

INVESTIGATING THE FINE-SCALE SPATIAL AND TEMPORAL DYNAMICS OF PACIFIC SARDINE (*Sardinops sagax*) IN THE SOUTHERN CALIFORNIA BIGHT: PRELIMINARY FINDINGS FROM A SALTONSTALL-KENNEDY GRANT

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1. Highlights

- Sardines have been present and captured by “live-bait” operators at five ports in the Southern California Bight (SCB) during most months from October, 2022 - March, 2023
- Sardines were captured in sea surface temperatures ranging from 12 to 20°C.
- The length composition of sardine indicated a decreasing trend in size from autumn, 2022 to winter, 2023.

2. Background

Since the closure of the commercial fishery for the northern subpopulation of Pacific Sardine (*Sardinops sagax*) (NSP) in 2015, commercial fishermen and live-bait operators throughout the Southern California Bight (SCB) have reported “high volumes” of sardine in their local waters throughout the year, which in their view contradicts the declining trends observed in the acoustic-trawl (AT) and the CalCOFI observations of adult and egg abundances, respectively. This apparent discrepancy in observations has led to frustration within the fishing community and reported economic losses. A confounding factor is the existence of a southern sardine stock (SSP), which is operationally defined to occur in the SCB when surface temperatures (SST) are 16.7°C or higher. Since the SST in the SCB often oscillates around this threshold, it is suggested that some degree of stock mixing likely occurs. Additionally, the SSP is unmanaged in US waters, and the Pacific Fishery Management Council (PFMC) considers all sardine landed in California, even if they are associated with SSTs much higher than the 16.7° C cutoff, as NSP, and all US catches are reduced from the NSP quota. To assess the year-round persistence of sardine in the SCB and identify their stock identification, the California Wetfish Producers Association (CWPA), were funded through a NOAA Saltonstall-Kennedy grant to investigate the fine-scale temporal and spatial distribution of sardine in the SCB over a duration of 19 months. The project extends from October 2022 - April 2024, and relies on a variety of data sources, including novel data streams from live-bait fishermen throughout the SCB, monthly catch samples from purse seine operators in central and southern California (authorized through Exempted Fishing Permits (EFP's)), historic log-book data from a live-bait operator, incidental sardine observation reports (typically provided when vessels are targeting squid, anchovy, or transiting to fishing grounds), as well as egg and larval data from the CalCOFI collection (Table 1).

3. Methods

To assess the fine-scale spatial and temporal dynamics of Pacific Sardine in the SCB, we are collecting and aggregating data from both novel data-sources (live-bait and commercial purse-seine collections) as well as aggregating historic data collections (fishing logs, CalCOFI survey data, and incidental observation logs). Data will be analyzed in part by comparing biological characteristics, i.e. length, and age at length of the sardines by month and SST, to evaluate the NSP and SSP SST-based rule and sardine population behavior dynamics and trends. Data from quarterly CalCOFI surveys will be used to link nearshore observations of sardine to the presence of spawners offshore. We will test operational hypotheses, which could potentially influence the method used to differentiate NSP and SSP sardine biomass and catches for use by stock assessors and the PFMC.

3.1 Live-Bait Collections

Live-bait fishermen from five port areas in the SCB have agreed to voluntarily participate and provide samples to this project. Participating ports include: San Diego-Mission Bay, Oceanside, Dana Point, Long Beach, and Marina Del Rey.

Each bait hauler is responsible for drawing one sample of 100 sardines per month starting in October 2022. The intent is to collect one sample per month from each area, spread throughout the month to have temporal variability. Individual sampling days are pre-arranged based on each bait hauler's schedule, weather dependent, in coordination with the research technician.

Samples are collected as the sardines are unloaded. Vessels typically "sluice" live fish from onboard tanks to bait receivers located on docks within their harbor, where the fish are then sold to the public. Fish are sampled as they are pumped out of the sluice and fall into the receiver. During unloading, the crew takes 5 small subsamples (20-25 fish) spread throughout the off-loading process, i.e. at the beginning, middle and end. For vessels with more than one live-bait well, the sample comes from only one well. The samples are tagged with: vessel name, date, and volume (either in number of scoops or tonnage of fish landed). Samples are subsequently collected by the research technician and taken for processing. Live-bait fishermen complete a log documenting the location of the catch and ocean conditions.

