

Navigation Agenda for 2018

- Day 1: Navigation Topics Overview (1 hr)
 - Key Learning Objectives
 - Wind and Weather
 - Tides and Currents
 - Washington Coastal Atlas
 - Moving Water
 - Charts
 - Group course plotting exercise
- Day 2: Planning for Tides & Currents (1.5 hr)
 - Tides Stations and Tide Tables
 - Tide Exercise – filling in tide worksheet
 - Current Stations and Current Tables
 - Current Exercise (fill in worksheet for Blake Island)
 - Hope/Skagit Islands Homework Assignment
- Day 3: (100 min)
 - Review Homework
 - Elementary navigation
 - pilotage, dead reckoning, range finding, current compensation strategies
 - 50/90 Rule (Rule of thirds)
 - Homework Assignment
- Day 4: (20 min)
 - Review Homework
 - Weather – NOAA site
 - Wind Terrain Effects
 - Wind Shadow

Key Learning Objectives

- Understand **weather's effects** on paddling
- Understand and interpret **basic water dynamics** and their impact on paddling
- Read and interpret **Tide and Current tables**
- Become familiar with and recognize importance of key elements of a **navigational chart**
- Perform basic **navigation** using **pilotage**
- Be able to make intelligent choices regarding paddling trips based on your own **interpretation of the trip** conditions and your skills.

A colorful, stylized illustration of a globe. The globe is divided into several colored sections: a green top section with small white and pink dots, a grey middle section with white wavy lines representing clouds, and a pink bottom section. A yellow sun with rays is on the left, a blue lightning bolt is on the right, and a rainbow is in the center. The text "Wind & Weather" is written across the middle in a blue, cursive font with a red outline.

Wind & Weather

What happens when the wind is blowing?

- Wind waves
- Slows you down or speeds you up
- Can push you over
- Pulls on your paddle
- Makes it hard to keep your boat going straight (tracking)

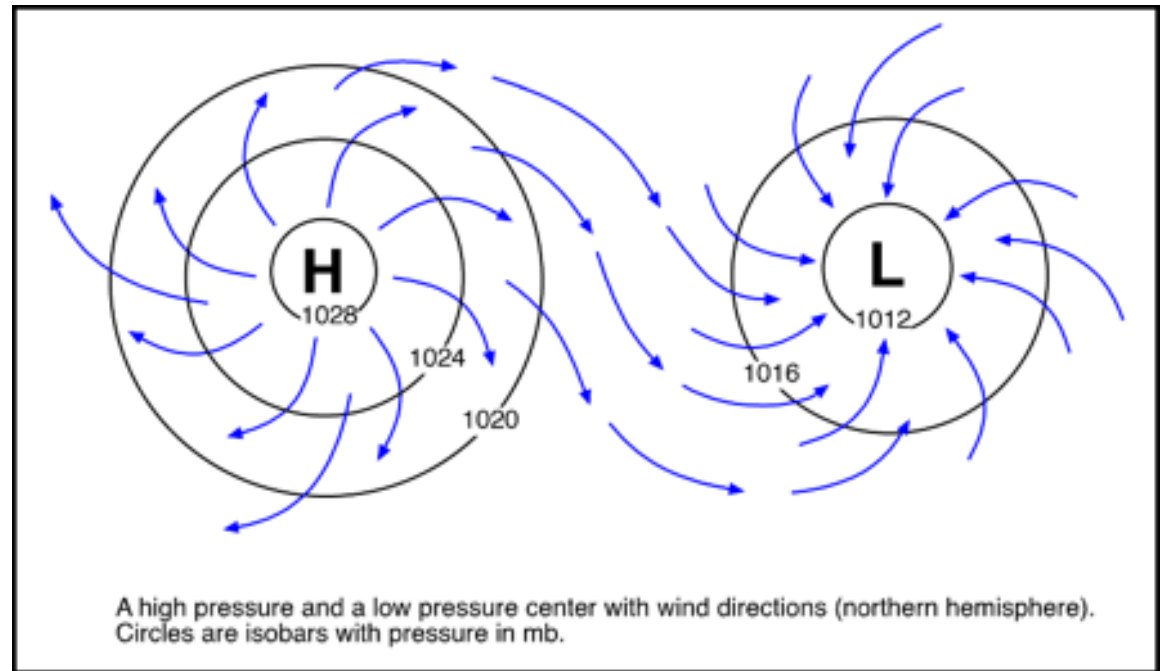
How can you anticipate what the wind and weather is going to do?

- NOAA Marine Forecast
- Weather sites (e.g. Windy.com, Wunderground...)
- Wind surfing sites (e.g. Windfinder, WindAlert...)
- Sharp changes in barometric pressure
- Count on an afternoon wind (sea breeze).

Wind

Atmospheric pressure at the Earth's surface is one of the keys to weather.

High and **low** pressure areas are important because they affect the weather.



A "high" is an area where the air's pressure is higher than the pressure of the surrounding air.

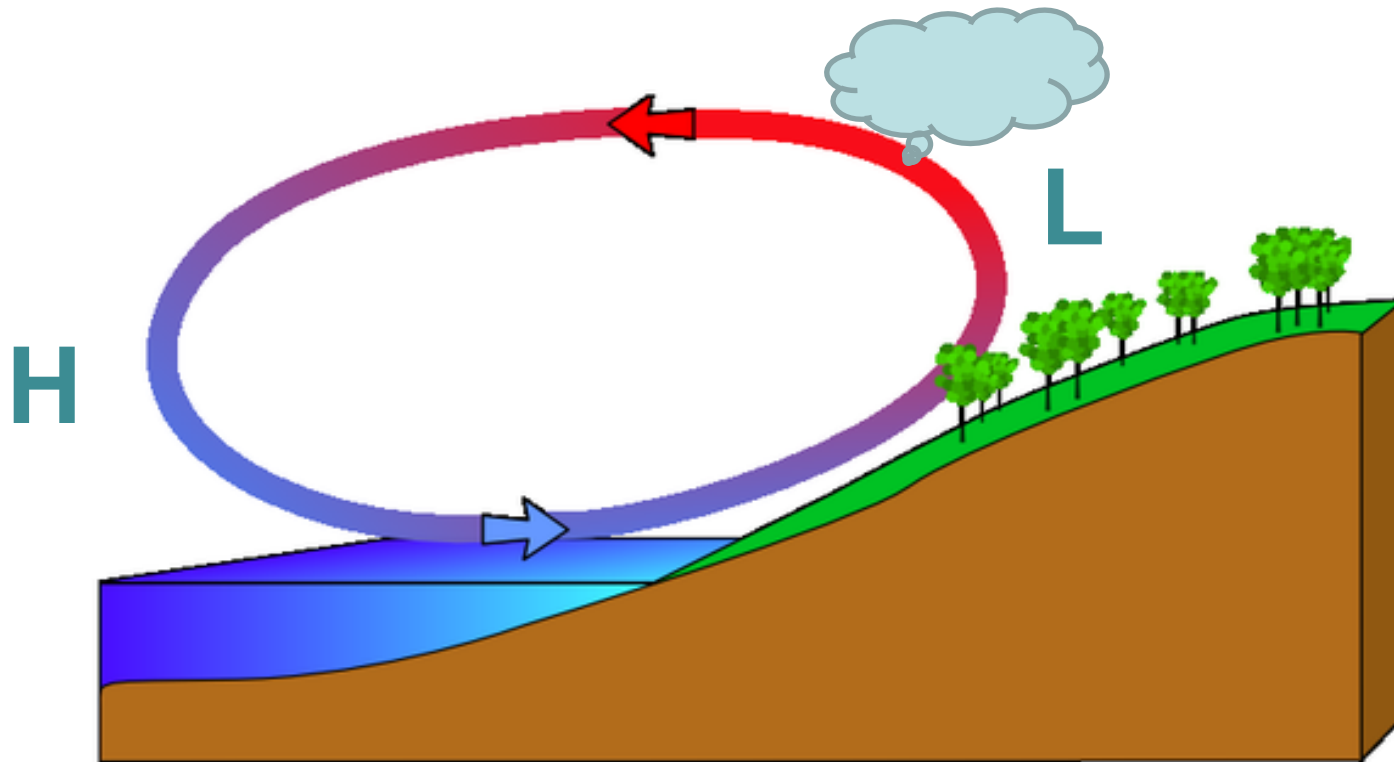
A "low" is where the air pressure is lower.

Meteorologists don't have any particular number that divides high from low pressure; it's the relative differences that count.

Wind

Sea Breeze

A **sea breeze** (or onshore breeze) is a wind from the sea that develops over land near coasts. It is formed by increasing temperature differences between the land and water which create a pressure minimum over the land due to its relative warmth and forces higher pressure, cooler air from the sea to move inland.

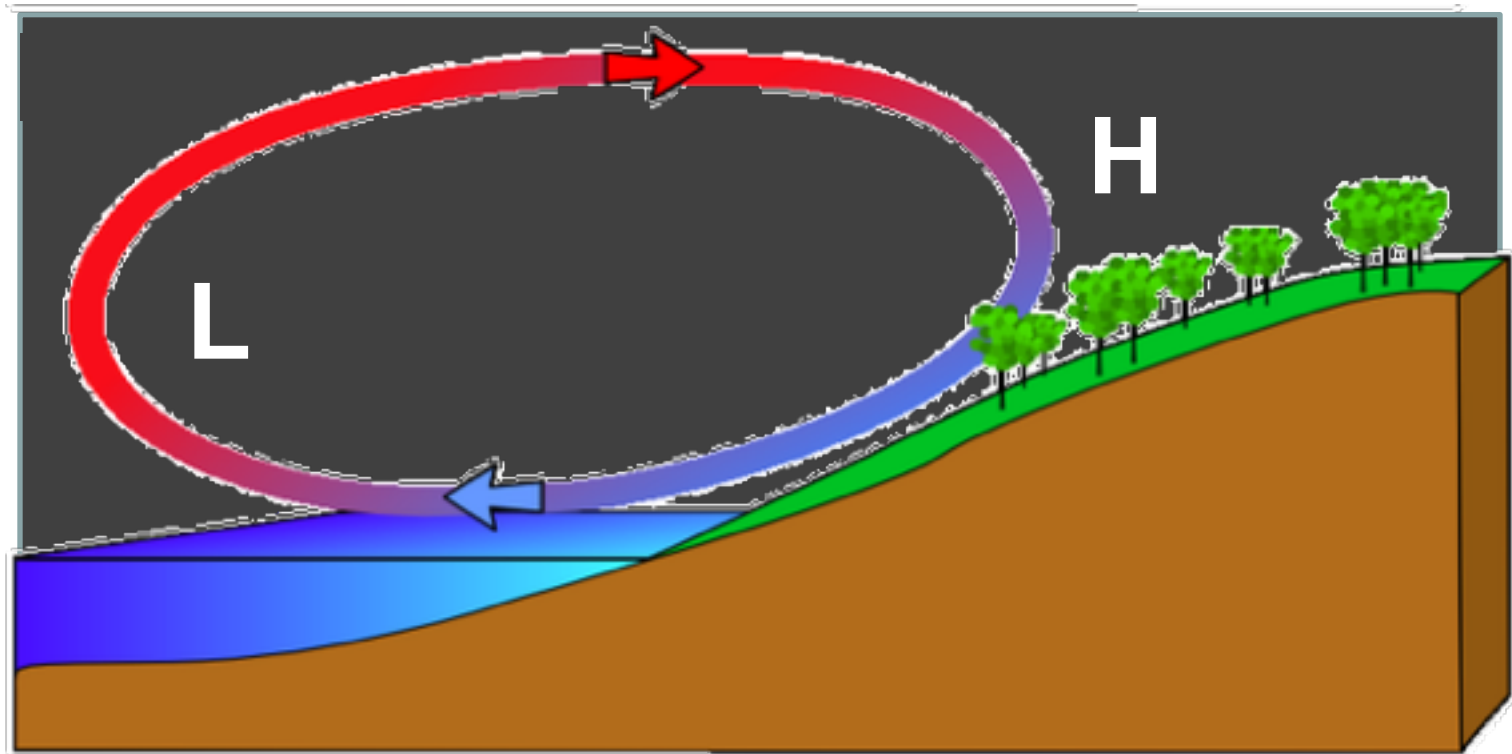


Wind

Land Breeze

A wind blowing from land to sea (an offshore wind) which develops in coastal districts **towards nightfall** and is called a **land breeze**.

Pressure is relatively higher above the land than above the sea as the land cools more rapidly in the evening, and air therefore moves seawards in order to even up the pressure difference.



Wind

Fetch
















Fetch is the distance the wind is able to move unobstructed over the water:

- As the wind blows over the water it causes friction and the water starts to ripple
- Given an unobstructed fetch, and time, the wind will generate enough friction to develop (wind) waves
- Combine that with an opposing current and the waves will get steeper.
- Fetch is an important factor in sea kayak (SK) trip ratings
- Always consider fetch!

