

COMIC BOOK

FANTASTIC TIDAL DATUMS

An obscure physical oceanographer entombed
in the
Ocean (Tides) and Lake Levels Division
of the
Office of Ocean and Earth Sciences
of the
National Ocean Service
of the
National Oceanic and Atmospheric Administration
of the
U.S. Department of Commerce
"Department of Commerce?" "Yes, Commerce!"

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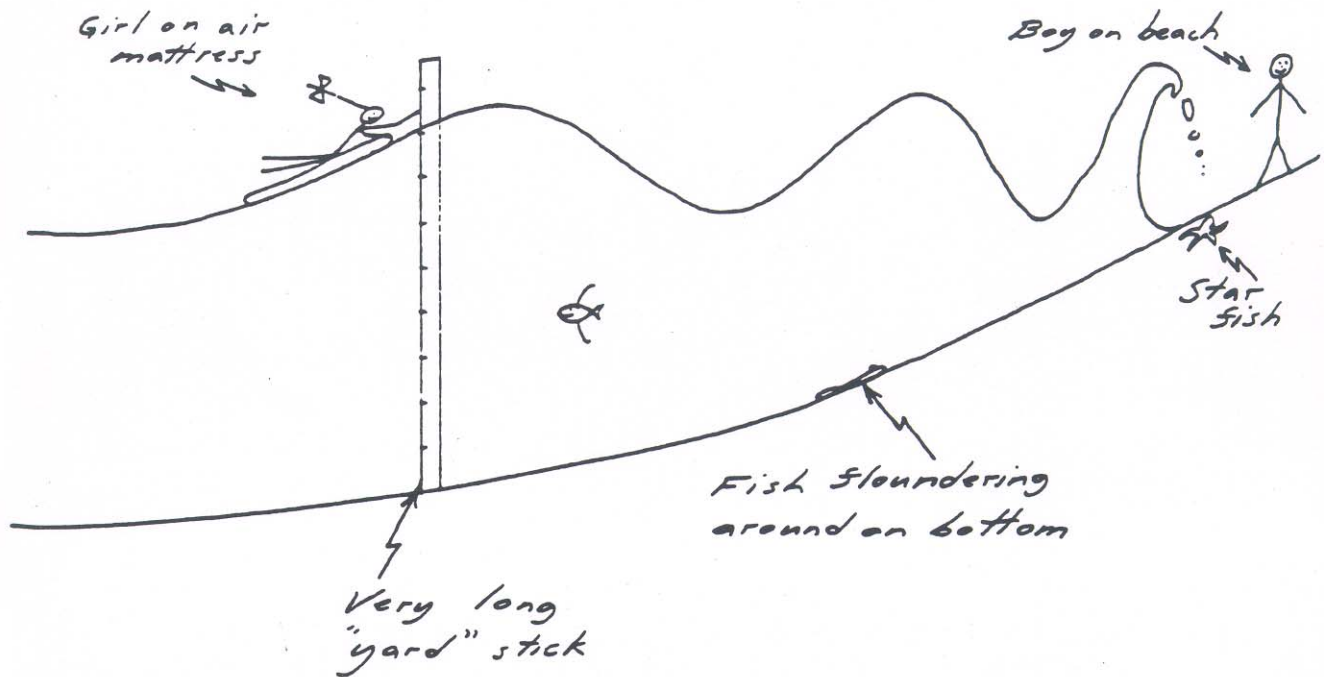
F O R E W O R D

Every mother should inform her offspring
that it is essential that they understand
tidal datums prior to their 15th birthday.
Otherwise, they will be a part of the population
that never understands tides and own
wealthy beachfront property.

Steacy Hicks

THE WATER KEEPS GOING UP AND DOWN. HOW WILL I TELL MY FRIENDS HOW DEEP IT WAS HERE?

AS THE WATER GOES UP AND DOWN, IT MOVES LANDWARD AND SEAWARD ON THIS SLOPING BEACH. WHERE DOES THE OCEAN REALLY END AND THE LAND REALLY BEGIN?



Send these kids with their smarty pants questions back to summer school in Kansas.

Who cares how deep it was
or where the ocean really ends?

This statement is sponsored by the International
American Society Against Tidal Datums (IASATD)

MARINERS NEED MAPS OF THE OCEAN AND ADJACENT LAND FOR NAVIGATION (CALLED NAUTICAL CHARTS). HYDROGRAPHERS MEASURE THE DEPTHS FOR THESE NAUTICAL CHARTS. THE DEPTH MEASUREMENTS ARE CALLED SOUNDINGS.

I CARE WHETHER THE WATER IS HIGH OR LOW OR IN BETWEEN. IF THE WATER IS HIGH (LIKE AT HIGH TIDE) THE SOUNDING WILL BE GREATER THAN WHEN THE WATER IS LOW (LIKE AT LOW TIDE).

SINCE I CAN ONLY PRINT ONE SOUNDING AT EACH LOCATION ON THE NAUTICAL CHART, SHOULD I PRINT IT FOR SOUNDINGS TAKEN AT HIGH WATER OR LOW WATER (OR SOMETIME IN BETWEEN)?

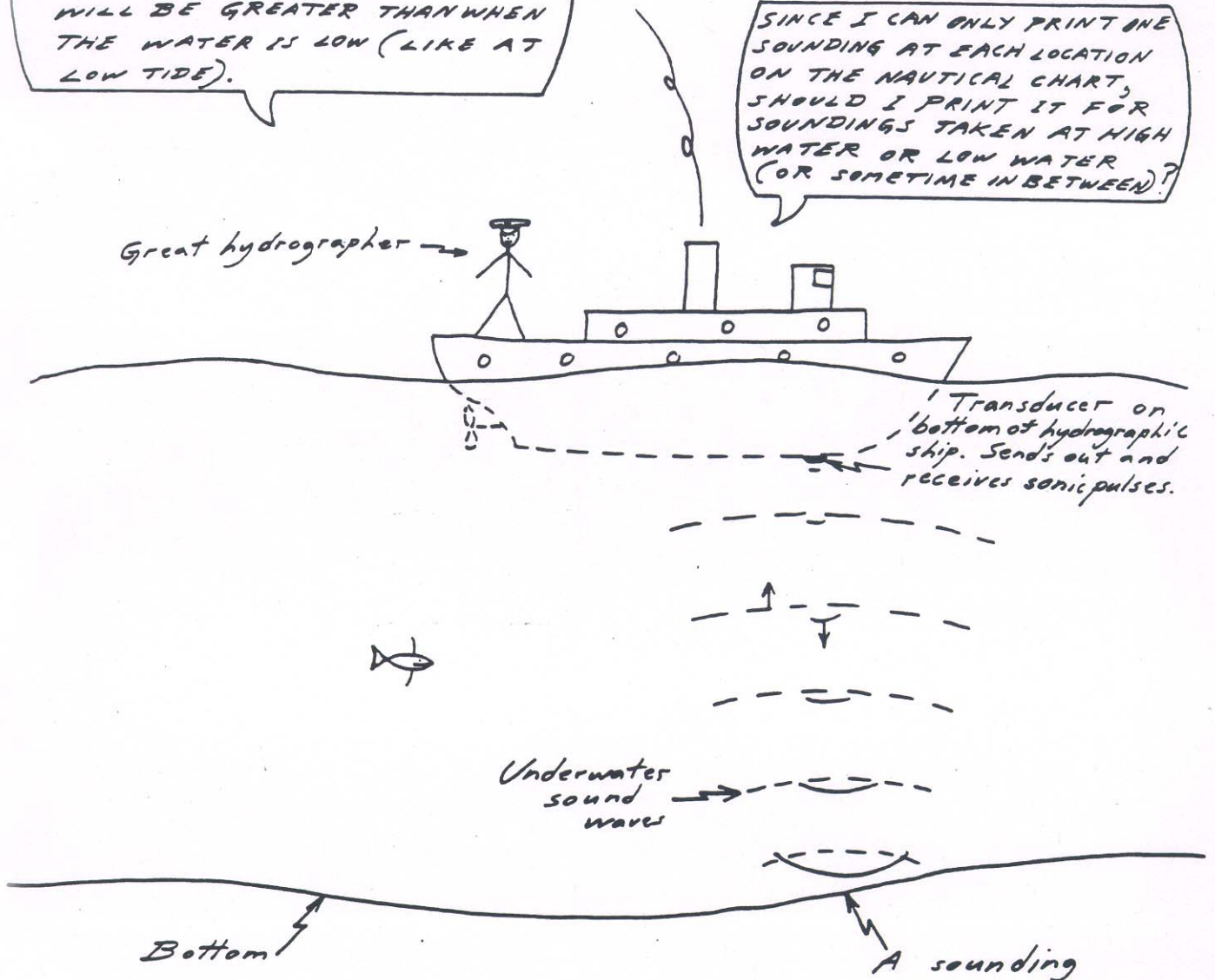
Great hydrographer →

Transducer on bottom of hydrographic ship. Sends out and receives sonic pulses.

