



CALIFORNIA WETFISH PRODUCERS ASSOCIATION

PO Box 1951 • Buellton, CA 93427 • Office: (805) 693-5430 • Mobile: (805) 350-3231 • Fax: (805) 686-9312 • www.californiawetfish.org

March 10, 2023

Mr. Marc Gorelnik, Chair
And Members of the Pacific Fishery Management Council

REQUEST RENEWAL OF EXEMPTED FISHERY PERMIT (EFP)
TO ALLOW TAKE OF PACIFIC SARDINE IN POINT SETS IN 2023-24
IN SUPPORT OF THE CPS-NCA RESEARCH PROGRAM

Dear Mr. Gorelnik and Council members,

On behalf of CWPA, we are submitting a renewal request for our Exempted Fishery Permit (EFP) to conduct point sets to validate biomass estimates made in the Coastal Pelagic Species Nearshore Cooperative Survey (CPS-NCS), a joint effort with California Department of Fish and Wildlife (CDFW), which provides sampling for the estimation of CPS biomass in shallow waters inaccessible to NOAA ships.

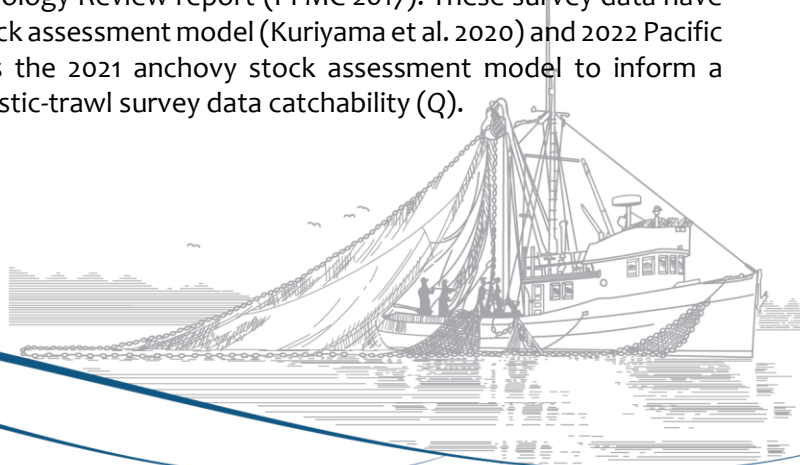
Date of Application (4a): March 10, 2023

Applicant Name and Mailing Address (4b):

California Wetfish Producers Association
PO Box 1951, Buellton, CA 93427
(805) 693-5430

Purpose and Goals/Justification/Rationale/Disposition of Catch (4c, d, and e)

The objective of this EFP is to collect data via point sets to maintain qualification of aerial CPS-NCS survey estimates for use in sardine and anchovy stock assessments. At its June 2017 meeting, the Pacific Fishery Management Council conditionally approved the CDFW/CWPA aerial survey methodology and data for use in CPS stock assessments, consistent with recommendations contained in the Southern California Coastal Pelagic Species Aerial Survey Methodology Review report (PFMC 2017). These survey data have since been used in the 2020 Pacific sardine stock assessment model (Kuriyama et al. 2020) and 2022 Pacific sardine stock assessment model, as well as the 2021 anchovy stock assessment model to inform a nearshore biomass correction factor for acoustic-trawl survey data catchability (Q).



Biomass estimates for anchovy and sardine stocks that exclude nearshore waters may be negatively biased, in part because substantial amounts of these species reside in shallow nearshore waters (< 40m depth) that cannot be surveyed by NOAA vessels. To estimate this nearshore biomass, the CDFW has conducted the aerial CPS-NCS in the Southern California Bight (SCB) since 2012, and in the Monterey-San Francisco area since summer 2017. The point sets under this EFP capture schools of CPS in conjunction with aerial observer estimates of school size and species composition. Captured schools are then weighed and sampled onshore to validate observer estimates and species identifications. CPS-NCS point sets have also been used to develop calibration curves to adjust observer biomass estimates (Dorval and Lynn 2019, PFMC 2020, Lynn, et al., 2023). CDFW used data collected in 2010 and then under EFPs from 2018 to 2022 to validate the estimates of sardine schools made in the nearshore aerial survey in those years (see Appendix 1 for a table summary of point set data). Beginning in 2019, we extended the work to also collect data for validating anchovy estimates. This work contributed to the development of correction factors that were applied to acoustic trawl survey estimates to account for nearshore biomass in the most recent sardine and anchovy stock assessments.

Additional point set data are needed to maintain and improve validation of observer estimates of biomass and school composition. This EFP will provide those data to further improve methodology for quantifying the level of bias and uncertainty of aerial surveys. Knowledge gained from the CPS-NCS survey could be applied to conduct broader sampling surveys and to account for bias and variance estimation when assessing CPS stocks in the future. This research is all in furtherance of addressing the recommendations of the Aerial Survey Methods Review Panel of April 17-8, 2017.

The data collected under this EFP will be used to maintain the scientific matrix of point sets established in Southern California and to build the matrix of point sets in Monterey-Central Coast to a comparable level. The focus of point sets under this EFP will shift relative to prior EFPs. Beginning in 2023-24 greater emphasis will be on targeting anchovy schools to build and strengthen that dataset. Sardine may continue to be collected as either pure schools (particularly for strengthening the data matrix in the Monterey-Central Coast area) or mixed with anchovy as we build the anchovy (and mixed school) data matrix in both areas.