Beaufort Wind Scale

Estimating wind speed by direct observation

Beaufort number (force)	Wind speed		Wave height (feet)	WMO* description	Effects observed on the sea	Effects observed on the land
	Knots	MPH				
0	Under 1	Under 1	-	Calm	Sea is like a mirror	
1	1 – 3	1 – 3	0.25	Light Air	Ripples with appearance of scales; no foam crests	
2	4 – 6	4 – 7	0.5 – 1	Light Breeze	Small wavelets; crests of glassy appearance, not breaking	
3	7 – 10	8 – 12	2 – 3	Gentle Breeze	Large wavelets; crests begin to break; scattered whitecaps	
4	11 – 16	13 – 18	3 ½ - 5	Moderate Breeze	Small waves, becoming longer; numerous whitecaps	
5	17 – 21	19 – 24	6-8	Fresh Breeze	Moderate waves, taking longer form; many whitecaps, some spray	
6	22 – 27	25 – 31	9 ½ - 13	Strong Breeze	Larger waves forming; whitecaps everywhere; more spray	
7	28 – 33	32 – 38	13 ½ - 19	Near Gale/Moderate Gale	Sea heaps up; white foam from breaking waves begins to be blown in streaks	

Beaufort number (force)	Wind speed		Wave height (feet)	WMO* description	Effects observed on the sea	Effects observed on the land
	Knots	Mph				
8	34 – 40	39 – 46	18 – 25	Fresh Gale/Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks	
9	41 – 47	47 – 54	23 – 32	Strong Gale	High waves; sea begins to roll; dense streaks of foam; spray may begin to reduce visibility	
10	48 – 55	55 – 63	29 – 41	Whole Gale/Storm	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks ; tolling is heavy and visibility is reduced	
11	56- 63	64 – 72	37 – 52	Violent storm	Exceptionally high waves; sea covered with white foam patches visibility further reduced	
12	64 and over	73 and over	45 and over	Hurricane	Air filled with foam; sea completely white with driving spray; visibility greatly reduced	
* World Meteorological Organization						

Small Craft Advisory – 21 to 33 Kt (24 to 38 MPH) winds and/or wave heights exceeding 10 feet.

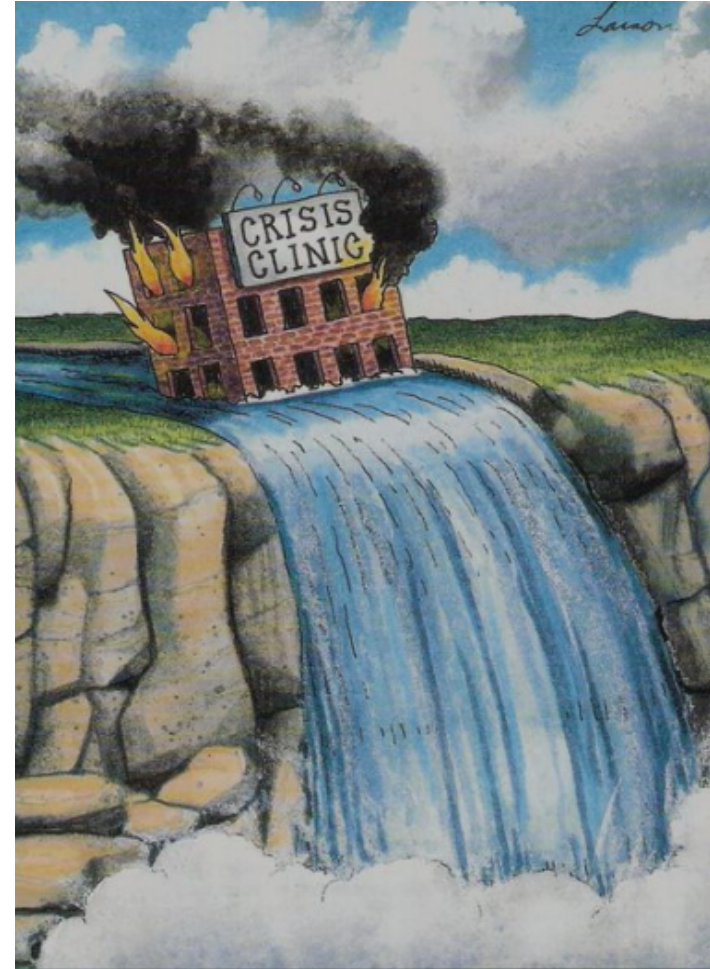
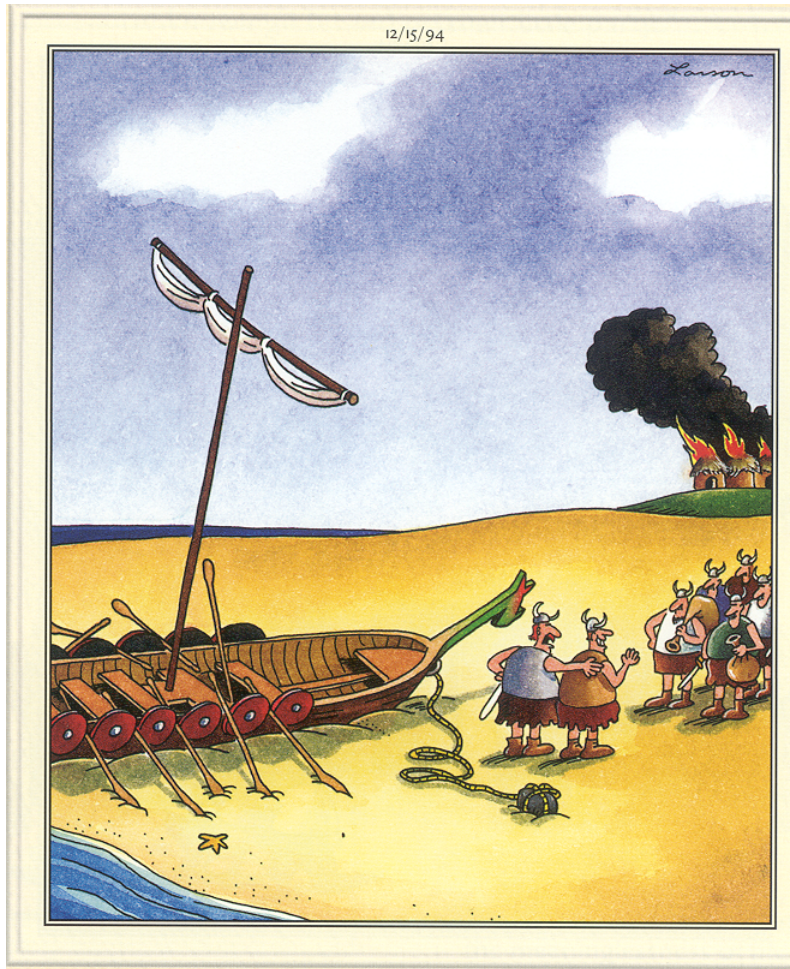
Gale Force Winds – 34 to 47 Kt (39 to 54 MPH) winds



Tides & Currents

Tides and Currents

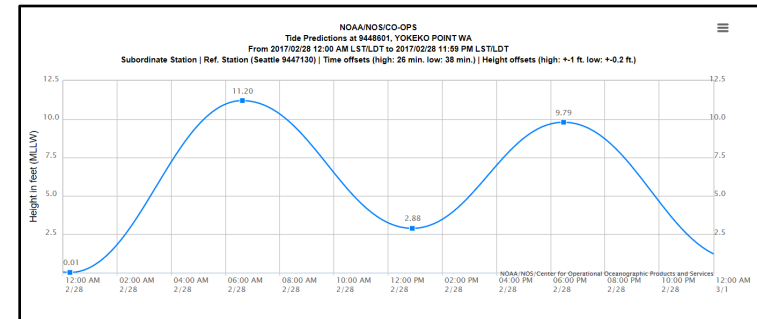
Why do I need to know???



Tides & Currents

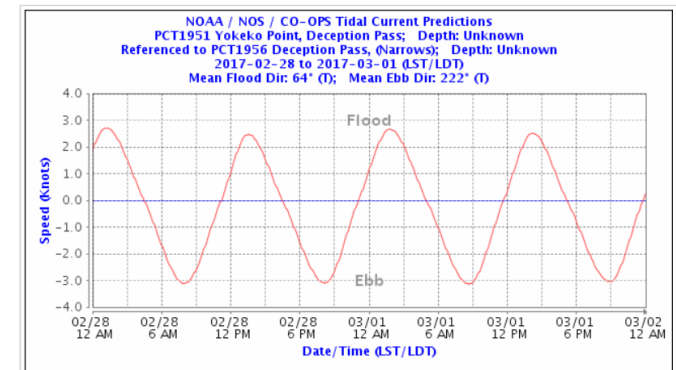
Tides \updownarrow

measured by height, tides are the vertical movement of water caused by the gravitational influences of other celestial bodies and the centrifugal forces as the earth rotates



Currents \leftrightarrow

measured by speed and direction, currents are the horizontal movement of water caused when it moves from one area to another

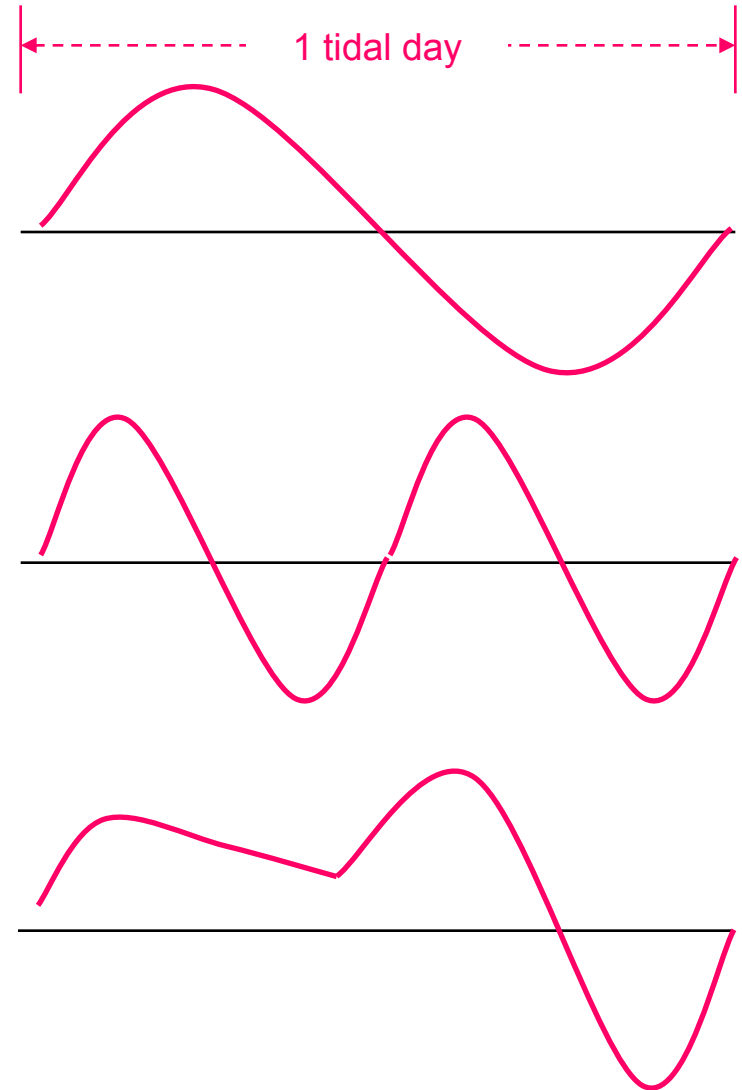


Tides

Diurnal Tide: Only a **single high and a single low during each tidal day**; successive high and low waters do not vary by a great deal. Such tides occur, for example, in the Gulf of Mexico, Java Sea and in the Tonkin Gulf

Semi-diurnal Tide: The most common tidal pattern, featuring **two highs and two lows each day, with minimal variation** in the height of successive high or low waters. Such tides occur, for example on the east coast of North America, Central and South America

Mixed Semi-diurnal Tide: Characterized by **wide variation in heights of successive high and low waters**, and by longer tide cycles than those of the semidiurnal cycle. Such tides occur, for example, in the U.S. Pacific coast and many Pacific islands.



Tides

Kayakers need very little water depth to paddle. Why worry about tides at all?

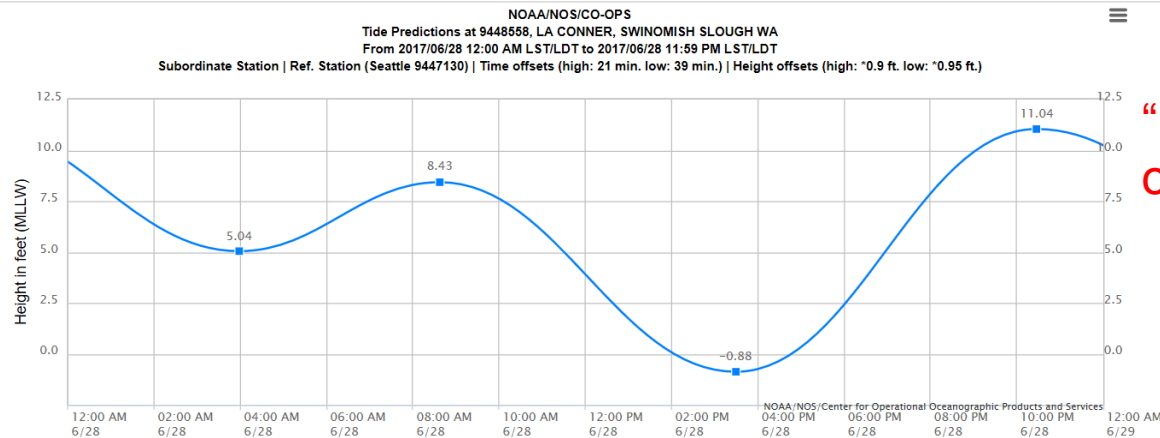
- Put in/Take out
- Lunch breaks (are you going to have to muck through mud to reach a beach?)
- Navigating in/around mudflats – who wants to wait for the tide to come back in while beached in their boat on a mudflat?