Underwater sound waves →

Bottom

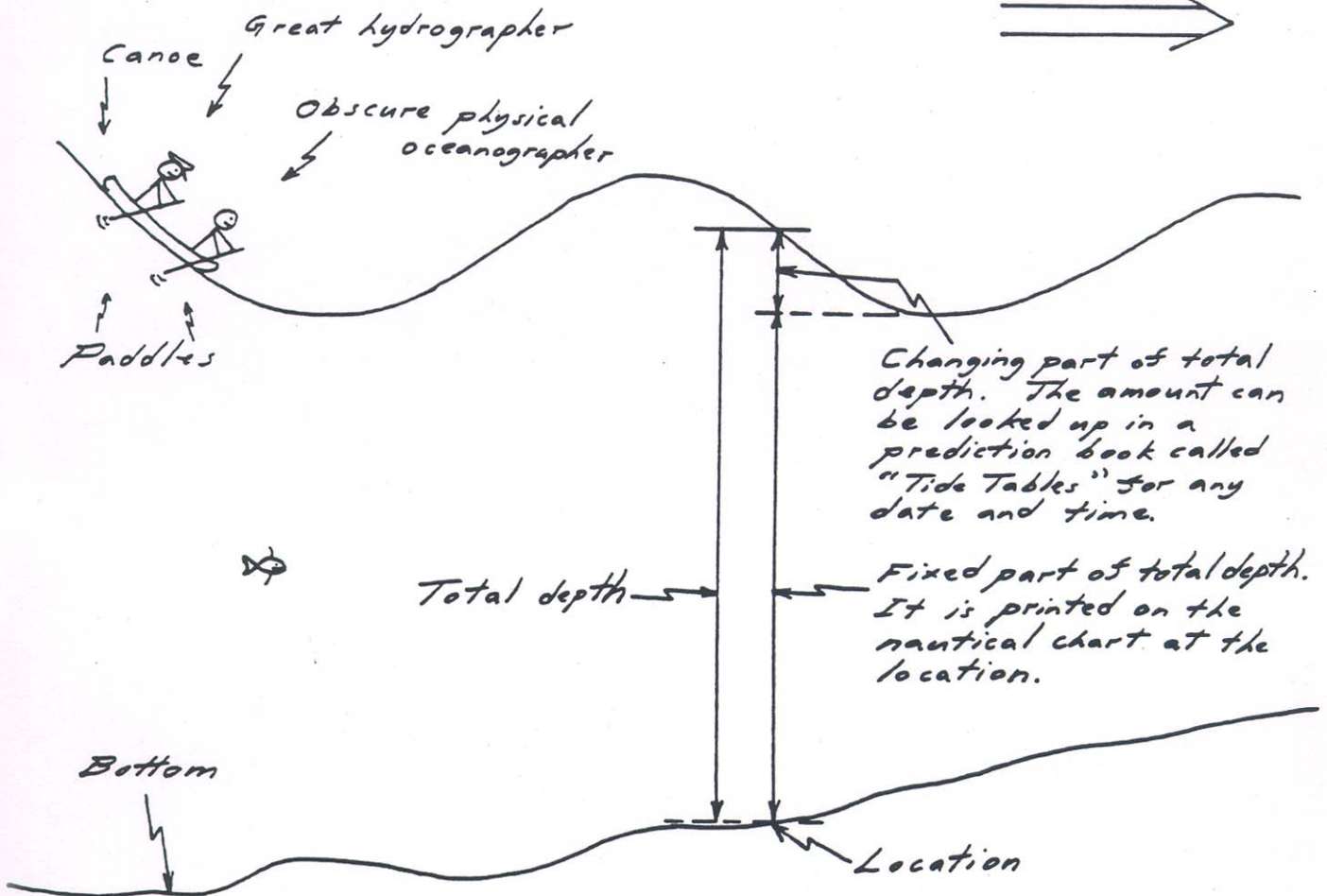
A sounding



I'VE GOT AN IDEA. LETS PRINT THE 'FIXED' PART OF THE TOTAL DEPTH ON THE NAUTICAL CHART. THEN, HAVE A SEPARATE BOOK THAT TELLS YOU HOW MUCH TO ADD FOR THE PREDICTABLE UP AND DOWN PART THAT DEPENDS ON DATE AND TIME (i.e., THE TIDE).

FANTASTIC * IDEA! I WISH I WERE SO CREATIVE.

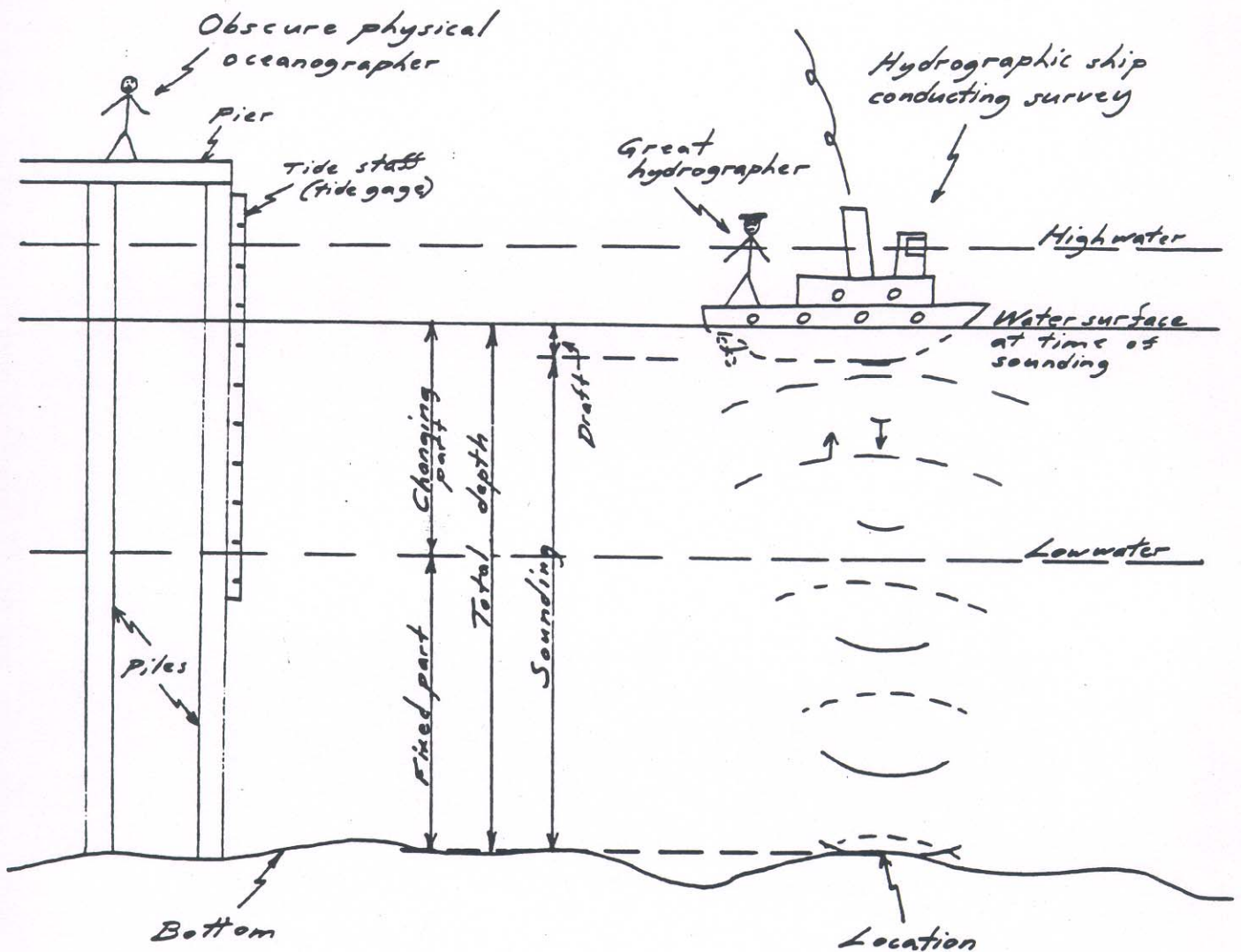
Direction of movement of tide wave as time goes on.



* From which the name of this comic book was derived

I'M MEASURING THE WATER HEIGHT IN THE VICINITY OF THE HYDROGRAPHIC SURVEY: 1.) SO I CAN PROVIDE THE AMOUNT OF THE CHANGING PART OF THE TOTAL DEPTH AT THE TIME OF EACH SOUNDING; AND 2.) SO I CAN GET ENOUGH HEIGHT DATA TO PREDICT THE TIDAL PORTION (MOST) OF THE CHANGING PART OF THE TOTAL DEPTH FOR ANY DATE AND TIME IN THE FUTURE. I'LL PRINT THEM IN THE TIDE TABLES.

SO NOW I'LL TAKE MY SOUNDING, ADD MY DRAFT, AND SUBTRACT YOUR CHANGING PART IN ORDER TO FIND THE FIXED PART. WHEN I GO HOME I'LL PRINT THE VALUE OF THE FIXED PART ON THE NAUTICAL CHART AT THE LOCATION.

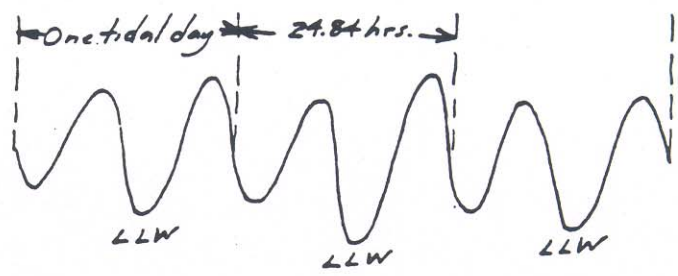


THIS IS ALL FINE, BUT WE'VE GOT ONE MAJOR PROBLEM LEFT. NAMELY, LOW WATER (WHERE THE FIXED PART BEGINS) IS NOT ALWAYS AT THE SAME HEIGHT.

HOW SO, PRAY TELL?

THE WATER GOES UP AND DOWN (PRIMARYLY DUE TO THE TIDE). IN MOST AREAS IT GOES UP AND DOWN TWO TIMES A DAY. BUT, THE LOW WATERS (AND HIGH WATERS TOO, FOR THAT MATTER) ARE SELDOM THE SAME HEIGHT WITHIN EACH DAY. ONE LOW WATER OF EACH DAY (ACTUALLY, TIDAL DAY - 24.84 HOURS LONG) IS USUALLY LOWER THAN THE OTHER. IT IS CALLED 'LOWER LOW WATER' (LLW).