Due to the continued closure of the directed sardine fishery, this EFP is necessary to allow fishermen to retain the entirety of any school they are directed to catch, including pure sardine schools or mixed schools exceeding the allowed incidental catch rate. Absent an EFP, fishermen would be prevented from targeting sardine schools or mixed schools believed to include sardine above allowable incidental catch limits.

All fish captured, including sardines requested in this EFP application, will be processed and sold by participating processors, and fishermen will be paid for their catches at the market rates.

Broader Significance (4e)

This research is necessary as we develop survey methods to quantify the biomass of CPS in the nearshore area inaccessible to large NOAA ships. The data collected from this study have already been used in the Pacific sardine and anchovy stock assessment models to adjust acoustic trawl survey catchability (Q). The survey methods and information developed in this project may prove useful for understanding CPS stock distributions, as well as age and growth, in nearshore areas coast-wide, which would improve the accuracy of future stock assessments. In addition, the collaboration between industry, the scientific

community, and federal and state agencies will facilitate increased information sharing and improved understanding of CPS resources.

Continuation of the EFP (4f)

The EFP is intended to be continued as long as necessary to support the ongoing need for validation of the CPS-NCS estimates for use of those survey data in stock assessments. Continuation also depends on the economic feasibility of the EFP, as determined by funding to support this activity.

Vessels, Processors and Captains in the EFP (4g)

CWPA has identified 5 vessels that meet the criteria for this research project:

VESSEL NAME	SKIPPER	OWNER	USCG /REG	CPS PERMIT
Southern CA				
Triton	Pete Ciaramitaro	Triton Fishing Inc.	CF7218UH	14
Provider	Jamie Ashley	Provider LLC	D572344	1
Eileen	Nick Jurlin / Corbin Hanson	South Sound Fisheries Inc.	D252749	38
Monterey				
King Philip	Anthony Russo	SAAS Fishing LLC	D1061827	9
Trionfo	Aniello Guglielmo	Captain Squid, Inc.	D625449	45

Four processors will participate in the EFP, 2 in Southern California and 2 in Monterey:

Cal Marine Fish Company, 220 Cannery Street, San Pedro, CA 90731
(offloads FV Eileen, FV Provider; Contact: Vince Torre)

J. DeLuca Fish Company, 2194 Signal Place, San Pedro, CA 90731
(offloads FV Triton; Contact: John DeLuca)

Monterey Fish Company, 960 South Sanborn Road, Salinas, CA 93901
(offloads FV King Philip, FV Sea Wave; Contacts: Anthony Tringali or Ken Towsley)

Southern Cal Seafood, Pillar Point Harbor, Half Moon Bay or Monterey;
Contact Pete Guglielmo

Species to be harvested (4h)

Under this project, purse seine vessels will be directed to capture schools of anchovy, sardines, and mixed schools identified by observers, in conjunction with the observer estimates of school size and species

composition. Harvests of sardines under this EFP will be no more than 150 mt. No measurable impacts to non-target species are anticipated.

Justification of the amount of harvest (4i)

The 150 mt sardine request to support this EFP is projected to support 7 to 10 days of research (spread strategically within the July 1, 2023 –June 30, 2024 study window). Schools targeted will be primarily anchovy and mixed anchovy/sardine schools and secondarily pure sardine schools in the Central Coast region. Vessels will be directed to capture as many schools as possible in a given day and will strive for 100 percent capture of individual schools. With the directed sardine fishery closed, the EFP allocation is needed to allow for directed sardine catches and to support mixed school catches with sardines in excess of the allowable incidental catch limit. The issuance of an EFP also allows the sale of the fish to help offset costs incurred by participating fishermen and processors. The amount of this request acknowledges the current stock status of the northern subpopulation of Pacific Sardine, and the need for allocation of available tonnage to other fishery sectors.

Monitoring of catch (4j)

Biologists will take samples of each set at the dock for later analysis biological characteristics of individual fish. All schools captured will be stowed in individual hatches in the hold, weighed at offload, and sampled for species composition following established protocol. Processors will maintain records of the weight of individual species groups, including sardine, to validate species composition.

CWPA will notify NMFS Office of Law Enforcement approximately 12 hours before a vessel going out to inform them of vessel name and locations to be surveyed and the processor who will be receiving fish from the trip.

CWPA will also maintain a record of the volume and total weight of each species captured and will monitor progress toward attaining the EFP limit. These weights and species composition per set will also be included in the final report.

Data collection methods (4k)

For aerial point sets, two spotter pilots flying in the same plane will make independent estimates of school size and species composition and record their individual tonnage estimates and species identification on separate log sheets (Dorval and Lynn 2019). The pilot will photograph vessels approaching and wrapping the schools. Fishermen will also record on log sheets during the capture process the school depth, shape and density depicted on their sonar and fathometer, along with any other observations. Participating processors will record species composition and weight for each set. Examples of photos and log forms are appended to this EFP application (Appendices 2-4). Attempts will be made to capture entire schools of CPS, to the degree possible. Point sets of 80 percent or greater school capture can be added to the archive of sets used for validation of CPS-NCS data. All schools captured will be stored in separate hatches onboard and will be weighed individually at the dock and sampled for species composition by the participating processors.