How are Mixed Semi Diurnal Tides different from Semi Diurnal Tides?

- Mixed Semi Diurnal Tides not only have **two high tides and two low tides** during a 25 hour period, **the highs and lows are at different heights.**

Why is that important?

- What if pull your kayak onto the beach just above the lower high tide of the day. What will happen when the higher high tide of the day comes along?



“Hey! Where did our boats go?”

Tides

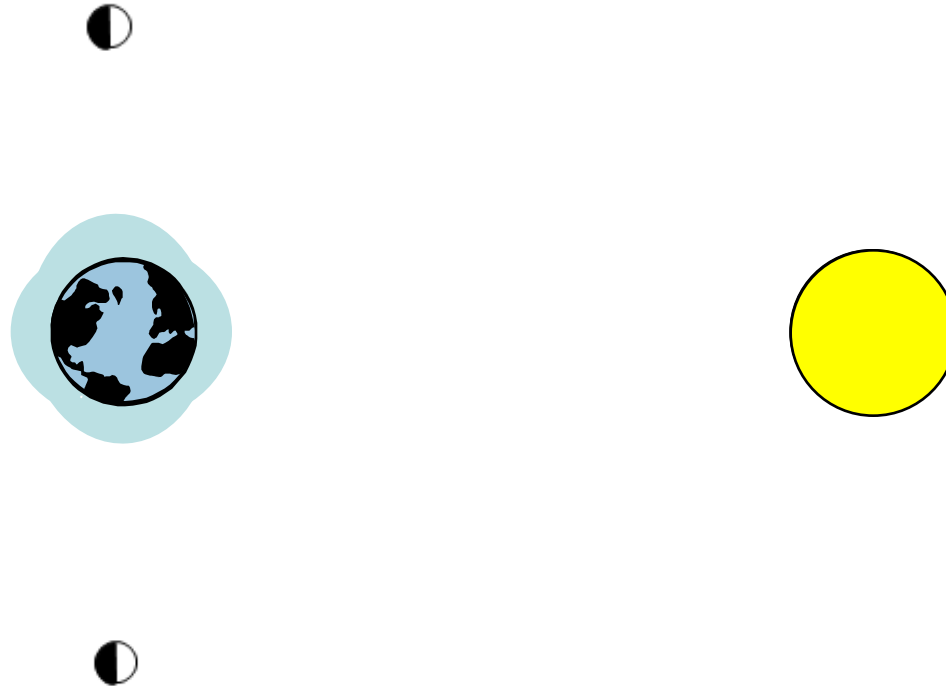
Spring tides - Moon is Full or New and gravitational + centrifugal forces aligned...



Result: Tides will be higher and lower (and currents faster)

Tides

Neap tides: Quarter moon. Sun and moon not in alignment...



Result: Tidal highs and lows will be less than average (and currents slower than average).

SOURCES OF TIDE INFORMATION

NOAA TIDE PREDICTIONS

https://tidesandcurrents.noaa.gov/tide_predictions.html

THE TIDEBOOK COMPANY

<https://www.tidebookcompany.com/>

TIDE & CURRENT APPS & LINKS

Always make sure to check the correct dates and relevant tide stations for your trip!

**CAUTION: tide and current tables DO NOT factor in effects of wind and weather!
Never depend on a single source of information when making travel decisions!!**

Tides

Here is a handy way to check out Washington shorelines: the Coastal Atlas...

The screenshot shows a web browser window displaying the Washington State Coastal Atlas. The browser's address bar shows the URL <https://fortress.wa.gov/ecy/coastalAtlas/>. The website header includes the Department of Ecology logo and the text "Washington State Coastal Atlas".

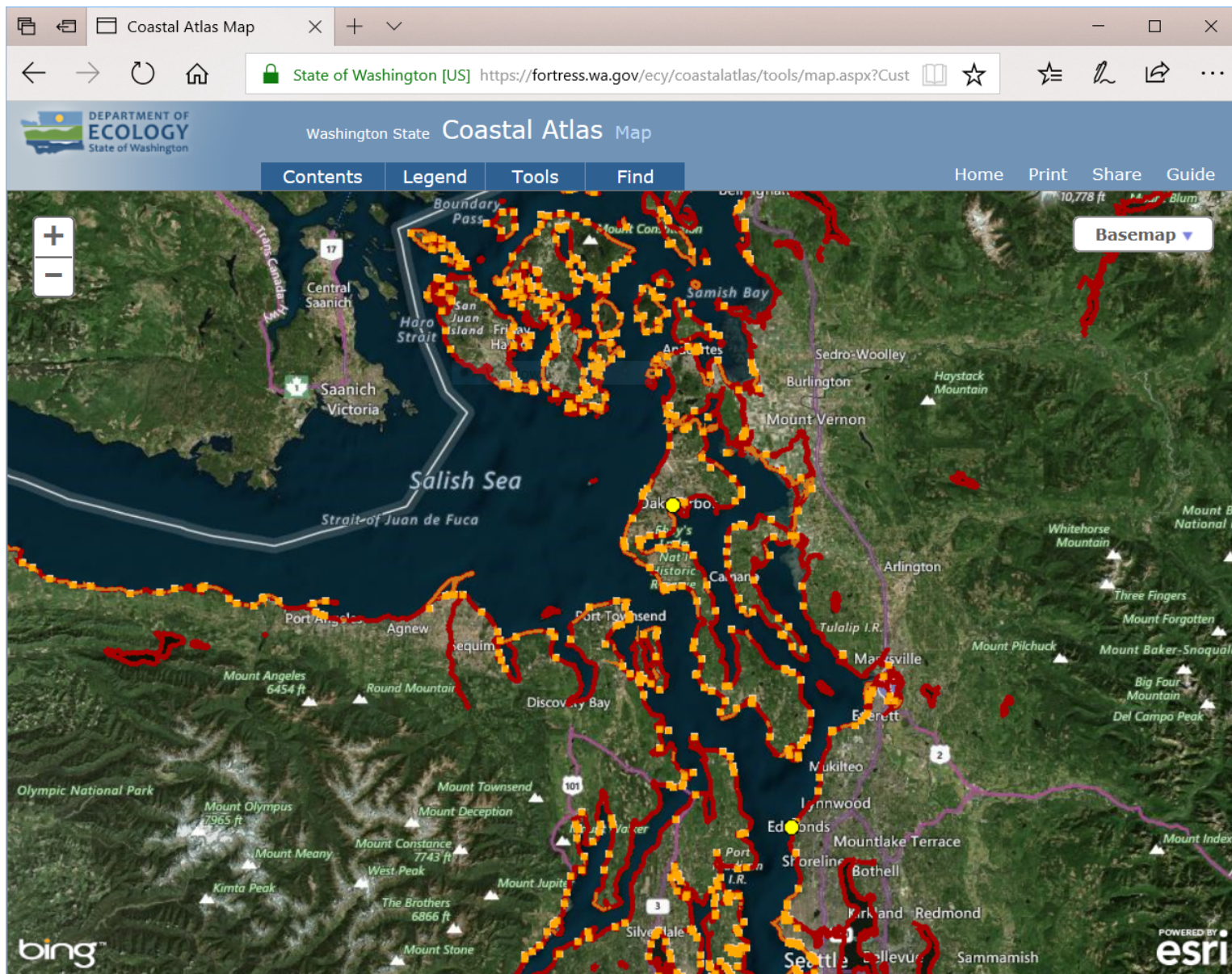
The main content area is divided into several sections:

- Home** and **Tools** navigation tabs.
- Find a lake**: Includes a photo of a lake with lily pads and a "Go" button to "View environmental data".
- Find beach closures**: Includes a photo of a "WARNING" sign on a beach and a "Go" button to "Check beach status".
- Find a public beach**: Includes a photo of a beach and a "Go" button to "Enter beach or place" or "go to page >".
- More atlas tools >**: A link to explore additional features.
- Coastal Map Quick Search**: A search interface with a dropdown menu for "-select county-", a "More search options >" link, and a "How do I" section.
- View shoreline photos**: A section for "Search for photos".
- Make a coastal map**: A section for "Select from all 122 map layers" including "Map shore photos, beach access, status" and "Map slope stability, drift cells".
- View flood hazard maps**: A section for "Find public beaches", "Find beach closures", and "Find a lake".
- COASTAL ISSUES**: A section featuring a photo of debris and the text "Tsunami debris on Washington beaches" with a "Learn more >" link.

A large map of Crescent Bay is visible at the bottom, showing various coastal features and a "Go to coastal map" button.

Tides

Use the Coastal Atlas to see aerial shore photos, beach access, and other info...



Tides

Fern Cove near low tide...check out that mudflat!

The screenshot shows a web browser window displaying the Washington State Coastal Atlas website. The browser's address bar shows the URL: <https://fortress.wa.gov/tools/ShorePhotos.aspx?photo=06081>. The website header includes the logo for the Department of Ecology, State of Washington, and the title "Washington State Coastal Atlas". Navigation links for "Home" and "Tools" are visible.

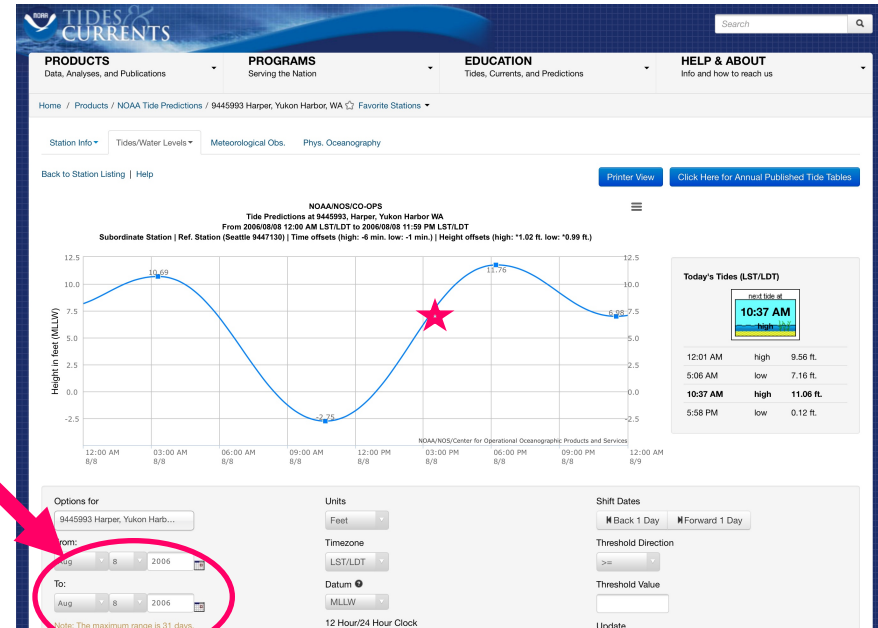
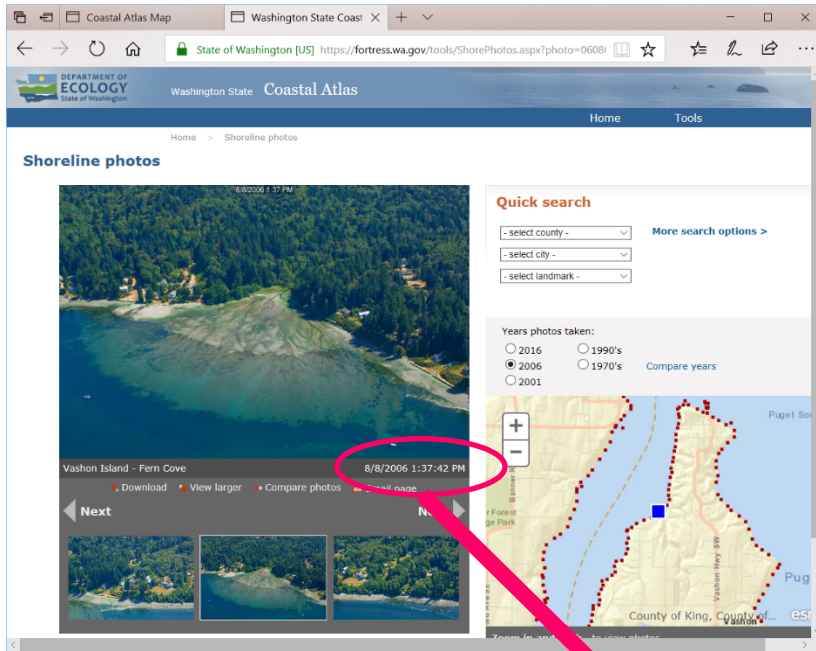
The main content area is titled "Shoreline photos" and features a large aerial photograph of a shoreline. The photo is dated "8/8/2006 1:37 PM" and shows a large, flat, light-colored area (mudflat) extending into the water. Below the photo, the caption reads "Vashon Island - Fern Cove" and "8/8/2006 1:37:42 PM". There are links for "Download", "View larger", "Compare photos", and "Email page".

