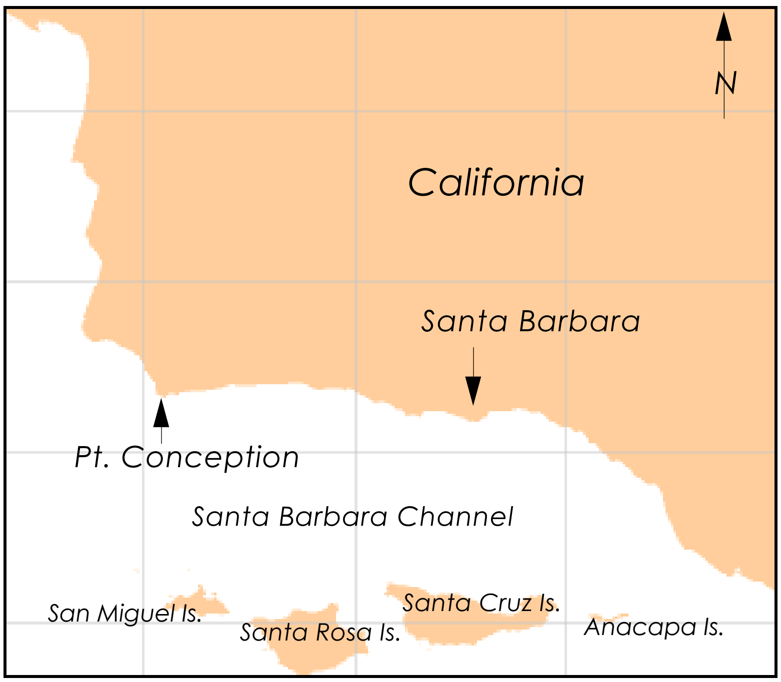
User's Guide

Welcome to the Location File for Santa Barbara Channel and Santa Maria Basin, located along the southern California coast of the U.S. Santa Barbara Channel and Santa Maria Basin are coastal areas where the circulation is constantly changing. The local winds are highly variable, and the channel is located within the Southern California Bight, where cold, upwelled water meets warmer water from farther south. The current field here is complex, with eddies and meanders on the scale of 30 mi (50 km). As a result, currents along the southern islands and northern continental coast can often flow in the opposite directions or even at right angles to one another.

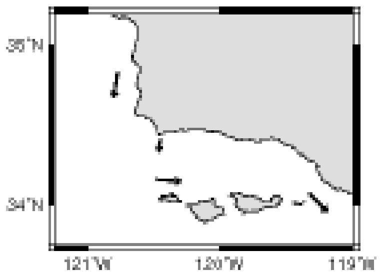


NOAA created Location Files for different U.S. coastal regions to help you use the General NOAA Oil Modeling Environment, GNOME. In addition, on a case-by-case basis, NOAA develops international Location Files when working with specific partners. Each Location File contains information about local oceanographic conditions that GNOME uses to model oil spills in the area covered by that Location File. Each Location File also contains references (both print publications and Internet sites) to help you learn more about the location you are simulating.

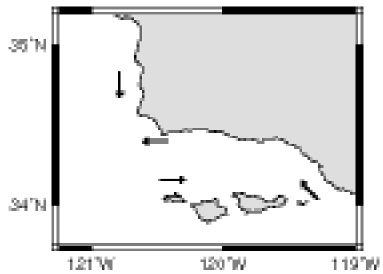
As you work with GNOME's Location File for Santa Barbara Channel, you'll be prompted to:

1. Select one of the three possible circulation patterns typical of this area.
2. Choose the model settings (start date and time, and run duration).
3. Input the wind conditions.

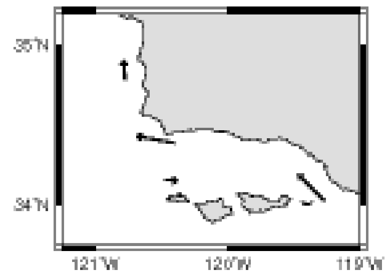
Oceanographers have defined three distinct circulation patterns that can occur within the Santa Barbara Channel (Dever personal communication):



Upwelling State



Convergent State



Relaxation State

To model spills in the channel, you'll need to pick one of these circulation patterns. For help in making this choice, try out GNOME's circulation pattern **decision tree**, which is included below. (To learn more about these circulation patterns, see the Technical Documentation section of this guide.)

