

Larval sablefish observations, environmental data, and associated analysis code from 1995-2018

Website: <https://www.bco-dmo.org/dataset/1009250>

Data Type: model results, Other Field Results

Version: 1

Version Date: 2026-10-07

Project

» [Collaborative Research: Tradeoffs between phenology and geography constraints in response to climate change across species life cycles](#) (Pheno Geo Tradeoffs)

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Abstract

Interannual variability in both local environmental conditions and basin-scale oceanographic modes of variability is thought to drive larval fish abundance by affecting the timing and location of spawning. We used an extensive compiled dataset of larval fish density from 1995-2018 from continental shelf regions off central California to the Gulf of Alaska to model how sablefish (*Anoplopoma fimbria*) shifted larval seasonality and geography in response to environmental variability and oceanographic regime shifts. The most predictive spatiotemporal model was the simplest and did not include seasonal or geographic variability, with bottom depth and sea surface temperature as the most predictive environmental covariates. Sablefish larval distributions were centered in the shelf region of the eastern Gulf of Alaska and exhibited correlated shifts among latitudinal, longitudinal, and onshore-offshore center of gravities, but not with seasonal changes. There were few links between geographic and seasonal center of gravities and average environmental conditions, though modeled larval abundance peaked earlier in the year during warmer, spicier average ocean conditions and positive Pacific Decadal Oscillation values. Phase-specific conditional effects models for the Pacific Decadal Oscillation and Oceanic Niño Index showed that sablefish larvae were uniformly associated with water temperatures between 7-8°C while having a more variable relationship with bottom depth. Our results indicate that sablefish larvae demonstrate seasonal shifts in order to maintain a consistent thermal habitat.

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Coverage

Location: Pacific coast between 35°N and the Gulf of Alaska
Spatial Extent: N:59.7952 E:-120.7583 S:35.0133 W:-161.9635
Temporal Extent: 1995-01-20 - 2018-12-06

Methods & Sampling

Sablefish larval data: We collated data from five long-term ichthyoplankton sampling programs covering the region between the Southern California Bight (35° latitude) to the Alaska Peninsula in the western Gulf of Alaska. From north to south, these surveys were the National Oceanic and Atmospheric Administration (NOAA) Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI), multiple compiled surveys organized by Department of Fisheries & Oceans Canada (DFO), the NOAA Pre-recruit Survey, Newport Hydrographic Line (NH-Line), and the California Cooperative Oceanic Fisheries Investigations (CalCOFI). Larval data includes samples taken by oblique and paired bongo tows with 236-505 µm mesh from throughout the study area, along with neuston tows from Alaska and southern California. Neuston tows had 505 µm mesh and net openings between 0.13-15 m². Tows were subset to 1995 to 2018 within the 200 nmi Exclusive Economic Zone within ocean or estuarine waters (salinity ≥ 30 ppt). The northern geographic extent of the area examined was bounded by the latitudinal range of positive tows (59.8°N). We restricted the southern limit to be ≥ 35°N latitude. From north to south, these surveys were the National Oceanic and Atmospheric Administration (NOAA) Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI), multiple compiled surveys organized by Department of Fisheries & Oceans Canada (DFO), the NOAA Pre-recruit Survey, Newport Hydrographic Line (NH-Line), and the California Cooperative Oceanic Fisheries Investigations (CalCOFI).

Environmental data: Environmental data were extracted from a 10-km Regional Ocean Modeling System (ROMS) configured for the eastern Pacific at a 10-km resolution from 1995-2020 (Pozo Buil et al. in prep). The model was forced with daily atmospheric fields from the ERA5 reanalysis produced by European Centre for Medium-Range Weather Forecasts (Hersbach et al. 2020) and with open-ocean boundary conditions from the 1/12° Global Ocean Reanalysis and Simulation (Lellouche et al. 2021) with a five-day resolution. We extracted sea surface temperature (SST), sea surface height (SSH), sea surface salinity (SSS), and spiciness from ROMS. Spiciness was averaged over the upper 250 m of the water column, corresponding to the maximum depth sampled across the five programs. Empirical catch data collected from field sampling were matched to ROMS data using bilinear interpolation. Bottom depth (i.e., water depth at each sampling location) was extracted for each data point using R package 'marmap' (Pante and Simon-Bouhet 2013) which uses bathymetry 15 arc-second data from the 2022 NOAA Earth TOPOgraphy dataset (National Centers for Environmental Information [NCEI] 2022).

Data Processing Description

We used R version 4.4.1 to collate and analyze data.