The catch taken from each school will be subsampled throughout the pumping of each haul. CDFW biologists will obtain a 5-gallon subsample of fish at quarterly intervals of pumping each set, using a quantitative bucket sampling method. The four collected fish subsamples will be sorted by species and stored in plastic bags and preserved on ice. Up to 50 fish per species per point set will be collected by a CDFW biologist/sampler upon landing of the daily catches. At the CDFW laboratories these samples will

be measured for biological characteristics including length, weight, sex, maturity, and otoliths taken for ageing.

CPS biomass and associated variances will be estimated from data collected. Data collected from point sets will be used to validate aerial tonnage estimates of targeted schools and school species composition and to obtain length and age composition. These data will provide additional information to quantify uncertainty surrounding biomass estimated by the pilot and observer. More details regarding the process of biomass estimation from the CPS-NCS are found in Dorval and Lynn (2019).

Scientific data collection and analysis will be supervised by CDFW and NOAA scientific staff, who will collaborate on procedures to ensure and evaluate data quality during the survey, and data analysis methodology through completion of the project. Weather permitting, we will strive to have multiple purse seine sets on schools of various sizes to derive unbiased estimates of biomass and associated variances (see Tables A1 and A2 and Figures A1 and A2 for examples).

All fish captured, including sardines requested in this EFP application, will be processed and sold by participating processors, and fishermen will be paid for their catches at the market rates. Aside from the sale of fish captured in this project, processors are not compensated for labor incurred weighing, sampling, and documenting species composition of schools. Sale of the EFP fish provides a beneficial use of the resource and avoids waste.

Vessel selection (4l)

Vessels were identified for participation in the research based on vessel size, equipment, skippers' experience, and commitment to the research. The five vessels identified have committed to participate voluntarily in this research, notwithstanding any other fishing opportunities during the project period. All vessels have participated in the EFP in prior years and have demonstrated the ability to carry out the required protocols.

Fishing time, place, and gear (4m)

This project will take place in nearshore waters of the Central Coast of California (Monterey – Half Moon Bay) and the Southern California Bight. We plan to follow the same protocols as currently employed. The tentative time frame for the survey window is July 1, 2023 – June 30, 2024. Fishing gear used will be purse seine nets of suitable mesh size and length for capturing CPS schools.

Thank you very much for your consideration of our request to continue this EFP research in 2023-24.

Best regards,

Mark Fina
Executive Director

References

Dorval, E. and K. Lynn. 2019. Accuracy and precision of Pacific Sardine (*Sardinops sagax*) and Northern Anchovy (*Engraulis mordax*) biomass estimated from aerial surveys in nearshore waters off California. Progress report.

<ftp://ftp.pcouncil.org/pub/CPS/CPSMtgOct2019/Documents%20for%20November%202019%20Council%20meeting/>.

Jagiello, T. H., Hanan, D., Howe, R., and M. Mikesell. 2010. West Coast Aerial Sardine Survey. Sampling Results in 2010. Prepared for Northwest Sardine Survey and the California Wetfish Producers Association. Pacific Fishery Management Council, Portland, OR, October 15, 2010. 51p.

Kuriyama, P. T., J. P. Zwolinski, K. T. Hill, and P. R. Crone. 2020. Assessment of the Pacific sardine resource in 2020 for U.S. management in 2020-2021. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-628. 171 p.

Kuriyama, P. T., J.P. Zwolinski, S.L.H. Teo, and K.T. Hill. 2022. Assessment of the Northern anchovy (*Engraulis mordax*) central subpopulation in 2021 for U.S. management. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-665.

<https://doi.org/10.25923/jv24-1539>

Lynn, K., E. Dorval, D. Porzio, T. Nguyen, D. Myers, and K. Grady. 2023. Estimation of nearshore aerial survey biomass for the 2021 stock assessment of the central subpopulation of Northern Anchovy (*Engraulis mordax*). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-677. <https://doi.org/10.25923/xpm9-wv27>

Lynn, K, D. Porzio, T. Nguyen, and L. Ryley. 2017. Southern California aerial survey for Pacific sardine (*Sardinops sagax*) and Northern anchovy (*Engraulis mordax*). PFMC June 2017 meeting, Agenda Item D.2.a, CDFW Report.

PFMC. 2017. Southern California coastal pelagic species aerial survey methodology review. PFMC June 2017 meeting, Agenda Item D.2, Attachment 1, Methodology Review Panel Report.

PFMC. 2020. Pacific sardine stock assessment review panel meeting report. PFMC April 2020 meeting, Agenda Item D.3, Attachment 2.

Appendix 1. CPS schools by size categories and number of purse seine point sets during 2010 and the 2018-20 NCS survey in Southern California (top), and 2019-22 in Monterey (bottom). All sets met the criteria of > 80% of school wrapped. The goal in 2023-24 is to attempt to capture anchovy schools (which may include mixed schools containing sardine) in Monterey-Central Coast (and possibly in Southern California) and sardine schools in Monterey-Central Coast.

