survey for effort and catch uses both a telephone survey and an on-site access point survey (Pollock et al. 1994). More recently, California developed a modified version of the latter called the California Recreational Fish Survey (www.psmfc.org). Report cards or diaries have also been used in conjunction with telephone surveys (Pollock et al. 1994). A report card for the California recreational red abalone, *Haliotis rufescens*, fishery was established in 2000, requiring pickers to record catch and effort and return the card to the Department of Fish and Game at season's end. The return rate for 2000 was only about 24% several months after the season ended. An estimate of catch and effort based on these returns

alone would likely be biased due to avidity and other non-random factors related to those who chose to return their card versus the group that did not (Pollock et al. 1994). Therefore, a telephone survey was designed to estimate the catch and effort of the non-return group for the 2002 abalone season. The estimate was statistically combined with the actual counts from the returned report cards to produce an overall catch and effort estimate for the sport abalone fishery.

Under present circumstances, we should not anticipate the near 100% report card return rates that would obviate the need for a companion telephone survey. Despite this, our goal is to create a long-term reliable method for estimating catch and effort in the California recreational abalone fishery.

METHODS

The sampling frame used for the telephone survey consisted of the abalone report card purchaser receipt database from 2002. Preliminary report card catch and effort data from 2001 was used to calculate the range of 'n' sizes needed to produce different confidence bounds around a mean number of abalone per picker-year. The sample size required to obtain a specific confidence bound can be calculated if the variance of the population is known (Scheaffer et al. 1990). So, to calculate the sample size needed for a particular confidence interval for a normal population, set $2SE = A$, where A is the desired confidence interval on each side of the mean, then:

$$n = (2SD / A)^2.$$

We used the mean, 15.4, and the variance, 285.61, from the 2001 abalone card returns to calculate the sample size needed in 2002 to estimate the number of abalone taken by anglers who did not return their abalone report cards. We decided that a confidence bound of ± 2 abalone was a reasonable goal. The sample size needed to obtain a confidence interval of ± 2 around the mean was 286.

In 2002, approximately 43% of pickers returned their cards. Based upon this ratio, about 500 completed phone interviews would be required to obtain 286 non-returnees from the list of abalone punch card purchasers. Our sampling frame included card returnees and non-returnees, with an unknown number of incorrect phone numbers and other contact problems. We called 1,064 systematically selected card purchase receipt numbers (every n th number) which yielded 569 completed interviews, of which 256 were non-returnees (which we accepted as a reasonable approximation of the 286 estimate), over a 10-week period beginning in April 2003.

For 2002, there were 15,004 returned cards (as of 9/2004) out of 35,146 purchased (42.7%), of these, 9297 were key-entered into a database, with 8844 having greater than zero effort (including estimated zero catches) (Table 1). Time and personnel constraints limited us to entry of a representative sample (62%) of the returned cards. Initially, all cards were entered as they came into the office, but as the number began to accelerate,

Table 1. Abalone catch and effort estimates from report card returns and telephone survey, 2002.

| | Report cards returned | 95% CI | Telephone survey (unreturned cards) | 95% CI | Total | 95% CI |
|--------------------------------------|-----------------------------|--------|--|--------|---------|--------|
| Cards sold | 35,146 | | | | | |
| Number of pickers* (N) | 14,329 | | 16,597 | | 30,926 | |
| Sample size (n) | 8,844 | | 211 | | 9,055 | |
| Effort (days) | 49,635 | 746 | 50,838 | 6,076 | 100,473 | 6,822 |
| Mean effort (days/ picker-year) | 3.46 | 0.052 | 3.06 | 0.336 | 3.25 | |
| Catch (number of abalone) | 135,873 | 2,052 | 128,293 | 14,771 | 264,130 | 16,823 |
| Mean catch (abalone/ picker-year) | 9.48 | 0.143 | 7.73 | 0.89 | 8.54 | |

* Returned and unreturned cards with > 0 effort, estimated from phone survey w/o variance.