Package | General purpose | Version | Citation

- blockCV | Analysis | 3.2-0 | Valavi et al. (2019)
- cmocean | Visualization | 0.3-2 | Thyng et al. (2016)
- corrplot | Visualization | 0.95 | Wei & Simko (2024)
- cowplot | Visualization | 1.2.0 | Wilke (2025)
- dplyr | Data management | 1.2.1 | Wickham et al. (2014)
- fmesher | Analysis | 0.7.0 | Lindgren (2023)
- ggeffects | Analysis | 2.3.2 | Lüdtke (2018)

- ggplot2 | Visualization | 4.0.2 | Wickham (2016)
- ggpubr | Visualization | 0.6.3 | Kassambara (2026)
- httr | Data management | 1.4.8 | Wickham (2026)
- lubridate | Data management | 1.9.5 | Golemund & Wickham (2011)
- marmap | Analysis | 1.0.12 | Pante & Simon-Bouhet (2013)
- mgcv | Analysis | 1.9-4 | Wood (2011)
- mgcViz | Visualization | 0.2.1 | Fasiolo et al. (2020)
- ncdf4 | Data management | 1.24 | Pierce (2025)
- nlme | Analysis | 3.1-169 | Pinheiro et al (2019)
- raster | Visualization | 3.5-32 | Fasiolo et al. (2020)
- readxl | Data management | 1.4.5 | Wickham & Bryan (2026)
- rerddap | Data management | 1.2.3 | Chamberlain (2026)
- rerddapXtracto | Data management | 1.2.5 | Mendelssohn (2026)
- sdmTMB | Analysis | 1.0.0 | Anderson et al. (2022)
- sdmTMBextra | Analysis | 0.0.5 | Anderson et al. (2022)
- sf | Data management | 1.1-0 | Pebesma & Bivand (2023)
- stringr | Data management | 1.6.0 | Wickham (2025)
- tidyr | Data management | 1.3.2 | Wickham & Bryan (2026)
- writexl | Data management | 1.5.4 | Ooms (2025)
- xlsx | Data management | 0.6.5 | Dragulescu & Arendt (2020)

BCO-DMO Curation Notes

This section documents curation actions performed prior to publication review with the submitter, and additional information relevant to understanding and reusing this dataset. It distinguishes changes made to the submitted (meta)data from unresolved issues and/or enhancements that improve future reuse and interoperability.

CURATION ACTIONS PERFORMED ON DATA

-

CURATION ACTIONS PERFORMED ON METADATA

-

ISSUES POTENTIALLY IMPACTING REUSE

NA

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Related Publications

Anderson, S. C., Ward, E. J., English, P. A., Barnett, L. A. K., & Thorson, J. T. (2022). sdmTMB: An R Package for Fast, Flexible, and User-Friendly Generalized Linear Mixed Effects Models with Spatial and Spatiotemporal Random Fields. <https://doi.org/10.1101/2022.03.24.485545>
Software

Asch, RG, Dale, KE, Ciannelli, L, Rogers, LA, Thompson, A. Phenological change detection from fisheries-independent surveys. In prep.
Results

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Results

Asch, RG, Dale, KE, Weisberg, S, Aceves-Medina, G, Brodeur, RD, Esteban García Gómez, R, P.A. Jiménez-Rosenberg, PA, Kellison, T, Murphy, H, McNeill, N, Perry, RI. P.A. Trends in the reproductive phenology and thermal sensitivity of thirteen populations of small pelagic fishes across North American waters. In prep.
Results

Chamberlain, S. (2026). rerddap: General purpose client for ERDDAP servers (R package version 1.2.3) [Computer software]. <https://docs.ropensci.org/rerddap/>

Software

Dale, KE, Ciannelli, L, Fiechter, J, Pozo Buil M, Esteban García Gómez, R, Jiménez-Rosenberg, SPA, Aceves-Medina, G, Brodeur, RD, Thompson, A, Field, JC, Auth, TD, Perry, RI, Rogers, LA, Howard, RA, Asch, RG. Northeastern Pacific fish early life history patterns demonstrate mixed spatiotemporal tradeoffs in response to environmental variability. In review. ICES Journal of Marine Science

Results

Dragulescu, A., & Arendt, C. (2010). xlsx: Read, Write, Format Excel 2007 and Excel 97/2000/XP/2003 Files [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation.

<https://doi.org/10.32614/cran.package.xlsx> <https://doi.org/10.32614/CRAN.package.xlsx>

Software

Fasiolo, M., Nedellec, R., Goude, Y., & Wood, S. N. (2020). Scalable visualization methods for modern generalized additive models. Journal of Computational and Graphical Statistics, 29(1), 78–86.

