Physical Oceanography Affecting Size and Siting Issues—presentation by Mike Kosro and Hal Batchelder, Oregon State University

Mike Kosro:

There are many oceanographic instruments in current use that enable physical oceanographers to gather pertinent data including salinity, temperature, chlorophyll levels, downwelling and upwelling, surface current mapping, surface properties, sea level, etc.

Knowledge of fish species and oceanographic data can be combined and analyzed to see how they correlate in time and space. There are generally five ocean habitats defined by currents and water column properties along the West Coast of the United States (Figure 1). These are highly variable habitat, river plume habitat, upwelling habitat, offshore habitat and highly variable upwelling habitat. These habitats vary in salinity, temperature and other properties.

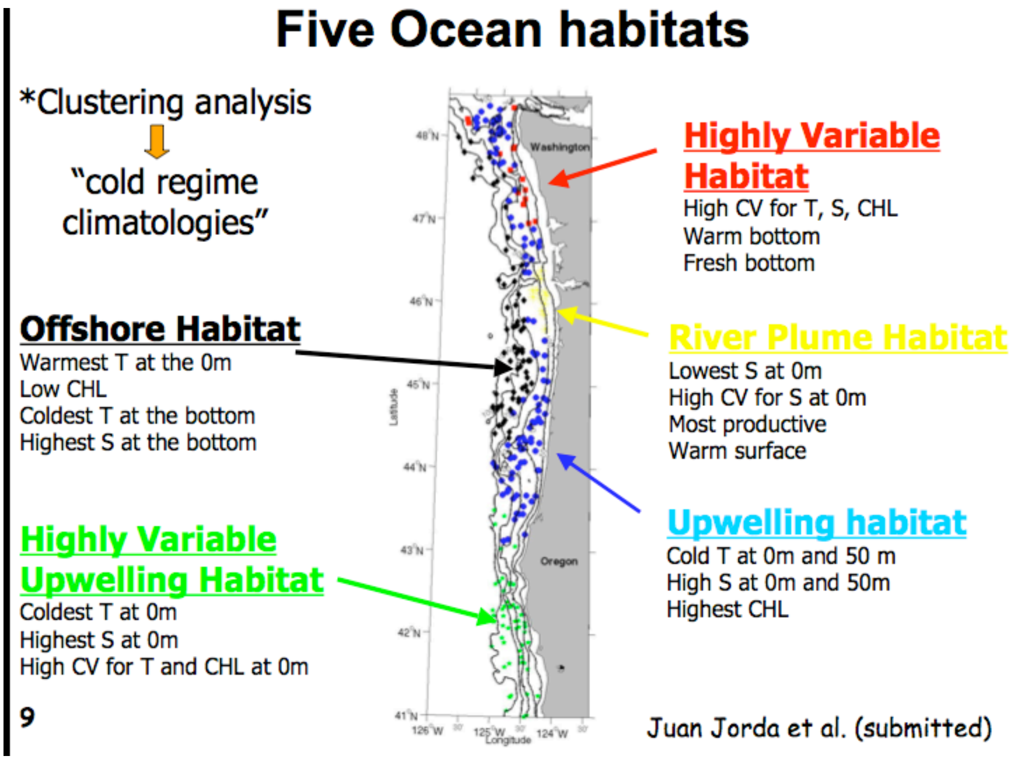

Figure 1. Diagram of locations and characteristics of the five general ocean habitats for the West Coast

Some fish species have a high affinity to specific habitats and can be considered "indicators" of a habitat type (Figure 2). For example, the distribution of catches of a fish with a high affinity for upwelling zones can indicate the likely presence of that habitat type. Likewise, oceanographic data can be used to identify likely biological hotspots, such as the Strait of Juan de Fuca.