every *n*th card was entered. In addition to providing catch and effort statistics for the non-return group, a number of key ratios could be developed from the telephone survey for refinement of the report card data (return group), including percentage of card purchasers who never used the card (zero effort) and those with a zero catch rate. The report card database program was designed to record zero catch, but does not distinguish zero catch from zero effort. Also, because effort on the report card is only recorded for a successful abalone trip, zero catch trips are not recorded and therefore the report cards underestimate effort. However, we assumed that those with at least one successful trip for the year would not have had any unsuccessful and therefore unrecorded trips. An ANOVA comparing catch rates from the telephone survey, between the return card group and the non-return group, shows a significant difference ($P < 0.05$), indicating that the returnee group did not accurately reflect the rest of the picker population. We therefore employed the phone survey to estimate the non-returnee catch and effort statistics. Variances for each estimation method, report card and telephone survey, were combined using the additive method of Pollock et al. (1994).

The telephone survey form (Fig. 1) was designed and reviewed within the Department of Fish and Game and consisted of four primary questions and seven secondary (optional) questions. The primary questions established whether or not the abalone report card had been returned prior to the time of the interview, and catch and effort information. The secondary questions concerned fishing mode and included a series of socio-economic questions to provide demographic information on the fishing population such as household income level, age and quality of fishing experience.

Introduction:

Hello. May I speak to (Mr. or Ms.) _____ please. [If not home then ask if you may try again later, do not leave a message]. My name is _____, and I am working for the California Department of Fish and Game. You have been randomly selected from the Department of Fish and Game's abalone card purchaser database for this telephone survey. The Department is seeking valuable information regarding abalone fishing in 2002 (last year). Future abalone management rules will be based in part on the accurate reporting of abalone catch data. This information will not be used for enforcement. Would you mind answering a few questions?

- 1) Did you return your pink 2002 abalone report card yet?*

Whether the answer to Question 1 is yes or no, we will ask the following:

- 2) How many days did you fish for abalone last year (2002), if any?*

Option to end interview if answer is none.

- 3) How many abalone did you take and retain last year, if any?
4) In what area did you take most of your abalone last year?*

Mr./Ms. _____, Would you be willing to answer a few more questions?

Continue if yes, if no, thank them and terminate interview.

Do you use swim fins in your pursuit of abalone? What percent of the time do you use a boat or kayak to get abalone?

What is your household income level [$< \$30,000$, $\$30$ to $\$60,000$, $\$60,000$ to $\$90,000$, $\$90$ to $\$120,000$, $> \$120,000$],

How many abalone trips did you make last year?,

How much did you spend on your abalone trip(s) last year, directly related to abalone, [include gas, food, lodging, incidentals] [$< \$100$, $\$100$ to $\$500$, $> \$500$]?,

How would you rate your abalone experience [excellent, good, fair, poor]?

And finally, I hope you won't mind me asking your age?

Thank you very much and good day, etc.

Figure 1. Recreational abalone telephone survey script: March 2003.

RESULTS

2002 Catch and Effort

The estimated 2002 northern California catch was 264,130 (95% CI 16,823) abalone, taken in 100,473 (95% CL 6,822) picker days of effort. There were 30,926 abalone report cards purchased and used (number estimated with greater than zero effort) in 2002, yielding an estimated 8.54 abalone per picker year (Table 1). The distribution of annual take per picker shows that over 30% of pickers took 3 or 6 abalone, multiples of the daily bag limit of 3 (Fig. 2).

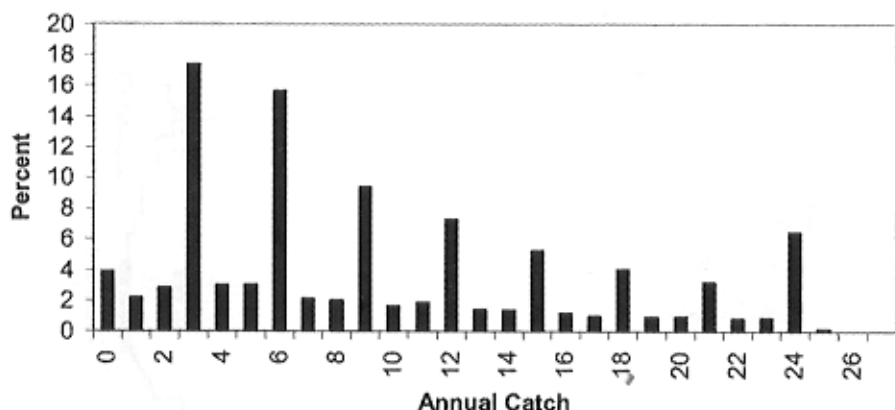


Figure 2. Frequency of annual abalone catch per picker-year for 2002.

