A Preliminary Guide to Tidal Currents in the coastal region of central Maine.
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NOTE: THIS IS AN EXPERIMENTAL RESEARCH PRODUCT, SUBJECT TO ONGOING FIELD VERIFICATION. NO ASSURANCES ARE EXPRESSED OR IMPLIED REGARDING ACCURACY OF THE TIDAL CURRENT MAPS.

Computer model details. The following .pdf files contain half-hourly maps of surface tidal currents in several regions of the central Maine coast near Boothbay Harbor. The model fields were determined using a three-dimensional, nonlinear hydrodynamic circulation model originally developed by NOAA for application to Chesapeake Bay (Hess, 2000). The full model domain includes the coastal waters, bays and principal rivers from Cape Small to Pemaquid, up to the head of tide in the major rivers. The region covers an area similar to NOAA chart 13293, excluding New Meadows River and Merrymeeting Bay.

The model calculates velocity, temperature and salinity on a rectangular grid with 92.7 m resolution in the horizontal and eleven levels in the vertical equally spaced between the sea surface and the bottom (defining ten layers). Bathymetric and coastline data were obtained from NOAA's National Geophysical Data Center websites. In some areas lacking observations, hand-digitized depths from charts were used to expand the bathymetric coverage. Amplitudes and relative phases of tidal water level variations were obtained from NOAA National Ocean Survey and applied at the open boundaries of the full model domain. Annual average river fluxes were specified, but wind forcing was not included for the examples shown here (some cases with winds included are available on a CD version). The tidal maps show model surface currents for *mean spring tidal range* at Boothbay Harbor (3.08 m or 10.1 ft).

Understanding the tidal maps. The local tide is prominently semi-diurnal, with period 12 lunar hours, or about 12 hours and 25 minutes clock time; thus, water level heights and current patterns closely repeat with this period. The maps (24 separate .pdf figures for each sub-region) show the surface tidal current vectors for one tidal cycle at each grid point at time intervals of 0.5 lunar hours after high water in Boothbay Harbor. One lunar hour equals 1.035 solar (clock) hour; i.e. 1 hour, 2 minutes and 6 seconds. Each vector shows the model-calculated current speed and direction at the tail of the arrow, corresponding to the grid point in the model domain.

The full-resolution current vectors are "dimmed" in each map. To improve readability, a reduced subset of the full-resolution vectors, decimated by a factor of three in both the east and north directions, are shown in color. The colors indicate speed thresholds as follows: black, 10 cm/s (about 0.2 knot); blue, 25 cm/s (about 0.5 knot); red, 50 cm/s (about 1 knot); green, 100 cm/s (about 2 knots); and magenta, 200 cm/s (about 4 knots). Thus a red arrow indicates a current speed greater than 1 knot but less than 2 knots. The scale arrows shown below the time stamp on each figure can be used to estimate the actual speed of the current vectors between threshold levels. Full detail can be recovered by zooming in on the area of interest.

The light gray contours on the maps show water depths below MLW of 5, 10, 20 and 50 m (16.4, 32.8, 65.5 and 164 ft) respectively; they are unlabelled to reduce clutter.

A separate CD version shows tidal maps for several additional model subregions. Currently, these are: Inside Passage (similar to NOAA chart 13296); Back, Sheepscot, and Damariscotta Rivers (no comparable chart); and Lower Kennebec River – Sheepscot Bay (similar to chart 13295). Some of these are also available at the above website.

Remember that the vectors represent the flow speed at the *tail* of the arrow, not at the head; this can be confusing in regions with strong currents, because the length of each arrow and the size of its head are proportional to the current speed at the corresponding model grid point. The tail of each arrow is marked by a small open or filled circle.

Using the maps. Each on-line .pdf file contains 24 concatenated tidal maps, covering one tidal cycle. These are huge files, approximately 40 MB each, so a high-bandwidth Internet connection is definitely needed for downloading. The CD version contains separate .pdf files for each half-hourly map; each of these is about 2 MB. The files can be opened with Adobe Acrobat©. For best results, you will need the full version (currently 'Acrobat 6.0.4 Professional'), although the figures will open with the more limited Reader version that can be downloaded at no cost. With Acrobat Pro, you can use the handy Loupe tool to slide a magnifying window around on the maps. It is also instructive to compare different maps side-by-side (In Acrobat, choose View>Page Layout>Facing)

The navigational aids shown on each map include lighthouses (stars), nuns (red diamonds), cans (black diamonds), and daymarks (black or green squares). Lighted bell or gong buoys are indicated by filled red circles. Keep in mind that the model grid resolution is about the length of a football field, so narrow channels such as Upper Hell Gate or Townsend Gut are poorly represented in some places. Also recall that the coastline and the water depth information come from different data sets, and they do not always agree in fine detail. As a result of these combined limitations, occasionally you will find shallow depth contours that cross the coast and velocity vectors on the land. In a few cases small islands or drying ledges obvious on charts are not resolved at all in the model bathymetry. The positions of the navigational aids were taken from current NOAA charts, but *please note that the tidal maps are not to be used for navigation and no assurance of accuracy is offered.*

A few brief notes follow for each of the three model sub-regions currently available on-line; there are many more interesting details in the maps. Recall that times refer to *lunar* hours, not clock hours. Also remember that the influence of the wind, which can be very important, has not been included in the maps shown here. The current speeds and patterns may be quite different under various wind conditions.