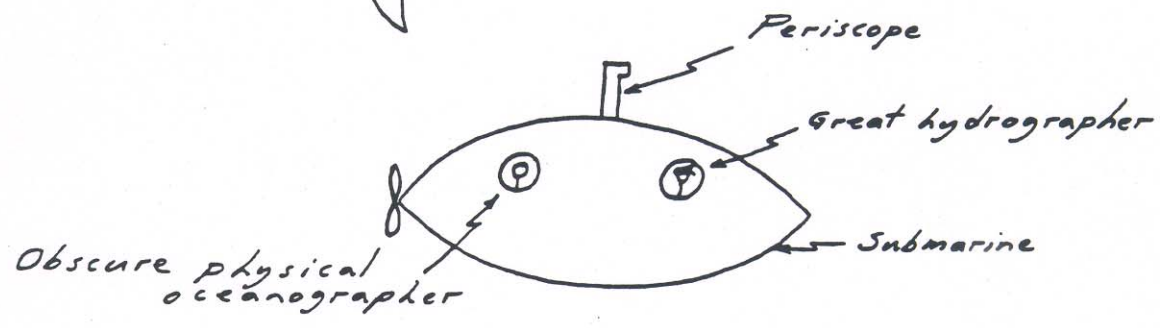
PROFOUND!



ALSO, YOU CAN SEE THAT THE LOWER LOW WATERS ARE NOT THE SAME, EVEN FROM TIDAL DAY TO TIDAL DAY.

THIS IS TERRIBLY INTERESTING.

YES, THANK YOU. I THOUGHT YOU'D BE ALL EARS. REST AWHILE, I'LL START IN AGAIN ON THE NEXT PAGE.

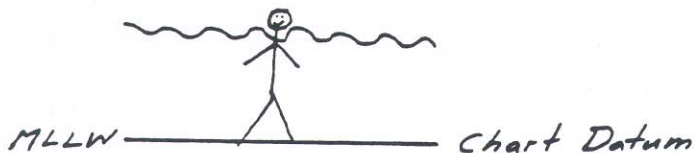


O.K., GO!

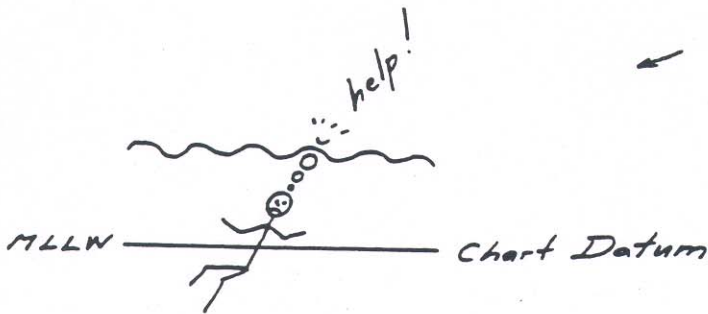
TO STANDARDIZE THE LOWER LIMIT OF THE CHANGING PART (AND THE TOP LIMIT OF THE FIXED PART), I WILL AVERAGE ALL THE LOWER LOW WATER HEIGHTS OVER A SPECIFIC 19-YEAR PERIOD OF OBSERVATIONS. I WILL CALL THIS STANDARD HEIGHT REFERENCE "THE TIDAL DATUM OF MEAN LOWER LOW WATER."

SO NOW I'LL 'REDUCE' MY SOUNDING, BY ADDING MY DRAFT AND SUBTRACTING YOUR HEIGHT OF THE CHANGING PART ABOVE THE TIDAL DATUM OF MEAN LOWER LOW WATER AT THE TIME OF THE SOUNDING. THIS REDUCED SOUNDING IS BELOW THE TIDAL DATUM OF MEAN LOWER LOW WATER AND IS THE SOUNDING VALUE I'LL PRINT ON THE NAUTICAL CHART AT THE LOCATION. BY THE WAY, I'M GOING TO CALL THE TIDAL DATUM USED IN HYDROGRAPHY AND NAUTICAL CHARTING, "CHART DATUM."

LOOK, MOM, I'M STANDING ON THE TIDAL DATUM OF MEAN LOWER LOW WATER (CHART DATUM).



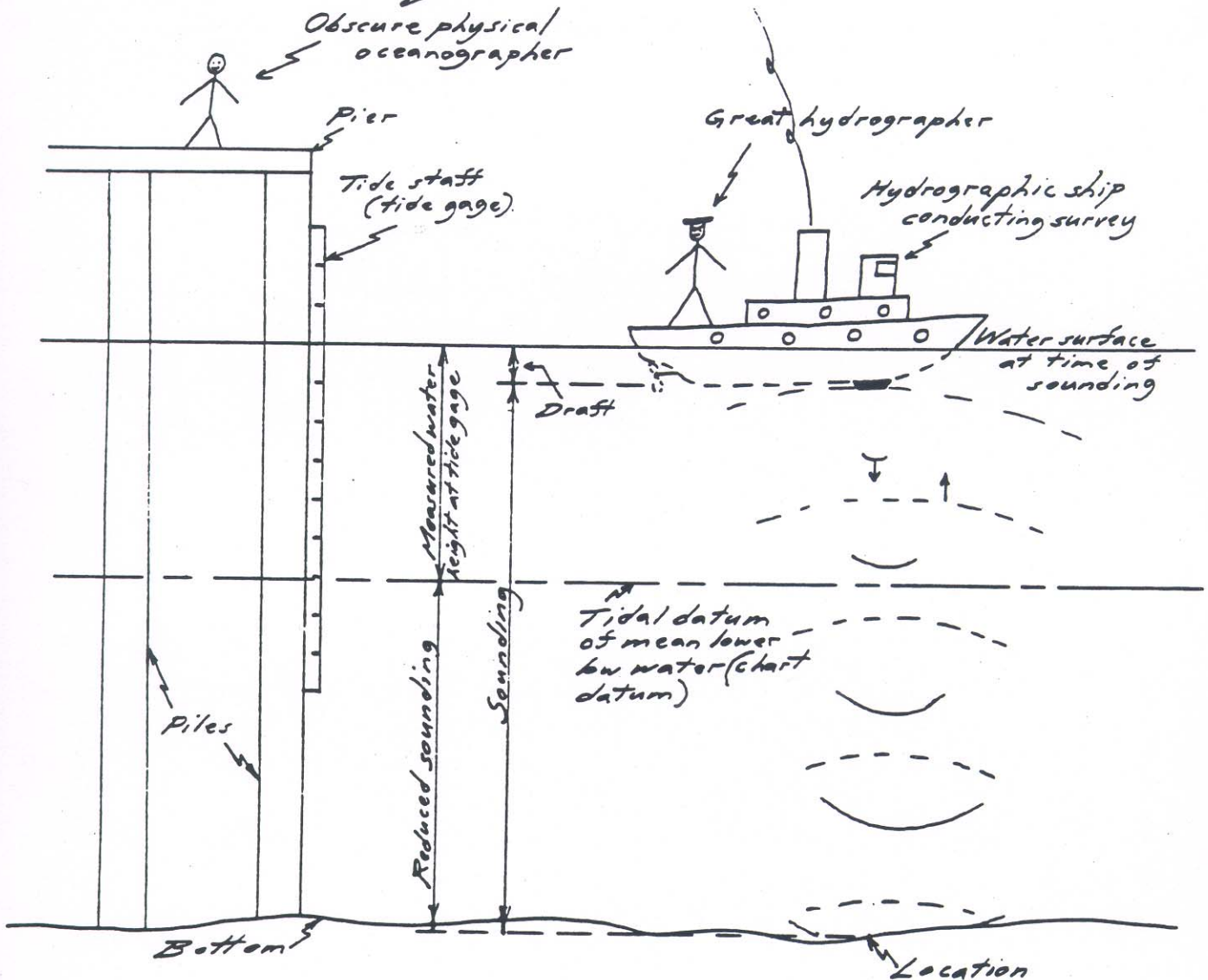
YOU JERK, YOU JUST GOT THROUGH EXPLAINING THAT A TIDAL DATUM IS MERELY A DERIVED AVERAGE VALUE OF WATER HEIGHT.



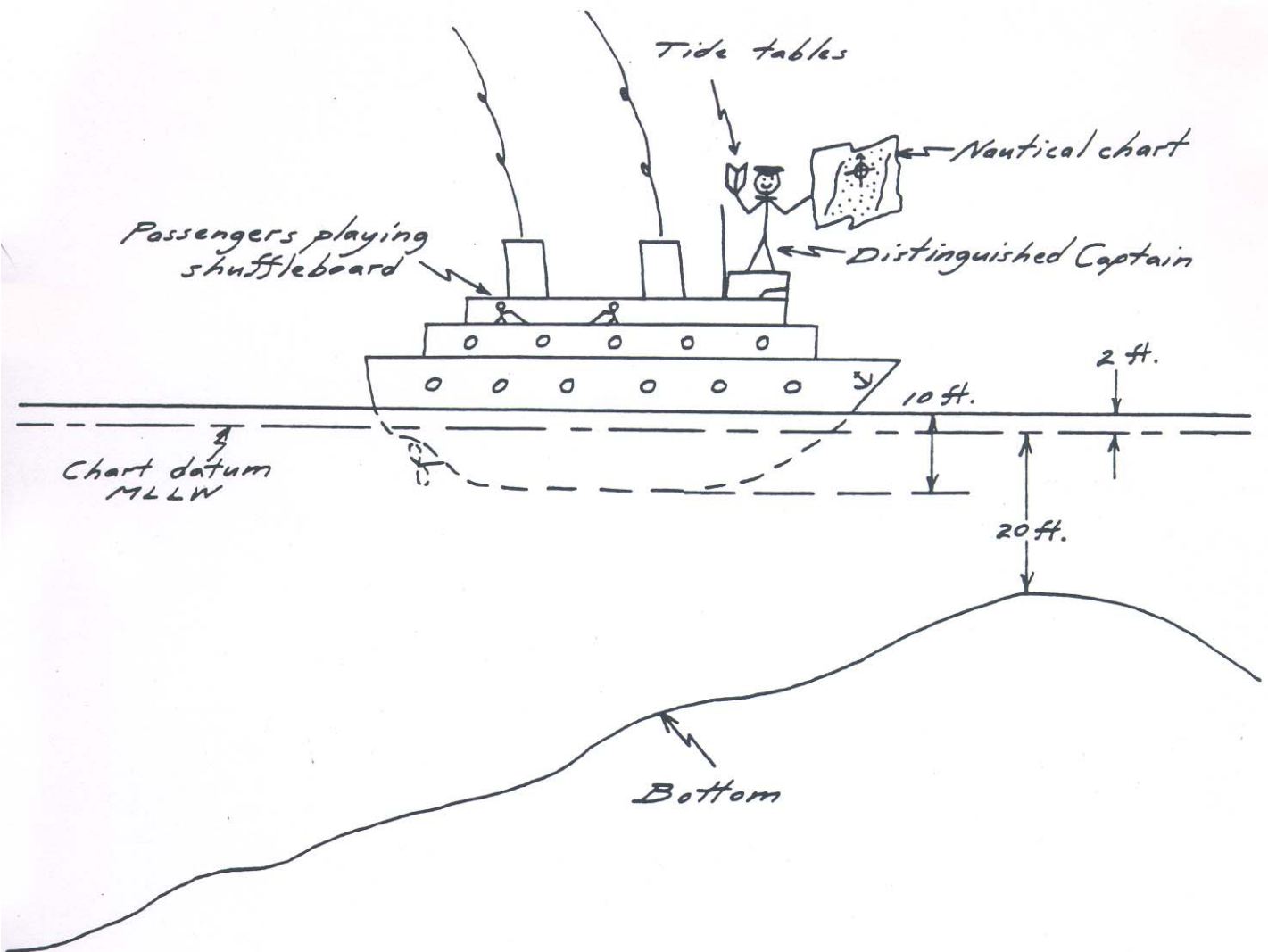
Recapitulation (using more acceptable jargon)