Your choice of circulation pattern depends on the purpose for which you're using GNOME. To learn how currents may affect oil spill trajectories within the channel, run GNOME using different circulation patterns. To create a specific scenario, choose the circulation pattern that will move the oil closest to your desired endpoint. To simulate today's conditions, access today's current and weather observations from http://www-ccs.ucsd.edu/oilspill, then use the decision tree or your own expertise to choose the pattern that best fits the real-life conditions.

To set up a spill scenario, you'll also choose model settings and enter wind conditions. Click Help anytime you need help setting up the model. Click Finding Wind Data to see a list of web sites that publish wind data for this region.

You can find more information about GNOME and Location Files at http://response.restoration.noaa.gov/software/gnome/gnome.html .

Decision Tree

Use this decision tree to narrow down your circulation pattern choices. If you are using current observations, you may not be able to select a *single* circulation pattern. In that case, either run the trajectory with each possible circulation pattern or choose the circulation pattern that most closely matches the observations in the vicinity of your oil spill.

At the Minerals Management Service (MMS) spill response web site maintained by the Center for Coastal Studies, Scripps Institution of Oceanography (**http://www-ccs.ucsd.edu/oilspill/**), you can find all the information to follow this decision tree. Under the first topic, "AVHRR Hi-Resolution Images," is a list of AVHRR data that you can use to get **sea-surface temperature**

(SST) information. Click the third map from the top, "NDBC Buoy Winds and 5m VMCM Ocean Currents," to view **current and wind observations** in the area.

In the decision tree, we will be referring to different current stations by their abbreviations. This list shows the general location of each current meter shown in the three circulation patterns:

SAMI	Purisma Point
SMIN	Point Conception
SMOF	San Miguel Island
ANMI	Eastern Entrance

The surface circulation patterns are simplified representations of a dynamic, changing system. They were developed statistically, although you can only expect to pick a single pattern unambiguously 60% of the time. Small-scale circulation features, transitions between synoptic states, and uncommon patterns can make it difficult to select a single circulation pattern. We have included information on the ranges within the patterns to help you narrow down your choices. If your data does not fit any of the above circulation patterns, you may be in a transitional period, or smaller-scale phenomena (e.g., eddies) may be masking the larger-scale circulation that might otherwise be evident in the current meter reading. You may want to look at the data for the previous few days to improve your sense of what is happening in the channel.

Remember, currents are described by where they are flowing to, and winds are described by where they are blowing from. So winds and currents in the same direction (e.g., both to the south) are described from different directions [e.g. south(ward) current and north wind].

What season of the year?

If spring, then look at UPWELLING.
If summer, then look at CONVERGENT.
If autumn or winter, then look at RELAXATION.

Compare SAMI and ANMI currents

If both currents are flowing equatorward, then look at UPWELLING.
If both currents are flowing poleward (although ANMI could be flowing across the entrance), then look at RELAXATION.
If the currents are pointing toward each other, then look at CONVERGENT.

Compare the two stations at the western entrance to the Santa Barbara Channel: SMIN and SMOF

If both are about the same magnitude (arrows the same size) but pointing in different directions (SMIN westward and SMOF eastward), then look at CONVERGENT.

If SMIN shows currents flowing westward at 50 cm/s or more and SMOF is flowing between as fast westward to more slowly eastward, then look at RELAXATION.
If SMIN shows currents flowing southward or weakly westward (<10 cm/s) and SMOF is flowing faster and toward the east, then look at UPWELLING.

Look at winds at NDBC buoy 46054

If weak or SE winds (< 4 m/s), then look at RELAXATION.
If strong (> 8 m/s) NW winds, then look at UPWELLING or CONVERGENT.
If strong (>7 m/s) NW winds, the look at CONVERGENT.

Look at the winds in the area

If winds have been strong (> 10 m/s) and equatorward for several days, then look at UPWELLING or, possibly, CONVERGENT; otherwise, consider RELAXATION or CONVERGENT.
If winds in the SMB are onshore or equatorward and winds in the SBC are relatively weak, then look at UPWELLING or, possibly, CONVERGENT; otherwise, consider RELAXATION or CONVERGENT.