To the right of the photo is a "Quick search" section with three dropdown menus: "- select county -", "- select city -", and "- select landmark -". A link for "More search options >" is also present. Below this is a "Years photos taken:" section with radio buttons for "2016", "2006" (selected), "2001", "1990's", and "1970's". A "Compare years" link is also available.

At the bottom right, there is a map showing the location of the photo on Vashon Island. The map includes a blue square indicating the photo's location and a red dashed line outlining the island's boundary. Labels on the map include "Puget Sound", "Banner", "Forest", "ge Park", "Vashon Hwy SW", "County of King", and "County of...".

Tides

Now compare the date on the aerial photo with the NOAA tide data for Fern Cove on 8/8/2006...



Currents Overview

Currents are the horizontal movement of water caused when it moves from one area to another.

Current speed, direction, and behavior is influenced by tides, geographic features, and weather/wind.

Currents are measured in units of speed and direction.

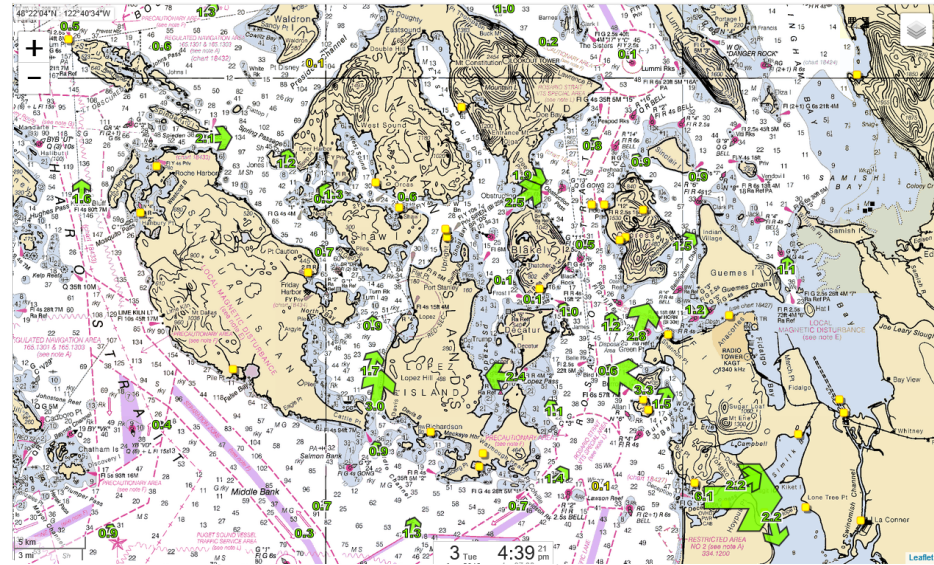
Current prediction graphs and tables are different from tide prediction graphs and tables.

Currents are affected by the same moon/sun alignments as tides:

When the sun and moon are aligned (spring tide), currents will typically move faster than average.

When the sun and moon are not in alignment (neap tide), currents will typically move slower than average.

In what circumstances can this knowledge help you?



Time (LST/LDT)	Event	Speed (knots)
2018-03-30 01:06 AM	flood	2.38
2018-03-30 04:24 AM	slack	-
2018-03-30 08:18 AM	ebb	-2.90
2018-03-30 11:36 AM	slack	-
2018-03-30 02:36 PM	flood	2.66
2018-03-30 05:18 PM	slack	-
2018-03-30 08:18 PM	ebb	-3.11
2018-03-30 11:18 PM	slack	-
2018-03-31 01:42 AM	flood	2.66
2018-03-31 05:00 AM	slack	-
2018-03-31 08:54 AM	ebb	-3.11
2018-03-31 12:18 PM	slack	-
2018-03-31 03:24 PM	flood	2.64

SOURCES OF CURRENT INFORMATION

NOAA CURRENT PREDICTIONS

<https://tidesandcurrents.noaa.gov/noaacurrents/Regions>

THE TIDEBOOK COMPANY

<https://www.tidebookcompany.com/>

TIDE & CURRENT APPS & LINKS

Always make sure to check the correct dates and relevant current stations for your trip!

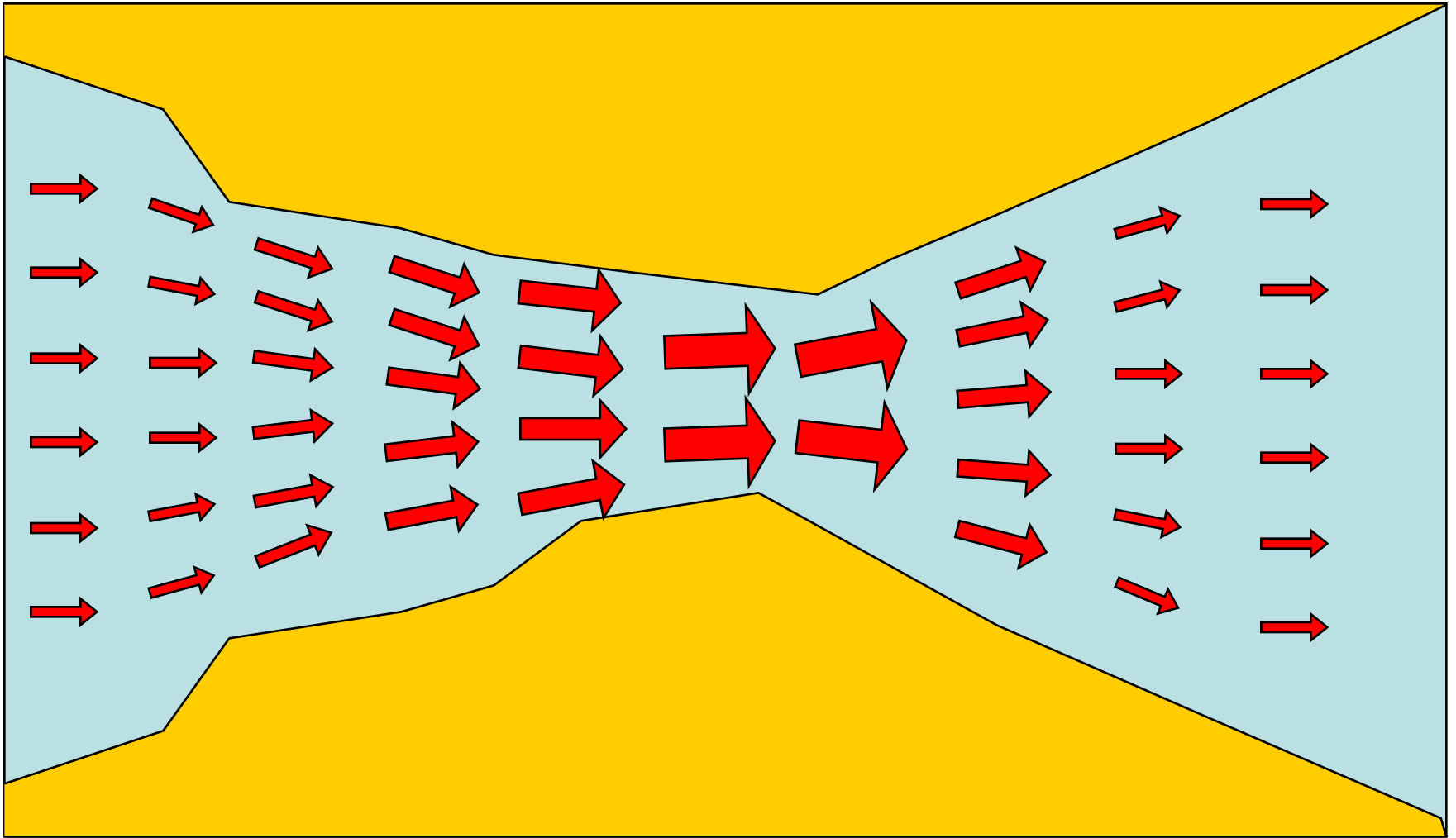
**CAUTION: tide and current tables DO NOT factor in effects of wind and weather!
Never depend on a single source of information when making travel decisions!!**