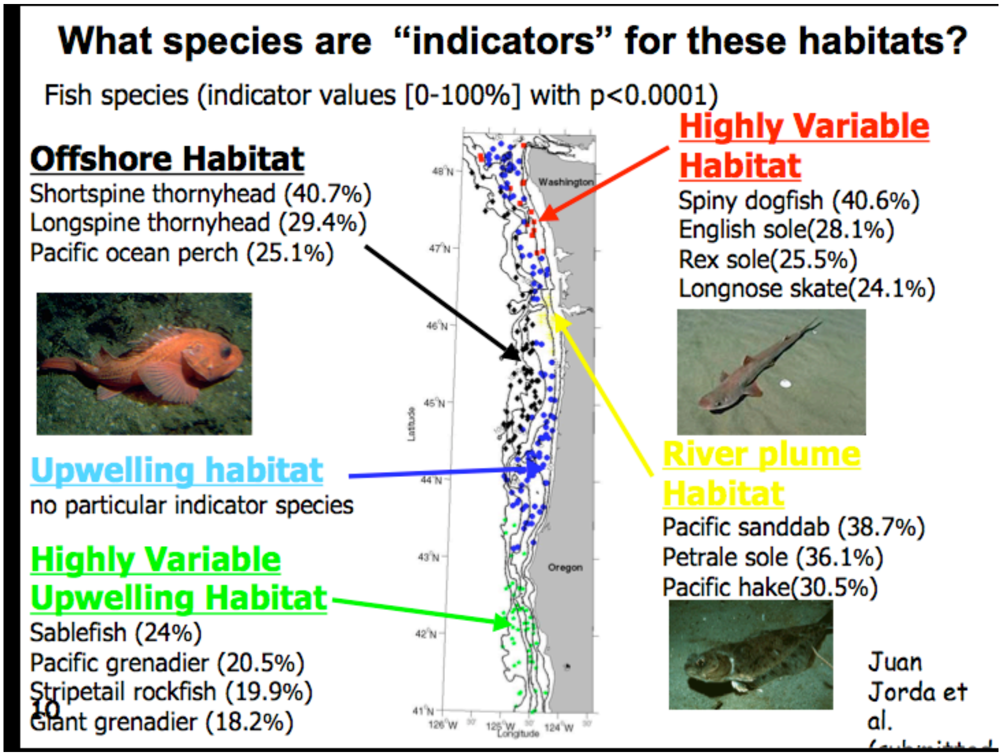

Figure 2. A diagram of indicator species for the five general habitats along the West Coast

Daily and monthly fluctuations in surface currents and upwelling or downwelling can be identified over large spatial scales along the Oregon coast using a variety of instruments and remote sensing from satellites. Links have been made between oceanographic data and salmon catches. For example, upwelling conditions in 2005 were weak. This year (2008) salmon catches were low and many researchers believe this is due to the weak upwelling conditions in 2005.

In conclusion, surface currents provide scientists with important information about ocean conditions, which are related to water properties that define habitat. Additionally, current data can allow scientists to estimate dispersion statistics, which indicate transport mechanisms for fish and invertebrate larvae. These statistics will change by location and will be affected by seasonal and interannual variability.

Hal Batchelder:

Computer simulations can be used to study circulation and other oceanographic processes. Physical circulation models of the region from Northern California to Tillamook, OR (Figure 3—upper figure) have been run using the best available high resolution wind forcing for calendar year 2002, and with initial conditions and boundary conditions provided by a lower-resolution, larger-domain model (10 km region outlined in green in Figure 3—lower figure).

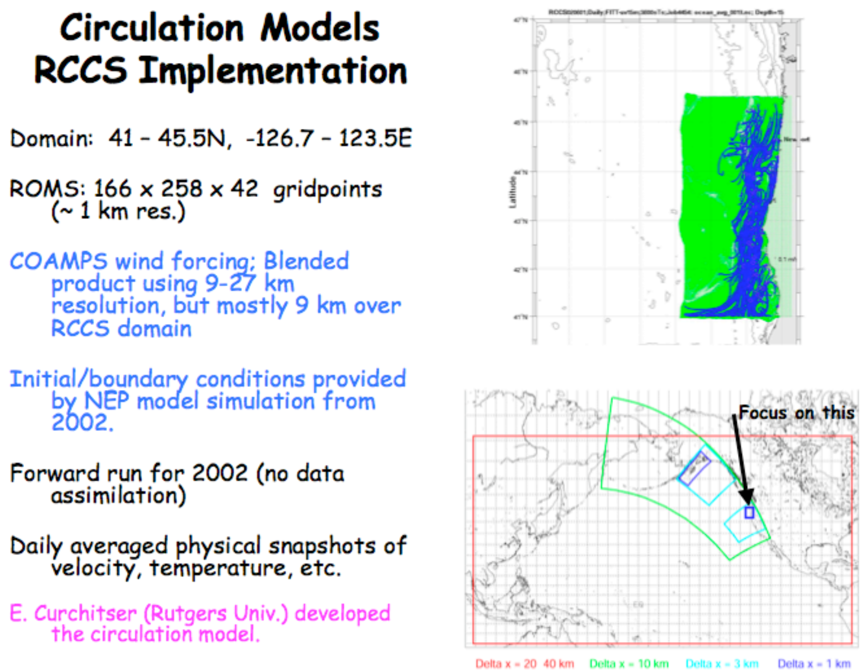

Figure 3. Top panel: The region modeled at 1 km resolution, from Northern California to Tillamook Bay. Bottom panel: various nested model domains showing the small region off Oregon-California and larger regions modeled at lower horizontal resolution.