Technical Documentation

Background

The Santa Barbara Channel region is oceanographically complex because of the variety of atmospheric and oceanic conditions that may be present in the area at one time, some with distinctly different regimes separated by up to 10 kilometers. Cold, upwelled water meets warm, subtropic Southern California Bight water in Santa Barbara Channel (Chelton 1984; Lynn and Simpson 1987). The large-scale surface flow is southward (alongshore) in spring and northward (alongshore) between summer and winter, but these large-scale flows can reverse for periods up to a week (Harms 1996). The mean flow of Santa Barbara Channel is a cyclonic (counterclockwise) eddy located at the western end of the channel.

The circulation in the Santa Barbara Channel is driven by (Harms 1996):

- Wind Stress.
- Wind Stress curl (Ekman pumping).
- Alongshelf pressure gradients.

Current Patterns

Introduction

The synoptic states described below are a compact way of describing certain commonly-observed features of the large-scale circulation in the Santa Barbara

Channel/Santa Maria Basin (SBC/SMB) region. Although they are subjectively defined, statistical descriptions of the near-surface circulation demonstrate similar spatial structures.

These descriptions are intended to be used with information available from the Minerals Management Service oil spill response page (http://www-ccs.ucsd.edu/oilspill/) maintained by the Center for Coastal Studies, Scripps Institution of Oceanography. Each synoptic state is described in terms of diagnostic features in the observed surface currents off Purisima Pt., Pt. Conception, San Miguel Island, and the eastern entrance to the Santa Barbara Channel. Ancillary information, such as regional winds and satellite sea-surface temperature imagery, are also described as a function of synoptic state.

Remember, these synoptic states are merely a conceptual model. They can be unambiguously identified about 60% of the time. Small-scale features, transitions between different synoptic states, and uncommon patterns can make it difficult to identify the observed flow with a single synoptic state. Therefore, variations on the basic synoptic states will also be described.

Upwelling State

The upwelling state is named for the upwelling of cold (approximately 11°C) subsurface waters near Pt. Conception that often accompanies this state. The upwelling state occurs primarily in spring, although it has also been observed in other seasons. In terms of the conceptual models of the momentum balance, the upwelling state occurs when strong (>10 m/s), persistent (several days or more), upwelling favorable (equatorward) winds overwhelm any poleward, along-shelf pressure gradient.

The most characteristic feature of the resulting flow field is southward flow at the western entrance to the SBC, which continues eastward from San Miguel to Santa Cruz and out the eastern SBC entrance. However, even during upwelling, the flow can be weakly (10 cm/s) westward on the mainland coast of the SBC. While there can be a cyclonic (counterclockwise) recirculation in the western channel during upwelling, the southern limb of the circulation is almost always stronger than the northern limb. Weaker velocities tend to occur in the eastern SBC over the broad shelf between Port Hueneme and Santa Barbara and in the SMB within 5 km of the coast. Within the SMB, the strongest (20 cm/s) velocities are observed over the 100 m isobath between Purisima Pt. and Pt. Arguello, where strong southward velocities are observed. Very weak velocities (<10 cm/s) are often observed within 5 km of the shore in San Luis Obispo Bay and between Pt. Sal and Purisima Pt. During upwelling, velocity fluctuations (relative to the mean upwelling state) are strongest southwest of Pt. Conception. This may be an expression of the tendency for an upwelling jet to fluctuate in direction and speed during upwelling. The weakest fluctuations are found over the northeast SBC shelf between Santa Barbara and Ventura, as well as the above-mentioned nearshore regions (within 5 km) of the SMB coast.

During upwelling, the wind field tends to show strong velocities (10 m/s) from the northwest (to the southeast) south of Pt. Conception at NDBC 46054. Within the SMB, winds are generally onshore and equatorward. Within the eastern SBC, winds can be relatively weak.

When available, satellite sea-surface temperature images often show cold water (11-12°C) between Pt. Arguello and Pt. Conception. Cooler water can be seen spreading southward from Pt. Conception past San Miguel Island and eastward from San Miguel towards the eastern entrance to the SBC.

