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AN EIGHTH GRADE UNIT GUIDE ON OCEANOLOGY HAS BEEN DEVELOPED BY THE CARTERET COUNTY PUBLIC SCHOOLS OF BEAUFORT, NORTH CAROLINA. NARRATIVE AND DIAGRAMMATIC DESCRIPTIONS DEAL WITH VARIOUS OCEAN PHENOMENA, SUCH AS TIDES, WAVES, CURRENTS, OCEAN FLOORS, BEACHES, ETC. CLASS QUESTIONS AND DISCUSSION QUESTIONS ARE PROVIDED AT THE END OF EACH SECTION OF THE UNIT. A VOCABULARY LIST IS FOUND AT THE END OF EACH NARRATIVE DISCUSSION. RELATED DOCUMENTS ARE RC 002 486, RC 002 488, AND RC 002 485. (DK)

EIGHTH GRADE UNIT

SEA - RESTLESS GIANT

PROJECT

CARTERET COUNTY PUBLIC SCHOOLS — E.S.E.A. TITLE I

INTRODUCTION (Students)

Leonard Engel was right when he said that our planet has the wrong name. There is three times as much water as land on the surface of our planet, yet we call our planet "Earth" why not "Ocean"? With all this water around us, it seems strange that man has only recently begun systematic study of this part of his environment. Scientists call this study OCEANOLOGY. Oceanology is the study of all things about the ocean.

Most oceanologists recognize four major bodies of water which they call"ocean". The Pacific is the largest, the Atlantic second, the Indian third, and the Arctic the smallest. Some oceanologists recognize a fifth ocean, the Antarctic, but this is all a matter of what we consider an ocean to be. Most agree that an ocean should be bounded by continents, distinctive bottom features, or other physical factors. Although oceans have different names, it should be remembered that all oceans are interconnected and water can go from one into the other.

It was once thought that all ocean floors; were smooth plains with few or no hills or mountains on the bottom. Modern methods of depth finding show that the bottom is quite rough. It contains mountains, hills, and valleys much like those found on the land. In many cases these are much larger than on land. Man has always been familiar with the effects that the ocean has on land. Often he has attempted to stop these processes. His attempts usually fail and more damage results, or something is changed that he did not want changed. These are just some of the things an oceanologist must deal with. In order to study the ocean and some of its effects, let's start at the edge of the land where its effects are more familiar to us.

TIDES

One of the things an "inlander" would see on a visit to the coast is the rhythmic variation in depth of the water at different times of the day. Coastal people would recognize this variation as the results of the TIDE.

The importance of tides to the people of the Atlantic Coast is great. Those who make a living from the sea are influenced in their fishing and shipping by the deep or shallow water resulting from the tides. Other coastal dwellers must keep a wary eye on storms. Storm winds can raise the level of the tide to great heights. Finally, and certainly not least, many marine animals and plants (including commercially important species) are influenced by the tides.

Man has been observing and recording the results of the tide since he took to the sea. Yet, it is only recently that he has been able to explain the tides. Ancient mariners thought the tide was caused by the breathing of the earth monster. They eventually noticed that tides closely followed the movement of the moon. They found that every 24 hours and 50 minutes a complete tidal cycle of 2 highs (floods) and 2 lows (ebbs) was completed. Modern science has confirmed that lunar cycles, along with solar cycles and others, do influence the tide.

Although the sun is much larger than the moon, the moon's pull is greater. This is because the moon is so much closer to the earth than the sun. Other celestial bodies also exert a gravitational pull on the earth's waters, but not very much.

How do the waters react to the pull of the moon and the sun? The gravitational pull of the moon causes a bulge of water toward itself, (See Fig. 1)

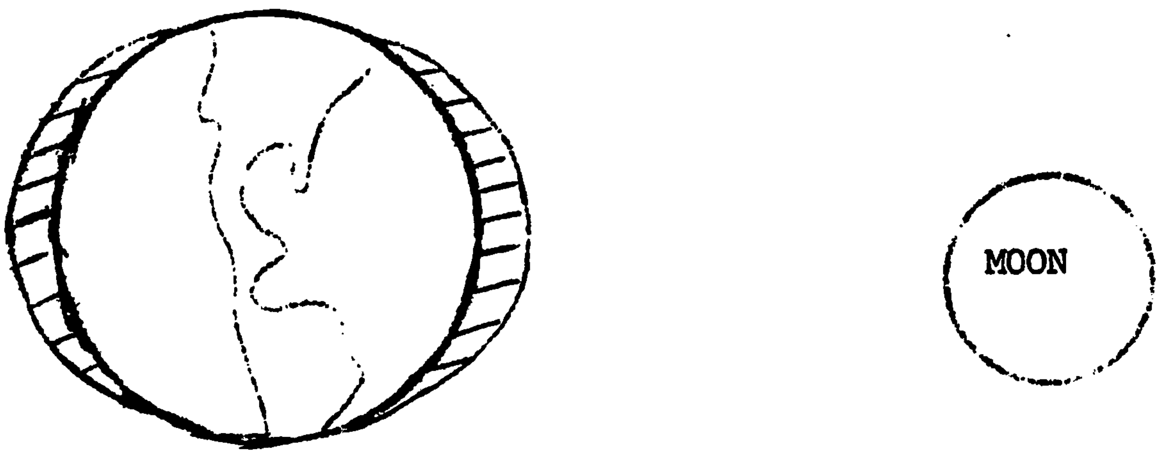


Fig. 1: Bulges of water caused by the gravity of the moon pulling on the water.

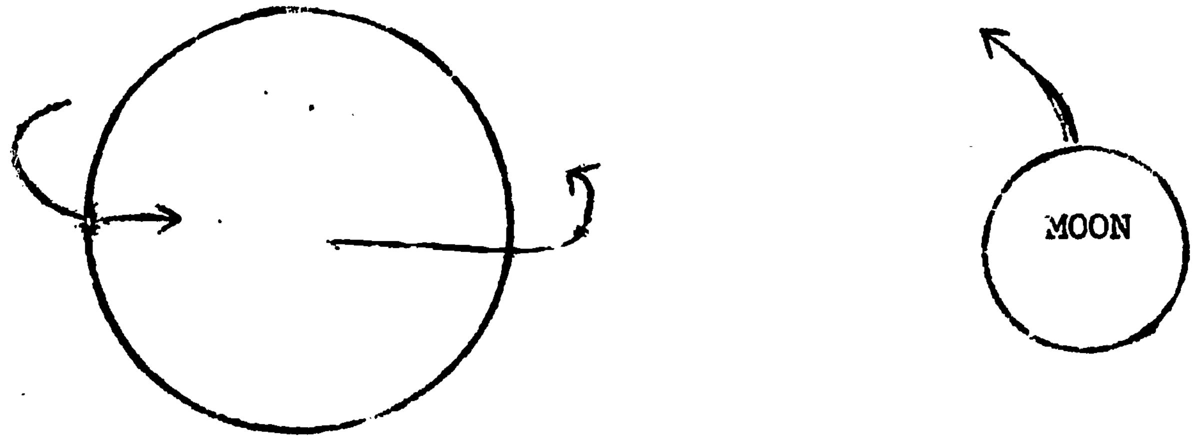


Fig. 2: If the moon remained in the same position with the earth at all times, Carteret County would pass under the moon every 24 hours. But, the moon revolves around the earth in the same direction that the earth rotates. While Carteret County makes a complete circle in 24 hours, the moon has traveled about 54,636 miles ahead. In order for Carteret County to pass directly under the moon again it must travel for about another 50 minutes. Thus, the tides are about 50 minutes later each day.

and also on the opposite side of the earth. It is as if the water directly under the moon was being pulled away from the earth while the earth was being pulled away from the water on the other side (actually it is more complicated and involves mathematical calculations of the moon's gravity and centrifugal forces on earth). Since the moon travels around the earth once every month, we should have one low (ebb) and one high (flood) tide each month. However, the earth rotates every 24 hours. This results in the daily high and low tides. But, one may ask: Why, if the earth rotates every 24 hours, is the tide averaging 24 hours and 50 minutes? This is because the moon is revolving around the earth in the same direction that the earth is rotating. It takes an average of 50 more minutes for a spot on the earth to pass under the moon each day. (The moon each day progresses in its revolution). (See fig. 2).