Pacific Sardine Point Sets - Southern California					
School Size (mt)	2010	2018	2019	2020	Total
0-10	4	12	0	0	16
10-20	6	4	1	0	11
20-30	3	0	3	0	6
30-40	2	0	0	1	3
40-50	6	0	1	0	7
50-60	0	0	2	0	2
60-70	2	0	0	0	2
70-80	1	0	1	0	2
80-90	2	0	0	0	2
90-100	0	0	0	0	0
100+	0	0	0	0	0
Total	26	16	8	1	51

Pacific Sardine Point Sets - Monterey			
School Size (mt)	2019	2020	Total
0-10	1	1	2
10-20	2	2	4
20-30	1	2	3
30-40	0	0	0
40-50	0	2	2
50-60	1	2	3
60-70	0	0	0
70-80	0	0	0
80-90	0	1	1
90-100	0	0	0
100+	0	0	0
Total	5	10	15

Northern Anchovy Point Sets - S CA	
School Size (mt)	2020
0-10	0
10-20	2
20-30	0
30-40	0
40-50	0
50-60	0
60-70	0
70-80	0
80-90	0
90-100	0
100+	0
Total	2

Northern Anchovy Point Sets - Monterey					
School Size (mt)	2019	2020	2021	2022	Total
0-10	0	1	1	0	2
10-20	1	0	0	0	1
20-30	0	0	0	0	0
30-40	0	0	0	0	0
40-50	0	0	0	0	0
50-60	0	0	0	0	0
60-70	2	1	0	0	3
70-80	0	0	0	0	0
80-90	0	0	0	0	0
90-100	0	0	0	0	0
100+	0	0	0	1	0
Total	3	2	1	1	7

For a number of reasons, including inclement weather and vessel and gear problems (split net and hydraulic issues) we did not use the entire 300 mt allocation provided for 2021-22. We attempted point sets in Monterey in October 2021, but weather conditions and sardine behavior foiled our efforts during the only time period that the spotter pilot was available to direct point sets. Although the pilot observed sardines in the Monterey – Half Moon Bay area, the schools were located on rocky bottom inaccessible for purse seine capture. In May 2022, an EFP vessel landed a valid 111 mt set, but split the net attempting a second sardine set, ending the spring effort. No sardines have been landed yet in the 2022-23 point set EFP. When the spotter pilot is available in spring 2023, we will attempt to collect sardine schools in Monterey before our 2022-23 point set EFP expires on June 30.

Appendix 2. 2010 point set photographs. Note the typical schooling pattern of CPS in nearshore waters in CA. Individual schools break away from the shoaling fish for a short period, and often outrun the vessel in the capture attempt. In the picture on the left, F/V Eileen approaches 20-ton sardine school in 2010 summer aerial survey. In the picture on the right, FV Eileen in process of wrapping school. This was a 100% capture point set.



Appendix 3. Fisherman’s log form.

**CPS Nearshore Cooperative Survey
Fisherman's Log Form**

Date: _____ Captain: _____

Vessel: _____ Processor: _____

Hydroacoustic Gear

Type	Make	Model	Frequency
Sounder			
Sonar			

Net Dimensions

Net Length (fm)	Net Depth (fm)	Mesh Size (in)

School and Ocean Data

Point Set Number	Point Set Start Time	Latitude	Longitude	Top Depth of School (fm)	Bottom Depth of School (fm)	Ocean Depth (fm)	SST (F)	Weather Condition	Picture of Sonar (Y/N)

Weather Codes: 1= calm, clear; 2= light wind, good visibility; 3= moderate wind, fair visibility; 4= poor fishing conditions

Captains Estimate and Delivery Information

Point Set No.	Species Observed	% of School Captured	Total Est. School Tonnage (mt)	Fish Hold (FP, FS, MP, MS, AP, AS)	*Delivered Weight (st)	*Fish Ticket Number

Comments and sonar interpretations:

Appendix 4. Flight log form.

CPS Nearshore Cooperative Survey

Point Set Flight Log Form

Date: _____ **Pilot:** _____

Processor: _____ **Observer:** _____

Set #	Time Pre & During	Photo #s Pre & During	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% Species Composition	Est. School Tonnage (st)	% of School Captured

Comments: _____

Set #	Time Pre & During	Photo #s Pre & During	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% Species Composition	Est. School Tonnage (st)	% of School Captured

Comments: _____

Set #	Time Pre & During	Photo #s Pre & During	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% Species Composition	Est. School Tonnage (st)	% of School Captured

Comments: _____

Set #	Time Pre & During	Photo #s Pre & During	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% Species Composition	Est. School Tonnage (st)	% of School Captured

Comments: _____

Set #	Time Pre & During	Photo #s Pre & During	Position (Lat/Long)	Altitude (ft)	Vessel	Species Observed	% Species Composition	Est. School Tonnage (st)	% of School Captured

Comments: _____

Table A1. Sardine and anchovy point set data collected from 2010 study (Jagiello et al. 2010), and 2018-2022 NCS for Spotter 1.