*Moving
Water
Dynamics*

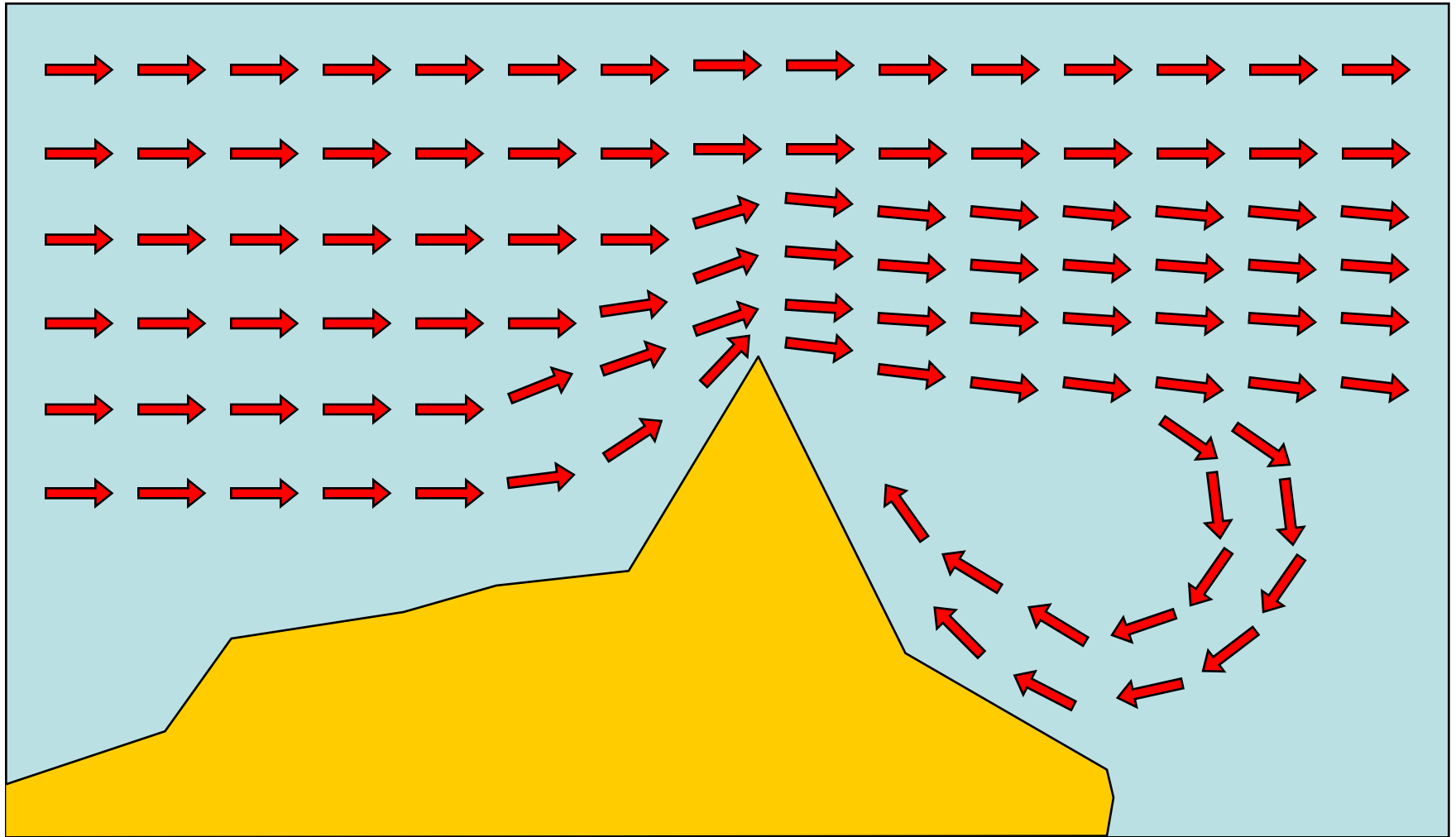
Water Dynamics

Swift currents



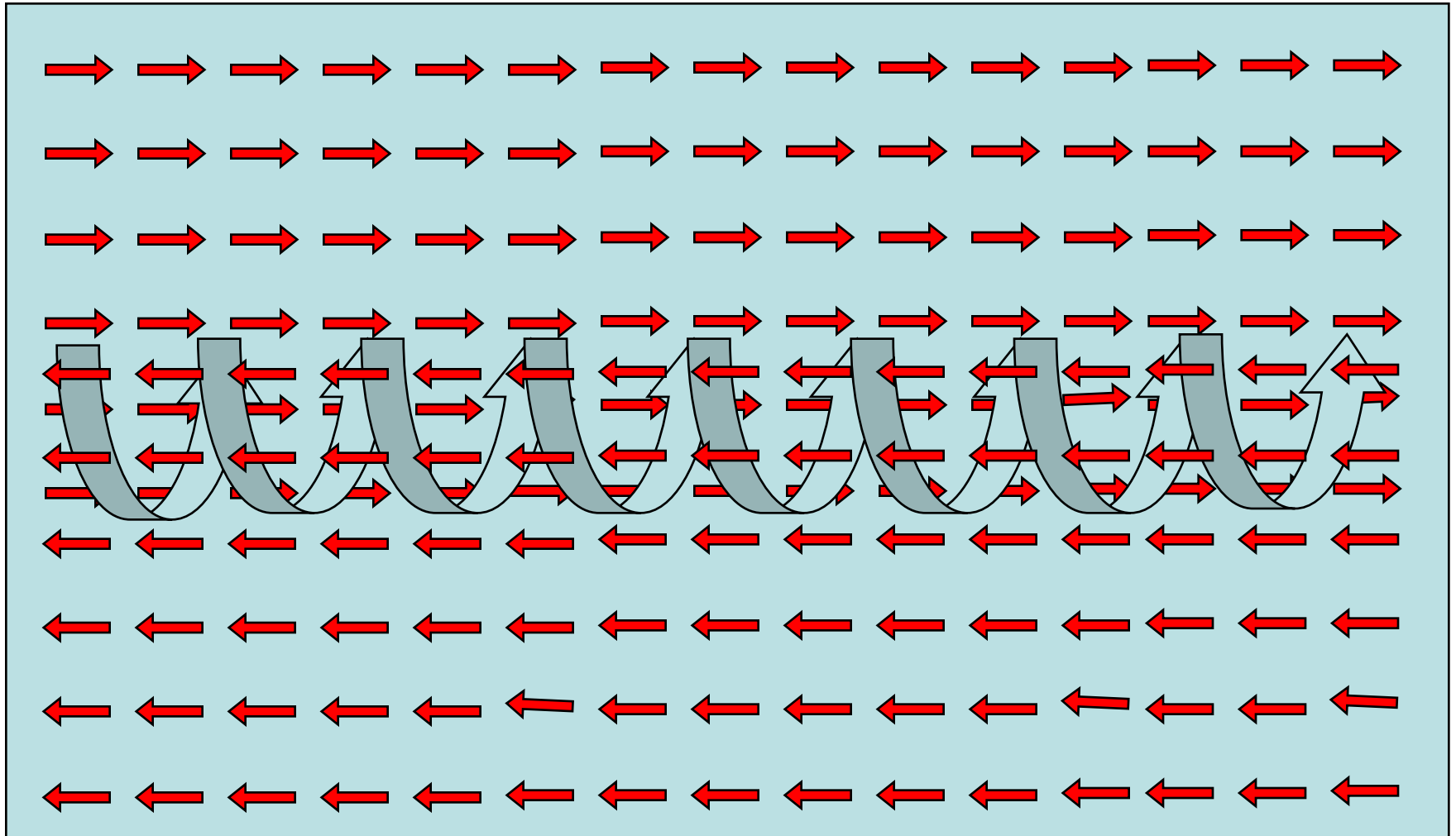
Water Dynamics

Back Eddys



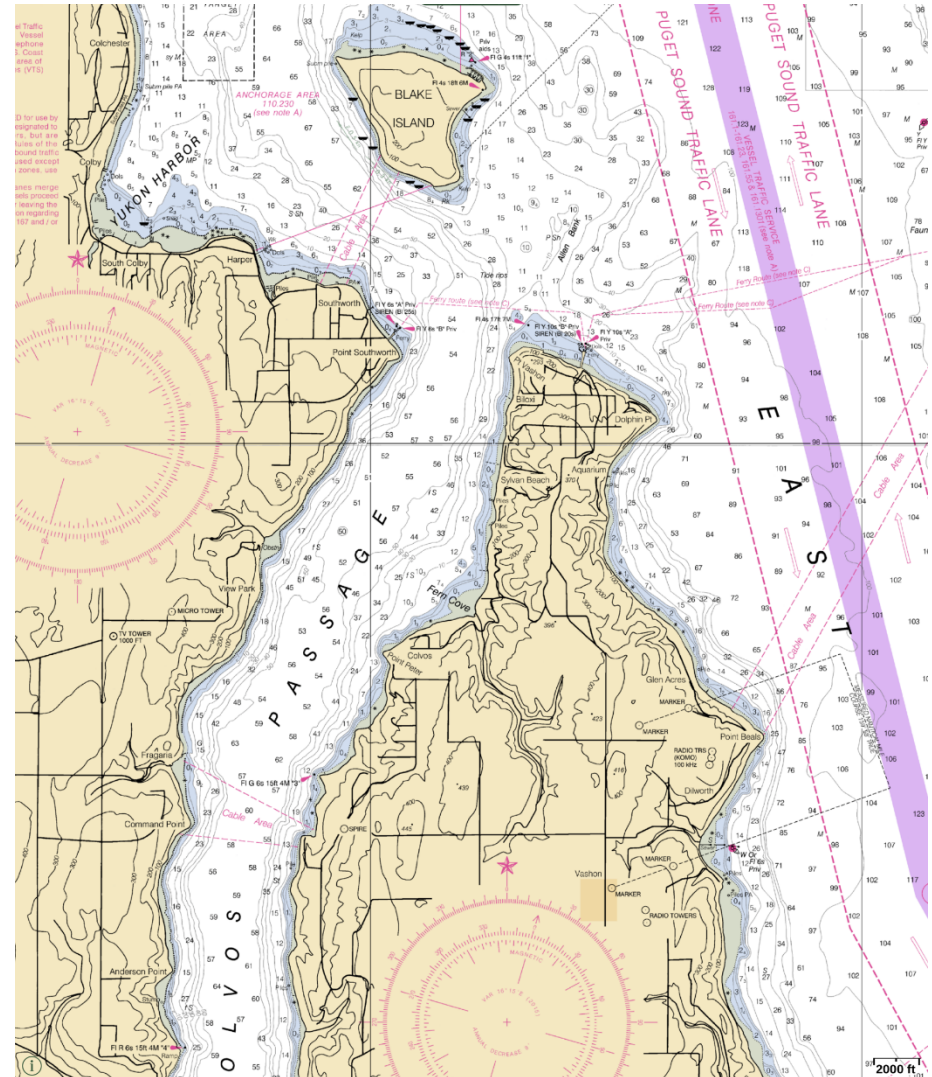
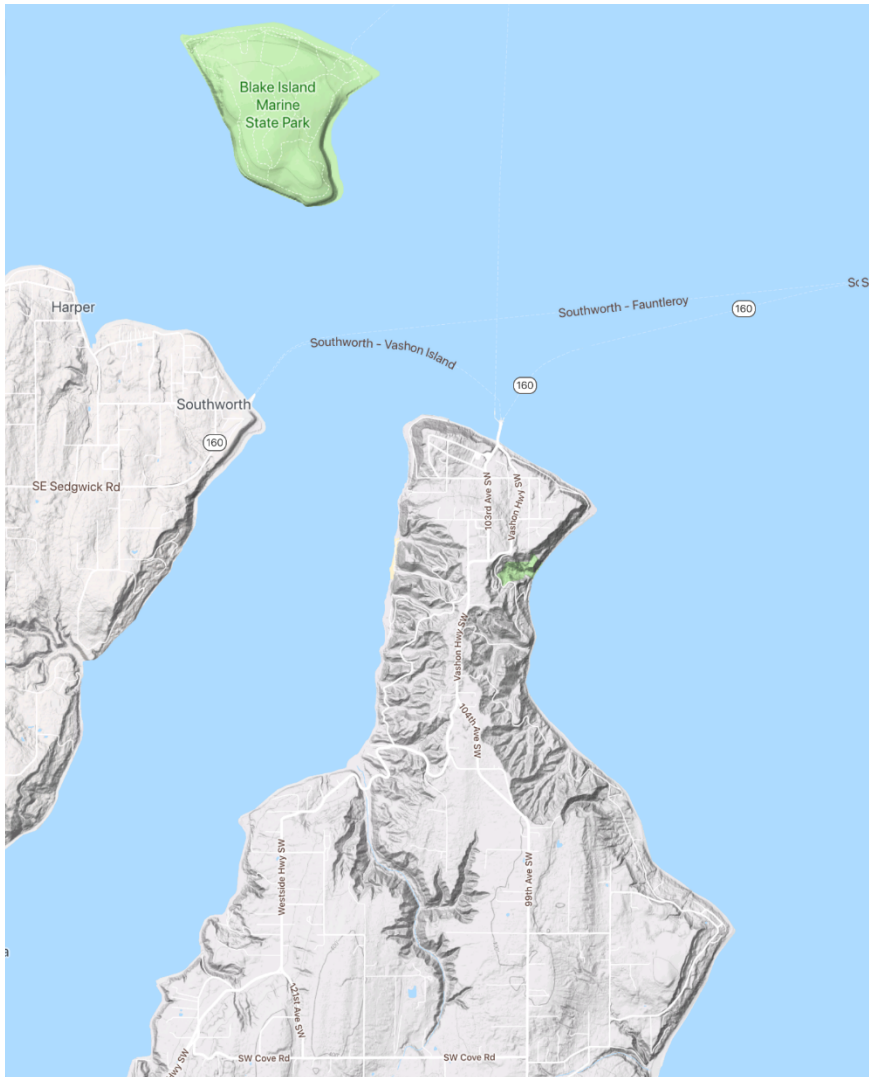
Water Dynamics

Tide Rips



Introduction to Charts

Charts vs. Maps ... What's the difference?



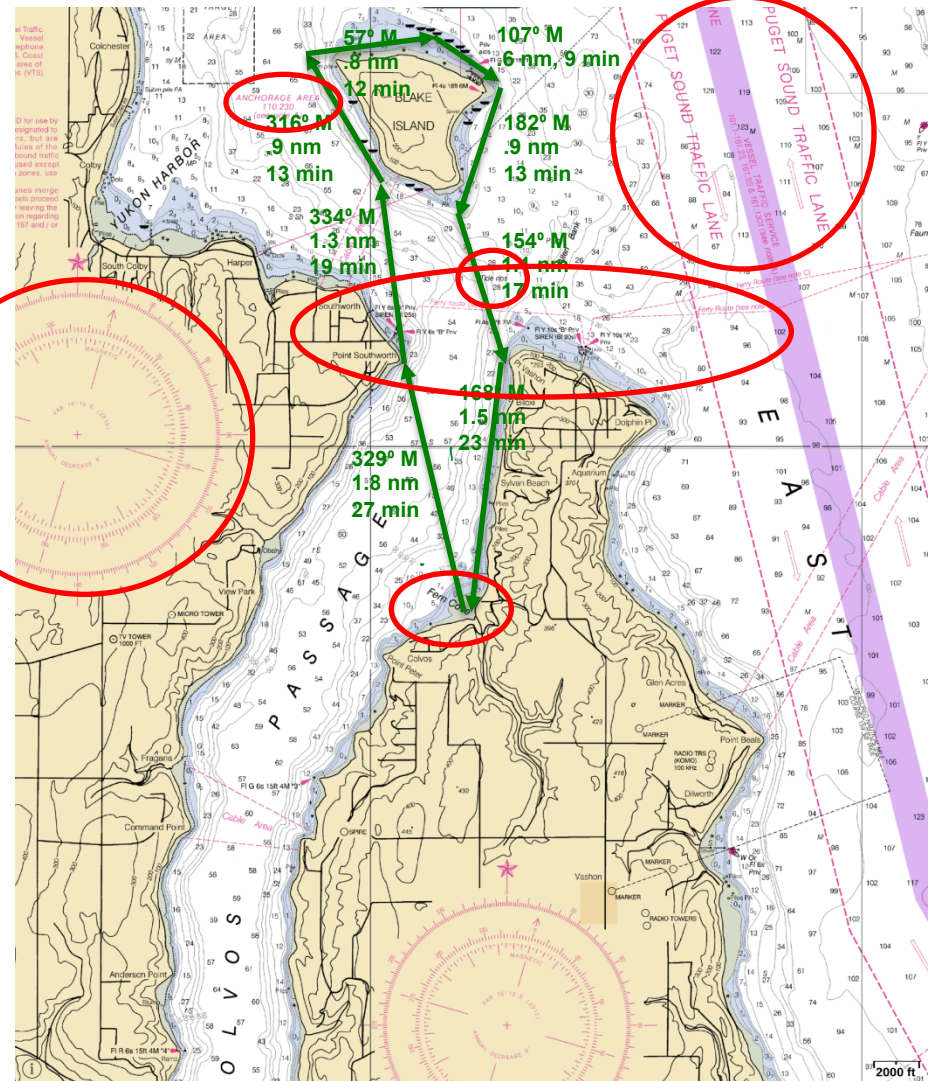
Charts

Charts vs. Maps ... What's the difference?