Phone Survey Respondent Recall Accuracy

The 2002 telephone survey yielded 169 respondents whose report cards were also entered into the database. Accuracy of respondent's recall was analyzed by matching corresponding report cards with regard to effort and take. Of these 169 individuals, 47 (27.8%) matched perfectly in both effort and take. Another category of recall accuracy was conditioned on matching the report card within one unit of effort (one fishing day) and one daily bag limit (3 abalone). There were 51 (30.2%) respondents who fell into this category, for a total of 58.0%, who were reasonably accurate for activities that could have occurred more than a year prior to the interview.

The average discrepancy between recall take and report card take was 3.7 abalone, ranging from 0 to 22. The average effort discrepancy was 1.6 days fished, ranging from 0 to 41. The average take overestimate was 5.8 abalone, and the average take underestimate was 4.7 abalone. For those with no successful trips on either the card or the interview, we assumed effort recall was accurate.

Fishing Location

The advent of the abalone report card allowed not only the estimation of catch but also analysis of catch location. The 2002 report card had 56 location codes in northern California from which to choose. Both the telephone survey of all respondents to the location question and the report card database reported that 6.8% of the abalone taken were from the Van Damme State Park site in Mendocino County (Fig. 3, Table 2). A simple arithmetic expansion yields 18,044 abalone, with a partitioned 95% CI of $\pm 1,149$ abalone. This was the second most productive location for abalone. Both the telephone survey and the report cards listed the Fort Ross area in Sonoma County as the most productive location. A simple expansion from the report card data estimates that 20,663