The sun presents some pull on the earths water. Smaller bulges caused by the sun are also present. These bulges are usually out of phase (sun and moon not lined up) with the bulges produced by the moon. Two times a month the bulges are in phase and this produces what is known as SPRING TIDES. These occur at the time of the NEW MOON (sun and moon lined up one side of the earth) and the FULL MOON (sun and moon on opposite sides of the earth). (See fig. 3).

Spring tides represent the "Highest" and "Lowest" of the tides. New moons produce higher water than full moons. Why? (sun and gravity pulling in same direction). Another and almost opposite effect is achieved when the moon is at its first and last quarter.

This produces the least high and low tides and is called the NEAP TIDE. In this phase the moon and earth are at 90° from each

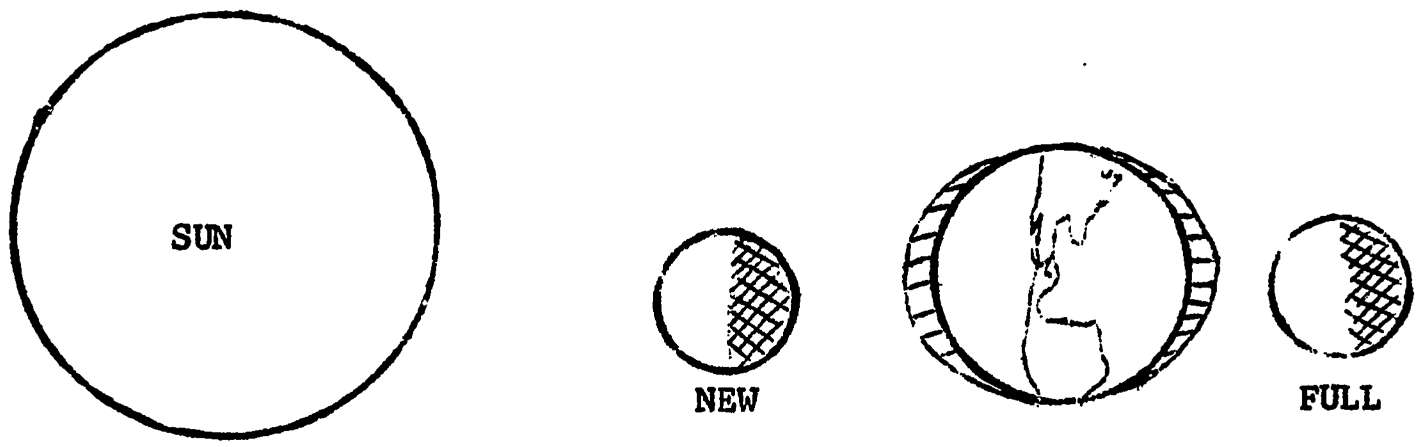


Fig. 3: When the moon, sun, and earth line up at full and new moon, the tides are highest and lowest. The tides at that time are called spring tides.

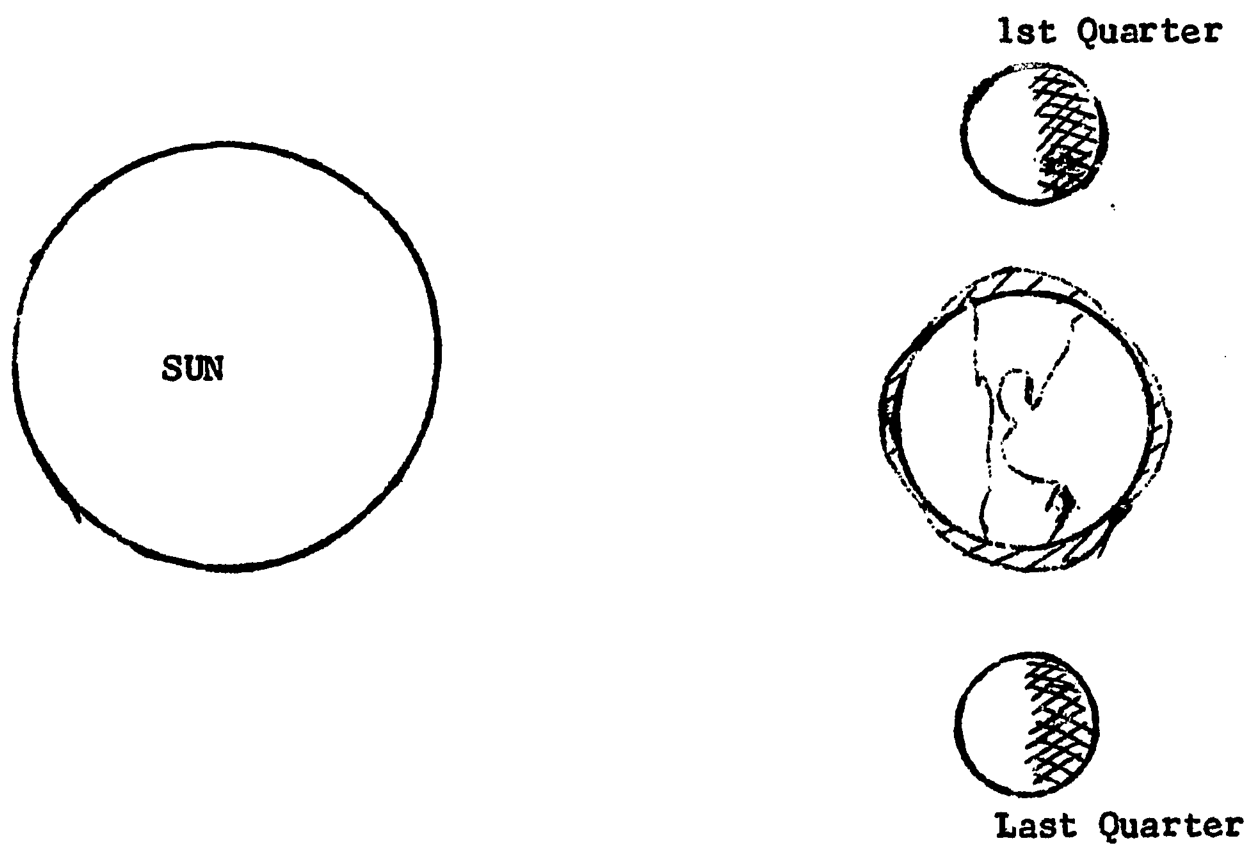


Fig. 4: Neap tides occur when the moon, earth, and sun form a 90° angle with each other. The tides do not change as much from low to high at this time.

other and the bulges are essentually out of phase. The change from spring tide to neap and back again is gradual, following the progressive shifts of earth, moon and sun. (See fig. 4).

Along the coast of North Carolina, we recognize that all tides are not equally high or low. There are several reasons for this.