At the lab, lengths and weights are taken from all sardines and a subsample of 15 fish are retained with stomachs and otoliths removed for habitat and age studies.

3.2 Exempted Fishing Permit Collections

EFP trips are coordinated with a CDFW port sampler and schedules are set in advance. Through collaboration with CDFW, sardines are sampled, and age and morphological data are collected by participating commercial-purse seine vessels operating under an existing Experimental Fishing Permit (hereafter, EFP vessels) program under NOAA exemption. EFP vessels are funded for one trip per month in both southern and central California and are asked to provide data on fishing trips where no sardine were captured

or observed. Sardine samples are collected monthly from two of five participating purse seine vessels, when fishing is successful, and processed by CDFW. EFP vessels operate out of Long Beach, San Pedro, Moss Landing, and Monterey.

3.3 Incidental Observations

Incidental Observations are requested from all participating fishermen when sardines are observed during trips that target other species. Reports of fish from places like the Northern Channel Islands and Monterey are useful for the basis of this study because they occur in different geographic areas than typically targeted by live-bait fleets, who typically fish as close to port as needed. Generally, if we receive more reports during a given time, there's a greater likelihood of sardines being found in those areas.

3.4 Stakeholder Engagement

Monthly meetings are held with stakeholders (industry members, CWPA, CDFW, and NOAA) to discuss fishermen's general ocean observations and maintain an open dialogue between industry members and scientists. These meetings are instrumental in building trust and common interest between industry members and scientists. They also allow for participants to refine the project as needed. Comments and observations are recorded for qualitative assessment. It is important to note that although these meetings offer a lot of information about fishing conditions and an on-the-ground perspective from the fishermen, this information is only recorded as observational data.

4. Preliminary Results

	October	November	December	January	February	Total
Live Bait Samples	4	5	4	5	3	21
Total Fish Processed	400	500	400	500	300	2100
Incidental Sardine Observations	4	2	4	0	1	11
EFP Trips	1	1	0	1	1	4
Stakeholder Meetings	2	0	1	1	0	4

Table 1) Total effort and data collected to date. Live bait samples, incidental observations, and EFP trips discussed in more detail below.

4.1 Live-Bait collections

Month	Mean Length (mm)
October	163.75 ± 4.54
November	156.49 ± 11.52
December	146.04 ± 6.03
January	142.11 ± 11.45

Table 2) Mean sardine length by month with standard deviation.

Port	Mean Length (mm)
Marina Del Rey	152.88 ± 13.13
Long Beach	159.06 ± 9.71
Dana Point	154.02 ± 19.46
Oceanside	154.03 ± 6.89
Mission Bay	140.54 ± 1.86

Table 3) Mean sardine length by port with standard deviation.