I'M MEASURING THE WATER HEIGHT WITH MY TIDE STAFF OR GAGE IN THE VICINITY OF THE HYDROGRAPHIC SURVEY: 1.) SO I CAN PROVIDE THE HEIGHT AT THE TIME OF EACH SOUNDING ABOVE THE TIDAL DATUM OF MEAN LOWER LOW WATER (CHART DATUM); AND 2.) SO I CAN GET ENOUGH HEIGHT DATA (ONE YEAR IS GREAT) TO PREDICT THE TIDAL HEIGHT ABOVE CHART DATUM FOR ANY FUTURE DATE AND TIME, AND TO PUBLISH THESE PREDICTIONS ONE YEAR IN ADVANCE IN THE 'TIDE TABLES' OF THE NATIONAL OCEAN SERVICE.

I'LL TAKE MY SOUNDING, ADD MY DRAFT, AND SUBTRACT YOUR MEASURED HEIGHT ABOVE MEAN LOWER LOW WATER (CHART DATUM) IN ORDER TO REDUCE MY SOUNDING TO A DEPTH BELOW CHART DATUM. I'LL PRINT MY SOUNDING ON THE NAUTICAL CHART AT THE LOCATION.



MY CHART SAYS THAT THE LEAST DEPTH INTO THE HARBOR IS 20 FEET BELOW CHART DATUM (MLLW). MY TIDE TABLES SAY THAT ON THE DATE AND AT THE TIME I PLAN TO ENTER, THE TIDAL HEIGHT WILL BE 2 FEET ABOVE CHART DATUM. SINCE MY DRAFT IS 10 FEET, I'LL HAVE 12 FEET UNDER MY KEEL ($20 + 2 - 10 = 12$) -- NO PROBLEM.



I REALIZE THE QUESTION I'M ABOUT TO ASK IS UNIMPORTANT IN THE APPLICATION OF TIDAL DATUMS, BUT I WAS JUST WONDERING. IN DETERMINING A TIDAL DATUM, WHY DO YOU AVERAGE 19 YEARS?

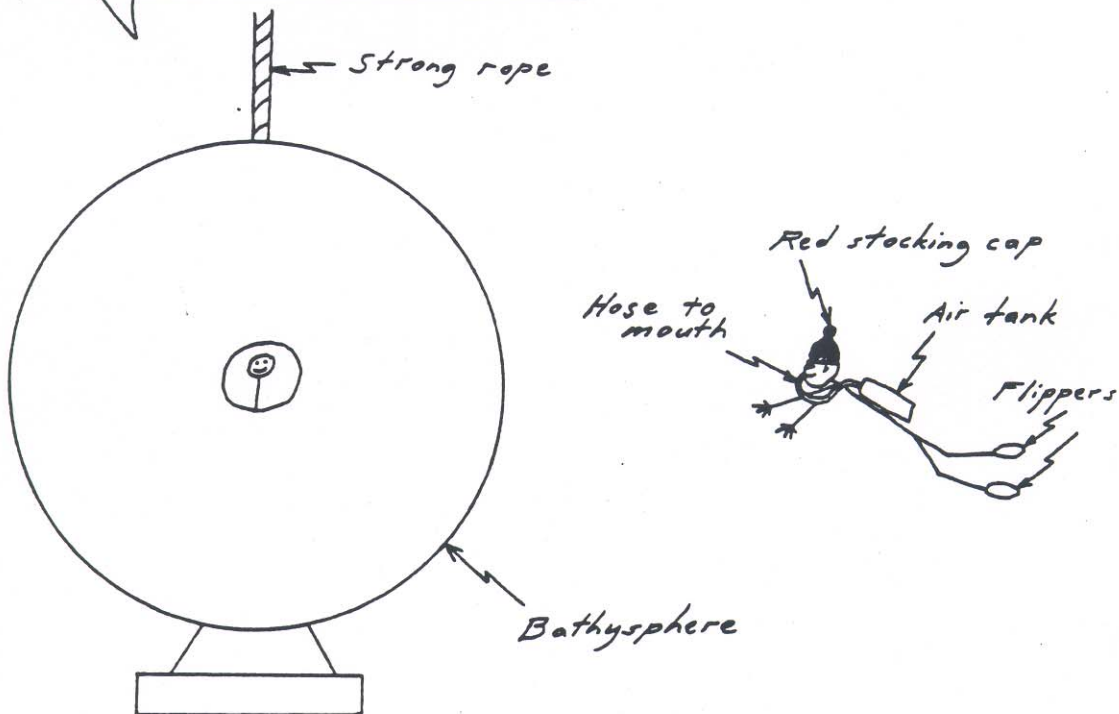
I'M GLAD YOU ASKED ME.

I WAS AFRAID YOU WOULD BE.

WHAT WE'RE REALLY AFTER IS A SIGNIFICANT PERIOD OF TIME TO AVERAGE OUT A LOT OF THE HEIGHT VARIABILITY DUE TO SUCH THINGS AS THE EFFECT OF VARIATIONS IN WINDS, ATMOSPHERIC PRESSURE, RIVER DISCHARGE, TEMPERATURE, SALINITY, CURRENTS, ETC. WE REALLY DON'T KNOW WHAT THE CORRECT LENGTH SHOULD BE, EXACTLY. HOWEVER, THE LONGEST ASTRONOMICAL CYCLE THAT WE HAVE TO CONTEND WITH IS THE 18.61-YEAR NODAL CYCLE. SO, 19 YEARS WOULD SEEM TO BE AN ADEQUATE LENGTH FOR STANDARDIZATION.

WHY NOT AVERAGE 18.61 YEARS ON THE NOSE?

THE REASON WE GO TO 19 COMPLETE YEARS, RATHER THAN STOPPING AT 18.61, IS BECAUSE THE ANNUAL CYCLE IS SO MUCH GREATER THAN THE NODAL CYCLE. THUS, THE AVERAGE WOULD BE VERY BIASED IF WE ENDED AT 18.61 YEARS.



AND THE NODAL CYCLE?

THE PLANE OF THE EARTH REVOLVING AROUND THE SUN IS CALLED THE PLANE OF THE ECLIPTIC. THE PLANE OF THE MOON REVOLVING AROUND THE EARTH IS INCLINED ABOUT 5° TO THE PLANE OF THE ECLIPTIC. THE POINTS OF INTERSECTION OF THE MOON'S ORBIT WITH THE PLANE OF THE ECLIPTIC ARE KNOWN AS THE ASCENDING AND DESCENDING NODES. SINCE THE MOON-EARTH PLANE PIVOTS ON ITS AXIS, THE NODES (AS POINTS OF REFERENCE) REGRESS THROUGH 360° IN 18.61 YEARS.

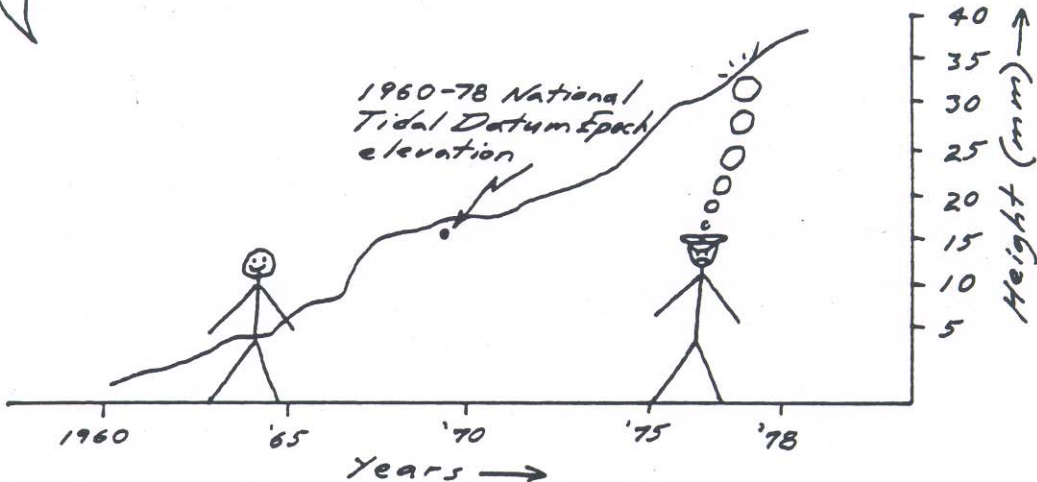
A TIDAL MAVEN PERHAPS, A CARL SAGAN YOU'RE NOT.