Convergent State

The convergent state is named for the convergence of southward flow west of Pt. Arguello with westward flow south of Pt. Conception. The convergent state occurs primarily in summer, although it has also been observed in other seasons. In terms of the conceptual models of the momentum balance, the convergent state tends to occur when upwelling favorable winds and a strong poleward, along-shelf pressure gradient exist.

The most characteristic feature of the resulting flow field is a strong cyclonic recirculation in the western SBC with about equal strength in the northern and southern limbs of the recirculation. During the convergent state, velocities in the western SBC are often 40 cm/s or more, up to 70 cm/s. While northwestward flow at the eastern entrance to the SBC often occurs during the convergent state, northeastward flow directly across the eastern entrance to the SBC can also occur. The convergent synoptic state averages are accompanied by southward flow in the SMB near the shore and off-shelf flow further away from the coast. The combination of westward flow at the northeast SBC entrance and southward flow along the SMB coast is associated with convergence and offshore flow southwest of Pt. Conception. Relative to the upwelling state, stronger velocities are observed in the western SBC and in most of the SMB. The highest velocity fluctuations are observed at the western entrance to the SBC. The lowest velocity fluctuations are again found between Santa Barbara and Ventura and in San Luis Obispo Bay.

In the convergent state, the wind field can resemble the upwelling wind field, although this is not diagnostic; weak winds sometimes accompany the convergent state, but not always. The average winds at NDBC 46054 during convergence are nearly equal to those observed in upwelling, above 7 m/s from the northwest (to the southeast).

In the convergent state, satellite sea-surface temperature images often show warm water (17-20°C) extending from the eastern SBC north and westward along the mainland coast. South of Pt. Conception, this warm water turns south and, in exceptionally clear images, a counterclockwise recirculation of warm water can often be discerned. Cold, upwelled waters are still present between Pt. Conception and Pt. Arguello, often with tongues of cold water reaching westward or southwestward.

Relaxation State

The relaxation state is named for the time periods when winds off Pt. Conception "relax" from their usual equatorward direction. The relaxation state occurs primarily in fall and early winter. In terms of the conceptual models of the momentum balance, the relaxation state occurs when poleward, along-shelf pressure gradients overwhelm upwelling favorable or weak winds.

The most characteristic feature of the resulting flow field is a strong westward flow (>50 cm/s) through the SBC and into the SMB. Flow in the SMB is strongest along the mainland coast. Cyclonic recirculation in the western SBC is often present, but with a northern limb strengthened with respect to the southern limb. Poleward flow continues out the western entrance to the SBC into the SMB. Within the SMB, the strongest poleward averages are found offshore of the 100 m isobath, where there is generally an offshore, in addition to poleward, component of flow. Closer to shore in the SMB, the flow velocity averages are weaker poleward flow and, in some nearshore locations, southward flow.

The highest velocity fluctuations occur west of Pt. Conception in the region where the westward flow from the SBC is turning poleward into the SMB. A secondary maximum in the western SBC occurs where recirculating cyclonic flow rejoins the westward flow along the mainland coast. The lowest velocity fluctuations are again found between Santa Barbara and Ventura and in San Luis Obispo Bay.

Winds during relaxation tend to be either weak and variable or poleward. That is, weak or northwestward winds are usually seen at NDBC 46054 at the western entrance to SBC.

Satellite sea-surface temperature images during relaxation will often show warm water (17-20°C) extending from Pt. Conception northwestward into the SMB.

Streamfunction Methodology

In brief, the following methodology was used to determine streamfunctions in the Santa Barbara Channel/Santa Maria Basin (SBC/SMB) region:

(1) only the days for which upwelling, relaxation, or convergent states were identified in the SBC/SMB were used,
(2) average velocities for each state were calculated, and
(3) streamfunctions were estimated from the resulting data.

Each of these steps are explained in more detail below:

(1) All mooring Vector Measuring Current Meter (VMCM) data acquired over the course of the SBC/SMB study was averaged over 6-hour periods. Available National Data Buoy Center (NDBC) Acoustic Doppler Current Profiler (ADCP) data were also used. Only days with good velocity data at ANMI, SMIN, and SAMI were considered.