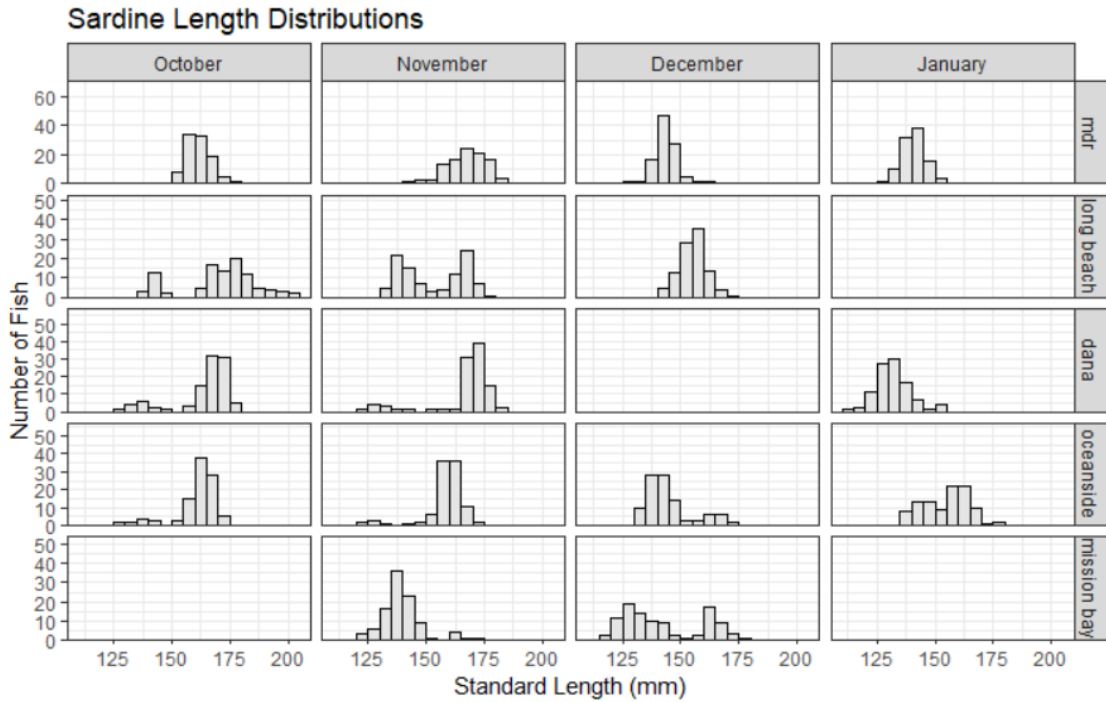


Figure 1) Preliminary length distributions of Pacific Sardine caught from October to January (some January data is yet to be processed). Samples were received from five ports within Southern California from live-bait fishermen. Dana and Mission Bay are operated by the same live-bait company and effort may be split and used to supply both ports; this is driven by a lower recreational need. This explains missing data from both ports. *The Long Beach sample for January has been collected but not yet processed.

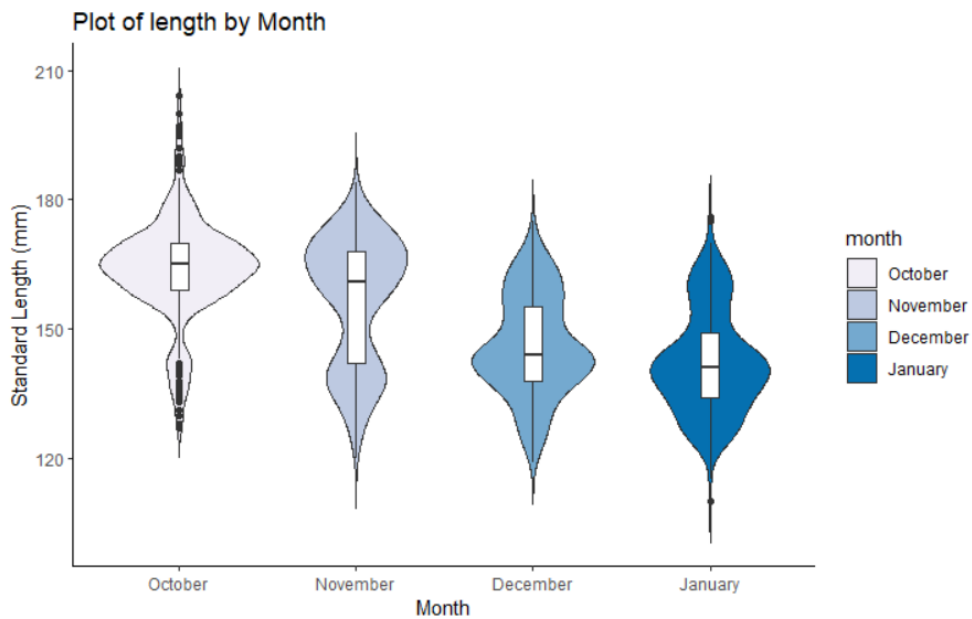


Figure 2) Sardine length by month of collection. Box plots display median length for each month and 1st and 2nd quartiles.

4.2 Exempted Fishing Permit Collections

Four EFP samples were collected from October, 2022 to January, 2023, while the target was ten. One set was made in Monterey during October, effort occurred in November in Monterey but no sardines were observed or landed. Participating vessels departed the Monterey Bay fishing grounds in November and traveled to Southern California to engage in the squid fishery, so participation decreased and no efforts were made in Monterey. One attempt was made in November from Santa Cruz but no sardines were found. However, in February 2023 a participating Monterey fisherman reported small sardines in his anchovy catch, and we obtained an observation log and a 100-fish sardine sample to include in analysis. Further EFP sets will be attempted in Monterey when weather permits. In southern California, there was an attempt to capture fish in December, but no catches were made due to the presence of a large number of dolphins, which scattered sardine schools, according to the fisherman. EFP samples from southern California were captured during November, 2022, January and February, 2023. These EFP trips rely on a CDFW port sampler and schedules are set in advance, which dictate how frequently vessels can go out.