YOU FORGOT TO ASK ME WHY WE PICK A SPECIFIC 19-YEAR PERIOD.

NO, I DIDN'T.

I'LL TELL YOU ANYWAY. RELATIVE¹ APPARENT² SECULAR³ SEA LEVEL HAS BEEN SLOWLY RISING ALONG THE COASTS OF THE UNITED STATES AT THE MEAN RATE OF ABOUT 2 mm PER YEAR. SINCE THE RATE IS NOT LINEAR (I.E. UNIFORM OVER TIME), A SERIES FROM ONE 19-YEAR PERIOD WILL NOT BE THE SAME AS FOR ANOTHER. THUS, ESPECIALLY IN COMPARING STATIONS, A COMMON 19 YEARS IS NECESSARY. THE SPECIFIC 19 YEARS IS DESIGNATED THE NATIONAL TIDAL DATUM EPOCH BY THE NATIONAL OCEAN SERVICE. IT IS PRESENTLY 1960-1978. IT IS REVIEWED FOR UPDATING ABOUT EVERY 20 YEARS.

- ¹ Water with respect to
- ² adjacent land.
- Not known if truly non-periodic or segment of much larger oscillation.
- ³ Non-periodic.



CHAPTER TWO

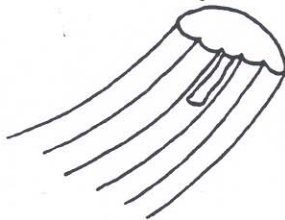
I DIDN'T KNOW THERE WAS A CHAPTER ONE.

ACTUALLY, THERE ARE MANY TIDAL DATUMS. SIX OF THEM ARE IN COMMON USE IN THE UNITED STATES.

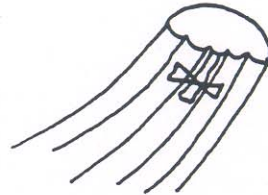
OH NO! YOU MEAN WE HAVE TO GO THROUGH THIS FIVE MORE TIMES?

NO, WE'LL ONLY GO THROUGH IT ONCE MORE. BUT THIS TIME WE'LL HAVE AN EXAMPLE OF THE USE OF TIDAL DATUMS FOR HORIZONTAL STABILITY; NAMELY, COASTAL AND MARINE BOUNDARIES.

Boy jellyfish



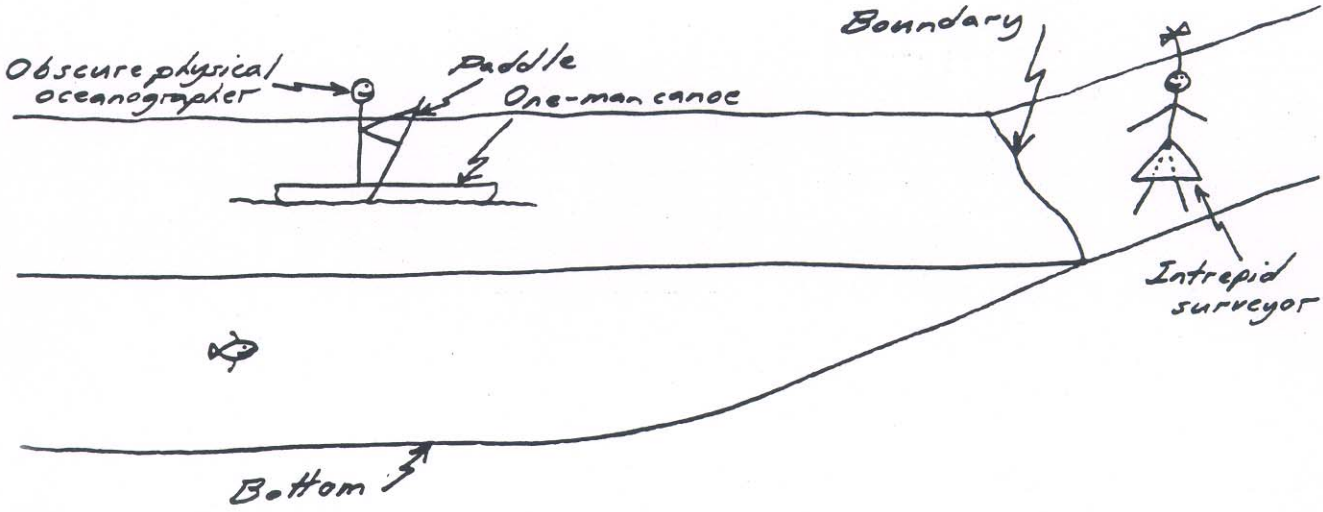
Girl jellyfish



THE LINE FORMED BY THE INTERSECTION OF THE WATER SURFACE WITH THE LAND HAS BEEN USED AS A BOUNDARY SINCE TIME IMMEMORIAL.

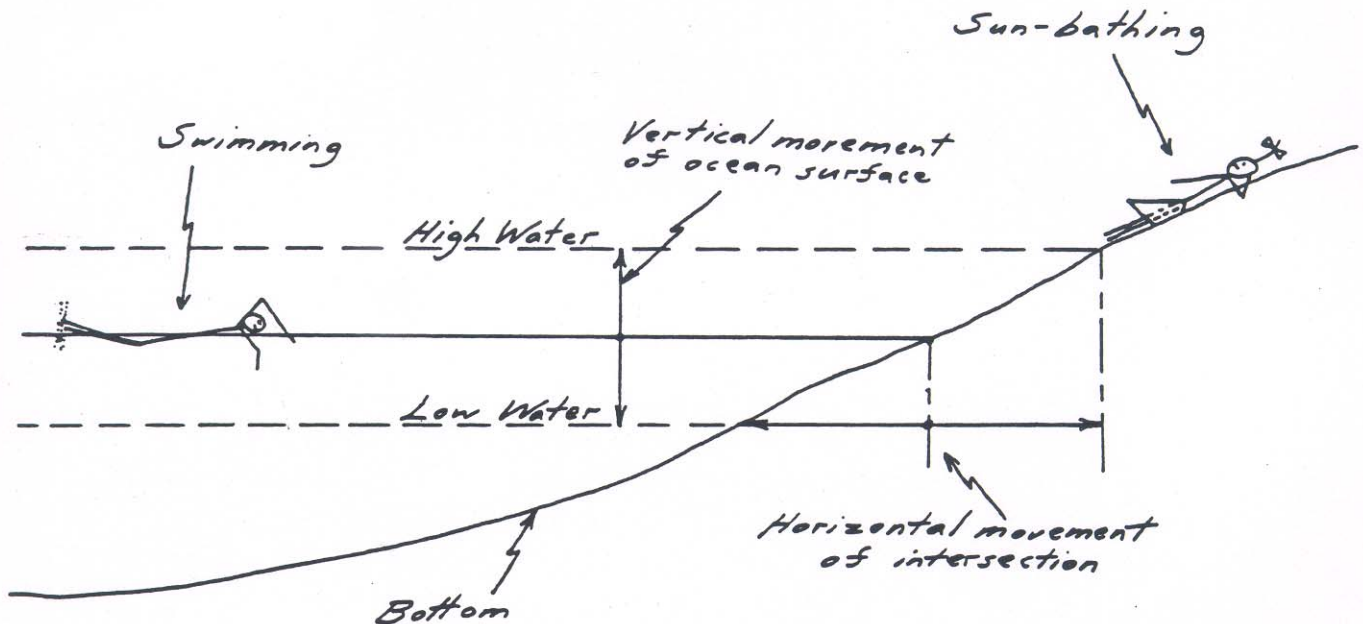
I KNOW THAT, I'M A SURVEYOR.

Sea gulls



THE PROBLEM IS, THAT WITH THE RISE AND FALL OF THE OCEAN, THE INTERSECTION MOVES UP-THE-BEACH LANDWARD AND DOWN-THE-BEACH SEAWARD. I NEED TO STOP THIS HORIZONTAL MOVEMENT IN ORDER TO USE THE INTERSECTION AS A FIXED PERMANENT BOUNDARY.

YOU KNOW, IF WE COULD STOP THE RISE AND FALL OF THE OCEAN SURFACE, IT WOULD AUTOMATICALLY STOP THE LANDWARD-SEAWARD MOTION OF THE INTERSECTION. THEN, THE INTERSECTION COULD BE USED AS A FIXED PERMANENT BOUNDARY.



WELL, AS BEFORE, WE CAN STOP THE RISE AND FALL OF THE OCEAN SURFACE WITH A TIDAL DATUM; REMEMBERING THAT A TIDAL DATUM IS ONLY AN ARTIFICIAL, MAN-MADE, MATHEMATICALLY DERIVED, NUMERICAL VALUE WITH A SPECIAL NAME.

I'LL REMEMBER, BUT WHICH TIDAL DATUM SHALL WE USE?

WE'LL USE MEAN HIGH WATER AS AN EXAMPLE THIS TIME, SINCE IT IS FREQUENTLY USED IN ESTABLISHING THE BOUNDARY BETWEEN STATE AND PRIVATE LAND.

AND USING THE LOGIC AS WITH MEAN LOWER LOW WATER, I'LL BET THE TIDAL DATUM OF MEAN HIGH WATER IS DEFINED AS THE AVERAGE OF ALL THE HIGH WATERS MEASURED OVER THE 1960-78 NATIONAL TIDAL DATUM EPOCH.