Charts

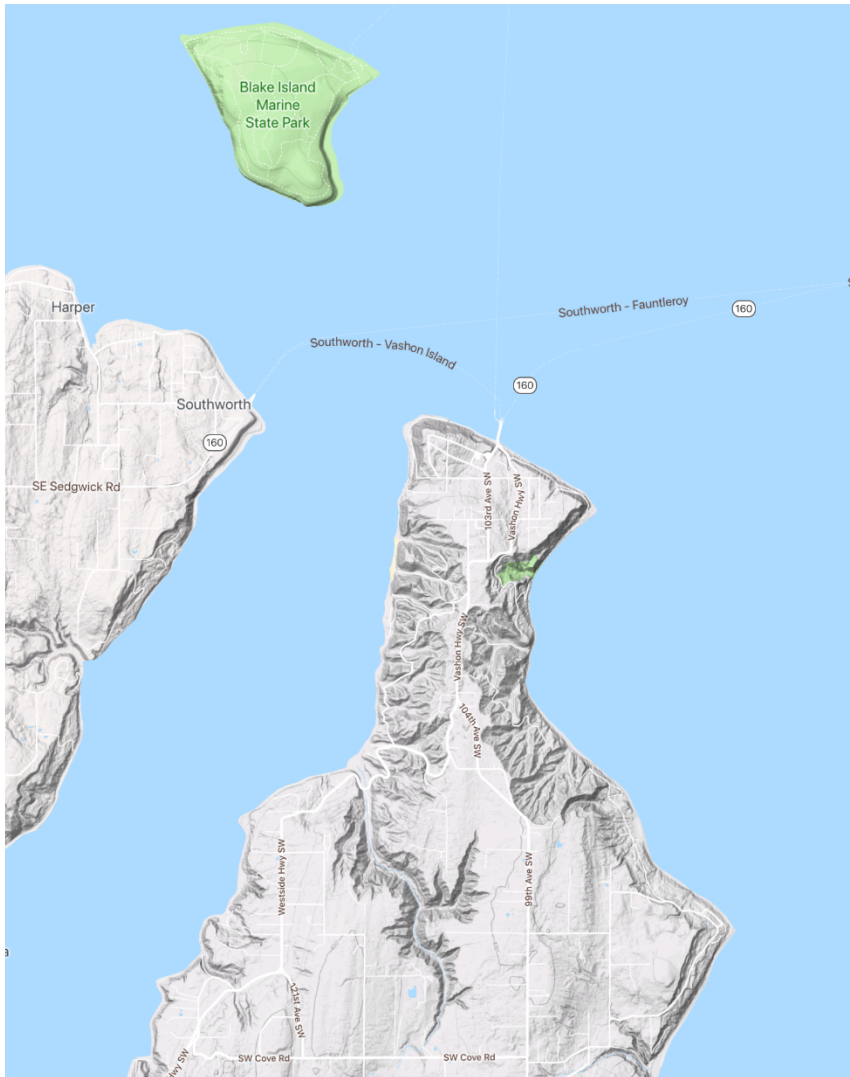
Have special unique characteristics including a very detailed and accurate representation of the coastline, which takes into account varying tidal levels and water forms, critical to a navigator.

- Working document used to plot courses for navigators.
- Way points are identified to indicate relative position and points at which specific maneuvers, such as changing courses, must be performed.
- Takes into account special conditions and risks such tide rips; submerged rocks, wrecks and other hazards; aids to navigation; restricted areas; vessel traffic management systems; natural and artificial features on land visible from the water.



Charts

Charts vs. Maps ... What's the difference?



Maps

Emphasize land forms, including the representation of relief, with shoreline represented as an approximate delineation usually at mean sea level.

- Static document used as a reference guide; can not be used to plot a course.
- Provides a predetermined course, usually a road, path, etc., to be followed. Special consideration for the type of vehicle is rarely a consideration.
- Provide predetermined points-road intersections-to allow one a choice to change to another predetermined direction.

Charts

What do I need to know about nautical charts?

- Scale
- Features
- Soundings
- Latitude & Longitude
- Chart date & update info

Charts: Scale

Scale: an expressed **ratio of the size of a feature on the chart to the actual size of the feature**

Example

1 : 10,000 scale

1 inch on the chart = 10,000 inches in real life

Charts: Scale

LARGE scale vs. small scale

The terms large and small scale refer to the fraction !

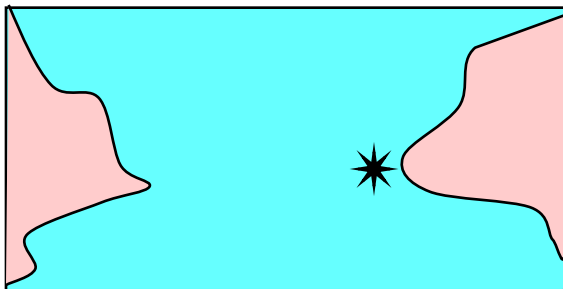
Example

$$\frac{1}{1} \quad \gg \quad \frac{1}{10,000} \quad \gg \quad \frac{1}{40,000} \quad \gg \quad \frac{1}{80,000}$$

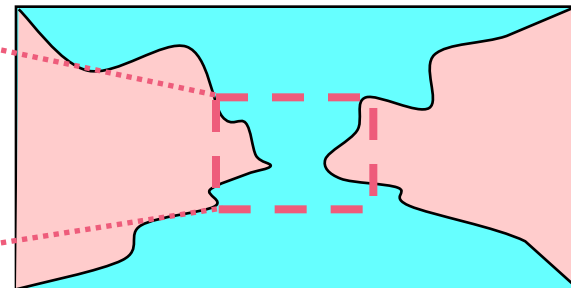
Bottom line:

A given feature will appear bigger on a large scale chart than on a small scale chart

**Large Scale Maps
Show More Detail**



**Small Scale Maps
Show More Area**

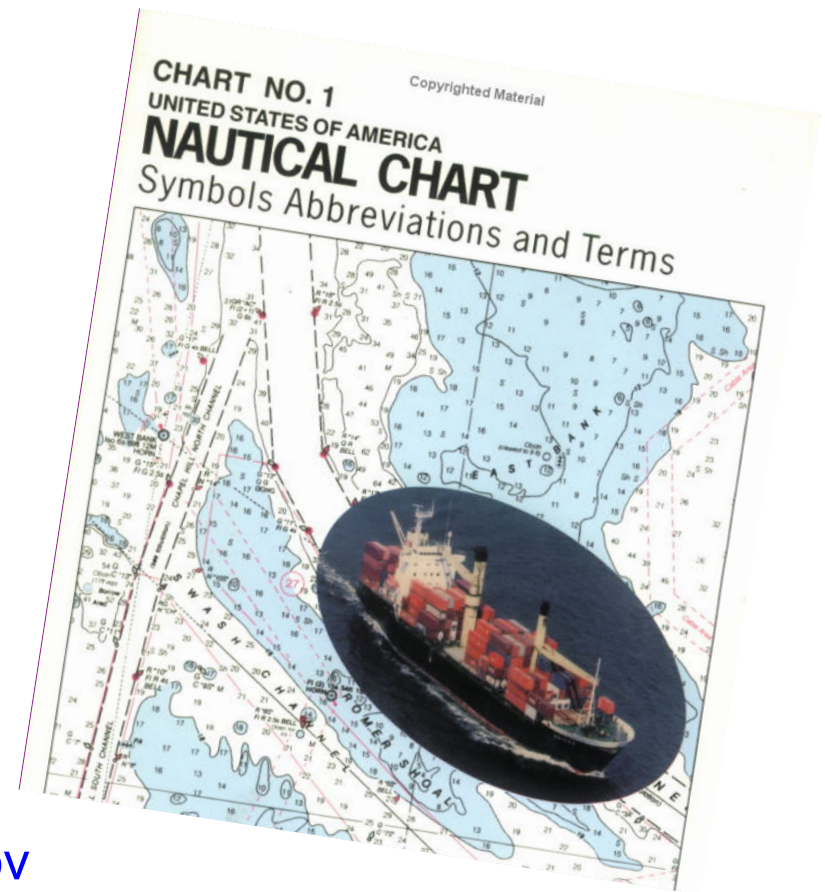


Charts: Features

Chart No. 1

Chart No. 1 is not really a chart at all. It is a manual over 100 pages containing the meaning of all the symbols nautical charts. These include:

- Natural and cultural features
- Landmarks and ports
- Hydrology features
- Aids and services
- Hazards to navigation
- Safety notices
- <https://www.nauticalcharts.noaa.gov/mcd/chartno1.htm>



**Printed version
now \$14.95 at
[Amazon.com](https://www.amazon.com)**

Section Key

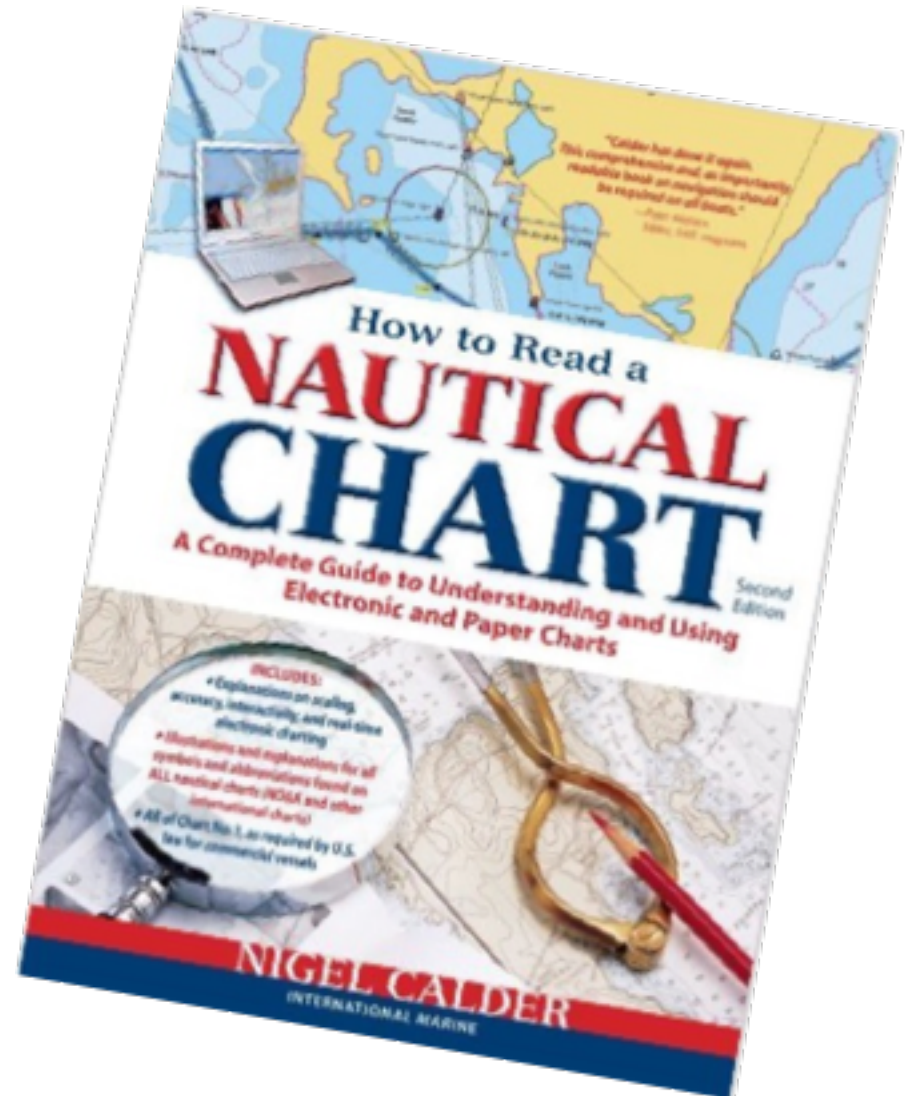
A		Chart Number, Title and Marginal Notes	INT 500 412	Mercator Projection Scale 1:100,000 at Lat. 59°30'	7th Ed., Mar. 5/09	DEPTHS IN METERS
B		Positions, Distances, Directions and Compass		$\pm 15^\circ$	Magnetic Variation 4°30' W 2011 (8°E)	LOCAL MAGNETIC ANOMALY (see note)
C		Natural Features				
D		Cultural Features				
E		Landmarks				
F		Ports				
H		Tides and Currents				
I		Depths				
J		Nature of the Seabed				
K		Rocks, Wrecks and Obstructions				
L		Offshore Installations				
M		Tracks and Routes				
N		Areas and Limits				
P		Lights'				
Q		Buoys and Beacons				
R		Fog Signals'				
S		Radar, Radio and Satellite Navigation Systems				
T		Services				
U		Small Craft (Leisure) Facilities				

Charts: Features

Chart No. 1 Alternative

Contains all the information as in Chart No. 1 published by the government, but adds much more such as:

- The history of chart making
- Chart accuracy
- GPS and Electronic charts
- More detailed explanations of the symbols



Currently \$13.98 at
[Amazon.com](https://www.amazon.com)

Charts: Features

Some general notes...

Coloring

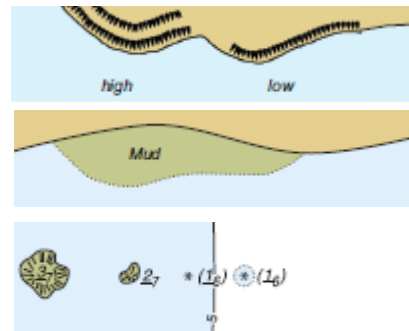
- Tan → Land masses
- Greenish → Mud at low tide
- Blue → Water, depth down to 60 feet
- White → Water, depth deeper than 60 feet

Italicized lettering → object is subject to tidal changes

Standard lettering → Object is fixed

Natural features

- Cliffs →
- Foreshore/
mudflats →
- Rocks →



Charts: Soundings

Soundings are depth measures at specific points as indicated on the chart. The number given is the measure as it would be at the published low water datum for the chart (usually mean low low water [MLLW] for NOAA charts).