The moon and sun are not always directly over the equator, rather they vary north or south. The moon varies as much as 28 degrees north or south each month. Two times in this 30 day period the moon moves across the equator. (See fig. 5)

Likewise, the sun is on the Tropic of Cancer (23½ degrees north) once each year, the Tropic of Capricorn (23½ degrees South) once each year and over the equator two times a year. As the moon and sun vary from northern to southern hemisphers and back again, the tidal bulges follow the movement.

The orbit of the moon around the earth is not round but rather it is elliptical with high point (apogee) and a low point (perigee). The same is true for the orbit of the earth around the sun. Since gravity exerts the strongest influence on objects when they are nearest, perigee tides will be the greatest. (See fig. 6)

Winds are important in producing variation in the tides. If a strong wind is blowing with an incoming (flooding) tide, the water may vary several feet higher. Likewise, if a wind is blowing in the opposite direction of the tide the water may remain higher than at normal low (ebb) tide. This is because of the friction of the

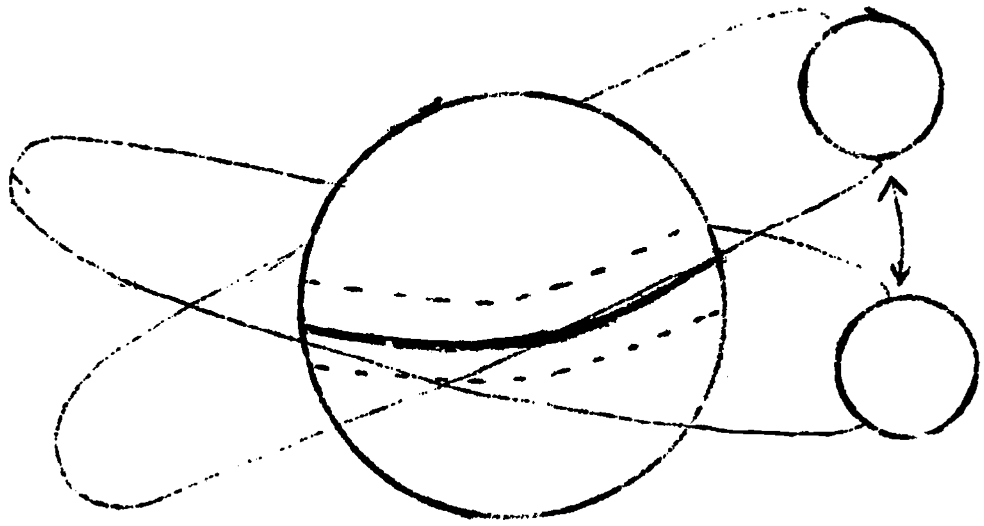
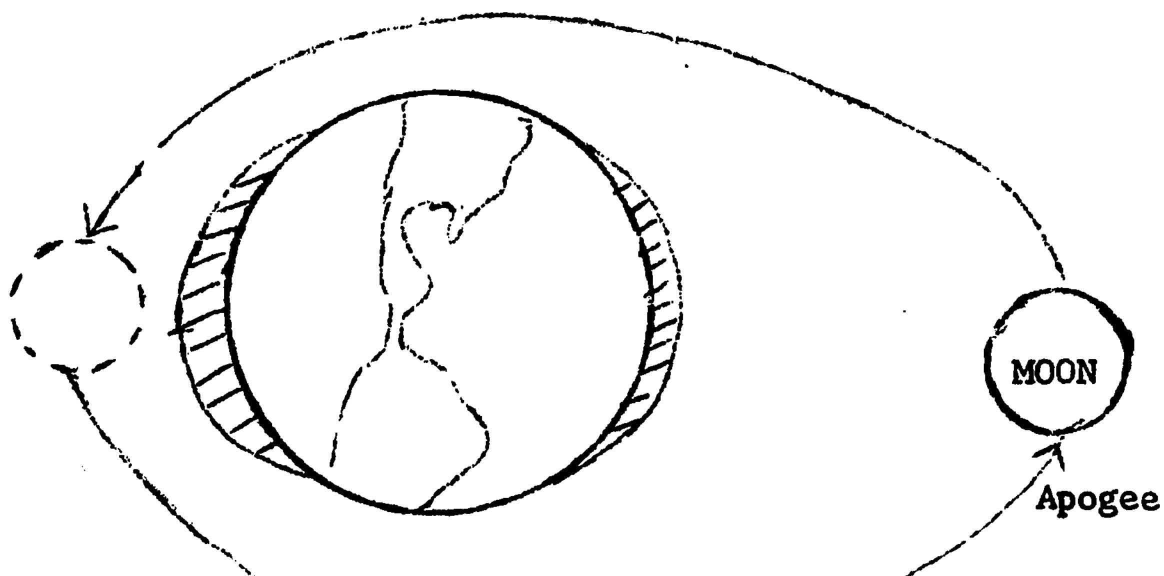


Fig. 5: The Moon changes positions in relation to the earth each month. Since the tidal Bulges follow the gravity of the moon. They will also change with the moon.



Perigee

Fig. 6: Tides will be higher and lower when the moon is closest to the earth at perigee.

air against the water. Witness the extreme tides of hurricanes, when water is actually blown in or out according to the wind direction.

The topography of the bottom of a body of water exerts a tremendous influence on the results of the tide. The Bay of Fundy with its 50 feet of variation at its head is an excellent example.

Fundy is deep and wide at its mouth and gradually gets shallow and narrow toward its head. At low water the upper reaches of the Minas Basin are dry. As the tide changes, large volumes of water entering the deep mouth find little of no place to gc as it proceeds toward the head of the Bay. Consequently the large volume of water is pushed upward by the rising bottom. At high tide (flood) the water level reaches as much as 50 feet and the tidal currents run as fast as 8 knots. This makes it very dangerous for fishermen caught in the basin on changing tides. (See fig. 7)

In contrast to the Minas Basin of Fundy are the tides at Halifax, Nova Scotia. Halifax is located on the Atlantic and is rather deep near shore. Tides here range at the most only 7 feet.

Also associated with bottom topography and flooding tides, are <u>TIDAL BORES</u>. Tidal bores are waves of water that move up a river. They are caused by an incoming tide. As the tide moves in the river it is held back by friction with the bottom of a shallow river. When it reaches a certain height the force of the water overcomes the force of friction. The tide then moves up the river as a translation waves that transport water from one place to another place.). The tidal bore of the Petitcodiac River (off the Bay of Fundy) ranges as high as 5 feet. The exact height depends on the phase of the moon).. The bores of the Tsientang River of China is said to reach a height of 25 fe3t and all shipping