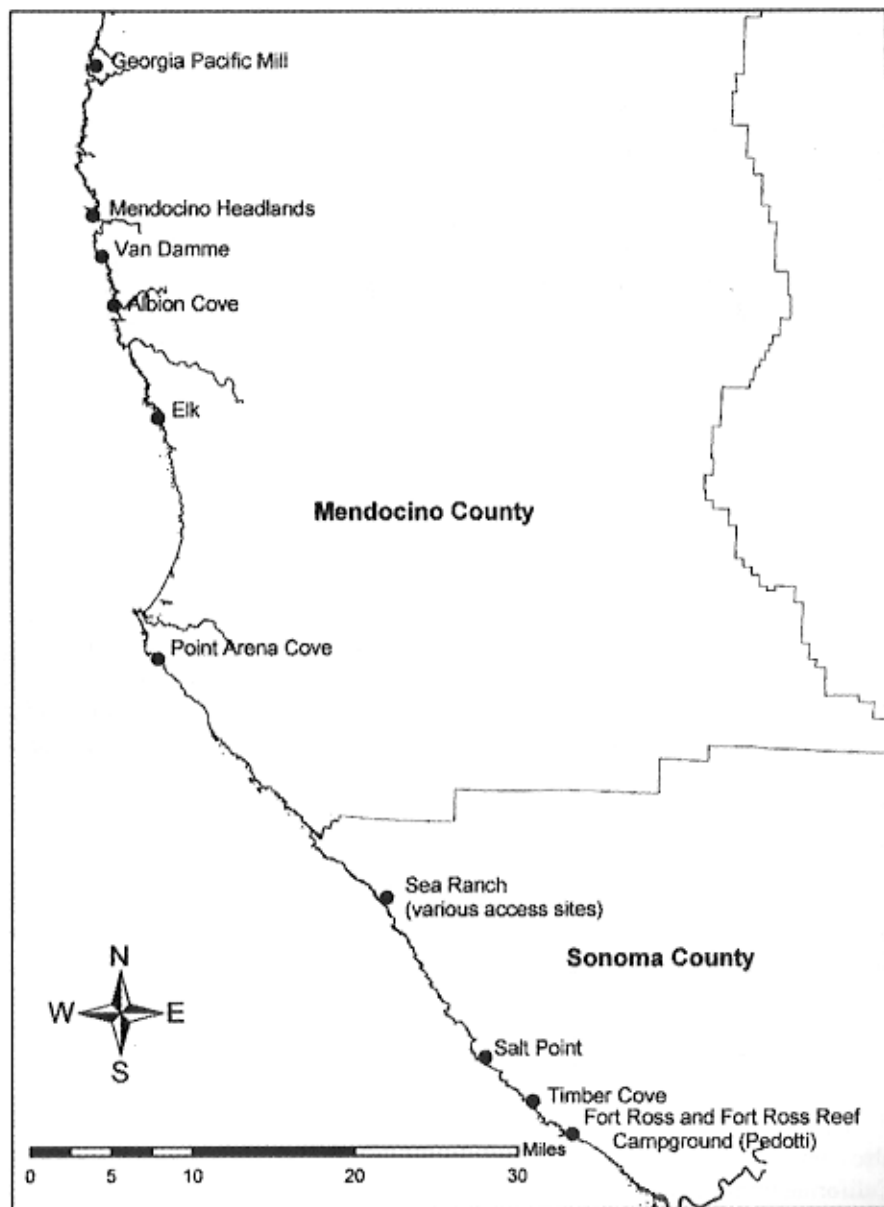


Figure 3. Ten highest use abalone report card sites in 2002.

Table 2. Estimated abalone recreational catch by location from report cards, 2002.

| *Location code | Location | County | Abalone | Percent | Cumulative percent | **Catch expansion | ***95% CI |
|----------------|---------------------|-----------|---------|---------|--------------------|-------------------|-----------|
| 82 | Fort Ross | Sonoma | 6,533 | 7.82 | 7.8 | 20,663 | 1,316 |
| 42 | Van Damme SP | Mendocino | 5,705 | 6.83 | 14.7 | 18,044 | 1,149 |
| 84 | Reef Camp (Pedotti) | Sonoma | 5,031 | 6.02 | 20.7 | 15,913 | 1,014 |
| 62 | Sea Ranch | Sonoma | 4,582 | 5.49 | 26.2 | 14,492 | 923 |
| 51 | Arena Cove | Mendocino | 4,000 | 4.79 | 31.0 | 12,652 | 806 |
| 45 | Albion Head | Mendocino | 3,802 | 4.55 | 35.5 | 12,025 | 766 |
| 74 | Salt Pt SP | Sonoma | 3,711 | 4.44 | 40.0 | 11,737 | 748 |
| 59 | Other Men Co | Mendocino | 2,972 | 3.56 | 43.5 | 9,400 | 599 |
| 40 | Mendocino Hdlnds | Mendocino | 2,844 | 3.41 | 46.9 | 8,995 | 573 |
| 80 | Timber Cove | Sonoma | 2,759 | 3.30 | 50.2 | 8,726 | 556 |
| 49 | Elk | Mendocino | 2,608 | 3.12 | 53.3 | 8,249 | 525 |
| 31 | GP Mill | Mendocino | 2,421 | 2.90 | 56.2 | 7,657 | 488 |
| 72 | Fisk Mill Cove | Sonoma | 2,231 | 2.67 | 58.9 | 7,056 | 449 |
| 32 | Todd's Pt | Mendocino | 2,228 | 2.67 | 61.6 | 7,047 | 449 |
| 38 | Russ Gulch SP | Mendocino | 2,211 | 2.65 | 64.2 | 6,993 | 445 |
| 36 | Caspar Cove | Mendocino | 2,112 | 2.53 | 66.8 | 6,680 | 426 |
| 52 | Moat Creek | Mendocino | 1,949 | 2.33 | 69.1 | 6,164 | 393 |
| 76 | Ocean Cove | Sonoma | 1,830 | 2.19 | 71.3 | 5,788 | 369 |
| 56 | Anchor Bay | Mendocino | 1,724 | 2.06 | 73.3 | 5,453 | 347 |
| 29 | MacKerricher SP | Mendocino | 1,620 | 1.94 | 75.3 | 5,124 | 326 |
| 35 | Jughandle SR | Mendocino | 1,488 | 1.78 | 77.1 | 4,706 | 300 |
| 18 | Shelter Cove | Humboldt | 1,349 | 1.62 | 78.7 | 4,267 | 272 |
| 78 | Stillwater Cove | Sonoma | 1,154 | 1.38 | 80.1 | 3,650 | 233 |
| 33 | Hare Creek | Mendocino | 1,150 | 1.38 | 81.4 | 3,637 | 232 |
| 89 | Other Sonoma Co | Sonoma | 1,054 | 1.26 | 82.7 | 3,334 | 212 |

