

Pacific Sardine Stock Definitions

Agenda Item J.3

November 2025

Current Management

- Pacific sardine came under Federal management in 2000, during a time of general acceptance of 3 subpopulations
- “northern stock” (aka northern subpopulation; NSP) was considered exploited by U.S. fisheries and included in the FMP
- CPS FMP includes FMU species considered ‘in the fishery,’ subject to provisions of the FMP, defines stocks managed

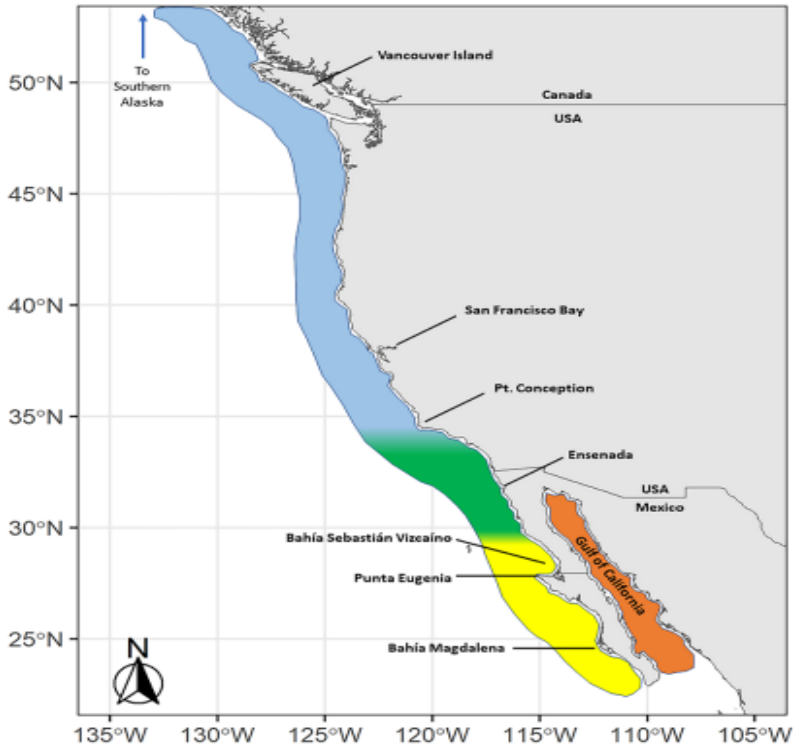


Figure: Generalized distributions of the hypothesized Northern subpopulation (blue), Southern subpopulation (yellow), and Gulf of California subpopulation (orange) of Pacific sardine While the Northern and Southern subpopulations show overlap, the two-stock hypothesis considers that they may move north-south at similar times and have limited overlap. Their potential overlap is shown in green (via Craig et al. 2025).