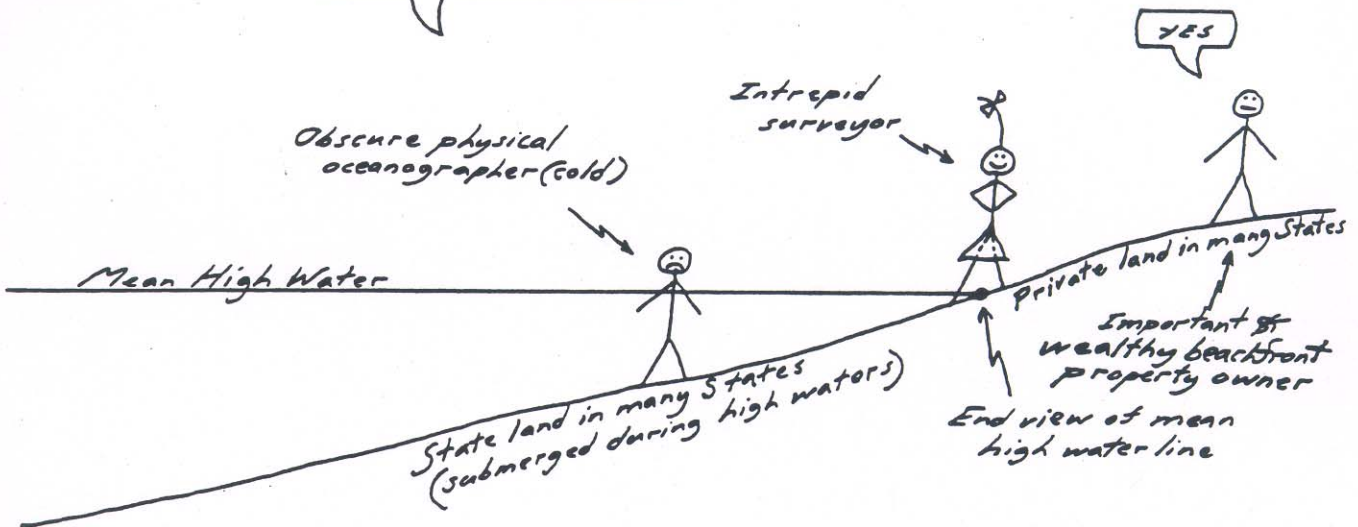
RIGHT ON!

SO NOW WITH THE WATER ELEVATION FIXED AT MEAN HIGH WATER, THE HORIZONTAL INTERSECTION IS AUTOMATICALLY FIXED. WE'LL CALL THE FIXED INTERSECTION LINE ALONG THE BEACH, THE MEAN HIGH WATER LINE.

I'M GETTING COLDER AND COLDER. WHERE IS THE LINE?

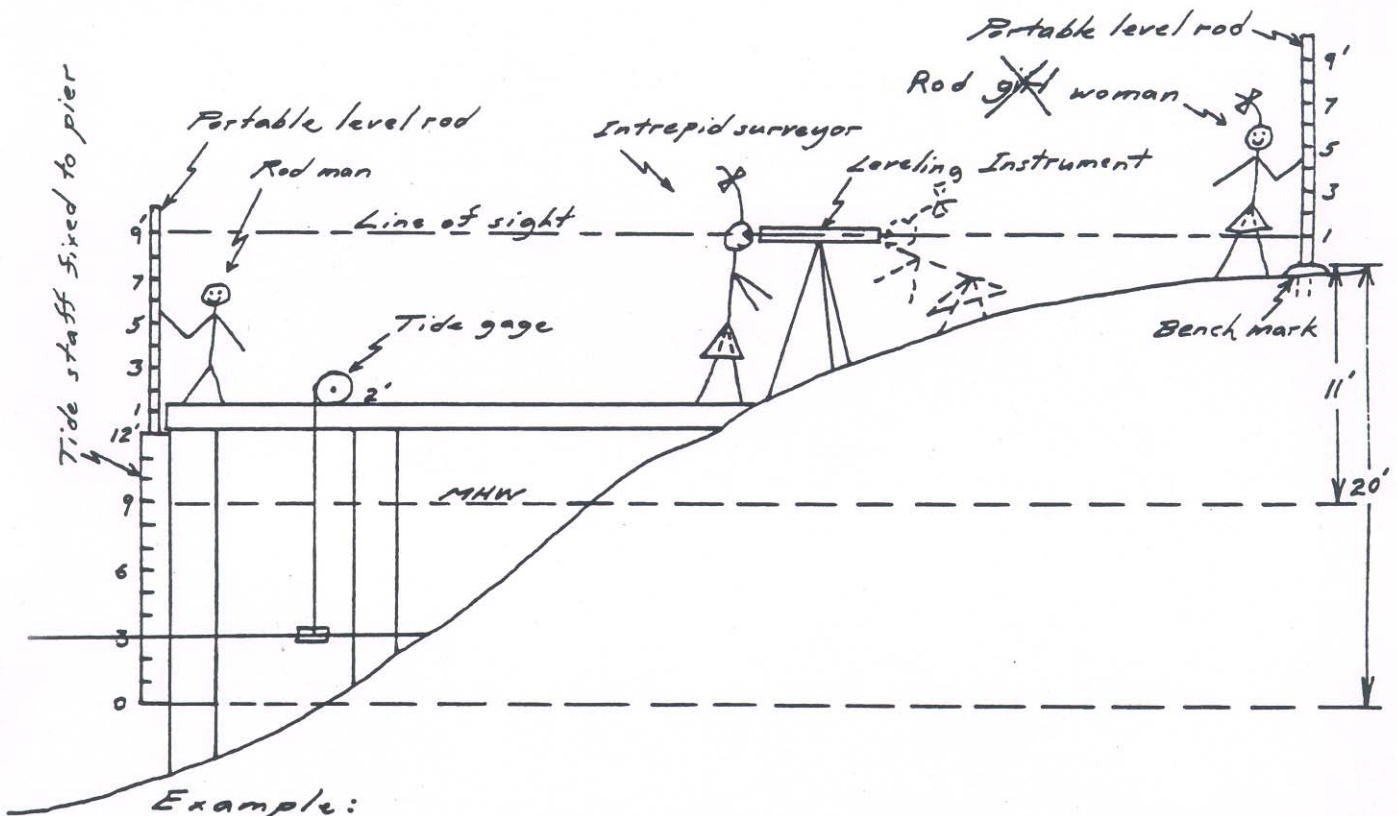
IF THE SURVEYOR AND I SAY, THIS IS IT!

MAY I PLEASE COME ACROSS THE MEAN HIGH WATER BOUNDARY LINE ONTO YOUR PRIVATE LAND? I'M REALLY COLD NOW.



I UNDERSTAND IN PRINCIPLE, BUT JUST SAYING 'THIS IS IT' DOES NOT QUITE DO IT. HOW DO YOU ACTUALLY (REALLY REALLY) FIND THIS ARTIFICIAL, MAN-MADE, MATHEMATICALLY DERIVED, NUMERICALLY VALUED LINE, CALLED THE MEAN HIGH WATER LINE.

AS WITH ALL DATUMS, WE START WITH THE MEASUREMENT. THE TIDE GAGE RECORDS CONTINUOUSLY IN ARBITRARY NUMBERS. SO, ONCE A DAY, A RECORDED NUMBER IS COMPARED WITH THE WATER ON THE NUMERICAL SCALE ON THE TIDE STAFF FOR SUBSEQUENT ADJUSTMENT BACK IN WASHINGTON. NOW, A REFERENCE POINT ON THE TIDE STAFF IS LEVELED TO A BUNCH OF BENCH MARKS ON THE NEARBY LAND ONCE A YEAR (SHOULD BE TWICE, BUT THERE'S NOT ENOUGH MONEY).

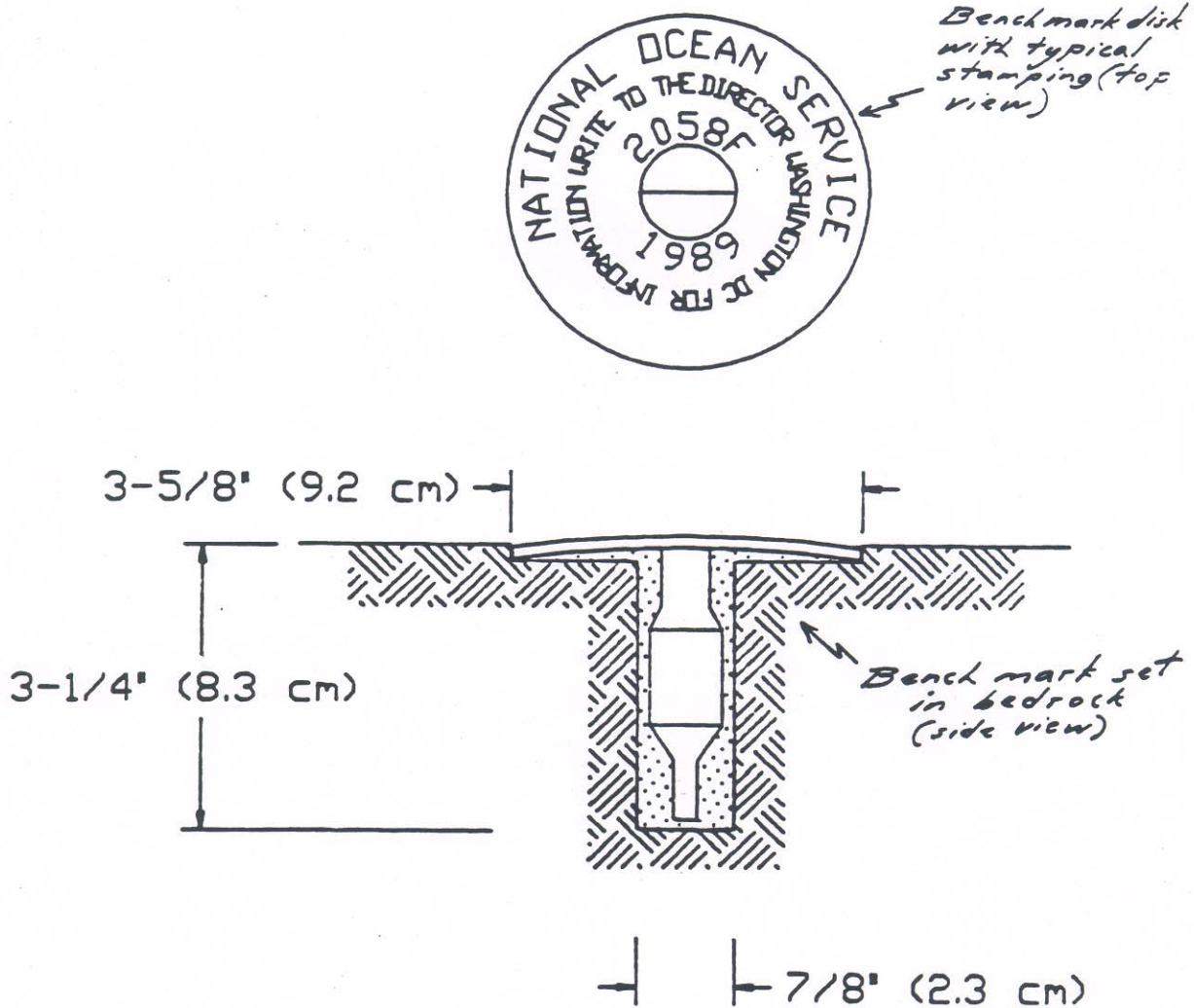


Example:

When tide gage says 2 feet, water on staff says 3. Analysis of tide gage record in Washington says mean high water is at 8 on the tide record. Therefore, mean high water on staff is 9 feet.