Data from December 1993 to November 1999 were used to characterize the synoptic state into one of 3 states (upwelling, convergence, or relaxation), using the following criteria:

a. **Upwelling** was identified when (subtidal) flow in the Santa Maria Basin (SAMI) was southward and flow at the eastern entrance to the Santa Barbara Channel (ANMI) was southeastward.
b. **Convergence** was identified when (subtidal) flow in the Santa Maria Basin was southward, flow at the eastern entrance to the Santa Barbara Channel was northwestward, and flow at Pt. Conception (SMIN) was westward.
c. **Relaxation** was identified when (subtidal) flow in the Santa Maria Basin was northward, flow at the eastern entrance to the Santa Barbara Channel was northwestward, and flow at Pt. Conception (SMIN) was westward.
d. **None-of-the-above** when flow conditions did not satisfy any of a-c.

(2) Data were sorted and averaged based on the characterization in Step 1 to form average upwelling, convergent, and relaxation states. Although data at SMIN, SMOF, SAMI and ANMI exist from 1993-1999 (data through August 2000 will be included in the future), data is more time-limited at other locations. Within the Santa Barbara Channel, data were acquired primarily between 1993 and 1995. Within the Santa Maria Basin, data were acquired primarily between 1996 and 1999. Thus the mean synoptic states contain realizations from 1993-1995 in the SBC and 1996-1999 in the SMB. This practice causes no apparent problems in the average states.

(3) Objective interpolation (OI) was used to estimate regional streamfunctions for each average synoptic state. The method used follows Bretherton et al. (1976). Curvilinear orthogonal coastline-following coordinates are used. OI methods require specification of the spatial correlation function. Here an isotropic Gaussian spatial correlation function was used with the decorrelation scale specified in the curvilinear coordinate system. The nominal decorrelation scale in physical units is approximately 35 km. This scale roughly matches that provided by the moored array. It is capable of reproducing features such as the cyclone in the western Santa Barbara Channel, but cannot reproduce smaller-scale features, such as flow through the inter-island passes.

The streamfunction is output in SI units (m^2/s^2). The velocity can be calculated from the streamfunction as follows:

u = -d(psi)/dy *1/f
v = d(psi)/dx *1/f

where u and v (m/s) are east and north velocity components, dy and dx (m) are derivatives in the north and east directions, f (s^{-1}) is the local Coriolis parameter (8.26 e-05 s^{-1} at 34.5° N).

References

You can get more information about Santa Barbara Channel from these publications and web sites:

Real-Time Data for Oil Spill Response: Santa Barbara Channel-Santa Maria Basin Regions
http://www-ccs.ucsd.edu/oilspill/
Near-real time data of the Santa Barbara Channel region to be used in oil spill response. The data are provided by the Center for Coastal Studies, with funding from the Minerals Management Service, as part of the Santa Barbara Channel-Santa Maria Basin Circulation Study.

Oceanographic

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Gunn, J.T., et al. 1987. Santa Barbara Channel Circulation Model and Field Study. OCS Study MMS 87-0089, 393 pp.

Harms, Sabine. 1996. "Circulation Induced by Winds and Pressure Gradients in the Santa Barbara Channel." Doctoral dissertation, University of California, San Diego, 161 pp.

Hickey, B. M. 1979. The California Current System--hypotheses and facts. Progress in Oceanography, Vol. 8, pp. 191-279.

Lynn, R. J. and J. J. Simpson. 1987. The California Current System: The seasonal variability of its physical characteristics. Journal of Geophysical Research. 92(C3): 12,947-12,966.

Wind and Weather

Scripps Institution of Oceanography (SIO)
http://meteora.ucsd.edu/weather.html
An informative weather-related web site. Offers local and regional weather reports, forecasts, and related links.

Scripps Institution of Oceanography California Coastal Weather
http://meteora.ucsd.edu/wx_pages/coastal.html
Local and regional weather reports, forecasts, and other weather sources.

Center for Coastal Studies
http://www-ccs.ucsd.edu/oilspill
Provides recent and archived wind and current data for the California Bight, including Santa Barbara Channel.

NOAA National Weather Service (NWS)
http://www.nws.noaa.gov
Current weather observations, forecasts, and warnings for the entire U.S.

Oil Spill Response

NOAA Hazardous Materials Response Division (HAZMAT)
http://response.restoration.noaa.gov
Tools and information for emergency responders and planners, and others concerned about the effects of oil and hazardous chemicals in our waters and along our coasts.