The unit represented by the number is in the chart notes. It is one of the following:

- Meters
- Feet
- Fathoms (units of 6 feet)

Key point to remember about soundings is that they are all relative to a particular low water datum, also known as the ***Chart Datum*** or ***Sounding Datum***.

Always check your chart notes for the sounding datum and determine if the water is ever likely to be less than what is shown, and if so **WHEN!**

Mercator Projection
Scale 1:25,000 at Lat. 48°26'
North American Datum of 1983
(World Geodetic System 1984)

SOUNDINGS IN FATHOMS
AT MEAN LOWER LOW WATER

SUPPLEMENTAL INFORMATION
Consult U.S. Coast Pilot 7 for important
supplemental information.

TIDAL INFORMATION

Place		Height referred to datum of soundings (MLLW)			
Name	(LAT/LONG)	Mean Higher High Water	Mean High Water	Mean Low Water	Extreme Low Water
Yokoko Point Deception Pass		feet	feet	feet	feet
(48°25'N/122°37'W)		10.5	9.5	2.6	-4.5
Deception Pass St. Park, Bowman Bay		7.7	7.0	2.5	-4.0
(48°25'N/122°40'W)					
Anacortes, Guemes Channel		8.2	7.4	2.6	-4.5
(48°31'N/122°37'W)					
Swinomish Channel Ent., Padilla Bay		8.4	7.7	2.6	-4.5
(48°28'N/122°31'W)					

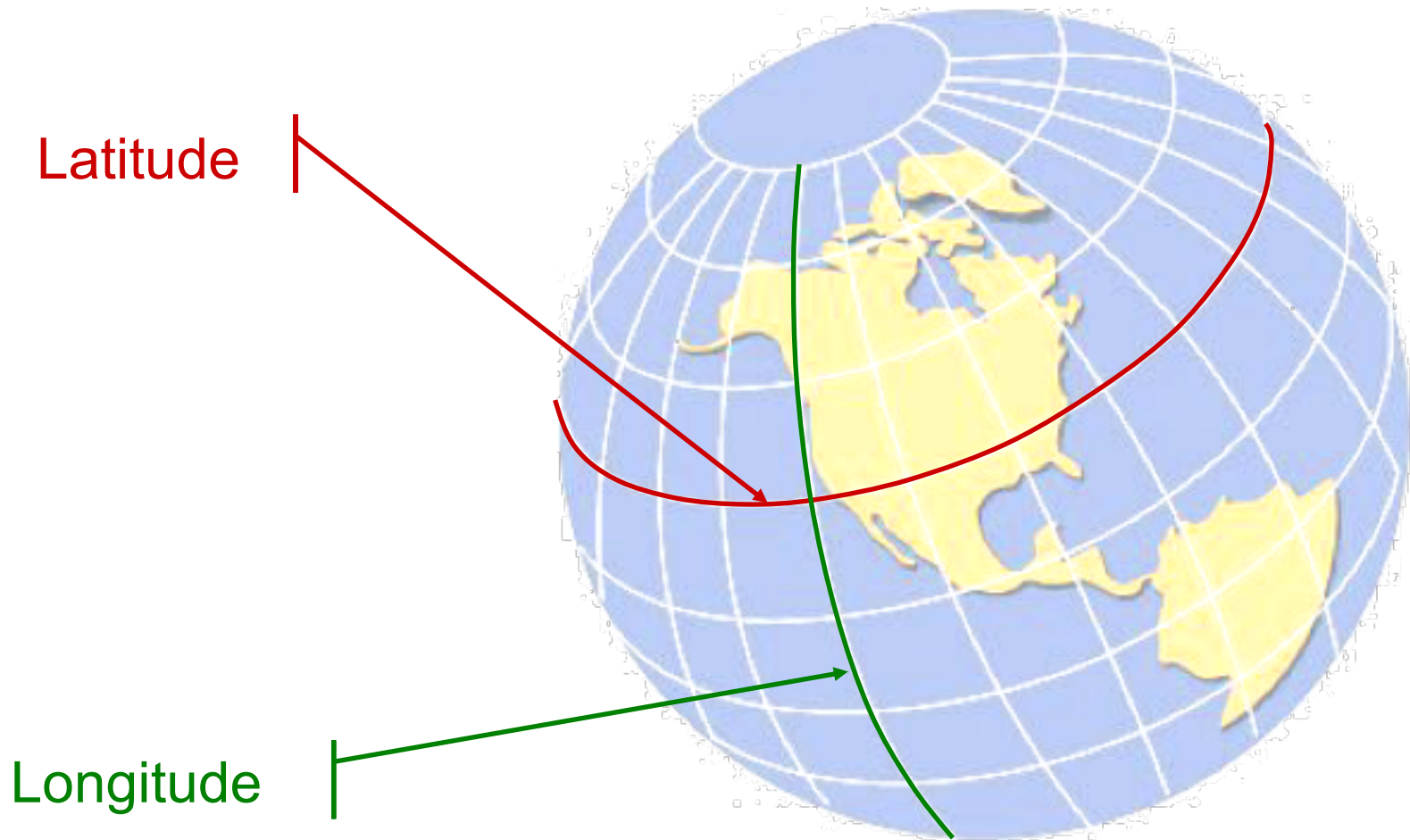
(100)

39'

38'

37'

Charts: Latitude & Longitude



Charts: Latitude & Longitude

Latitude

180°

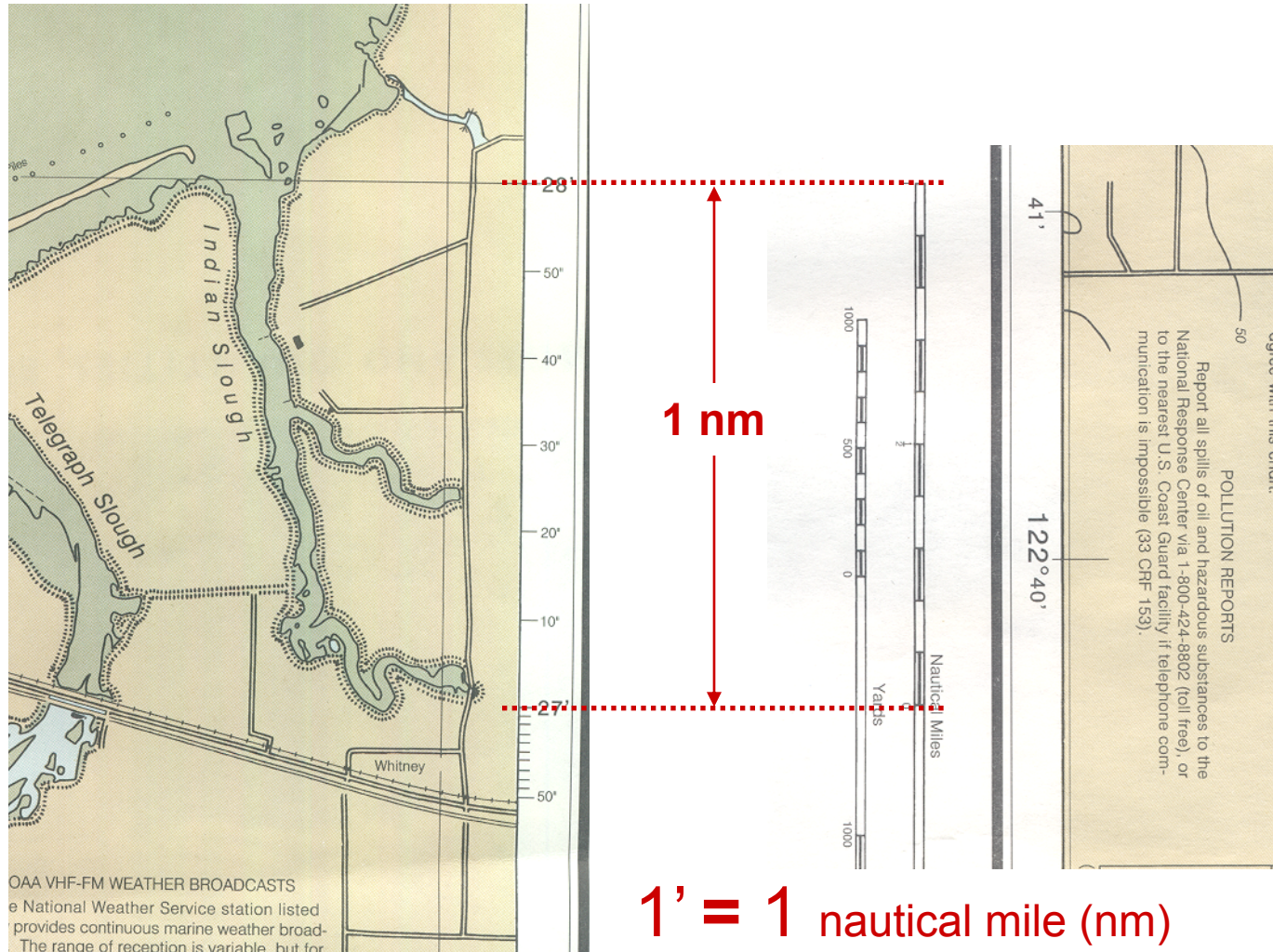
From pole to pole



1° = 60' (minutes)

1' = 1 nautical mile (nm)

Charts: Latitude



1' = 1 nautical mile (nm)

1 nm = 1.15 statute miles

Charts: Latitude & Longitude



Because longitude is measured laterally (east to west), degrees of longitude must not be used for measuring distance.

Why?



Charts: Date and Updates

Find charts at <http://www.charts.noaa.gov/InteractiveCatalog/nrnc.shtml>

Make sure your charts are up-to-date!

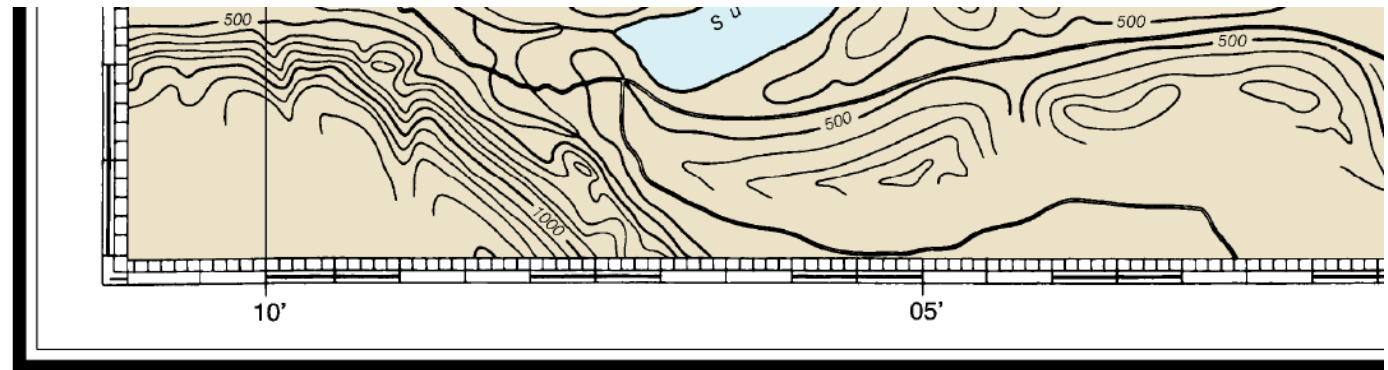


Chart #

18448

**Chart
Edition,
Date and
corrections
info**

36th Ed., Dec. 2015. Last Correction: 3/15/2018. Cleared through:
LNM: 1218 (3/20/2018), NM: 1318 (3/31/2018), CHS: 0218 (2/23/2018)

CAUTION

This chart has been corrected from the Notice to Mariners (NM) published weekly by the National Geospatial-Intelligence Agency and the Local Notice to Mariners (LNM) issued periodically by each U.S. Coast Guard district to the dates shown in the lower left hand corner. Chart updates corrected from Notice to Mariners published after the dates shown in the lower left hand corner are available at nauticalcharts.noaa.gov.

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about this cha

Check the U.S. Coast Guard's Navigation Center for more information on Notice to Mariners, Local Notice to Mariners, Coastal Pilot, and other update information.