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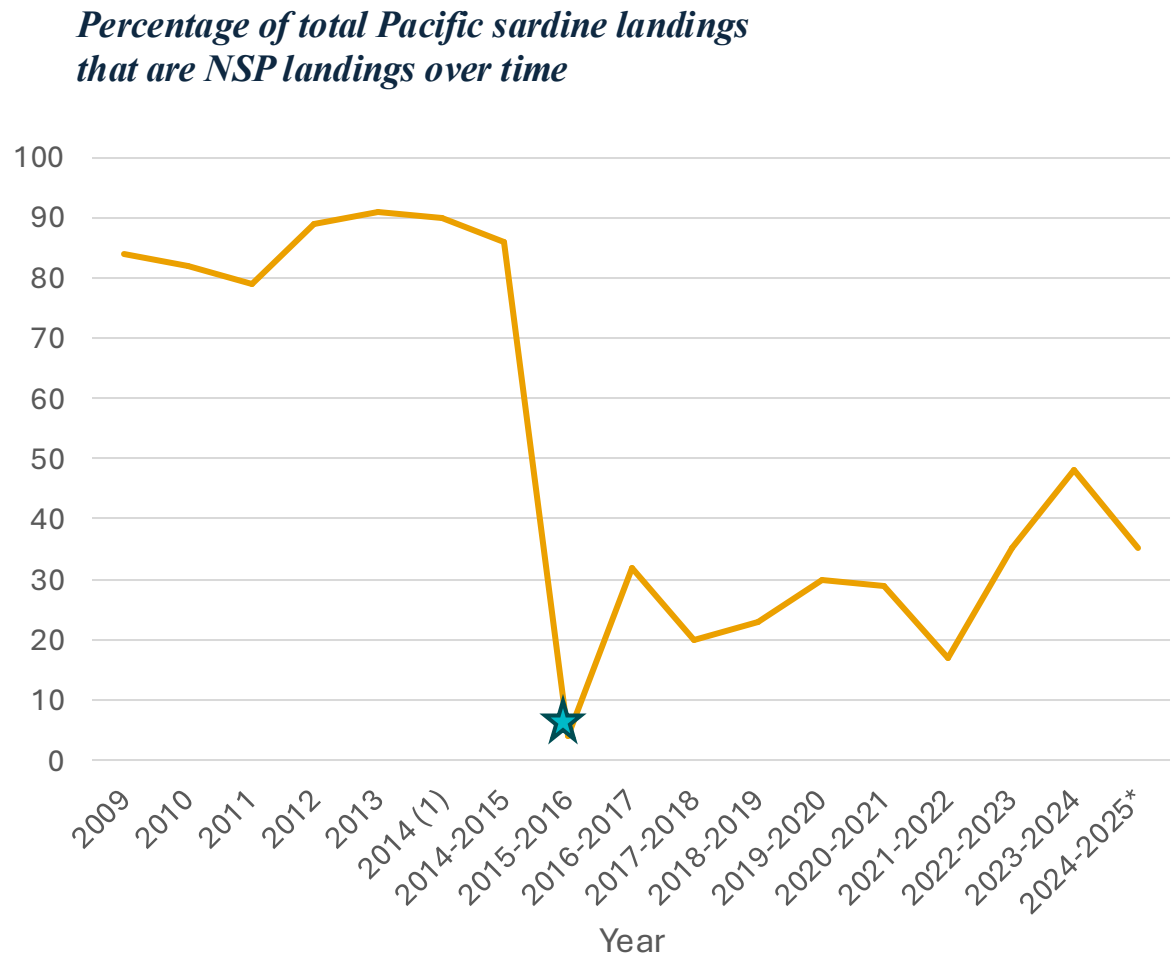
Table 1-1 includes the fishery management unit species which are “in the fishery” and subject to provisions of the CPS FMP.

Table 1-1. Stocks managed under this FMP.

Common Name	Scientific Name
Pacific sardine	*Sardinops sagax*
Northern subpopulation	
Pacific (chub) mackerel	*Scomber japonicus*
Northern anchovy	*Engraulis mordax*
Central and northern subpopulations	
Market squid	*Doryteuthis opalescens*
Jack mackerel	*Trachurus symmetricus*
Krill or Euphausiids	*All Species in West Coast EEZ*
Including these eight dominant species.	*Euphausia pacifica*
First two species are common and are	*Thysanoessa spinifera*
most likely to be targeted by fishing	*Nyctiphanes simplex*
	Nematocelis difficilis
	T. gregaria
	E. recurva
	E. gibboides
	E. eximia

Current Management

- Prior to 2014, stock assessments differentiation between NSP and SSP was based on assumption that SSP was off Mexico
- Habitat index/model developed to apportion annual catch (Demer and Zwolinski 2014; updated in 2023)
- Apportionment of catch occurs during annual assessments, while in-season, all catch attributed to NSP
- The directed fishery has been closed since 2015, with a rebuilding plan developed and implemented since 2021 and EFPs, live bait, and minor directed fisheries allowed to operate
- In recent years, a large proportion of landings is attributed to SSP



Why is this Action Considered?

- Increased attention brought to a southern subpopulation (SSP), which are indistinguishable from NSP, and comprise an increasing proportion of landings
  - Attention from the CPSMT, CPSAS, SSC, and eventual prioritization by the Council
- Identifying and defining a stock is one of the most basic and essential steps to fishery management
  - National Standard guidelines recommend that Councils periodically review their FMPs and the BSIA to determine if stocks are 'appropriately identified,' and whether a stock needs to be removed from or moved into an FMP based on updated information
  - Needed to meet goals of MSA and National Standards to prevent overfishing and achieve OY
  - Mis-aligned stock definitions can mis-align management measures with population dynamics
- Recent scientific evidence and a review of historical information indicate that sardine management unit may not represent the biological population in U.S. waters
  - Lack of evidence to distinguish between hypothesized subpopulations
  - Emergence of Japanese sardine in U.S. waters

Council’s Task

Council’s task is to determine whether the current FMU and the stocks defined within it are appropriately identified; adequately encompassing the available Pacific sardine resource — including whether Japanese sardine should be added—so that management actions remain consistent with the principles of the MSA, National Standards, and sound fishery science.