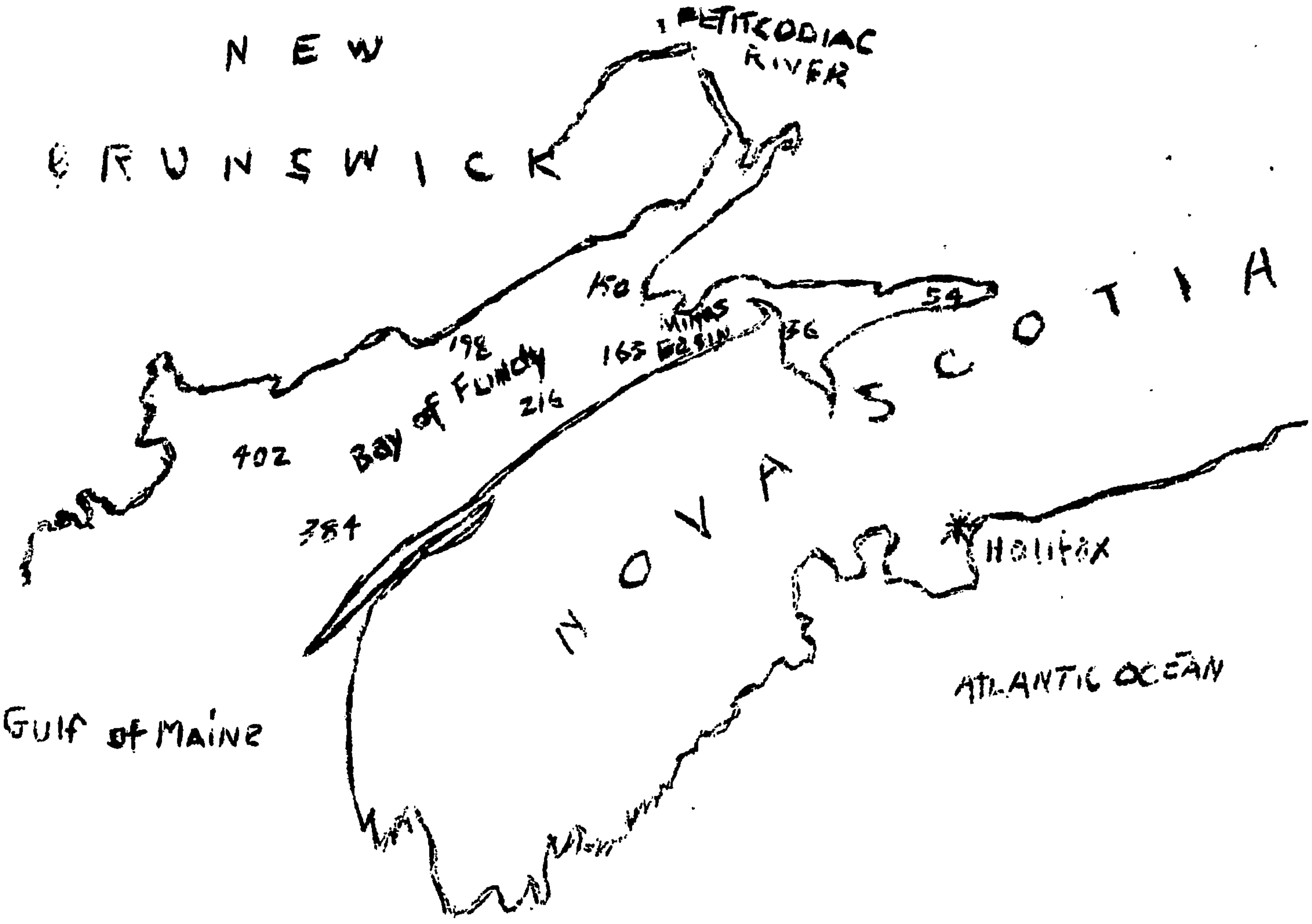


Fig. 7: Map of New Brunswick and Nova Scotia showing the Bay of Fundy as it narrows and shallows at the Minas Basin and Petitcodiac River.

Fig. 7A: Diagram of tidal bore moving down a river. Note that water remains high after the bore front passes.

is controlled by this bore (See fig. 7A)

The coast of Carteret County experiences.

2 flood and 2 ebb tides per 24 hours and 50 minutes. This is called a SEMIDUIRNAL TIDE. Another cycle found in the United States on areas of the Gulf of Mexico Coast is the DIURNAL TIDES. The diurnal tide consists of one high and one low per 24 hours and 50 mintues.

The tides of the Society Islands in the Pacific show an unusual situation. The tide is high at approximately 12 o'clock Noon and 12 o'clock Midnight everyday. Their tides are evidently responding to the movements of the sun. How can we explain this solar produced tide when we know the moon exerts much more influence on the earth's waters than does the sun?

Two theories have been formulated to account for unusual solutions such as this. The progressive wave theory holds that tides are the results of waves, like ripples in a pond. (See fig. 8)

On the Atlantic coast of the United States these waves appear to move from south to north, with high tides generally progressing later to the north. In the Society Islands, two such waves moving from different directions would have to meet in the spot 2 times per day to result in the tidal cycles present there. There are some errors in the theory and scientists now think that the stationery or standing wave theroy may be the most important.

The standing wave theory is based on the fact that every body of water has a natural oscillation. If water in a disphan is made to slosh back and forth (oscillate) we will see that it goes almost over one side while it is almost gone from the other in a back and forth manner. This water will shift back and forth very rapidly in our dishpans but more slowly in a large container. (See fig. 9)

While the water is sloshing back and forth, in the middle of the

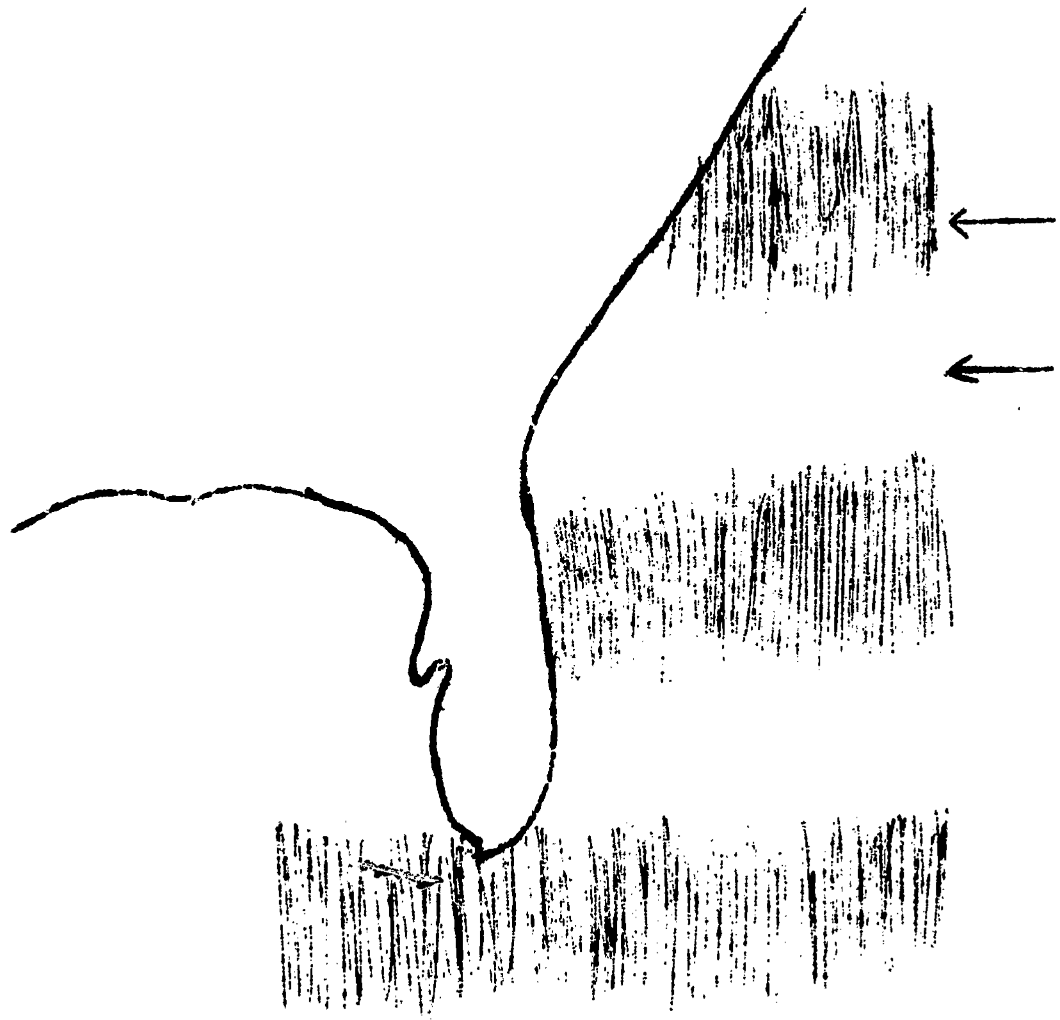


Fig. 8: The progressive wave theory holds that tides represent waves like ripples on a pond, that progress from south to north.