The Booth Bay region (BHYC sailors' special). The region extends from approximately Tumbler Island offshore to Bantam Rock south of Damariscove Island, and from Southport Island to the entrance to the Damariscotta River. The strongest surface currents (2-3 knots) occur in the passages between islands or headlands, as one would expect. The maximum ebb in Fisherman Passage and in Fisherman-Damariscove Passage occurs between 3 and 3.5

hours after high water at Boothbay Harbor; the slacks occur near the times of low and high water. You will also note intensified currents over shoal ledges or rocks; e.g. south of Damariscove Island near Bantam Rock. Elsewhere in the region, the surface currents are quite small. Recall that the maps correspond to the *mean* spring tide situation; under perigean spring tides, the speeds will be higher, and conversely for neaps. For comparison, the largest current speeds in the full model domain occur in Lower Hell Gate and Goose Rock Passage (>4 knots), with somewhat lesser speeds in constricted parts of the Kennebec, Sheepscot and Damariscotta Rivers.

Lower Kennebec – Sheepscot Bay region (cf. chart 13295). The swiftest surface currents occur in the constricted lower reaches of the river; e.g. off Fort Popham point and Cox Head where the ebb speed exceeds 100 cm/sec (about 2 knots) and approaches 3 knots in places about 4.5 hours after high water at Boothbay Harbor. The ebbing currents, which include the natural river flow as well as the tide, are generally stronger and last longer than the flood in the river and near its mouth. The maximum speeds in Sheepscot Bay are much smaller, generally less than one knot. The flood in the lower Kennebec begins about a half-hour earlier than in the lower Sheepscot, and the maximum flood speeds near the river mouth occur about two hours before high water at Boothbay Harbor. The currents are intensified over or near shoal ledges or small rocks; e.g. The Sisters and Seguin Ledges. Strong tidal convergences occur near the mouth of the river between Pond Island Shoals and Seguin Island during the maximum ebb, about four hours after high water in Boothbay Harbor. The slack following ebb in the lower reach of the river occurs about one hour after low water in Boothbay Harbor, by which time the subsequent flood is making strongly at the mouth.

Lower Hell Gate – Goose Rock Passage – Middle Sheepscot region (c.f. chart 13296). The maximum ebb currents of about 4 knots occur in Lower Hell Gate and Goose Rock Passage between 4 and 4.5 hours after high water in Boothbay Harbor; the following slack is very brief and occurs near 7 hours. A prominent clockwise eddy forms off Robinhood in the lee of The Knubble during the strongest part of the ebb, and a prominent convergence front occurs east of Clous and Middle Ledges where the outflow from the passage pushes into the Sheepscot River. The flooding tide is strongest along the west side of the Sheepscot until it turns into Goose Rock Passage. Maximum flood in the passage and Lower Hell Gate, according to the model, occurs between 10 and 10.5 hours after high water (2 to 1.5 hours before low water) in Boothbay Harbor. The flood impinges directly on Robinhood Point, where it splits, most going north toward Hells Gate, Hockomock Bay, and Montsweag Bay (Back River). The tide floods simultaneously north and south in Back River, meeting near Cowseagan Narrows (not shown in these figures).

An important cautionary note. The details and timing of the model-calculated currents sensitively depend on the phase differences of the tidal forcing applied at the model boundaries. As noted above, water level amplitudes and relative phases (i.e., times of high water relative to Portland) are taken from tables available at the NOAA/NOS website, but such data are available at relatively few locations. Thus interpolation of amplitudes and phases is inevitable, and with that comes some uncertainty in the details of the model predictions. These uncertainties can be reduced by direct observations of the tidal currents at controlling locations, such as Fisherman Passage or between Fisherman and Damariscove

Islands, because such observations can be used to “tune” the model forcing for the best fit. The most important observations needed are timed records of speed and direction of the tidal flow in narrow passages, especially the times of reversals or maximum flows. The boundary conditions have been adjusted so that the model currents are generally consistent with current observations reported in the US Coast Pilot, but such observations are available at only a few sites.

And an appeal for data. As noted above, these maps are preliminary research products that require further verification by checking the predictions against observations. Information that may help in this process is much desired. Obviously, local knowledge of the tides is of the greatest utility and will help improve the model predictions in the long run, so any comments or suggestions about the maps will be gratefully appreciated. You can send them to me at dbrooks@ocean.tamu.edu. And thanks.

References:

Hess, K.W., 2000. Mecca2 Program Documentation, NOAA Technical Report NOS CS-5, Silver Spring, MD, 49 pp.

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