Defining a Fishery Management Unit

Definitions

Meeting the goals of the MSA, National Standards, CPS FMP

Scientific Considerations

Definitions of Terms

Stock – a species, subspecies, geographical grouping, or other category of fish capable of a management as a unit

Population – a biological unit, a group of individuals of the same species that are separated from others within the same species

Fishery Management Unit – a fishery or that portion of a fishery identified in an FMP as relevant to the FMP's management objectives, including biological, geographic, economic, technical, social, or ecological perspectives. All species 'in the fishery.'

Defining an FMU – MSA, National Standards and the Objectives of the CPS FMP

- § 302(h)(1) of the MSA requires the Council to prepare an FMP for each fishery under its authority that requires conservation and management
- Preventing overfishing, achieving OY, and meeting the goals and objectives of the CPS FMP
- Councils should consider which stocks require conservation and management
- National Standards relevant, particularly 1, 2 & 3

600.305(c) Factors

Factor (i) – The Stock is an important component of the marine environment

- Pacific sardine and other CPS populations are important components of the California Current ecosystem as a vital forage species
- Unclear ecological role of Japanese sardine

Factor (ii) – The stock is caught by the fishery; Factor (iv) – the stock is a target of a fishery

- SSP and Japanese sardine indistinguishable from NSP, fished and targeted within the same fishery
  - SSP in summer months
  - Small scale and directed fisheries catch all

Factor (iii) – Whether an FMP can improve or maintain the condition of the stock

- Sardine and CPS have larger, more variable ranges and migration patterns compared to groundfish, proportion of EEZ and off the West Coast states varies within the year and year-to-year
- Likely condition of whole Pacific sardine population, if defined as a stock would benefit from management in the FMP
- Unclear whether management is required to improve or maintain the condition of Japanese sardine

600.305(c) Factors

Factor (v) The stock is important to commercial, recreational, or subsistence users and Factor (vi) The fishery is important to the Nation or to the regional economy

- Pacific sardine fishery was historically the largest contributor to CPS fisheries
- Even with directed fishery closed, sardine supports economic revenue, particularly in live bait fisheries located in southern CA, where both NSP and SSP are present

Factor (viii) The economic condition of a fishery and whether an FMP can produce more efficient utilization

- Current catch accounting system may contribute to prematurely approaching ACL, ABC, potential restriction
- Revision of FMU could allow for more efficient utilization of the resource

Factor (x)

- Factor (x) The extent to which the fishery is already adequately managed by states, by state/Federal programs, or by Federal regulations pursuant to other FMPs or international commissions, or by industry self-regulation, consistent with the requirements of the Magnuson-Stevens Act and other applicable law

National Standards

NS1 – Optimum Yield

- Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the OY from each fishery
- Stock delineations should align with these objectives

NS2 – Scientific Information

- Conservation and management measures be based upon the best scientific information available

Considerations for meeting BSIA

Literature and SSC have suggested population structure is foundational to defining stocks and delineating boundaries for management

- Identification and delineation of stocks should represent spatially discrete populations or population structure
- SSC has suggested that genetic differences are strongest evidence for population structure
- A stock should consist of all individuals that interact enough to create a coherent population trend, including multiple subpopulations within a stock if they demonstrate comparable recruitment patterns, life histories, and exploitation histories
- Management boundaries should anticipate changing environmental conditions

National Standards

NS3 – Management Units

- To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination
- Purpose is to “induce a comprehensive approach to fishery management” and define a “management unit” as the fishery or portion of the fishery relevant to the FMP’s management objectives
- Stocks should include a whole biological population and should not be arbitrarily divided
- Stocks that interact ecologically or within a common fishery should be managed within the same FMU or within coordinated management
- Multiple stocks may be managed together as a unit if they are caught within the same fishery and cannot be easily identified and separated

Application to this Action

- Reviewing the FMU to ensure it meets the goals of National Standards, and the CPS FMP
- Ensure it is feasible to manage stocks as defined to meet goals of National Standards and CPS FMP
- Align stock definitions with BSIA, including recommendations of literature and SSC

Under Consideration

- Adjusting Pacific sardine stock definition
- Whether to bring Japanese sardine into FMU

Next Up: Scientific and Management Considerations

Delineation of a stock must combine both scientific information and management considerations to support the goals and objectives of the MSA, National Standards, and the CPS FMP