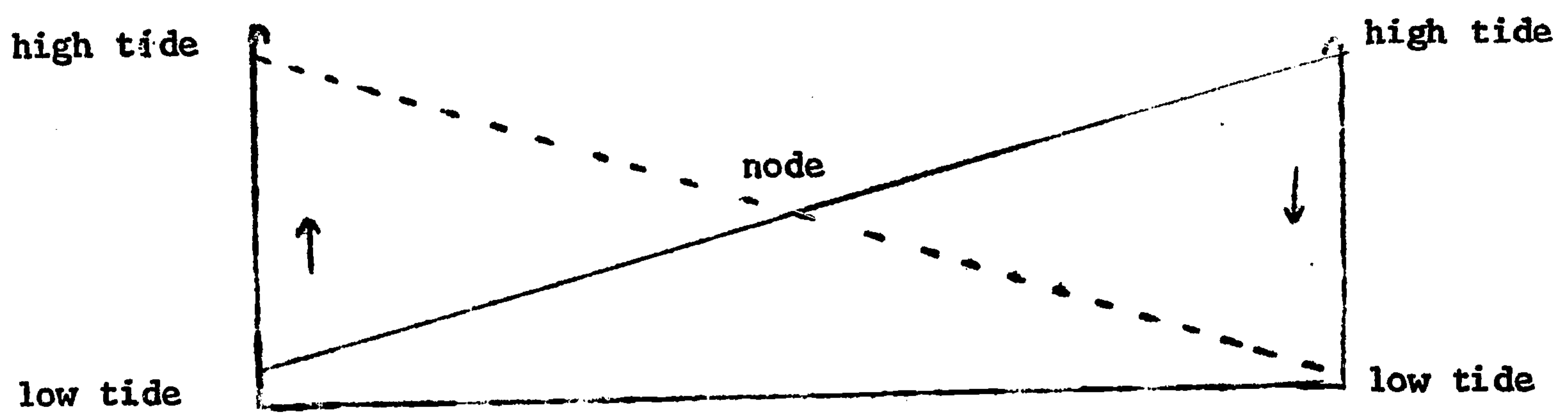


Fig. 9: The Standing wave theory states that natural basins of water slosh back and forth. At the outer of this slosh there will be no movement of water but, on both ends the tides will be extreme for the basin.

pan there will be an area where there is no movement of the water up and down. This point is called the node of the wave. The ocean has many such basins (dishpans) caused by the Topography of the bottom. Each of these has its own PERIOD OF OSCILLATION (time to complete a cycle from one side to the other and back again). Little force is needed to keep this oscillation in motion and the force of the moon and sun is sufficient for natural basins on earth. The Society Islands may be located in the node of a moon influenced oscillating basin. At least, tides in areas around the society is islands fluctuate with movements of the moon. Since the moon would cause little movement at the Society Islands (node) the sun would be free to influence tides here. Indeed, this seems to be the case.

Like most natural phenomena now studied we find the tides are complicated. They are the results of many combined factors and no two places are alike. One tidal theory may explain the tides at one place but not another. So we must understand both to understand tides over the world.

As tides are regular in their movements they can be predicted for long periods in the future. The United States Department of Commerce, Coast and Geodetic Survey have published daily tide tables for the Atlantic Coast since 1867. These can be purchased from the United States Printing Office in Washington, District of Columbia.

It would be impossible for the tide tables to cover every spot along the Atlantic Coast, however, they do cover the most important areas for shipping. If you desire to know the tides for an area between two reported spots, you would have to estimate according to the distance between two reported spots. This is called interpolation.

For instance, high tide occurs at 0400 hours at spot A and 0200 hours at spot C. Spot B half way between spot A and C will have high tide at 0300 hours. Some areas are covered by a full report, Hampton Roads, Virginia is one of these (see fig. 9 A). Other areas can be calculated by adding or subtracting a particular time factor from one of the complete charts. For instance, Cape Lookout and Shell Point, Harkers Island is calculated from Hampton Roads, Virginia. (see fig. 9B). In order to determine the time of high water at Cape Lookout you must subtract 2 hours and 8 minutes from the Hampton Roads tide table. For low water we must subtract 2 hours and 18 minutes from the Hampton Roads tide table.

Included with the time of high and low water is the expected heigh of the tides. It must be remembered that the tides are influenced by many factors and these predictions are for ideal conditions. Referring to charts 9A and 9B, what is the time and heights of high and low tides at Cape Lookout on 23 October 1968? By using the chart we can calculate that high tide will occur at 0740 (zero seven fourty hundred) hours and 2004 (two zero zero four hundred)hours. Tides are read from the 24 hour clock. This reduces the chance of the A.M. and P.M. error.

0948	Hampton Roads high	2212	Hampton Roads high
-0208	Cape Lookout correction	-0208	Cape Lookout correction
0740	Hours	2004	Hours

Calculated for the low tides on 23 October 1968 in the same manner. Be careful to note that the correction factor for high and low is different. Low tides occur at 0106 hours and 1354 hours.

To find the height of high water from the chart, we must add 1.2 feet on to Hampton Roads high water. 2.3 feet + 1.2 feet above average sea level for Cape Lookout. The chart also says that low water at the Cape will be the same as at Hampton Roads.

FIG. 9A

HAMPTON ROADS (SEWELLS PT.), VA., 1968
TIMES AND HEIGHTS OF HIGH AND LOW WATERS

OCTOBER

DAY	TIME H.M.	HT. FT.
16 W	0406	2.1
	1006	0.7
	1630	2.5
	2254	0.5
17 TH	0506	2.3
	1106	0.5
	1725	2.6
	2348	0.4
18 F	0554	2.6
	1206	0.3
	1818	2.7
19 SA	0030	0.2
	0642	2.8
	1300	0.1
	1906	2.8

DAY	TIME H.M.	HT. FT.
20 SU	0112	0.0
	0730	3.1
	1348	0.0
	1954	2.8
21 M	0154	0.1
	0818	3.3
	1436	-0.2
		2.9
22 TU	0242	-0.2
	0900	3.4
	1524	-0.2
	2124	2.8
23 W	0324	-0.3
	0948	3.5
	1612	-0.2
	2212	2.7

FIG. 9B

No.	Place	Position Lat.	Position Long.	Differences High water	Differences Low water	Differences High water	Differences Low water
	North Carolina's Outer Coast	° ' N.	° '	h.m.	h.m.	feet	feet
				On Hampton Roads, Time meridian, 75°W.			
2461	Cape Lookout----------	34 37	76 32	-2 08	-2 18	+1.2	0.0
2463	Shell Point, Harkers Island.--	34 41	76 32	+0 08	+0 40	-1.2	0.0
2465	Beaufort-------------	34 43	76 40	-1 00	-0 51	0.0	0.0

VOCABULARY

Diurnal tides-------------------One high and one low tide in a tidal cycle of 24 hour and about 50 minutes.

Ebb tide------------------------A tide that is falling, receding.

Flood tide----------------------A tide that is rising.

Neap tide-----------------------Tides that have the least variation of water level. Occurs when the sun, moon, and earth are at right angles with each other.

Node----------------------------A point in the middle of an oscillating basin that remains stationary.

Progressive wave theory---------A theory on tides which states the rise and fall of the tides are the results of large water waves moving past an area.