<https://www.navcen.uscg.gov/>



Group Exercise

Plot a Course Using a Chart

Objectives:

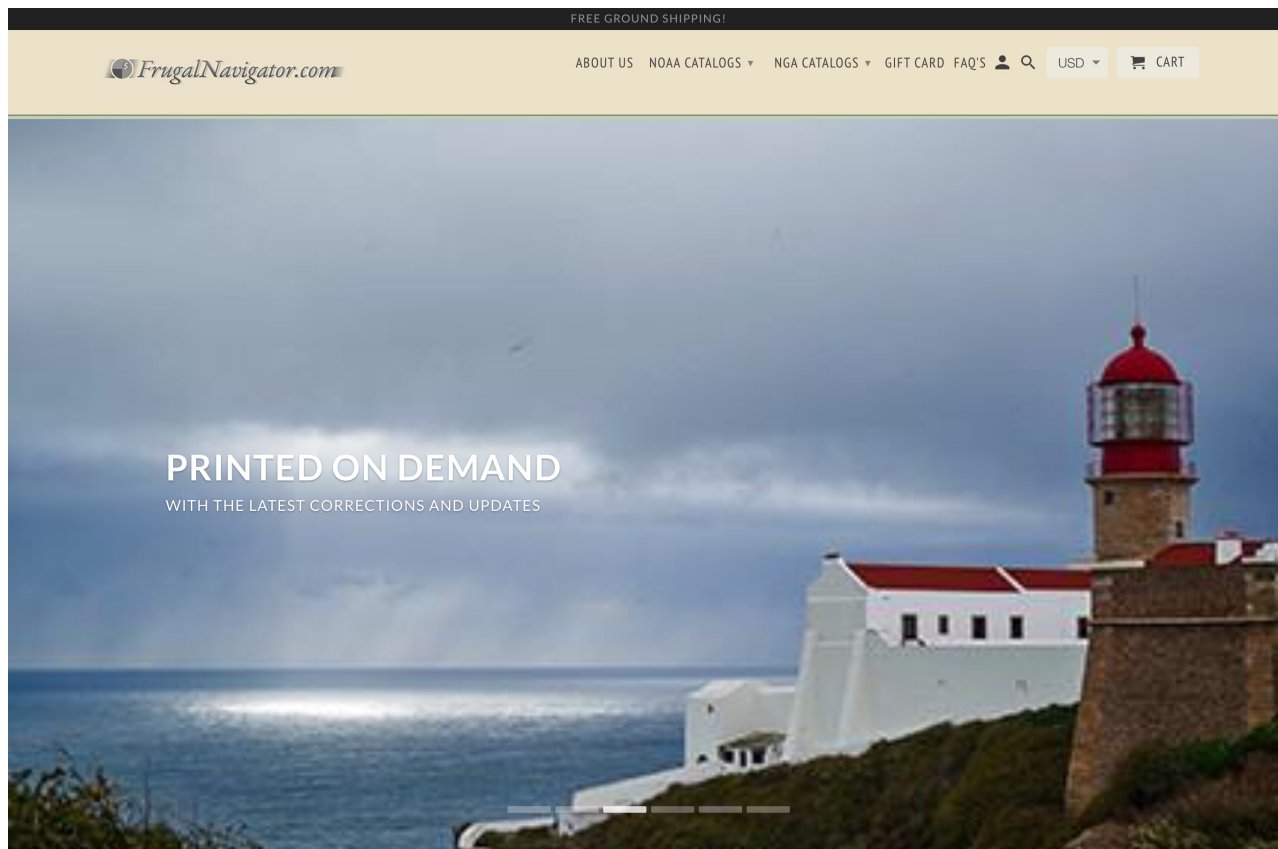
- Identify important chart details and symbols along your planned course.
- Determine when and where tide and current might affect the trip.
- Identify areas where long fetch could be an issue and when.
- Plot waypoints and draw course legs.
- Determine compass readings (magnetic) for each leg.
- Determine distances traveled for each leg.
- Determine travel time for each leg.
- Estimate total trip time, including breaks.

What else should you know or do when planning this trip?

- ✓ Complete tide and current information for the date and locations planned
- ✓ Determine trip length, trip duration, launch time, and approximate ending time
- ✓ Latest NOAA marine weather and wind area and zone forecasts for the area
- ✓ Ability of participants to handle potentially challenging conditions and a long trip
- ✓ Alternate take-out options should conditions warrant.

Many thanks to Frugal Navigator for the donation of the Small Craft charts used in tonight's class!

www.frugalnavigator.com



Group Exercise

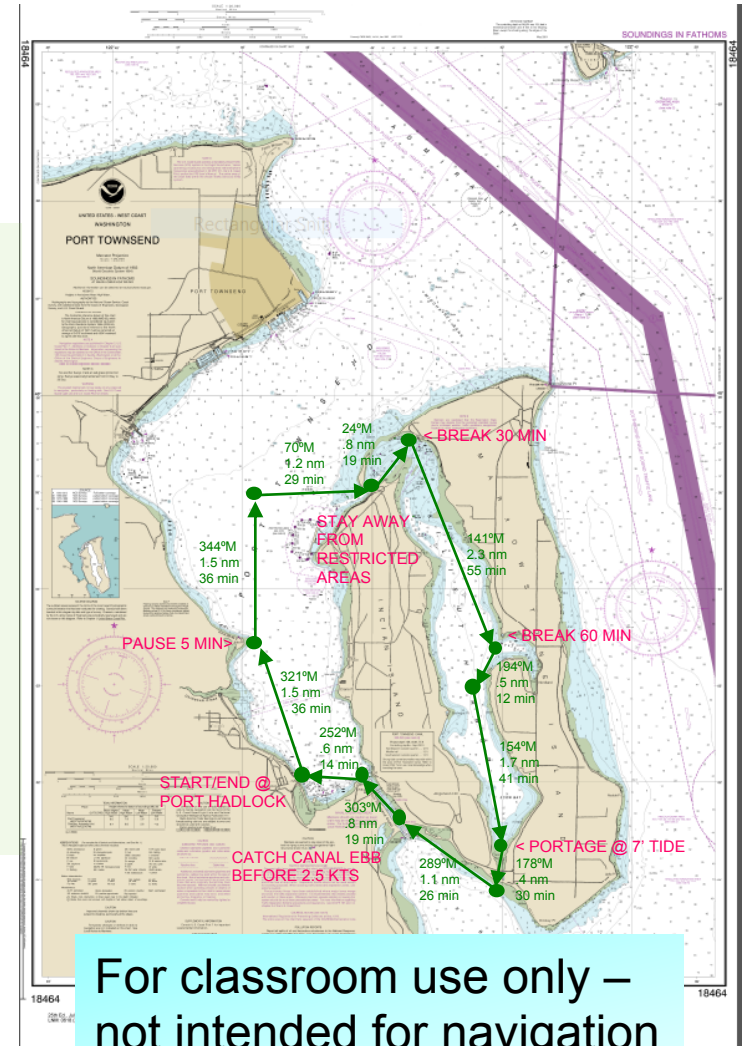
Plot a Course Using a Chart

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Plot a clockwise trip around Indian Island for 8/28/2016: Trip rating SK III/III+, challenging due to distance, fetch, current in excess of 2 kts, portage, boat traffic.

- 1) Assume sunny 70°F weather with 3-5kt winds from the south increasing to 8-10 kts after 2pm. Average group paddling speed 2.5 kts. On this day the tide is estimated to be at about 7 feet at Mystery Bay at 2:45pm and the current in the Port Townsend Canal is estimated to be ebbing northward at about 2.5 kts by 4:00pm, toward a maximum of about 3 kts by 5:30pm.
- 2) Put-in and take-out at Port Hadlock.
- 3) Five minute rest stop off Dana Point.
- 4) Stay well away from the restricted area at Walan Point and other Navy facilities.
- 5) Thirty minute rest break at Fort Flagler boat launch.
- 6) Sixty minute lunch break at Mystery Bay State Park boat ramp.
- 7) Thirty minute rest break and portage at the isthmus between Indian and Marrowstone Islands at the 7 foot tide.
- 8) Paddle Port Townsend Canal before the current reaches 2.5 kt.
- 9) Mark waypoints in pencil on the chart.
- 10) Draw trip legs connecting waypoints then write down direction, distance, and time next to each leg. Assuming 2.5 kts paddling speed and magnetic variation 16° E..
Travel time (minutes) = Distance (nm) / speed (knots) x 60



What else should you know or do when planning this trip?

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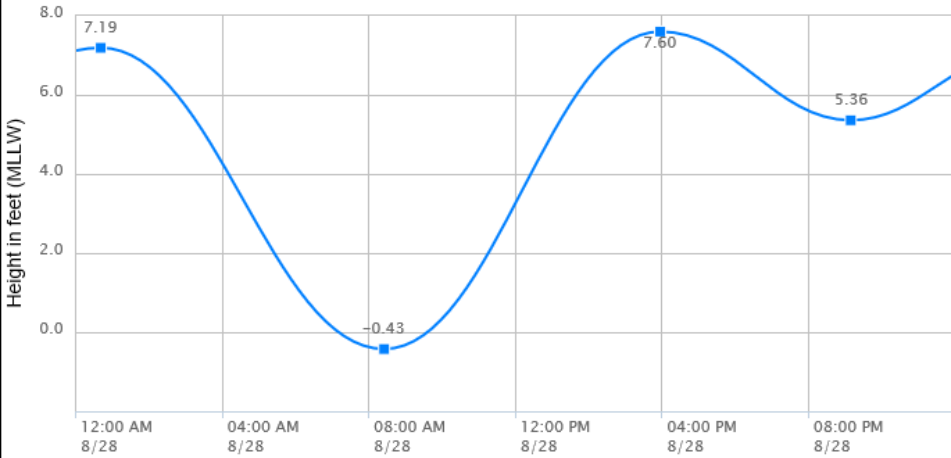
For classroom use only –
not intended for navigation

NOAA/NOS/CO-OPS

Tide Predictions at 9444971, Mystery Bay, Marrowstone Island WA

From 2016/08/28 12:00 AM LST/LDT to 2016/08/29 11:59 PM LST/LDT

Subordinate Station | Ref. Station (Port Townsend 9444900) | Time offsets (high: 15 min. low: 52 min.) | Height offsets (high: *0.95 ft. low: *0.99 ft.)



Data Listing

[Web Services](#)
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Date	Day of the Week	Time (LST/LDT)	Predicted (ft)	High/Low
2016/08/28	Sun	12:40 AM	7.19	H
2016/08/28	Sun	08:24 AM	-0.43	L
2016/08/28	Sun	3:56 PM	7.60	H
2016/08/28	Sun	9:08 PM	5.36	L

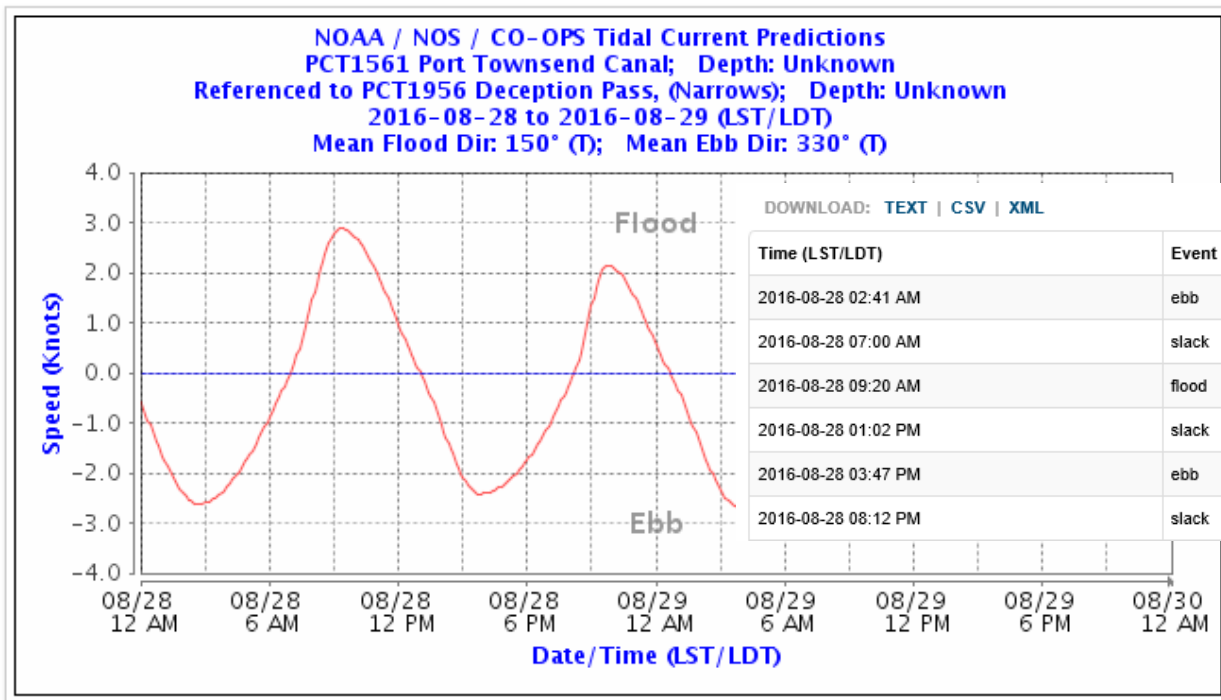
Port Townsend Canal (PCT1561)

LAT/LON: 48.0333° N 122.7333° W

Note: Depth source is unknown. Subordinate station: only max/slack predictions available.

Reference station: Deception Pass, (Narrows) (PCT1956).

For predictions of Subordinate stations, the solid red line depicts a curve fit between the flood, ebb and slack values and approximates the segments between.



DOWNLOAD: [TEXT](#) | [CSV](#) | [XML](#)

Time (LST/LDT)	Event	Speed (knots)
2016-08-28 02:41 AM	ebb	-2.62
2016-08-28 07:00 AM	slack	-
2016-08-28 09:20 AM	flood	2.88
2016-08-28 01:02 PM	slack	-
2016-08-28 03:47 PM	ebb	-2.42
2016-08-28 08:12 PM	slack	-

Disclaimer: These data are based upon the latest information available as of the date of your request, and may differ from the published tidal current tables.