Table 2 (continued)

| *Location code | Location | County | Abalone | Percent | Cumulative percent | **Catch expansion | ***95% CI |
|-------------------|---------------------|-----------|---------|---------|-----------------------|----------------------|-----------|
| 30 | Glass Beach | Mendocino | 1,045 | 1.25 | 84.0 | 3,305 | 211 |
| 44 | Dark Gulch | Mendocino | 934 | 1.12 | 85.1 | 2,954 | 188 |
| 39 | Jack Peters Gulch | Mendocino | 930 | 1.11 | 86.2 | 2,941 | 187 |
| 93 | Tomales Pt | Marin | 910 | 1.09 | 87.3 | 2,878 | 183 |
| 41 | Gordon Lane | Mendocino | 831 | 1.00 | 88.3 | 2,628 | 167 |
| 25 | Westport | Mendocino | 818 | 0.98 | 89.3 | 2,587 | 165 |
| 24 | Abalone Pt | Mendocino | 815 | 0.98 | 90.2 | 2,578 | 164 |
| 47 | Navarro Ridge | Mendocino | 810 | 0.97 | 91.2 | 2,562 | 163 |
| 70 | Horseshoe Cove | Sonoma | 766 | 0.92 | 92.1 | 2,423 | 154 |
| 66 | Stewarts Pt | Mendocino | 765 | 0.92 | 93.0 | 2,420 | 154 |
| 27 | Kibesillah | Mendocino | 713 | 0.85 | 93.9 | 2,255 | 144 |
| 86 | Jenner | Sonoma | 596 | 0.71 | 94.6 | 1,885 | 120 |
| 22 | Hardy Creek | Mendocino | 550 | 0.66 | 95.3 | 1,740 | 111 |
| 50 | Pt Arena Lighthouse | Mendocino | 530 | 0.63 | 95.9 | 1,676 | 107 |
| 16 | Punta Gorda | Humboldt | 469 | 0.56 | 96.5 | 1,483 | 94 |
| 60 | Gualala Pt | Sonoma | 374 | 0.45 | 96.9 | 1,183 | 75 |
| 88 | Bodega Head | Sonoma | 348 | 0.42 | 97.3 | 1,101 | 70 |
| 19 | Other Humboldt Co | Humboldt | 303 | 0.36 | 97.7 | 958 | 61 |
| 54 | Saunders Landing | Mendocino | 289 | 0.35 | 98.0 | 914 | 58 |
| 20 | Bear Harbor | Mendocino | 256 | 0.31 | 98.3 | 810 | 52 |
| 58 | Robinson Pt | Sonoma | 250 | 0.30 | 98.6 | 791 | 50 |
| 96 | Pt Reyes | Marin | 197 | 0.24 | 98.9 | 623 | 40 |
| 53 | Schooner Gulch | Mendocino | 186 | 0.22 | 99.1 | 588 | 37 |
| 99 | Other Marin Co | Marin | 151 | 0.18 | 99.3 | 478 | 30 |
| 13 | Patrick's Pt | Humboldt | 148 | 0.18 | 99.5 | 468 | 30 |
| 68 | Rocky Pt | Sonoma | 119 | 0.14 | 99.6 | 376 | 24 |

| | | | | | | | |
|--------|-----------------|-----------|--------|--------|-------|---------|--------|
| 64 | Black Pt | Sonoma | 114 | 0.14 | 99.7 | 361 | 23 |
| 14 | Trinidad | Humboldt | 107 | 0.13 | 99.9 | 338 | 22 |
| 21 | Usal | Mendocino | 103 | 0.12 | 100.0 | 326 | 21 |
| 05 | Crescent City | Del Norte | 8 | 0.01 | 100.0 | 25 | 2 |
| 09 | Other Del Norte | Del Norte | 6 | 0.01 | 100.0 | 19 | 1 |
| TOTALS | | | 83,509 | 100.00 | | 264,130 | 16,825 |