Semidiurnal tides---------------Two high and two low tides in a single tidal cycle of 24 hours and about 50 minutes.

Spring tide---------------------Tides that have the greatest variation of water level. Spring tides occur when the sun, moon, and earth are in a line.

Standing wave theory------------A theory on tides which states that tides result from oscillation (sloshing) of water back and forth in a natural basin.

Tidal bore----------------------A translation wave that travels up a river when the tide rises.

Tidal currents------------------Movements of water from one place to another in response to the tides.

CLASS QUESTIONS

1. On the North Carolina coast there are two high and two low tides each 24 hours and 50 minutes. We call this a kind of tide a ____________tide.

2. Neap tides occur when the sun, moon and earth form a ______degree angle with each other.

3. During a__________tide a coastal area will experience its highest and lowest tides.

4. A high or rising tide is called a________________tide.

5. Water sloshing back and forth in a basin is said to be____________.

6. If the tide is high at Beaufort, North Carolina at 12 o'clock noon, the next high tide occurs at______________o'clock.

7,8. Two theorys that attempt to explain the tides of the world are the ________________and____________________. theorys.

9. The great range of high and low tide in the Bay of Fundy is due in large part to the ________________of the bottom.

10. The ________________of the Tsientang River of China is a translation wave that passes up the river at high tide.

DISCUSSION

1. Explain why the tides in at Beaufort, North Carolina differ in height from one time to another.

2. Explain why the high tides of the Society Islands in the Pacific occur at 12 noon and 12 midnight. Explain how both tide theory can account for this.

3. Explain why the tidal cycle is 24 hours and 50 mintues when the earth makes a complete rotation in 24 hours.

4. Design a device for measuring the tides. Explain how it will work.

SEA VS. LAND

If you have ever been surfing you know there is more to it than just standing on a board. In fact, one of the first things a beginner must learn is how to get through the surf. The next thing a surfer must learn is to judge the incoming waves. With little practice he will see that waves follow each other in somewhat of a pattern. In fact, they seem to break at about the same spot every time. With this knowledge he can now concentrate on trying to ride his board.

Most of us may never go surfing, but waves are still important to us. Waves can cause serious damage, or perhaps their energy can be harnessed for our benefit. Lets begin a study of waves by studying their anatomy.

The CREST of the wave is its highest part. The TROUGH is the low part between two crests. The distance between two crests is called the WAVE LENGTH. The vertical distance between the crest and the trough is called the WAVE HEIGHT. (See Figure 10 A for clarification). The measurement of time between the passing of two wave crests is called the WAVE PERIOD.

There are two kinds of waves that we want to talk about, breakers (the surfer is interested in this type), which we see at the beach, and SWELLS which we encounter on boat trips. We know that waves move from place to place. Does this mean they carry water from one place to the next? In order to find this out, scientists built a wave tank. The wave tank is a long rectangular structure with glass sides. Waves are generated at one end and observed as they move to the other end. Neutrally bouyant particles were introduced in the tank and this

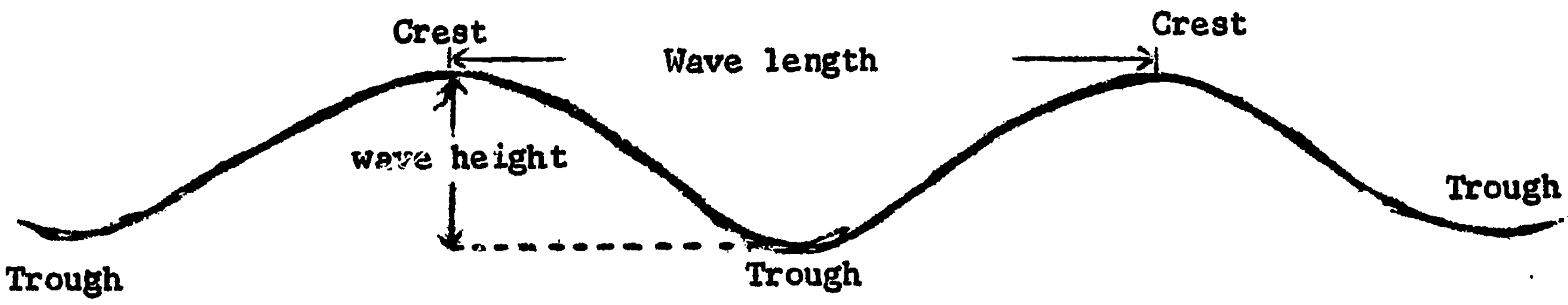


Fig. 10 Anatomy of a wave. The time for two successive waves to pass any spot is called the wave Period.

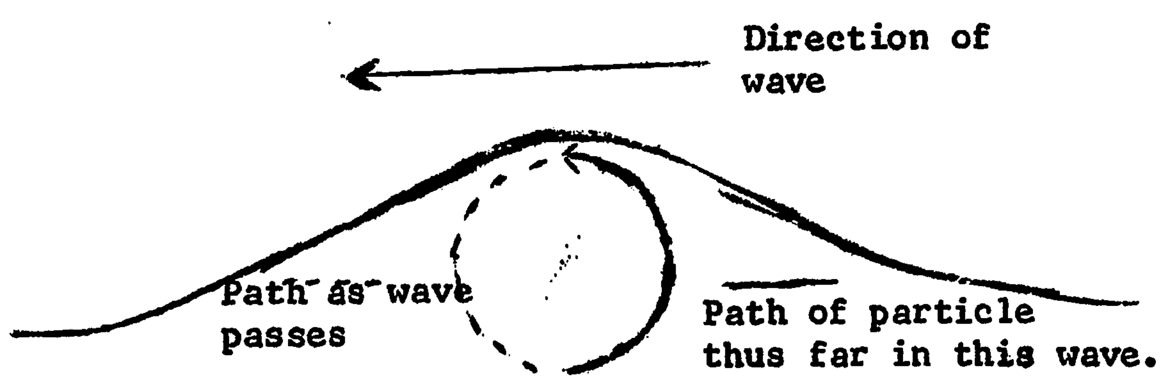


Fig. 11 Motion of a particle of water in a wave. Notice the path forms a circle. There is slight movement forward, but not very noticeable. When many waves pass however, a large mass of water is moved very slowly. We call this mass movement.

movement was drawn on the side of the tank as a swell passed. Interestingly, the particles did not move forward, but moved in a circle when the swell passed (Fig. 11). This can be observed on a windless day when there are swells present. Throw a floating object on the water and observe its movements. You should be able to trace the circular movement of the object. Does this circular motion occur only at the top? No! The wave tank again became useful as a scientists tool. They found there was a disturbance to a depth equal to ONE-HALF THE WAVE LENGTH. Below this there was no disturbance caused by the wave. When waves encounter water shallower than ½ their wave length, they are said to FEEL BOTTOM. As the water becomes shallower the circular motion at the bottom is altered. The water there is slowed down. At the surface the circular motion is still moving very rapidly. In fact, it moves so much faster than the bottom of the wave that the top spills over in front. Then the wave is known as a BREAKER. Breakers do carry water along with them. Waves that transport water are technically called TRANSLATION WAVES. If the wave breaks very quickly, the crest will be thrown into the trough in front. This leaves for a short time a tunnel of water (surfers call this the Banzai Tunnel) and the wave is known a as a PLUNGING WAVE (See Fig. 12). If the process is slow, the crest simply tumbles down itself into the trough. This kind of breaker is known as a SPILLING WAVE (See Fig. 12). Surfers prefer spilling waves because they last much longer than plunging waves.

