ABSTRACT

To investigate the connectivity between the Point Buchon marine protected area (MPA) and other oceanic Central California MPAs, back-projections were calculated using the ocean surface currents measured by the network of CODAR high-frequency (HF) radar stations operated along the California coast by the member institutions of the Coastal Ocean Currents Monitoring Program with funding provided by California voters through Propositions 40 & 50 and administered by the State Coastal Conservancy. Trajectories of a 1 km resolution grid of water particles were back-projected from the Pt. Buchon MPA each hour, out through 40 days in the past (Figure 2). Repeating these calculations for the other Central California MPAs would result in a connectivity matrix between all the MPAs in the region.

RESULTS

Connection time between Pt. Buchon SMCA/SMR and other central California MPAs

The connection times between the Pt. Buchon MPA and other central California MPAs were then calculated by comparing the number of days taken by any back-projected track-points falling within those other MPAs to reach the Pt. Buchon MPA (Table 1; Figure 4).

Graphing the back-projected points yielded a map of where surface waters traveled over 40 days before entering the Pt. Buchon MPA, and a visualization of how long it took those waters to travel along these paths (Figure 5).

MEASUREMENTS & METHODS

Calculated with HF Radar Surface Currents: Hourly back-projections of water particles, out through 40 days in the past, from the Pt. Buchon SMCA/SMR; repeated daily with surface currents measured from October 2006 – October 2007

Necessary to perform these calculations were time-series from October 2006 – October 2007 of ocean surface current vectors measured hourly throughout the Central California coastal ocean (Figure 3). These measurements were recorded by the CODAR SeaSnipe® HF-radar stations operated along the California coast by the Coastal Ocean Currents Monitoring Program – Northern California (COCMP-NC) as a program of the Central & Northern California Ocean Observing System (CenCOOS).

Back-projecting the trajectories of the water particles was a straightforward process with the HF-radar measurements –

Example: If the currents at a given location flowed south at a speed of 10 cm s\(^{-1}\) over the course of an hour (1 hour = 3600 seconds), then the waters at that location would have been 360 m to the north the previous hour (3600 s x 10 cm s\(^{-1}\) = 36000 cm = 360 m). Continuing to “step backwards” each hour in this fashion provides the means to calculate the trajectories of source waters and their transit times.

CONCLUSIONS

Management Applications: Larval duration; seedling between MPAs, ...

Repeating the calculations performed for the Pt. Buchon MPA for the other Central California MPAs would result in a connectivity matrix between all the MPAs in the region. A challenge central to the design and management of the MPA network is accurately understanding the larval transport which links the Central California MPAs.

<table>
<thead>
<tr>
<th>MPA</th>
<th>% of trajectories to Pt. Buchon MPA back-projected to have gone through the given MPA</th>
<th>Mean number of days until intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt. Santa Cruz</td>
<td>14.5%</td>
<td>10.4 days</td>
</tr>
<tr>
<td>Pt. San Luis Obispo</td>
<td>15.4%</td>
<td>11.9 days</td>
</tr>
<tr>
<td>Pt. San Clemente</td>
<td>15.1%</td>
<td>11.9 days</td>
</tr>
<tr>
<td>Pt. San Francisco</td>
<td>16.8%</td>
<td>12.4 days</td>
</tr>
<tr>
<td>Pt. San Miguel</td>
<td>13.0%</td>
<td>10.6 days</td>
</tr>
</tbody>
</table>

Table 1. Percentage of the 16,455 trajectories (68 traj. x 365 days) back-projected through 40 days intersecting the Pt. Buchon MPA and the average connection time.

Figure 3. Map of 4 km resolution ocean surface currents measured by the CODAR SeaSnipe® HF-radar array on February 18, 2009 0000 UTC (vectors are shaded according to their speed in cm s\(^{-1}\) per the color-bar). The HF-radar network provides measurement coverage of all the Central California MPAs which extend 6 km or more out to sea.

Figure 4. Graphs of the positions of the particles (in blue back-projected from the Pt. Buchon MPA at 5, 10, 20, 30, and 40 days). The extent of the excursions at these durations demonstrates the time it took the particles to reach a given density of observations within the regions of the other MPAs (in red) along the Central California coast.

Figure 5. Graphs of the back-projected particle projections of water particles, out through 40 days (960 hours) in the past, into the Pt. Buchon MPA; repeated daily for each of the 8.1 km grid-points with surface currents measured from October 2006–October 2007 (69 trajectories x 960 time-steps x 365 start-days = 15,780,800 back-projected points). These water particle track-points are color-coded to show the travel time (up through 40 days) the waters took to reach the Pt. Buchon MPA.

Through this 6-365 day trajectory analysis, the COCMP-NC provides the density of continuous measurements necessary for developing a data-based understanding of larval transport and connectivity between MPAs.