From leveling, bench mark is 20 feet above 0' on tide staff. Therefore, bench mark is 11 feet above mean high water.

For each tide station, bench mark sheets are prepared. They include such things as a description of the location of each mark, the identification number stamped on each mark, and the elevation of the bench mark above all the various tidal datums. These sheets are on file with the National Ocean Service, and can be obtained by the public at minimal cost.



LOOK, I'M AN IMPORTANT & WEALTHY BEACHFRONT PROPERTY OWNER WITH VERY EXPENSIVE WATERFRONT LAND. I'D LIKE TO CONTRACT YOU TO DELINEATE THE BOUNDARY BETWEEN THE STATE'S LAND AND MINE.

IN THIS STATE THE BOUNDARY BETWEEN STATE AND PRIVATE LAND IS THE MEAN HIGH WATER LINE. I'LL WRITE THE NATIONAL OCEAN SERVICE TO FIND OUT IF THEY HAVE ANY TIDAL BENCH MARKS ON OR NEAR YOUR PROPERTY.

GOOD

write-write-write-time passes

WE'RE IN LUCK, FOR A CHEAP PRICE THEY SENT ME BENCH MARK SHEETS FOR A FORMER TIDE STATION NEAR YOUR PROPERTY. THE SHEETS TELL ME HOW TO FIND THE MARKS AND HOW HIGH THEY ARE ABOVE MEAN HIGH WATER.

FINE

look-look-look-time passes

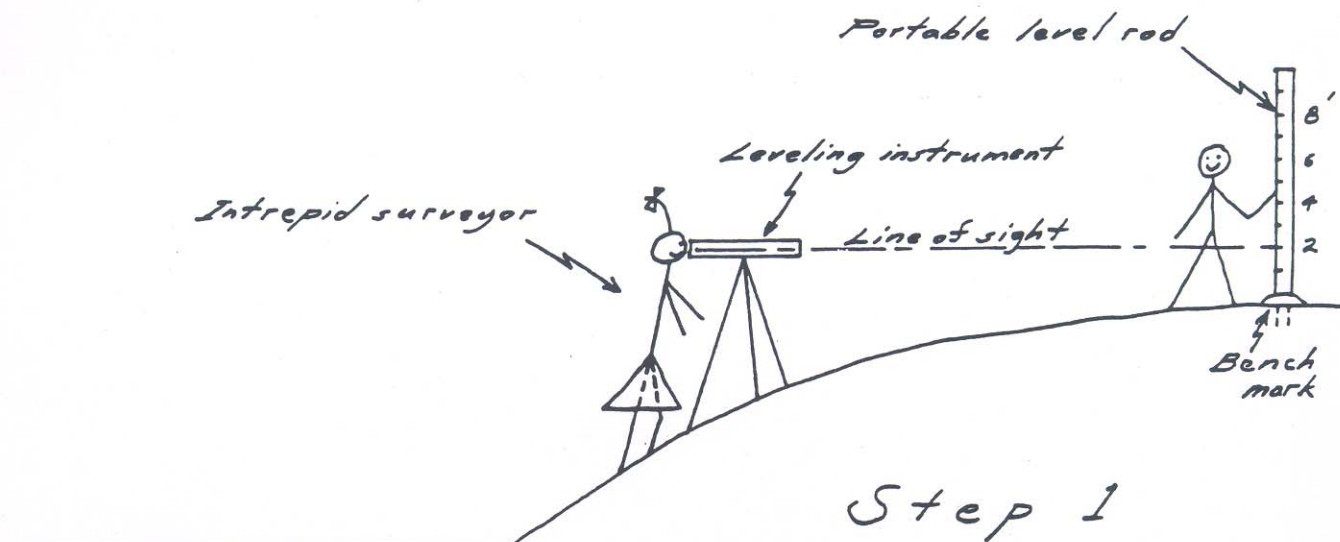
I'VE RECOVERED A BENCH MARK (THAT'S FANCY SURVEY TALK FOR 'I'VE FOUND IT').

OH

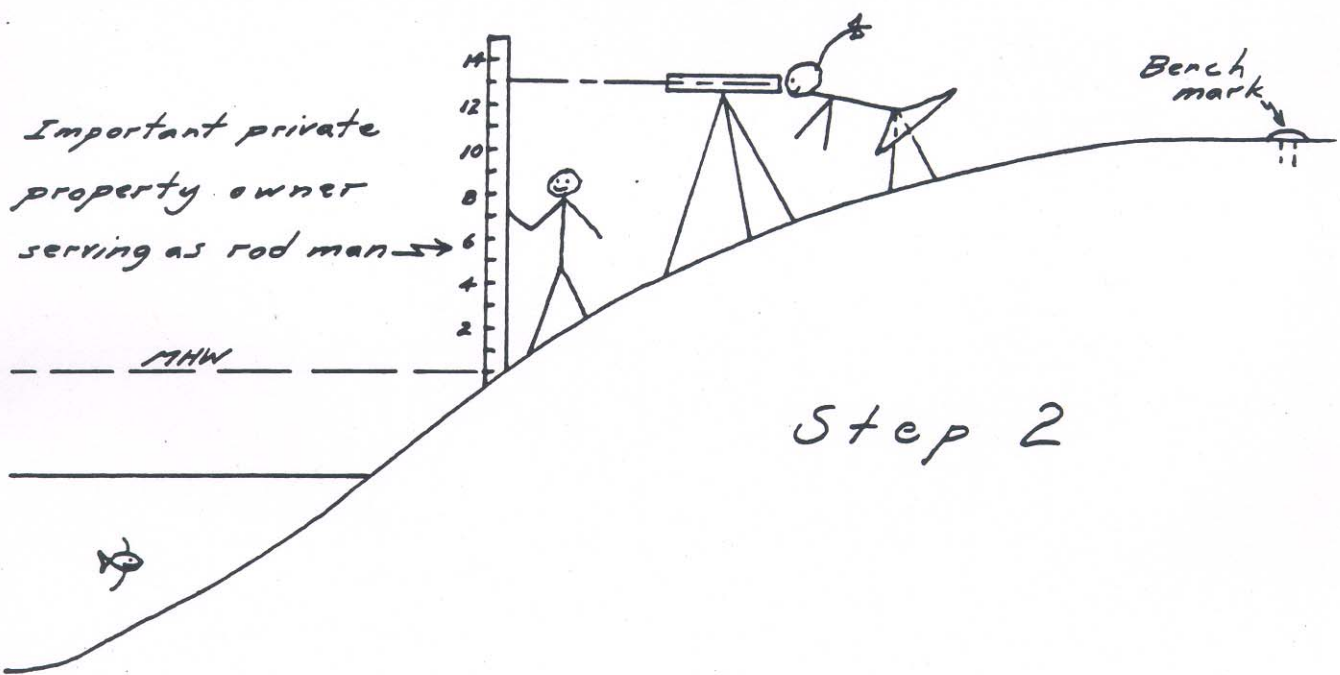
NOW I CAN FIND A POINT ON THE MEAN HIGH WATER LINE. HERE, YOU CAN HELP BY BEING THE ROD MAN.

YOU MEAN I'M PAYING YOU FOR THE PRIVILEGE OF HOLDING THE PORTABLE LEVEL ROD?

THINK OF IT AS AN HONOR. YOU'RE LEARNING A NEW SKILL. IT'S AN OPPORTUNITY.



COME UP THE BEACH CLOSER - NO, DOWN THE BEACH A LITTLE - NOW, UP THE BEACH A SMIDGEN - THAT'S IT, THE '13' IS LINED UP WITH MY LEVEL SIGHT AND 13-22 IS FEET WHICH IS THE VERTICAL DISTANCE FROM THE BENCH MARK TO MEAN HIGH WATER. POUND A STAKE INTO THE BEACH WHERE THE FOOT OF THE LEVEL ROD WAS, AND TIE ONE OF THOSE FADED ORANGE PLASTIC RIBBONS (YUCK) AROUND THE STAKE. YOU KNOW, THE KIND YOU SEE AT CONSTRUCTION SITES. THAT'S OUR FIRST MARK ON THE MEAN HIGH WATER LINE!