*Location code from report cards

**Catch expansion uses estimated total catch partitioned

***CI is based on CI for total catch partitioned

abalone came from this location ($95\% \text{ CI} \pm 1,316$) (7.8% of report card entries listed this site vs. 9.9% from the telephone survey of all respondents). The Reef Campground site (Pedotti Ranch) is just south and contiguous with the Fort Ross site, and it is more likely that some Reef Campground pickers mark down Fort Ross as their location, rather than the converse. Taken together, report cards show that 13.8% of the abalone take comes from these two sites, which expands to 36,576 abalone ($95\% \text{ CI} \pm 2,330$). More than one out of every five abalone recorded in the report card database originated from the Fort Ross-Pedotti area or the Van Damme area. Nine sites accounted for about 50% of the total catch.

Fishing Mode

Department-managed northcoast abalone on-site creel surveys have categorized abalone pickers as divers or shorepickers since 1975 by asking them whether or not they use fins in pursuit of their abalone. In the telephone survey, there were 514 respondents who answered 'yes' or 'no' to the question of whether swim fins were used in pursuit of abalone. There were four people who answered 'both'. Of the 514 'yes' or 'no' respondents, 80.5% answered 'yes' and 19.5% answered 'no'. In a winter 2000 mail survey conducted by the Department ($n=283$), 73.3% of respondents described themselves as divers (94.7% of this group said they used fins), while 26.7% called themselves shorepickers (12.0% of this group said they used fins).

In the winter 2000 mail survey, 23.3% said they used a boat of some kind (including kayaks). Telephone survey results showed boat use frequency as 14.8% "sometimes", 11.8% "always", and 73.3% "never". The "always" and "sometimes" groups add to 26.6%, similar to the winter 2000 mail survey result of 23.3% saying they usually use a boat.

Economic Survey

There were five questions in the economic survey that 389 interviewees (68.4%) answered all or in part. They were: annual household income level, number of abalone trips in 2002 (these could be more than 1 day in duration), money spent on all trips combined in 2002, rating the overall abalone experience (on a scale of "excellent", "good", "fair", or "poor"), and age of abalone report card purchaser (Fig. 1). The mean number of abalone trips was 3.1, with the mean age of abalone pickers at 43.8, though 81% of pickers were between 30 and 60 years old. The other questions with categorical responses and are shown in Tables 3a-e. Interestingly, 85% of respondents termed their experience "good" or "excellent", with 42% calling it an "excellent" experience. The breakdown by county of residence of 2002 abalone card purchasers, shows Sonoma and Mendocino counties contributing almost one quarter of all purchasers, and 6 northern California counties accounting for over half of the purchasers (Table 4).

Tables 3a-e. Abalone picker telephone survey socio-economic data, 2002.

Table 3a. Abalone trip frequency.

| Abalone Trips | | Trip category | Frequency | Percent |
|-----------------|--------------------|---------------|-----------|---------|
| Mean SE N | 3.1 0.20 381 | 0 | 13 | 3.4 |
| | | 1 | 288 | 75.6 |
| | | 5 | 65 | 17.1 |
| | | 10 | 11 | 2.9 |
| | | 15 | 0 | 0 |
| | | 20 | 2 | 0.5 |
| | | 25 | 1 | 0.3 |
| | | 50 | 1 | 0.3 |
| Total | | | 381 | 100 |

Table 3b. Abalone picker age frequency.

| Picker Age | | Age Category | Frequency | Percent |
|-----------------|---------------------|--------------|-----------|---------|
| Mean SE N | 43.8 0.58 388 | 10 | 7 | 1.8 |
| | | 20 | 32 | 8.2 |
| | | 30 | 110 | 28.4 |
| | | 40 | 122 | 31.4 |
| | | 50 | 83 | 21.4 |
| | | 60 | 26 | 6.7 |
| | | 70 | 8 | 2.1 |
| Total | | | 388 | 100 |