<https://doi.org/10.1080/10618600.2019.1629942>

Software

Grolemund, G., & Wickham, H. (2011). Dates and Times Made Easy with lubridate. Journal of Statistical Software, 40(3). <https://doi.org/10.18637/jss.v040.i03>

Software

Hijmans, R. J. (2010). raster: Geographic Data Analysis and Modeling [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.raster>

Software

Kassambara, A. (2016). ggpubr: 'ggplot2' Based Publication Ready Plots [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.ggpubr>

Software

Lindgren, F. (2023). fmesher: Triangle meshes and related geometry tools [Computer software]. The R Foundation. <https://doi.org/10.32614/cran.package.fmesher>

Software

Lüdtke, D. (2018). ggeffects: Tidy Data Frames of Marginal Effects from Regression Models. Journal of Open Source Software, 3(26), 772. <https://doi.org/10.21105/joss.00772>

Software

Mendelsohn, R. (2019). rerddapXtracto: Extracts environmental data from ERDDAP web services [Computer software]. The R Foundation. <https://doi.org/10.32614/cran.package.rerddapxtracto>

Software

Ooms, J., & Denney, B. (2017). writexl: Export Data Frames to Excel 'xlsx' Format [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.writexl>

Software

Pante, E., & Simon-Bouhet, B. (2013). marmap: A Package for Importing, Plotting and Analyzing Bathymetric and Topographic Data in R. PLoS ONE, 8(9), e73051. <https://doi.org/10.1371/journal.pone.0073051>

Software

Pebesma, E., & Bivand, R. (2023). Spatial Data Science. <https://doi.org/10.1201/9780429459016>

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Pierce, D. (2010). ncdf4: Interface to Unidata netCDF (Version 4 or Earlier) Format Data Files [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.ncdf4>

Software

Pinheiro, J., & Bates, D. (1999). nlme: Linear and Nonlinear Mixed Effects Models [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.nlme>

Software

Sanborn, J, Dale, KE, Van Etten, M, Auth, TD, Perry, RI, Pozo Buil, M, Rogers, LA, Thompson, AR, Asch, RG. Larval sablefish exhibit stable geographic distributions and variable phenology in response to interannually variable environmental conditions. Accepted. ICES Journal of Marine Science.

Results

Thyng, K., Greene, C., Hetland, R., Zimmerle, H., & DiMarco, S. (2016). True Colors of Oceanography: Guidelines for Effective and Accurate Colormap Selection. Oceanography, 29(3), 9–13.

<https://doi.org/10.5670/oceanog.2016.66>

Software

Valavi, R., Elith, J., Lahoz-Monfort, J. J., & Guillerá-Arroita, G. (2019). blockCV: An R package for generating spatially or environmentally separated folds for k-fold cross-validation of species distribution models. *Methods in Ecology and Evolution*, 10(2), 225–232. <https://doi.org/10.1111/2041-210x.13107>
Software

Wei, T., & Simko, V. (2010). corrplot: Visualization of a Correlation Matrix [Data set]. In (Editor), CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.corrplot>
Software

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Methods

Wickham, H. (2025). stringr: Simple, Consistent Wrappers for Common String Operations (R package version 1.6.0) <https://doi.org/https://stringr.tidyverse.org>
Software

Wickham, H. (2026). httr: Tools for working with URLs and HTTP (R package version 1.4.8) [Computer software]. <https://github.com/r-lib/httr>
Software

Wickham, H., & Bryan, J. (2026). readxl: Read Excel files (R package version 1.5.0) [Computer software]. <https://readxl.tidyverse.org>
Software

Wickham, H., François, R., Henry, L., Müller, K., & Vaughan, D. (2014). dplyr: A Grammar of Data Manipulation [dataset]. In CRAN: Contributed Packages. The R Foundation. <https://doi.org/10.32614/cran.package.dplyr>
<https://doi.org/10.32614/CRAN.package.dplyr>
Software

Wilke, C. O. (2015). cowplot: Streamlined plot theme and plot annotations for ggplot2 [Computer software]. The R Foundation. <https://doi.org/10.32614/cran.package.cowplot>
Software

Wood, S. N. (2010). Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 73(1), 3–36. <https://doi.org/10.1111/j.1467-9868.2010.00749.x>
Software

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Related Datasets

IsDerivedFrom

Alaska Fisheries Science Center. (2025, April 16). Ichthyoplankton Information System (IIS). National Oceanic and Atmospheric Administration. <https://apps-afsc.fisheries.noaa.gov/ichthyo/index.php>

Fisheries and Oceans Canada. (n.d.). Fisheries and Oceans Canada. Government of Canada. <https://www.dfo-mpo.gc.ca/index-eng.html>

Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D., Simmons, A., Soci, C., Abdalla, S., Abellan, X., Balsamo, G., Bechtold, P., Biavati, G., Bidlot, J., Bonavita, M., ... Thépaut, J. (2020). The ERA5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society*, 146(730), 1999–2049. Portico. <https://doi.org/10.1002/qj.3803>

Investigaciones Mexicanas de la Corriente de California. (n.d.). Base de datos [Database]. Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE). <https://imecocal.cicese.mx/wp/base-de-datos/>

Jean-Michel, L., Eric, G., Romain, B.-B., Gilles, G., Angélique, M., Marie, D., Clément, B., Mathieu, H., Olivier, L. G., Charly, R., Tony, C., Charles-Emmanuel, T., Florent, G., Giovanni, R., Mounir, B., Yann, D., & Pierre-Yves, L. T. (2021). The Copernicus Global 1/12° Oceanic and Sea Ice GLORYS12 Reanalysis. *Frontiers in Earth Science*, 9. <https://doi.org/10.3389/feart.2021.698876>

NOAA Integrated Ecosystem Assessment. (n.d.). Newport Hydrographic Line. National Oceanic and Atmospheric Administration. <https://www.integratedecosystemassessment.noaa.gov/regions/california->

[current/newport-hydrographic-line](#)

NOAA National Centers for Environmental Information. (2022). ETOPO 2022 15 Arc-Second Global Relief Model [Dataset]. NOAA National Centers for Environmental Information. <https://doi.org/10.25921/FD45-GT74>
<https://doi.org/10.25921/fd45-gt74>

NOAA Southwest Fisheries Science Center, Environmental Research Division. (n.d.). CalCOFI: California Cooperative Oceanic Fisheries Investigations. National Oceanic and Atmospheric Administration. <https://coastwatch.pfeg.noaa.gov/erddap/tabledap/erdCalCOFIrvcnt.html>

Northwest Fisheries Science Center, 2026: Ichthyoplankton Data - Coastwide Cooperative Pre-recruit Survey <https://www.fisheries.noaa.gov/inport/item/18603>

IsRelatedTo

Sanborn, Janie, Dale, Katherine, Van Etten, Martina, Auth, Toby, Perry, R. Ian, Pozo Buil, Mercedes, Rogers, Lauren, Thompson, Andrew, & Asch, Rebecca. (2026). *Larval sablefish observations, environmental data, and associated analysis code from 1995-2018* (Version 6) [Dataset]. Dryad. <https://doi.org/10.5061/DRYAD.8GTHT772S> <https://doi.org/10.5061/dryad.8gtht772s>

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Parameters

Parameter	Description	Units
year	Year in YYYY	YYYY
month	Month in MM	MMMM
program	Name of long-term ichthyoplankton sampling program.	unitless
date	Date in YYYY-MM-DD format	YYYY-MM-DD
timeblock	4- or 5 year time blocks were used to temporally aggregate points for better modeling. Character value, one of '1995-1999', '2000-2004', '2005-2009', '2010-2014', or '2015-2018'.	unitless
latitude	Latitude in decimal degrees.	Decimal degrees
longitude	Longitude in decimal degrees	Decimal degrees
X	Latitude in equidistant conic coordinates. Kilometer from 45 deg N	kilometer (km)
Y	Longitude in equidistant conic coordinates. Kilometer from -135 deg W	kilometer (km)
gear	Gear used in the survey. Character value, one of Manta" or "Ring/Bongo".	unitless
sst_roms	Sea surface temperature in degrees Celsius, from regional oceanographic model	Degrees Celsius (°C)

sst_scaled	Sea surface temperature centered (mean subtracted) and scaled (divided by the standard deviation)	Degrees Celsius (°C)
ssh_roms	Sea surface height in meters, from regional oceanographic model	Meters (m)
ssh_scaled	Sea surface height centered (mean subtracted) and scaled (divided by the standard deviation)	Meters (m)
salinity_roms	Sea surface salinity in parts per thousand, from regional oceanographic model	Parts per thousand
salinity_scaled	Sea surface salinity centered (mean subtracted) and scaled (divided by the standard deviation)	Parts per thousand
spice_roms	Spiciness (a measure of water density calculated from salinity and temperature), from regional oceanographic model	unitless
spice_scaled	Spiciness centered (mean subtracted) and scaled (divided by the standard deviation)	unitless
bottom_depth	Bottom depth in m (more negative values indicate deeper depths)	Meters (m)
bottom_depth_scaled	Bottom depth centered (mean subtracted) and scaled (divided by the standard deviation)	Meters (m)
larvae_m3	Larval density metric in abundance/meters cubed.	Larvae per meters cubed
presence	Presence (1) or absence (0)	unitless
region	General geographic region. Character value, one of 'Continental US', 'Canada', or 'Gulf of Alaska'	unitless
pdo	Pacific Decadal Oscillation value	unitless
pdo_regime	PDO values above 0 are classified as 'Warm', values less than 0 are classified as 'Cool'.	unitless
oni	Oceanic Niño Index values	unitless