Date	Region	Species	Aerial observation		Purse seine sampling	
			Est. School Biomass (mt)	Est. % School Wrapped	Landed Catch (mt)	Adj. Landed Catch
			x'		y	y'
8/9/10	SCA	Sardine	4.54	100	4.80	4.80
8/12/10	SCA	Sardine	27.22	90	40.20	44.67
8/16/10	SCA	Sardine	27.22	100	38.50	38.50
8/17/10	SCA	Sardine	13.61	100	10.90	10.90
8/18/10	SCA	Sardine	13.61	100	15.40	15.40
8/18/10	SCA	Sardine	9.07	95	15.00	15.79
8/18/10	SCA	Sardine	4.54	100	6.70	6.70
8/18/10	SCA	Sardine	10.89	90	17.90	19.89
8/19/10	SCA	Sardine	9.07	100	2.80	2.80
8/19/10	SCA	Sardine	9.07	100	9.60	9.60
8/22/10	SCA	Sardine	9.07	95	14.90	15.68
8/23/10	SCA	Sardine	22.68	100	20.00	20.00
8/23/10	SCA	Sardine	10.89	95	10.70	11.26
8/31/10	SCA	Sardine	45.36	95	58.70	61.79
8/31/10	SCA	Sardine	22.68	100	31.30	31.30
8/31/10	SCA	Sardine	31.75	100	44.00	44.00
9/1/10	SCA	Sardine	58.97	95	67.40	70.95
9/1/10	SCA	Sardine	40.82	100	45.00	45.00
9/8/10	SCA	Sardine	49.90	90	38.80	43.11
9/8/10	SCA	Sardine	49.90	95	23.90	25.16
9/9/10	SCA	Sardine	40.82	95	46.80	49.26
9/10/10	SCA	Sardine	72.57	100	84.90	84.90
9/12/10	SCA	Sardine	68.04	100	84.60	84.60
9/13/10	SCA	Sardine	22.68	95	20.20	21.26
9/13/10	SCA	Sardine	45.36	100	64.20	64.20
9/13/10	SCA	Sardine	31.75	90	40.50	45.00
8/20/18	SCA	Sardine	2.72	100	3.38	3.38
8/20/18	SCA	Sardine	3.63	95	4.09	4.31
8/21/18	SCA	Sardine	4.54	95	5.70	6.00
8/21/18	SCA	Sardine	4.54	100	5.01	5.01
8/21/18	SCA	Sardine	1.81	100	2.74	2.74
8/22/18	SCA	Sardine	3.63	100	5.38	5.38
8/22/18	SCA	Sardine	16.33	100	18.79	18.79
8/22/18	SCA	Sardine	9.07	100	11.01	11.01
8/22/18	SCA	Sardine	12.70	100	14.20	14.20
8/22/18	SCA	Sardine	11.79	100	11.86	11.86
8/27/18	SCA	Sardine	2.72	100	3.36	3.36
8/27/18	SCA	Sardine	6.35	100	5.45	5.45
8/27/18	SCA	Sardine	1.81	90	2.14	2.38
8/28/18	SCA	Sardine	1.81	100	2.76	2.76
8/28/18	SCA	Sardine	2.72	90	2.76	3.06
8/28/18	SCA	Sardine	5.44	100	4.91	4.91
3/26/19	SCA	Sardine	27.22	100	29.78	29.78
3/26/19	SCA	Sardine	39.01	100	41.02	41.02
3/26/19	SCA	Sardine	13.61	100	15.15	15.15
4/1/19	SCA	Sardine	58.97	100	57.91	57.91
4/1/19	SCA	Sardine	31.75	100	29.97	29.97
4/1/19	SCA	Sardine	49.90	100	51.66	51.66
4/2/19	SCA	Sardine	24.49	100	25.64	25.64
6/28/19	SCA	Sardine	72.57	95	71.49	75.26
8/13/19	Monterey	Sardine	6.35	90	5.88	6.53
8/14/19	Monterey	Anchovy	9.07	90	10.88	12.09
8/15/19	Monterey	Anchovy	66.22	100	67.33	67.33
8/21/19	Monterey	Sardine	5.44	95	11.21	11.80
8/21/19	Monterey	Sardine	33.57	90	27.60	30.67
8/21/19	Monterey	Sardine	9.07	95	13.24	13.93
9/12/19	Monterey	Sardine	54.43	90	62.07	68.97
9/12/19	Monterey	Anchovy	58.97	90	51.82	57.58
4/14/20	Monterey	Anchovy	68.95	100	69.10	69.10
4/22/20	SCA	Sardine	33.57	90	32.21	35.79
6/18/20	SCA	Anchovy	15.42	100	16.62	16.62
6/18/20	SCA	Anchovy	18.14	100	19.93	19.93
10/12/20	Monterey	Anchovy	48.99	100	43.21	43.21
10/12/20	Monterey	Sardine	5.44	100	7.03	7.03
10/13/20	Monterey	Sardine	16.33	100	17.83	17.83
10/13/20	Monterey	Sardine	22.68	100	22.25	22.25
10/14/20	Monterey	Sardine	9.07	100	10.37	10.37
10/14/20	Monterey	Sardine	6.35	100	5.96	5.96
10/15/20	Monterey	Sardine	22.68	100	22.33	22.33
10/15/20	Monterey	Sardine	45.36	100	44.73	44.73
10/15/20	Monterey	Sardine	54.43	100	51.85	51.85
10/21/20	Monterey	Sardine	56.25	100	58.82	58.82
10/21/20	Monterey	Sardine	72.57	100	80.08	80.08