The question remains important to our study of the waves. What generates them and where do they come from? The waves we see at the seashore are WIND WAVES. These are generated by the friction of wind

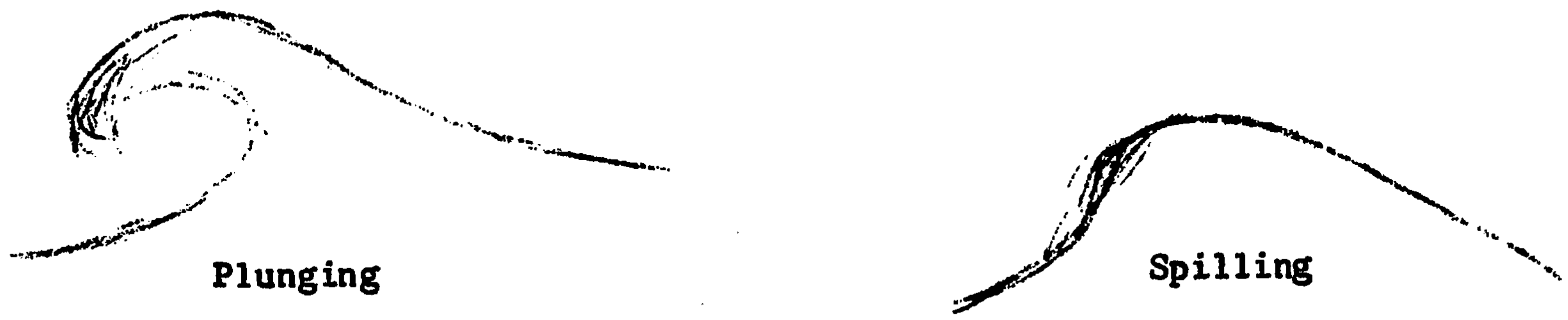


Fig. 12: Two types of Breaker

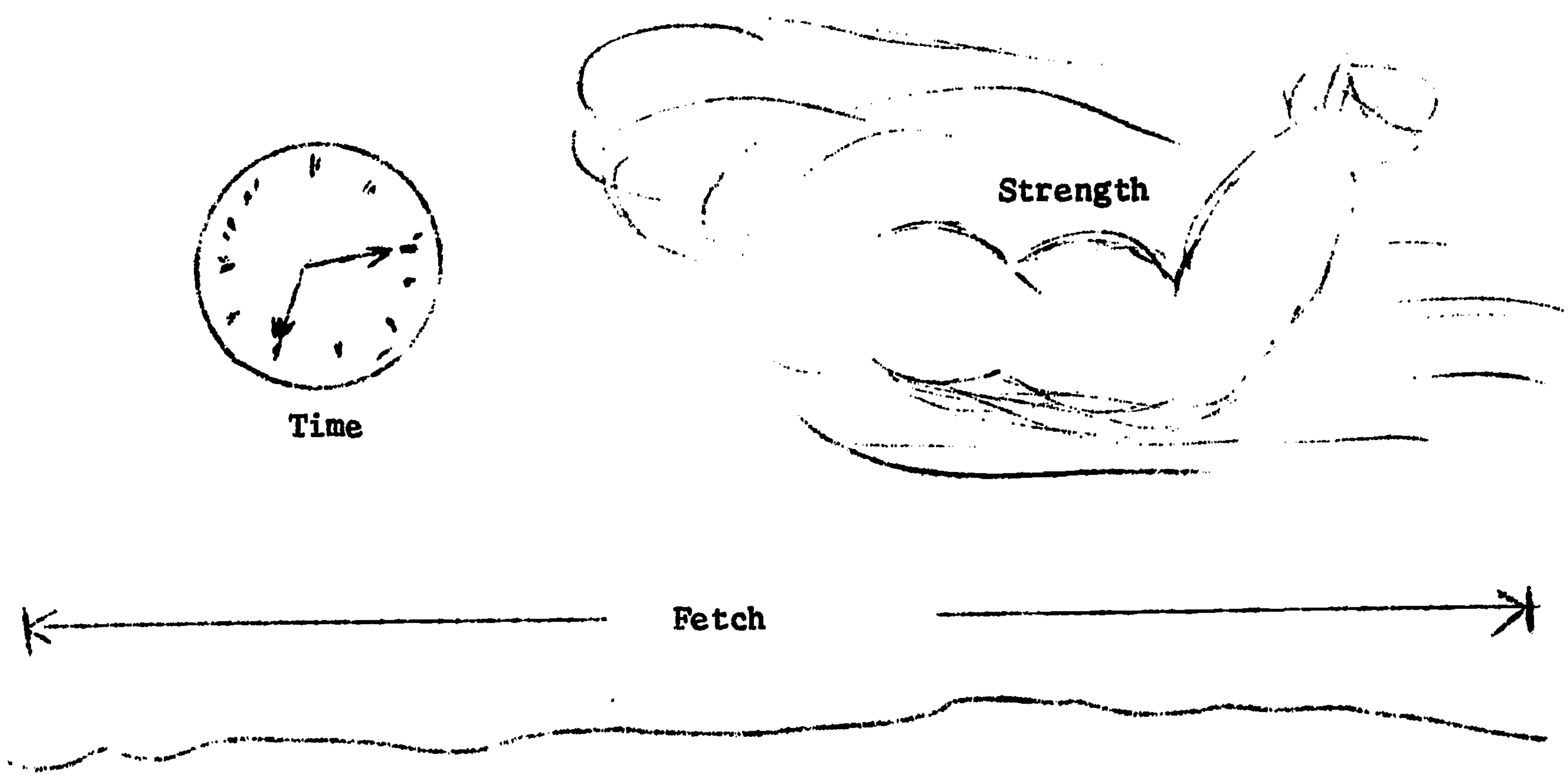


Fig. 13: The size of wind waves is dependent on 3 factors, the length of time the wind blows, the strength of the wind, and the distance over which the wind blows (Fetch).

blowing across water. Storms in the Ocean produce waves of very large size. Usually, though, waves are rather small. These are the waves produced by normal winds. The size of wind waves are dependent on three factors, the FETCH (distance over which the wind blows), the STRENGTH OF THE WIND and the LENGTH OF TIME THE WIND BLOWS. If all three factors are large, the waves will be large. (Fig. 13)
Large storm waves can cause great damage. In fact, they are responsible for new inlets in many spots along the outer banks of North Carolina. Even normal waves can erode vast areas of shoreline. The white Cliffs of Dover, England are an excellent example of how the constant action of normal waves can cut back the land.

The most spectacular kind of wave is the SEISMIC WAVE. These are commonly called "tidal wave". Seismic waves are the results of movement of the sea bottom or undersea landslides. In fact the word "seism" in Greek means earthquake. Since seismic waves have nothing whatsoever to do with the tides, scientists have named them TSUNAMI (pronounced sue'-nah-mee). Tsunami is the Japanese word for seismic waves.

Although tsunamis are large at the coast, a ship at sea would hardly notice one passing. This is because their crests and troughs are so wide. In shallower water the situation is completely different.
The waves may become breakers as much as 100 feet high. On April 1st, 1946 at Scotch Gap, Alaska a tsunami completely demolished a radio tower that was placed on a rock 103 feet above the sea.

On the same day Dr. Francis P. Shepard witnessed the results of that disturbance in Hawaii. The wave took many lives and wrecked much property. Today there is a tidal wave warning system around the

Pacific Ocean. When a seismograph station detects an earthquake, a warning is sent to all areas that could be hit by a tsunami.

WAVES AND BEACHES

The beach bordering an ocean is a constantly changing area. This is due to the forces of the wind and the waves. Energy is picked up by the waves, from wind and it is releases on the beach by friction with the bottom. The larger the waves the more energy they carry.