Lagrangian particle tracking was used to examine trajectories of particles as they experience the seasonally-variable wind forcing. New simulations were initiated weekly and particles tracked for 15 days or until they exited the model domain. Using the particle positions, it was possible to quantify spatial and temporal patterns of retention times of particles that originated on the Oregon shelf. Statistics derived from the Lagrangian experiments revealed that the Heceta Bank region, and especially the near-coastal waters inshore of Heceta Bank have longer retention times (more sluggish flow), suggesting that these may be areas of self-recruitment for marine species with short (<14 d) pelagic larval durations.

Using these Lagrangian experiment results, other metrics of potential value to siting and evaluation of marine protected areas may be derived. Of particular note are "destination maps" and "source maps". Destination maps identify sites with a high potential to export larvae to many other locations. Source maps identify areas that might receive new individuals (young; recruits) from many other regions (Figure 4). The model domain was subdivided into regions of approximately 10 km by 10 km for calculating these statistics. Regions in Figure 4 that are in warm colors (reds and yellows) are regions that have high potential for providing young to many other sites (destination map; left panel) or receive young from many other sites (source map; center panel). For the examples shown here, ca. 50000 particles were tracked for each simulation. If greater numbers of particles are tracked, and or particles are seeding into the nearest shore regions only, it would be possible to provide maps of retention, destinations and sources at higher (ca. 1 km) resolution.

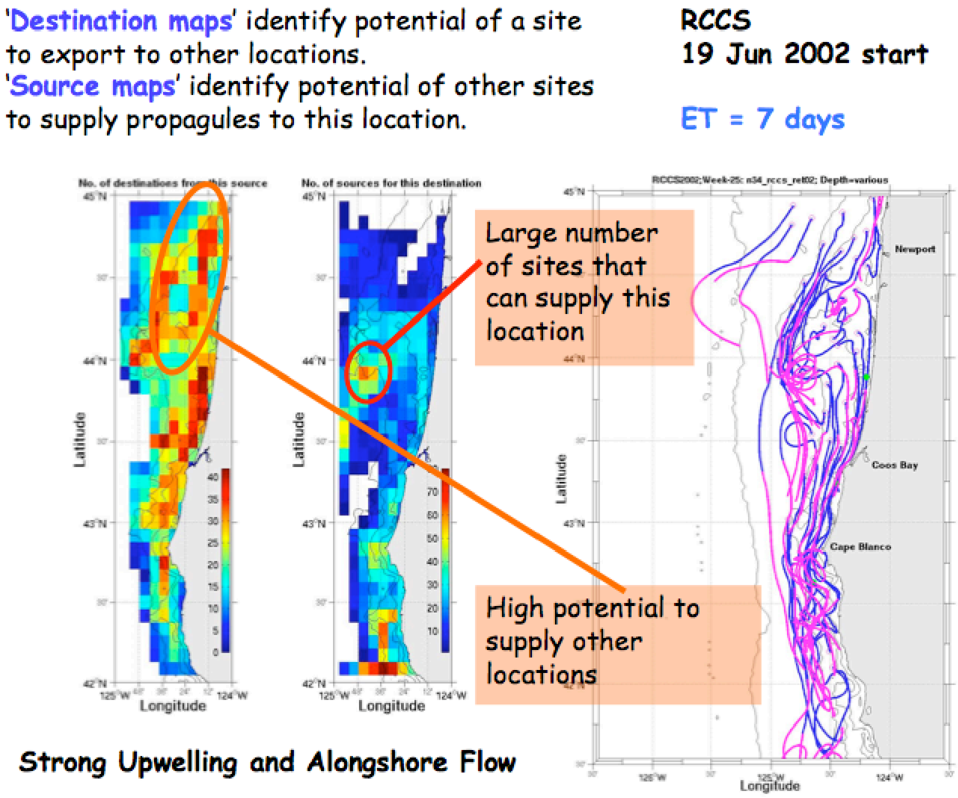

Figure 4. Diagram of destination and source maps—destination areas are identified with red.

In conclusion, the coupling of high-resolution models of ocean circulation using realistic bathymetry and wind forcing produce circulation fields that can be explored using particle tracking experiments to estimate some metrics, such as retention times, destination and source maps, that provide key transport-related information regarding the potential ability of specific regions to recover from overfishing, or of regions to serve as exporters of young to other regions, or to self-seed. For now, these simulations are of limited use because only one year of data (2002) has been analyzed and only a portion of the coast has been thoroughly investigated. Using Lagrangian experiments to analyze multiple years of ocean simulations would enable better statistics of these processes—esp. how they vary seasonally, spatially and interannually. Future simulations need to be done with a larger model domain, which will allow better spatial description, but also allow for longer duration Lagrangian experiments. Currently, the duration of Lagrangian experiments is limited by the desire not to have individual particle interactions with the boundary of the physical model domain.