Date	Region	Species	Aerial observation		Purse seine sampling	
			Est. School Biomass (mt)	Est. % School Wrapped	Landed Catch (mt)	Adj. Landed Catch (mt)
8/9/10	SCA	Sardine	4.54	100	4.80	4.80
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8/18/10	SCA	Sardine	13.61	100	15.40	15.40
8/18/10	SCA	Sardine	9.07	95	15.00	15.79
8/18/10	SCA	Sardine	4.54	100	6.70	6.70
8/18/10	SCA	Sardine	10.89	90	17.90	19.89
8/19/10	SCA	Sardine	9.07	100	2.80	2.80
8/19/10	SCA	Sardine	9.07	100	9.60	9.60
8/22/10	SCA	Sardine	9.07	95	14.90	15.68
8/23/10	SCA	Sardine	22.68	100	20.00	20.00
8/23/10	SCA	Sardine	10.89	95	10.70	11.26
8/31/10	SCA	Sardine	45.36	95	58.70	61.79
8/31/10	SCA	Sardine	22.68	100	31.30	31.30
8/31/10	SCA	Sardine	31.75	100	44.00	44.00
9/1/10	SCA	Sardine	58.97	95	67.40	70.95
9/1/10	SCA	Sardine	40.82	100	45.00	45.00
9/8/10	SCA	Sardine	49.90	90	38.80	43.11
9/8/10	SCA	Sardine	49.90	95	23.90	25.16
9/9/10	SCA	Sardine	40.82	95	46.80	49.26
9/10/10	SCA	Sardine	72.57	100	84.90	84.90
9/12/10	SCA	Sardine	68.04	100	84.60	84.60
9/13/10	SCA	Sardine	22.68	95	20.20	21.26
9/13/10	SCA	Sardine	45.36	100	64.20	64.20
9/13/10	SCA	Sardine	31.75	90	40.50	45.00
8/20/18	SCA	Sardine	2.72	100	3.38	3.38
8/20/18	SCA	Sardine	3.63	95	4.09	4.31
8/21/18	SCA	Sardine	4.54	95	5.70	6.00
8/21/18	SCA	Sardine	4.54	100	5.01	5.01
8/21/18	SCA	Sardine	1.81	100	2.74	2.74
8/22/18	SCA	Sardine	3.63	100	5.38	5.38
8/22/18	SCA	Sardine	16.33	100	18.79	18.79
8/22/18	SCA	Sardine	9.07	100	11.01	11.01
8/22/18	SCA	Sardine	12.70	100	14.20	14.20
8/22/18	SCA	Sardine	11.79	100	11.86	11.86
8/27/18	SCA	Sardine	2.72	100	3.36	3.36
8/27/18	SCA	Sardine	6.35	100	5.45	5.45
8/27/18	SCA	Sardine	1.81	90	2.14	2.38
8/28/18	SCA	Sardine	1.81	100	2.76	2.76
8/28/18	SCA	Sardine	2.72	90	2.76	3.06
8/28/18	SCA	Sardine	5.44	100	4.91	4.91
3/26/19	SCA	Sardine	27.22	100	29.78	29.78
3/26/19	SCA	Sardine	39.01	100	41.02	41.02
3/26/19	SCA	Sardine	13.61	100	15.15	15.15
4/1/19	SCA	Sardine	58.97	100	57.91	57.91
4/1/19	SCA	Sardine	31.75	100	29.97	29.97
4/1/19	SCA	Sardine	49.90	100	51.66	51.66
4/2/19	SCA	Sardine	24.49	100	25.64	25.64
6/28/19	SCA	Sardine	72.57	95	71.49	75.26
8/13/19	Monterey	Sardine	6.35	90	5.88	6.53
8/14/19	Monterey	Anchovy	9.07	90	10.88	12.09
8/15/19	Monterey	Anchovy	66.22	100	67.33	67.33
8/21/19	Monterey	Sardine	5.44	95	11.21	11.80
8/21/19	Monterey	Sardine	33.57	90	27.60	30.67
8/21/19	Monterey	Sardine	9.07	95	13.24	13.93
9/12/19	Monterey	Anchovy	54.43	90	62.07	68.97
9/12/19	Monterey	Sardine	58.97	90	51.82	57.58
4/14/20	Monterey	Anchovy	68.95	100	69.10	69.10
4/22/20	SCA	Sardine	33.57	90	32.21	35.79
6/18/20	SCA	Anchovy	15.42	100	16.62	16.62
6/18/20	SCA	Anchovy	18.14	100	19.93	19.93
10/12/20	Monterey	Anchovy	48.99	100	43.21	43.21
10/12/20	Monterey	Sardine	5.44	100	7.03	7.03
10/13/20	Monterey	Sardine	16.33	100	17.83	17.83
10/13/20	Monterey	Sardine	22.68	100	22.25	22.25
10/14/20	Monterey	Sardine	9.07	100	10.37	10.37
10/14/20	Monterey	Sardine	6.35	100	5.96	5.96
10/15/20	Monterey	Sardine	22.68	100	22.33	22.33
10/15/20	Monterey	Sardine	45.36	100	44.73	44.73
10/15/20	Monterey	Sardine	54.43	100	51.85	51.85
10/21/20	Monterey	Sardine	56.25	100	58.82	58.82
10/21/20	Monterey	Sardine	72.57	100	80.08	80.08
10/5/21	Monterey	Anchovy	9.07	90	7.34	8.16
5/24/22	Monterey	Anchovy	107.96	100	111.40	111.40

Table A2. Sardine and anchovy point set data collected from 2018-2022 NCS for Spotter 2.