Table 3c. Abalone picker household income.

| Household income | Frequency | Percent |
|------------------|-----------|---------|
| <\$30,000 | 30 | 8.3 |
| \$30,000 | 104 | 28.7 |
| \$60,000 | 129 | 35.5 |
| \$90,000 | 68 | 18.7 |
| >\$120,000 | 32 | 8.8 |
| Total | 363 | 100 |

Table 3d. Abalone picker quality of experience.

| Quality of experience | Frequency | Percent |
|-----------------------|-----------|---------|
| Excellent | 163 | 41.9 |
| Good | 168 | 43.2 |
| Fair | 44 | 11.3 |
| Poor | 14 | 3.6 |
| Totals | 389 | 100 |

Table 3a-e (continued)

Table 3e. Abalone picker trip expenditures.

| Trip expense | Frequency | Percent | Permittees | Group total \$ |
|--------------|-----------|---------|------------|----------------|
| <\$100 | 161 | 41.8 | 14,993 | \$749,650 |
| \$100-\$500 | 182 | 47.3 | 16,949 | \$5,084,700 |
| >\$500 | 42 | 10.9 | 3,911 | \$1,955,500 |
| Total | 385 | 100 | 35,854 | \$7,789,850 |

*Permittees x midpoint of expense category

Table 4. County of residence of abalone report card purchasers, 2002.

| County | Percent | Cumulative percent |
|-----------------|---------|--------------------|
| Sonoma | 13.73 | 13.7 |
| Mendocino | 8.63 | 22.4 |
| Alameda | 8.60 | 31.0 |
| Santa Clara | 8.09 | 39.1 |
| Sacramento | 6.96 | 46.0 |
| San Mateo | 5.60 | 51.6 |
| San Francisco | 5.47 | 57.1 |
| Contra Costa | 5.46 | 62.5 |
| Humboldt | 4.49 | 67.0 |
| Marin | 4.41 | 71.4 |
| Napa | 3.03 | 74.5 |
| Solano | 2.89 | 77.4 |
| Butte | 2.73 | 80.1 |
| San Joaquin | 2.34 | 82.4 |
| Santa Cruz | 2.32 | 84.7 |
| Placer | 1.81 | 86.6 |
| Yolo | 1.65 | 88.2 |
| Shasta | 1.58 | 89.8 |
| Los Angeles | 1.10 | 90.9 |
| San Diego | 0.98 | 91.9 |
| Sutter | 0.95 | 92.8 |
| Nevada | 0.86 | 93.7 |
| Stanislaus | 0.68 | 94.4 |
| San Luis Obispo | 0.66 | 95.0 |
| Orange | 0.55 | 95.6 |

| | | |
|----------------|-------|-------|
| Santa Barbara | 0.45 | 96.0 |
| Plumas | 0.40 | 96.4 |
| Fresno | 0.37 | 96.8 |
| Monterey | 0.37 | 97.2 |
| Ventura | 0.31 | 97.5 |
| Del Norte | 0.29 | 97.8 |
| El Dorado | 0.24 | 98.0 |
| Yuba | 0.24 | 98.2 |
| Amador | 0.21 | 98.5 |
| San Benito | 0.21 | 98.7 |
| Tuolumne | 0.21 | 98.9 |
| Calaveras | 0.19 | 99.1 |
| Lake | 0.13 | 99.2 |
| Riverside | 0.13 | 99.3 |
| Inyo | 0.11 | 99.4 |
| Lassen | 0.11 | 99.5 |
| Tulare | 0.11 | 99.7 |
| Kern | 0.06 | 99.7 |
| Kings | 0.06 | 99.8 |
| San Bernardino | 0.06 | 99.9 |
| Tehama | 0.06 | 99.9 |
| Madera | 0.03 | 100.0 |
| Merced | 0.03 | 100.0 |
| Imperial | 0.02 | 100.0 |
| Total | 100.0 | |