State of the Science



Pacific Sardine

Population Dynamics

- Review of historical information
- New evidence



Introduction of

Japanese Sardine

Literature on Pacific Sardine Population Dynamics

- Building on 2022 Stock Structure Workshop
- Review of Historical Literature
  - Craig et al. (2025) – critical, historical literature review
    - Reviews studies on adult movement, growth, morphology, spawning, landings, temperature relationships
    - There is little, if any evidence supporting a hypothesis of multiple subpopulations in their North American range
  - Erisman et al. (2025) – systematic review of somatic growth patterns
    - Length-at-age and growth information should not be used to delineate subpopulations or apportion biomass of Pacific sardine
- Genetic differentiation
  - Adams and Craig (2024)
    - Low, but statistically significant genetic differentiation overall, with mostly panmitic gene flow
  - Longo et al. (2025) – whole genome sequencing
    - Evidence of panmixia
    - Results do not support current management and suggest multiple management units have been defined for a single biological population

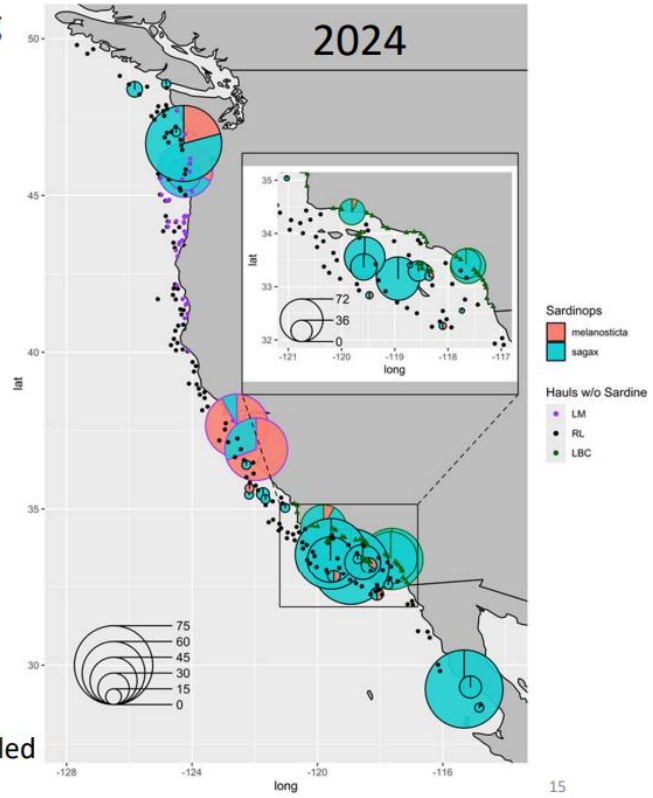
Japanese Sardine

- Present in U.S.
- Frequency and cause for the cl e hypothesized
- 18.3 percent of
  - Not necessa
  - Trawl sampl
- Not yet separat
- Changes since
  - Cohort effec
  - Reproducing
  - No evidence

Genetics Research: Japanese sardine

Samples collected during trawling of summer CPS surveys.
No synoptic collecting has occurred yet.

Year	# Analyzed	# Pacific Sardine	# Japanese Sardine	% Japanese Sardine
2024	613	501	112	18.27
2023	825	491	334	40.48
2022	172	100	72	41.86
2021	81	81	0	0
2019	198	198	0	0
2018	131	131	0	0
2017	269	269	0	0
2016	622	622	0	0
2015	175	175	0	0
2014	211	211	0	0
2013	892	892	0	0



NOAA-TM-NMFS-SWFSC-717

*% individuals sampled

Operational and Implementation Considerations: Pacific Sardine

- Catch Accounting and Enforcement
- Assessment and Surveys
- Uncertainty and Risk
- Harvest Control Rules

Catch Accounting and Enforcement

- Coastwide
  - All sardine landed would contribute towards a single ACL
  - Catch would not be delineated in season or post-season
- Multiple stocks
  - Could require accounting and multiple limits, unless managed in a complex
  - NSP and SSP are indistinguishable → some sort of estimation (habitat index, geographic boundaries, etc.)
  - Differences in stock status would need to be considered
- Burden
  - Greater for multiple stocks
- Council should consider long term outcomes

Assessment and Surveys

- CPS AT survey method would not change, continue to collect data on sardine from Mexico to Canada
- Single stock assessment would require similar sampling effort
- Multiple stocks would increase the number of samples required and delineation of samples to each stock