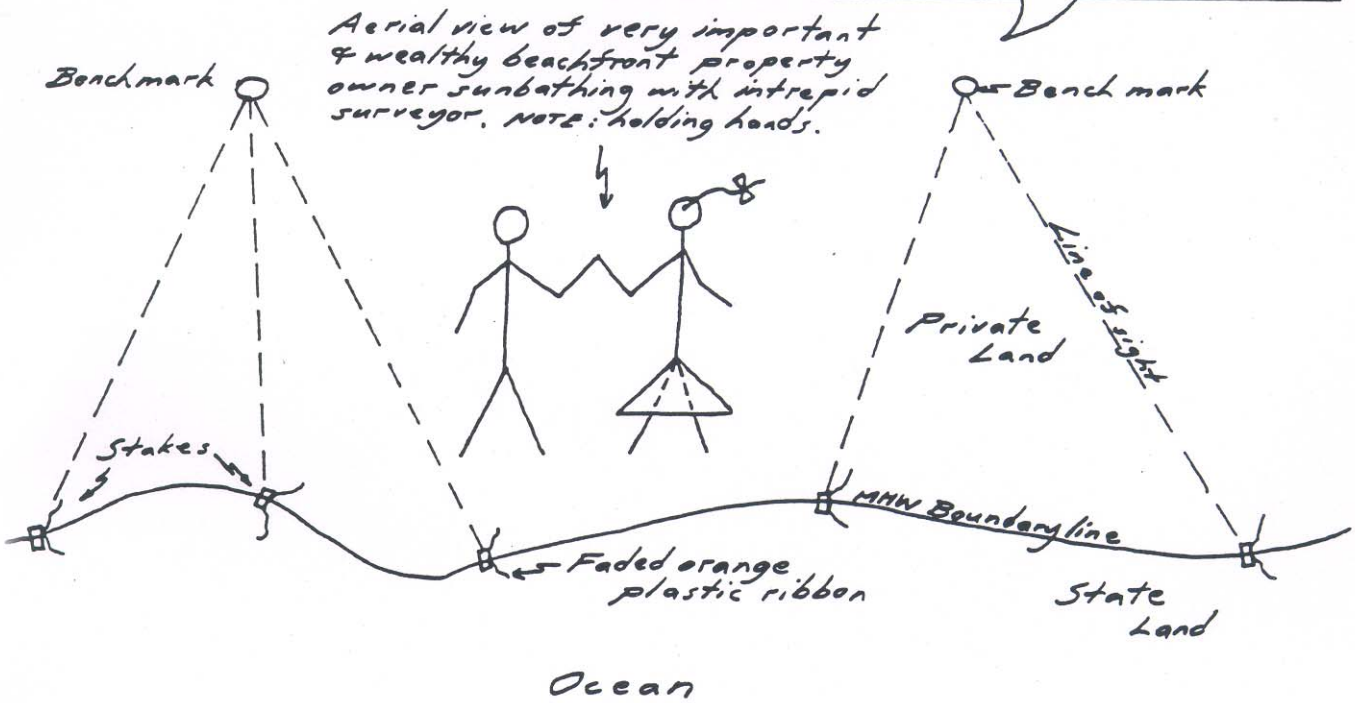


IN ORDER TO FIND THE MEAN HIGH WATER (MHW) BOUNDARY LINE ON THE BEACH AND PORTRAY IT ON A MAP OR NAUTICAL CHART, WE MUST ESTABLISH MORE THAN ONE MHW MARK (STAKE) TO FAIR IN THE CURVING LINE.

JUST DO IT, I'M TIRED OF EXPLANATIONS.

- WE DO IT BY:
- 1) GOING IN OTHER DIRECTIONS TOWARD THE OCEAN FROM THE SAME BENCH MARK, AND/OR
 - 2) GOING FROM NEARBY BENCH MARKS, AND/OR
 - 3) GOING ALONG THE MHW LINE BY LEVELING FROM OUR FIRST AND/OR SUBSEQUENT MHW MARKS (STAKES), AND/OR
 - 4) WHEN THE WATER GETS TO THE FIRST STAKE, POUND IN MORE ALONG THE BEACH (QUICKLY), AND/OR
 - 5) WHEN THE WATER GETS TO THE FIRST STAKE, RADIO TO A PHOTOGRAMMETRIC AIRPLANE TO TAKE PICTURES, AND/OR
 - 6) WHEN THE TIDE TABLES SAY THAT THE OCEAN (AT THAT LOCATION) IS AT MHW, POUND IN STAKES AND/OR TAKE AN AERIAL PHOTO.

NOT SO ACCURATE



WHAT ABOUT ALL THOSE OFFSHORE MARINE BOUNDARIES THAT I'VE BEEN HEARING OF LATELY: YOU KNOW, LIKE THE 3-MILE BOUNDARY BETWEEN THE TERRITORIAL AND HIGH SEAS; THE OUTER LIMIT OF THE 12-MILE CONTIGUOUS AND EXCLUSIVE FISHING ZONES; AND THE OUTER LIMIT OF THE 200-MILE FISHERY CONSERVATION AND EXCLUSIVE ECONOMIC ZONES?

THESE MARINE BOUNDARIES ARE DELINEATED BY MEASUREMENTS ON NAUTICAL CHARTS. THE MEASUREMENTS ARE MADE FROM THE MEAN LOWER LOW WATER OR MEAN LOW WATER LINES (OR STRAIGHT SEGMENTS THEREOF AND/OR POINTS THEREON).

IN OTHER WORDS, ALL COASTAL AND MARINE BOUNDARIES ARE FUNDAMENTALLY BASED ON A TIDAL DATUM.

OH, YOU SAY THE MOST INTIMATE THINGS.



Maid of honor

Bride

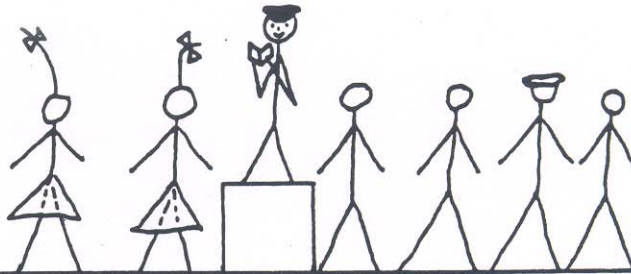
Officiating

Bridegroom

Best man

Usher

Usher



Red woman

Intrepid surveyor

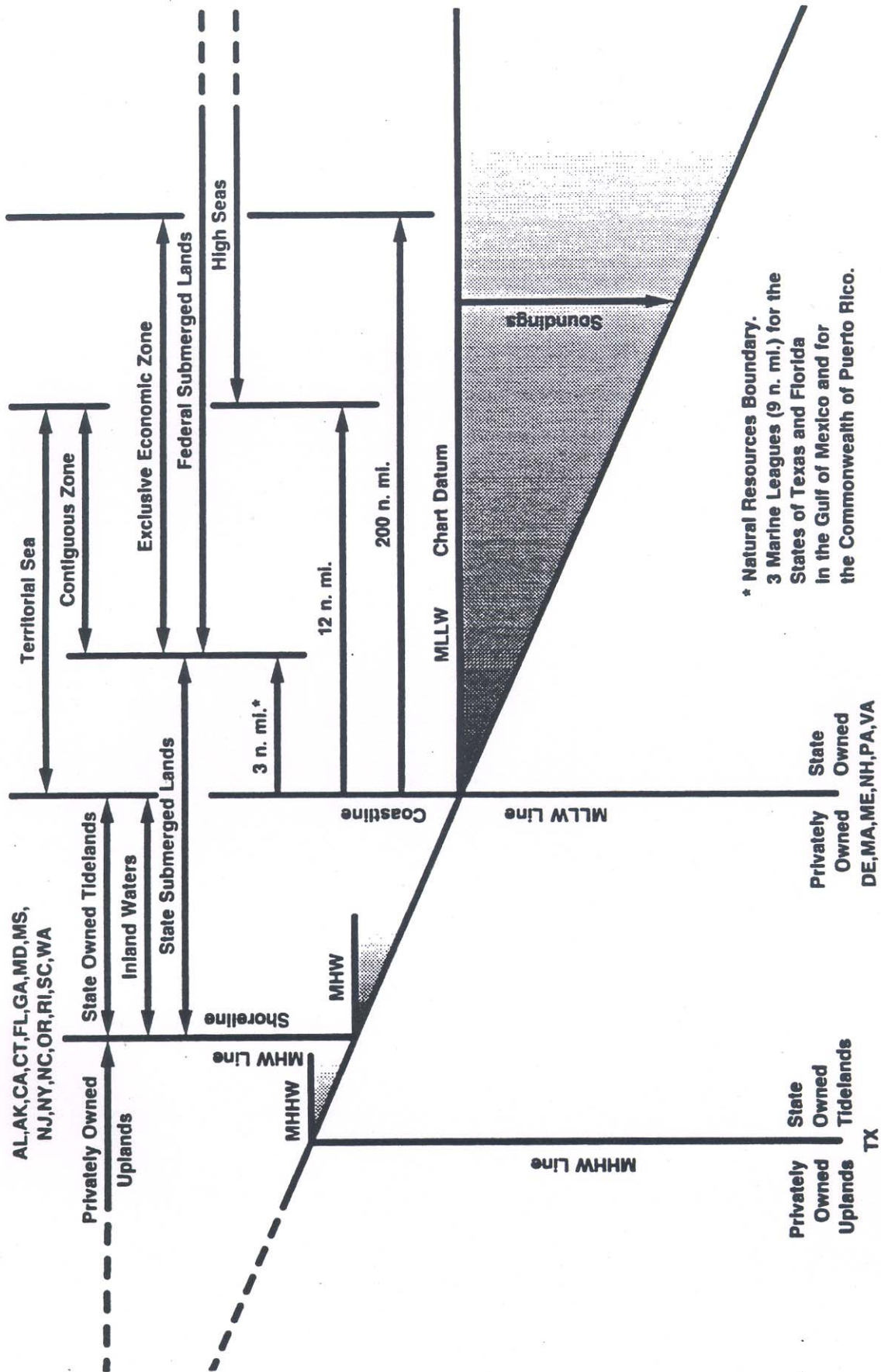
Distinguished Captain

Important & wealthy beachfront property owner

Obscure physical oceanographer

Great hydrographer

Red man



* Natural Resources Boundary.
 3 Marine Leagues (9 n. mi.) for the States of Texas and Florida in the Gulf of Mexico and for the Commonwealth of Puerto Rico.