DISCUSSION

Karpov¹ (1992) estimated that 80,405 ($\pm 24,092$) pickers made 134,996 ($\pm 34,082$) trips for 433,069 ($\pm 110,222$) red abalone (the daily bag limit was four at that time and there was no annual limit, 2002 limits were 3 daily and 24 annually) in the 1989 combined creel and telephone survey (the last survey completed prior to this one). Catch per picker year was estimated at 5.39 abalone. The 1988 combined creel and telephone survey estimated that 80,891 ($\pm 24,301$) pickers made 162,127 ($\pm 34,690$) trips for 450,747 ($\pm 107,969$) red abalone (Karpov² 1991). Catch per picker year was estimated

¹Karpov, K.A. 1992. A combined telephone and creel survey of the red abalone, *Haliotis rufescens* (Swainson), sport fishery in California from Monterey to the Oregon border, April through November 1989. California Department of Fish and Game, Marine Resources Administrative Report 92-3.

²Karpov, K.A. 1991. A combined telephone and creel survey of the red abalone, *Haliotis rufescens* (Swainson), sport fishery in California from Monterey to the Oregon border, April through November 1988. California Department of Fish and Game, Marine Resources Administrative Report 91-2.

Table 5. Comparison of abalone fishery catch and effort estimates: 1988, 1989 and 2002.

| Year | Number of pickers | Number of picker-days | Mean abalone/picker-year | Total number of abalone taken |
|------|-------------------|-----------------------|--------------------------|-------------------------------|
| 1988 | 80,891 | 162,167 | 5.57 | 450,747 |
| 1989 | 80,405 | 134,996 | 5.39 | 433,069 |
| 2002 | 30,926 | 100,473 | 8.54 | 264,130 |

at 5.57 abalone. This compared with 8.54 red abalone per picker-year estimated for the 30,926 abalone card purchasers with greater than zero effort in 2002 (Table 5). A comparison of confidence limits between the 1988 and 1989 estimates and the 2002 estimate shows the value of the combined report card and telephone survey targeting abalone card purchasers, versus a general telephone directory frame-based phone survey in which both fishing and non-fishing households are contacted. The latter was characterized by a very small sample size of abalone pickers and relied on bootstrapping to estimate variances. Confidence intervals for the 1988 and 1989 abalone catch estimates ranged from $\pm 24.0\%$ to $\pm 25.5\%$, while the 2002 CIs were within 6.4% of the estimate.

While the point estimates of number of pickers in 1988 and 1989 were remarkably similar, the 2002 estimate is only 38.5% of the 1989 estimate. The lower confidence bound of the 1989 estimate is almost twice the 2002 estimate as well. So, the appearance of a large reduction in northern California abalone effort during this time period seems to be accurate. In 1989, an estimated 30.1% of the abalone pickers were shorepickers, while the estimate in 2000 from a mail survey was 26.7%, and by the 2002 telephone survey, shorepickers made up an estimated 19.5%. The reduction in the proportion of shorepickers in the fishery is likely due to a combination of factors, including the fact that divers are not as dependent as shorepickers on low tides to hunt for abalone, and divers have much larger reef areas accessible to them compared to shorepickers, even at minus tides. In addition, shorepicker catch and effort data from 1989 to 2000 showed an increased take of abalone from more remote populations at Sonoma County and southern Mendocino County creel survey sites, indicating a probable depletion of abalone near access points for shorepickers (ARMP³).

It is useful to place the abalone take in a specific area in the context of what is known about local populations. Creel-type surveys combined with subtidal SCUBA surveys determined that about 33.3 hectares of shallow (< 5.5 m) reef habitat are available to abalone pickers in the Van Damme area. The 1999 Department subtidal abalone survey determined there were about 5,000 legal sized abalone per hectare, for a population estimate of about 166,550 red abalone (J. Kashiwada, California Department of Fish and Game, personal communication). The estimate of 18,000 legal sized (> 178 mm) abalone

³California Department of Fish and Game. 2005. Abalone Recovery and Management Plan. Sacramento, California.

taken from Van Damme SP in 2002 would represent about 10.8% of this population. Whether this number is sustainable is questionable given the slow growth and erratic recruitment patterns of red abalone (Haaker et al., 1998, Karpov et al. 1998).

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