Uncertainty and Risk

- Stock definitions should align with the best scientific information available on the species' population structure; the stock unit should align with the biological unit as best possible, given management feasibility
- 'Incoherent dimensionality' is the misalignment of management and biological units
  - Can create risks when (1) managing discrete biological units as a single population AND (2) managing a single population as discrete units
  - Risk is highest when ignoring underlying population structure and processes AND when ignoring connectivity
  - Managing multiple biological units as a single population can lead to management that does not capture reproductive isolation, allowing for localized depletion of reproductive units
  - Splitting a single biological population into multiple units may generate biased reference points and fail to capture migration, movement, and connection across space and time

Harvest Control Rules

- Any change or new stock definition could require a change in or development of new HCRs and reference points
- Council could also consider how to make the HCR adaptable to change and able to account for uncertainty, including uncertainty in population structure and distribution of the stock(s) over time
- Parameters in HCR formulas (DISTRIBUTION and EMSY) prioritized for review as a part of the stock definitions

Japanese Sardine

- Fishermen targeting Pacific sardine likely frequently catch Japanese sardine, indistinguishable from Pacific sardine
- Presence of Japanese sardine can complicate stock assessments and management, as catch estimates will likely include multiple species
  - Could affect Pacific sardine population estimates, biomass projections, and the sustainability of catch limits
- Limited information to date on Japanese sardine
- Several pathways, whether brought into FMU or not

Council's decision on how to address the challenges presented by Japanese sardine will need to balance scientific rigor, management feasibility, practical considerations, and the potential for future environmental change

Next Steps

- An adjustment to the Pacific sardine definition in the FMU would require an FMP amendment
- Addition of a new species to the FMU would require an FMP amendment and a regulatory amendment
- FMU and stock definitions can be reviewed and re-adjusted as necessary if scientific information or the ability to manage changes in the future, per NS guidelines
- Following this action, there would be a need for further Council action (i.e. sub-actions after this step) adjustments to reference points, HCRs, coordination of management of multiple stocks via complexes or other method; shaded on the YAG)

Conclusion

- Coastwide stock of Pacific sardine, capturing coastwide population
  - New research on the population structure of Pacific sardine shows little, if any, evidence to support the hypothesis of a subpopulation structure that has been the basis of sardine management for the last 25 years
  - Does not incur additional management burden
  - A coastwide stock may could account for population structure in additional management measures
- Multiple stocks of Pacific sardine, splitting up population
  - May benefit in the Council continuing to consider delineating multiple stocks of Pacific sardine based on finer-scale dynamics, if determined to exist
  - May be differences within population, though little evidence of population structure
  - Increases management burden and requires estimation
- Japanese sardine
  - Indistinguishable and targeted in mixed landings with Pacific sardine
  - Little information
  - Council may opt to bring into FMU

Council’s Task

Council’s task is to determine whether the current FMU and the stocks defined within it are appropriately identified; adequately encompassing the available Pacific sardine resource — including whether Japanese sardine should be added—so that management actions remain consistent with the principles of the MSA, National Standards, and sound fishery science.

Purpose and Need

- Action aims to reevaluate the fishery management unit (FMU) for sardine in the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP)
- Action will determine if the sardine stock is ‘appropriately identified,’ and whether a stock needs to be moved into the FMP or adjusted based on updated information
- This action is necessary to ensure sardine management is consistent with the goals and objectives of the Magnuson-Stevens Act, the National Standards, and the objectives of the CPS FMP

Range of Alternatives

No Action - The Council would not define stocks other than those currently defined in the CPS FMP (Section 1.2, Table 1-1). Only the northern subpopulation of Pacific sardine would continue to be defined as a stock in the FMU.

Alternative 1 - The Council would amend the CPS FMP (Section 1.2, Table 1-1) to include all Pacific sardine in U.S. waters in the FMU. The FMU would include one stock of Pacific sardine, delineated coastwide.

> ***Option (a)*** – The Council would also amend the CPS FMP to add Japanese sardine in U.S. waters to the FMU.

Alternative 2 - The Council would amend the CPS FMP (Section 1.2, Table 1-1) to include all Pacific sardine in U.S. waters in the FMU. The FMU would include two stocks of Pacific sardine, delineated by northern and southern subpopulations.

> ***Option (a)*** – The Council would also amend the CPS FMP to add Japanese sardine in U.S. waters to the FMU.

These alternatives are proposed and could be modified by the Council to reflect how they determine is the most appropriate way to factor in new information – CPSAS and CPSMT have made revisions in their recommendations

Council Action

Adopt

(1) Purpose and Need Statement

(2) Range of Alternatives

(3) Preliminary Preferred Alternative, as Appropriate