Date	Region	Species	Aerial observation		Purse seine sampling	
			Est. School Biomass (mt)	Est. % School Wrapped	Landed Catch (mt)	Adj. Landed Catch
8/20/18	SCA	Sardine	1.81	100	3.38	3.38
8/20/18	SCA	Sardine	2.72	100	4.10	4.10
8/21/18	SCA	Sardine	3.63	95	5.67	5.97
8/21/18	SCA	Sardine	4.54	100	5.01	5.01
8/21/18	SCA	Sardine	1.81	100	2.74	2.74
8/22/18	SCA	Sardine	4.54	100	5.38	5.38
8/22/18	SCA	Sardine	18.14	100	18.79	18.79
8/22/18	SCA	Sardine	7.26	100	11.01	11.01
8/22/18	SCA	Sardine	10.89	100	14.20	14.20
8/22/18	SCA	Sardine	9.07	100	11.86	11.86
8/27/18	SCA	Sardine	2.72	100	3.35	3.35
8/27/18	SCA	Sardine	5.44	100	5.45	5.45
8/27/18	SCA	Sardine	1.81	100	2.14	2.14
8/28/18	SCA	Sardine	1.81	100	2.71	2.71
8/28/18	SCA	Sardine	2.72	100	2.74	2.74
8/28/18	SCA	Sardine	4.54	100	4.82	4.82
3/26/19	SCA	Sardine	23.59	100	29.74	29.74
3/26/19	SCA	Sardine	36.29	100	41.02	41.02
3/26/19	SCA	Sardine	13.61	100	14.22	14.22
4/1/19	SCA	Sardine	54.43	100	57.95	57.95
4/1/19	SCA	Sardine	27.22	100	29.97	29.97
4/1/19	SCA	Sardine	54.43	100	51.61	51.61
4/2/19	SCA	Sardine	22.68	100	25.55	25.55
6/28/19	SCA	Sardine	63.50	95	71.49	75.25
8/13/19	Monterey	Sardine	4.54	85	5.88	6.91
8/14/19	Monterey	Sardine	9.10	90	10.88	12.09
8/15/19	Monterey	Anchovy	54.40	100	67.33	67.33
8/21/19	Monterey	Anchovy	4.54	95	11.21	11.80
8/21/19	Monterey	Anchovy	27.22	90	27.60	30.67
8/21/19	Monterey	Sardine	9.07	90	13.24	14.71
9/12/19	Monterey	Anchovy	45.36	90	51.82	57.58
9/12/19	Monterey	Sardine	54.43	90	62.07	68.97
4/14/20	SCA	Sardine	63.50	100	69.10	69.10
4/22/20	Monterey	Sardine	27.22	90	32.25	35.83
6/18/20	SCA	Anchovy	13.60	100	16.62	16.62
6/18/20	SCA	Anchovy	18.10	100	19.93	19.93
10/12/20	Monterey	Anchovy	40.86	100	43.21	43.21
10/12/20	Monterey	Sardine	4.54	100	7.03	7.03
10/13/20	Monterey	Sardine	13.60	90	17.83	19.81
10/13/20	Monterey	Sardine	22.70	100	22.25	22.25
10/14/20	Monterey	Sardine	9.10	100	10.37	10.37
10/14/20	Monterey	Sardine	4.50	100	5.96	5.96
10/15/20	Monterey	Sardine	18.14	100	22.33	22.33
10/15/20	Monterey	Sardine	36.29	100	44.73	44.73
10/15/20	Monterey	Sardine	54.43	100	51.85	51.85
10/21/20	Monterey	Sardine	45.36	100	58.82	58.82
10/21/20	Monterey	Sardine	63.50	100	80.08	80.08
10/5/21	Monterey	Anchovy	9.07	90	7.34	8.16
5/24/22	Monterey	Anchovy	108.86	100	111.40	111.40