oni_regime	ONI values greater than 0.5 indicated an El Niño phase, values less than -0.5 indicated a La Niña phase, and values between -0.5 and 0.5 indicated a "Null" period.	unitless
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Instruments

Dataset-specific Instrument Name	Oblique and paired bongo nets
Generic Instrument Name	Bongo Net
Dataset-specific Description	Oblique and paired bongo nets with 236-505 µm mesh and 56-60 cm openings.
Generic Instrument Description	A Bongo Net consists of paired plankton nets, typically with a 60 cm diameter mouth opening and varying mesh sizes, 10 to 1000 micron. The Bongo Frame was designed by the National Marine Fisheries Service for use in the MARMAP program. It consists of two cylindrical collars connected with a yoke so that replicate samples are collected at the same time. Variations in models are designed for either vertical hauls (OI-2500 = NMFS Pairovet-Style, MARMAP Bongo, CalVET) or both oblique and vertical hauls (Aquatic Research). The OI-1200 has an opening and closing mechanism that allows discrete "known-depth" sampling. This model is large enough to filter water at the rate of 47.5 m3/minute when towing at a speed of two knots. More information: Ocean Instruments, Aquatic Research, Sea-Gear

Dataset-specific Instrument Name	
Generic Instrument Name	Neuston Net
Dataset-specific Description	Neuston tows with 505 µm mesh and net openings between 0.13-15 m2.
Generic Instrument Description	Neuston Nets are nets that collect zooplankton that live in the top few centimeters of the sea surface (the neuston layer). This specialized net has a rectangular mouth opening usually 2 or 3 times as wide as deep, i.e. 1 meter by 1/2 meter or 60 cm by 20 cm, with sometimes hollow piping construction to aid in flotation. They are generally towed half submerged at 1-2 kts from the side of the vessel on a boom to avoid the ship's wake.

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Project Information

Collaborative Research: Tradeoffs between phenology and geography constraints in response to climate change across species life cycles (Pheno Geo Tradeoffs)

Coverage: California Current System and Gulf of Alaska

NSF Award Abstract:

The investigators are using statistical and biophysical modeling techniques to examine the characteristics and drivers of timing (phenology) and distribution (geography) of fish eggs, larvae, and juveniles. They are focusing on the California Current and western Gulf of Alaska regions of the Northeast Pacific. Changes in phenology and geography are anticipated responses of marine organisms to global change in climate, with consequences for food web interactions, species abundance and productivity, and local extinctions. These responses, in turn, will have important implications for marine conservation, resource management, and the economies of coastal communities that depend on marine resources for sustenance and livelihoods. Data analysis is in collaboration with fisheries scientists at National Oceanic and Atmospheric Administration, and results will be of interest to resource managers. One of the investigators is an early-career female scientist, and the study provides training for REU students, other undergraduates, graduate students, and a postdoctoral scientist. Educational outreach includes development of online classroom and lab modules.

The overarching objective of this project is to examine the drivers and characteristics of phenology and geography of fish early life history stages (ELS) in the Northeast Pacific Ocean. Most research on how climate change impacts marine organisms has focused on adult life history stages, even though existing literature indicates that early life history stages may be more vulnerable to climate stressors. During ELS, marine fish and invertebrates can be limited in their ability to move in space and time due to strong ecological, physiological, physical, and evolutionary constraints. For these species, their ability to adapt to global change in climate through shifts in distribution and phenology depends on the events that occur during the early portion of their life cycle. Similarly, climate change impacts on organismal distribution and phenology have principally been studied separately, without any consideration of interactions between these two types of responses to changing oceanic conditions. The investigators are conducting modeling analyses based on ELS collected since the mid-1950s to test the null hypotheses that: 1) fish ELS will experience similar spatio-temporal variability in relation to ocean climate regardless of the life history strategy; 2) changes will be greater at the leading edge of a species' distribution and that the start of the spawning season will exhibit the greatest change in phenology; 3) species with large distribution changes will have smaller changes in phenology, and vice versa; and 4) historical and future projections of fish distribution that include life history information will be more skillful than those that do not include life history.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2049626

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