4.3 Incidental Observations

Eleven incidental observations were made. Generally, these incidental observations provided anecdotal evidence of sardines at the northern Channel Islands, while vessels were targeting market squid. In February, a subsample of small sardines was observed in Monterey while targeting anchovies; the fisherman submitted an observation log with the location, and we obtained a 100-fish sample to include in analysis..

4.4 Stakeholder Engagement

Four stakeholder meetings were held: two during October, one each in December, 2022, and January, 2023 (Table 4). Of notable observation, fishermen observed the presence of sardine along the coast of California up to Monterey for the month of October. In December, fishermen commented that the size of sardines decreased. Opinions differed during times, with some fishers reporting an increase, and some a decrease, in the amount of time required to locate fishable schools. For instance, live-bait fishermen from Oceanside reported that they went further out and in deeper water to harvest sardines whereas live-bait fishermen from Marina Del Rey reported large schools observed just a few miles outside of the harbor. Market demand also influences the type of live-bait fished, and sardines are not always the preferred target. The demand of the recreational fleet often dictates the catch, as well as seasonality, and survivability of fish within live-wells.

	October	December	January
Live- Bait Fishermen	2	2	2
EFP Fishermen	4	3	2
Associated Scientists	4	4	5
Total	10	9	9

Table 4) Attendance for monthly stakeholder meetings.

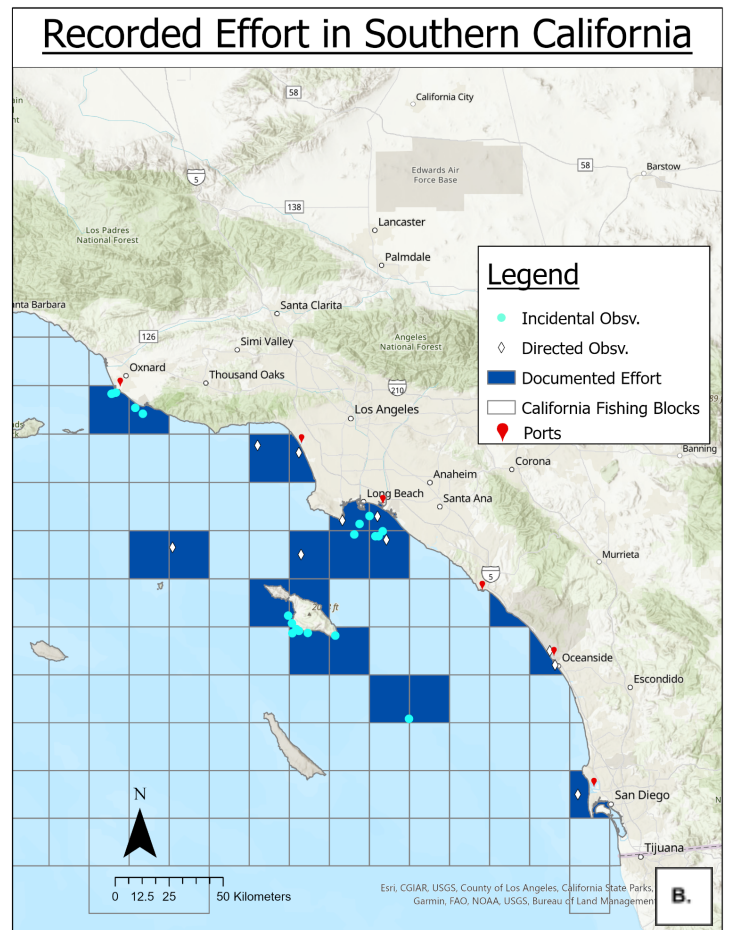


Figure 3) Map displaying all effort within commercial fishing blocks for the nearshore coast of California. Blocks filled in with blue denote areas that have been reported to have caught or observed sardine schools. A) Displays reported effort for northern California while B) displays all reported effort in southern California.

5. Preliminary Observations

Live-bait fishermen have provided sardines on a monthly basis from most ports, for a duration of six months (preliminary data from the first four months included in this report), indicating that sardines were inhabiting the SCB, in some abundance, across seasons. Fish were observed occupying a wide SST range, from 12- 20°C. Fish were generally small, but a decrease in mean size was observed from October to February. Continued sampling will provide important insight into how sardines utilize the SCB for a full year.