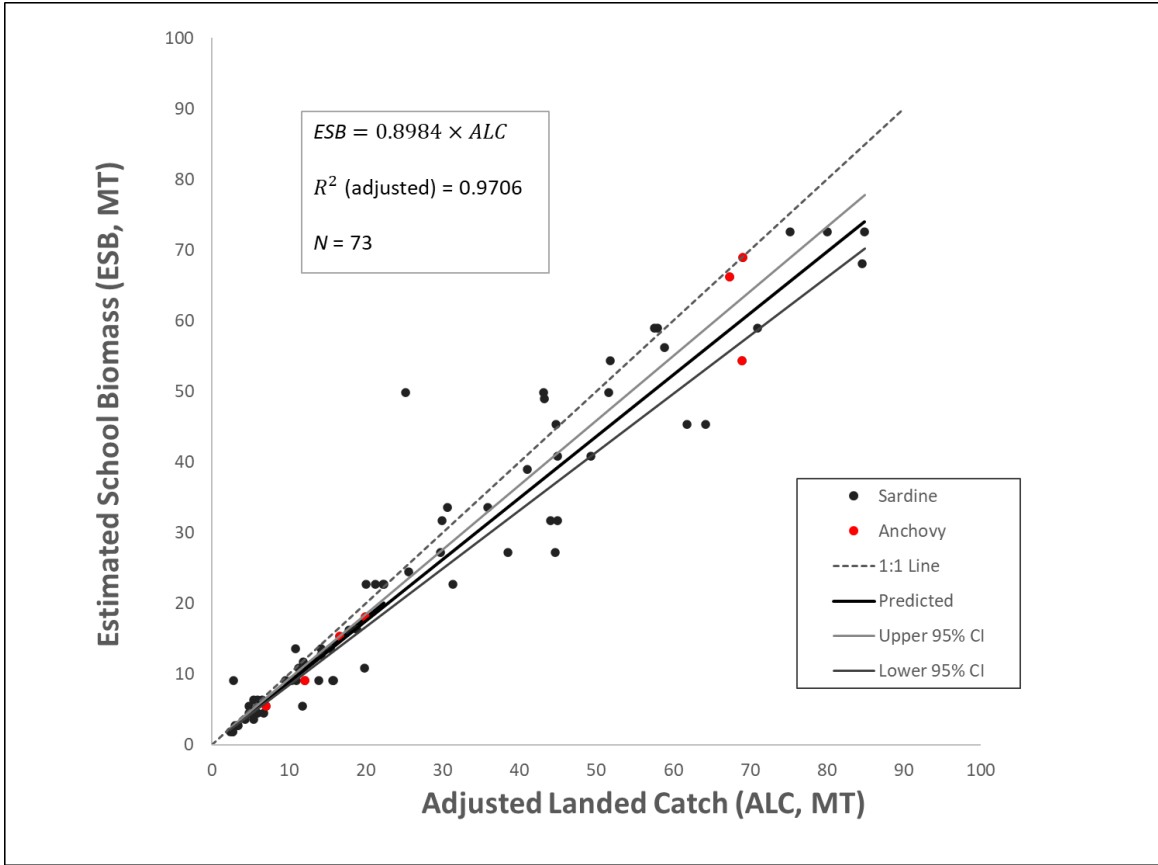


Figure A1. . Survey biomass calibration curve used for 2021 central subpopulation of northern anchovy tock assessment (Kuriyama et al. 2022) for Spotter 1. Linear regression model and parameter estimates, based on aerial school biomass estimated by Spotter 1 and purse seine point sets collected during the 2010 and 2018-20 nearshore NCS off Southern California and Monterey.

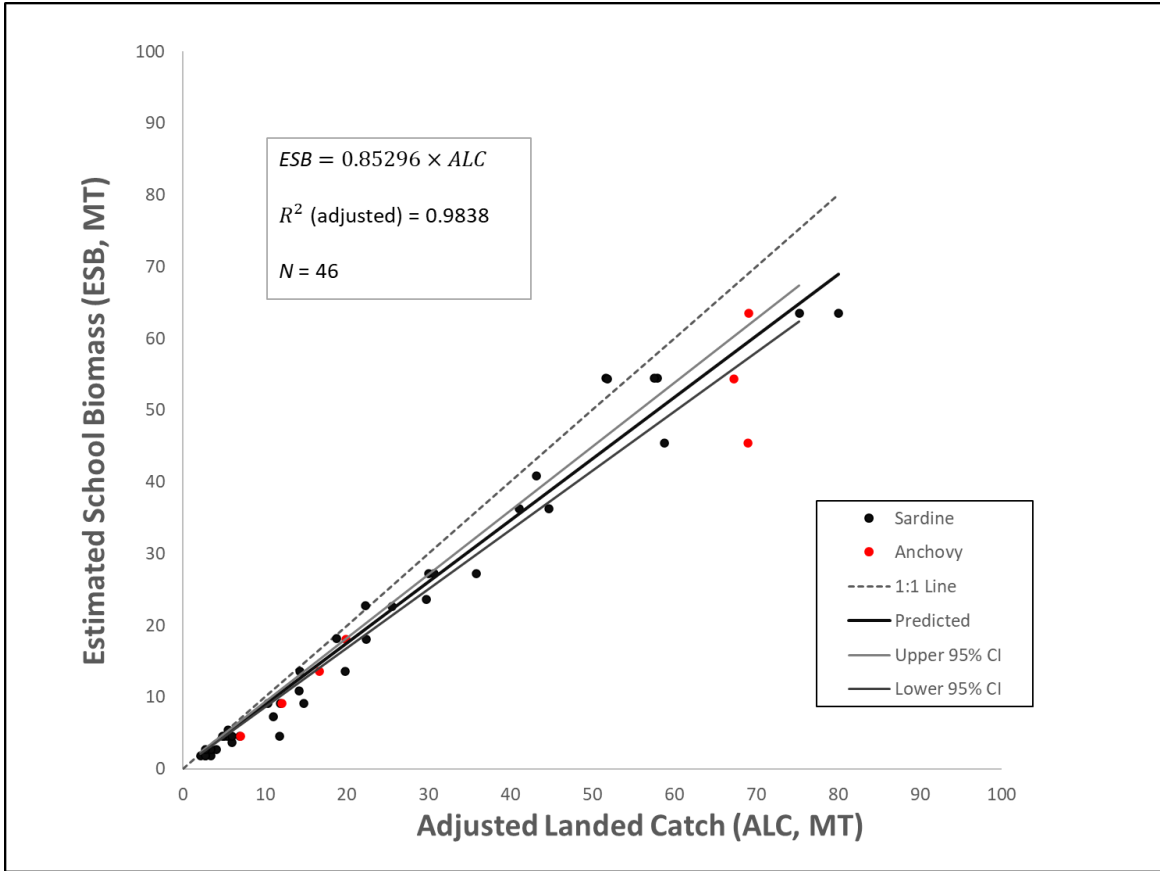


Figure A2. Linear regression model and parameter estimates, based on aerial school biomass estimated by Spotter 2 and purse seine point sets collected during the 2018-20 NCS off Southern California and Monterey.