Waves always appear to hit the beach parallel (straight in), but seldom exactly straight in. Instead, they come from an angle.

The part of the wave feeling bottom first is slowed down allowing the rest of the wave to "catch up". From the air, the wave would appear to be bent toward parallel (See Fig. 14). This bending is referred to as REFRACTION. Refraction takes most of the angle with the shoreline out of a wave. However, there is always a slight angle left.

Many breakers hitting the beach at that angle can transport large amounts of water along the beach. This movement of water along the beach is called that LONGSHORE CURRENT (See Fig. 15).

The longshore current is responsible for a lot of the natural alterations taking place on beaches. It can and does move tons of sand from one spot on the beach to the other. For instance notice the sand kicked up by incoming breakers. Sand is kindked up from the bottom and moved along by the current. The movement of sand along a beach is called the LITTORAL DRIFT or LONGSHORE TRANSPORT. The effects of the littoral drift can be seen on the ends of islands or peninsulars where the longshore current is operating. There the waves no longer hit against the shoreline and the longshore current loses its energy. Sand is no longer carried along, but settles to the bottom. The results are long extensions of sand on the ends of these islands or peninsulars. We call these extensions SPITS (See Fig. 16).

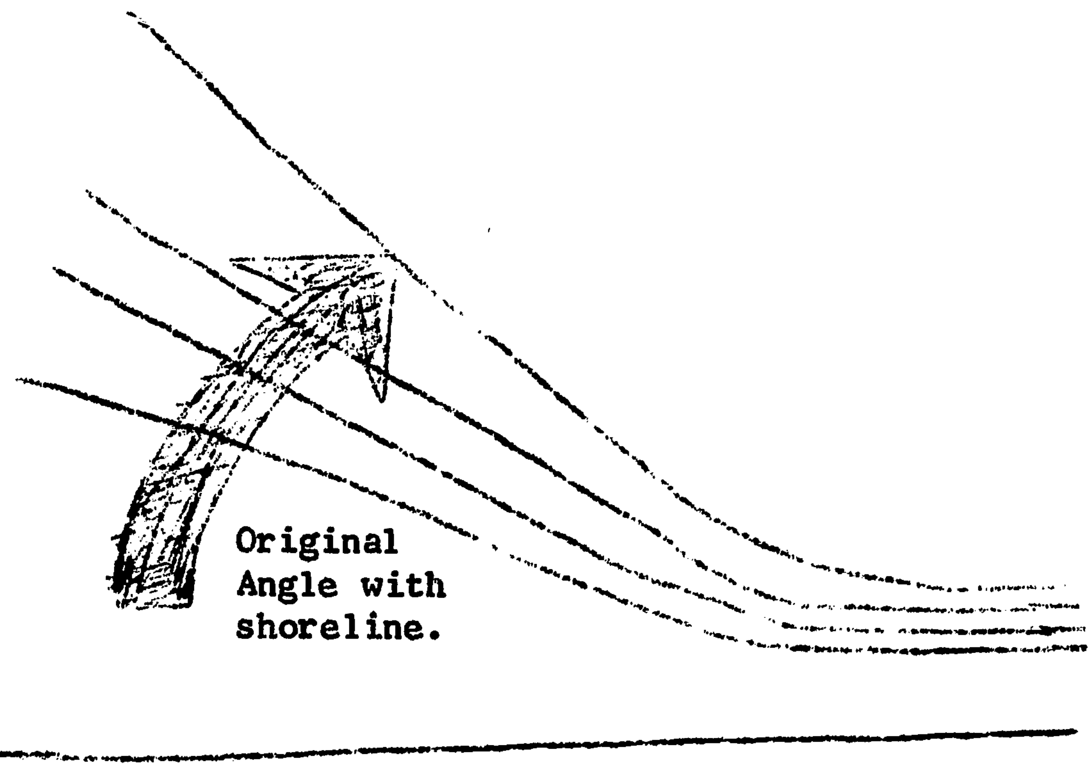


Fig. 14: Waves approaching a beach at an angle will be refeacted. As they approach the beach, the part of the wave near shore will feel bottom. That part of the wave will slow down. The other part will continue to move as fast as always. It will soon catch up with the other part.

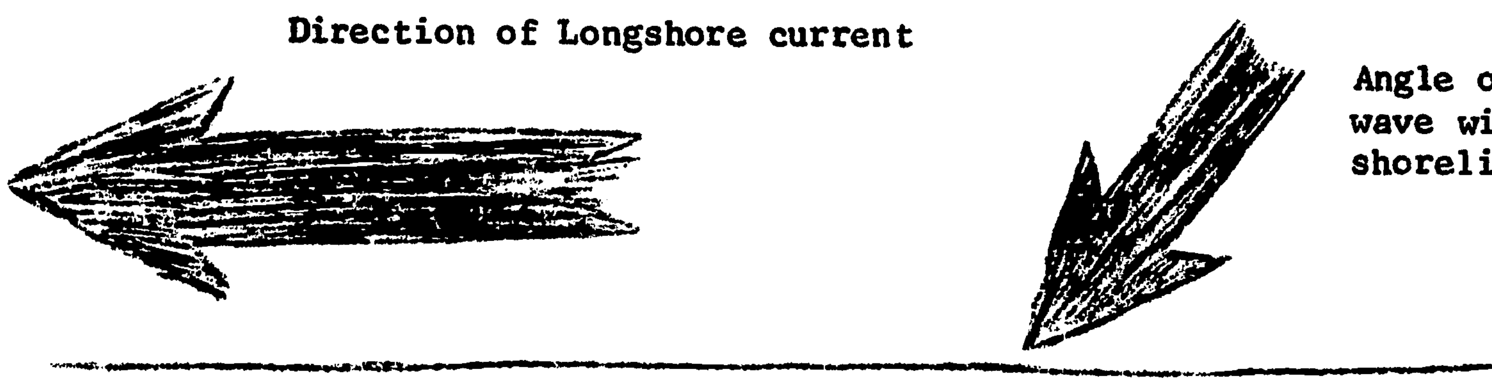


Fig. 15: Waves hitting the shore at a slight angle eause a water current in the surf zone.)translation wave zone) in the direction of the wave.

Another common movement of sand at the beach is a movement offshore and onshore. The results of this movement are long mounds of sand parallel to the beach called SAND BARS. Sand Bars are usually present offshore after a week or two of high breakers. When the waves are small for long periods, the sand bar is pushed toward shore and spread out by the waves.

Associated with sand bar are RIP CURRENTS. Breaking waves carry large amounts of water over the bar. The force of many waves breaking over the bar keeps water trapped between the bar and the beach, If the bar is broken anywhere along its length, water will go back to the ocean through the hole. This water comes from both directions and a current going straigh away from the beach results (See Fig. This is the rip current. It is sometimes called a RUNOUT but, we will call it a rip current. (See Fig. 17)

Rip currents are responsible for carrying many bathers "over their heads" at the beach. Surfers and lifeguards use rips to get through the surf rapidly. Coming back through one is a little more difficult and should be attempted only if you are an excellent swimmer. With a little practice, you can learn to spot rip currents on a beach. They usually hold back the waves somewhat and are sometimes discolored by sand and other debris.

Years ago, ocean engineers thought barriers were the best way to keep a beach from washing away. Lately they found that stabelizing one beach may cause trouble somewhere else. For instance, if we stopped the littoral drift at the middle point of one of the outer banks, the down current section of the beach would soon be deprived of sand from the littoral drift, Eventually that section of the beach would erode

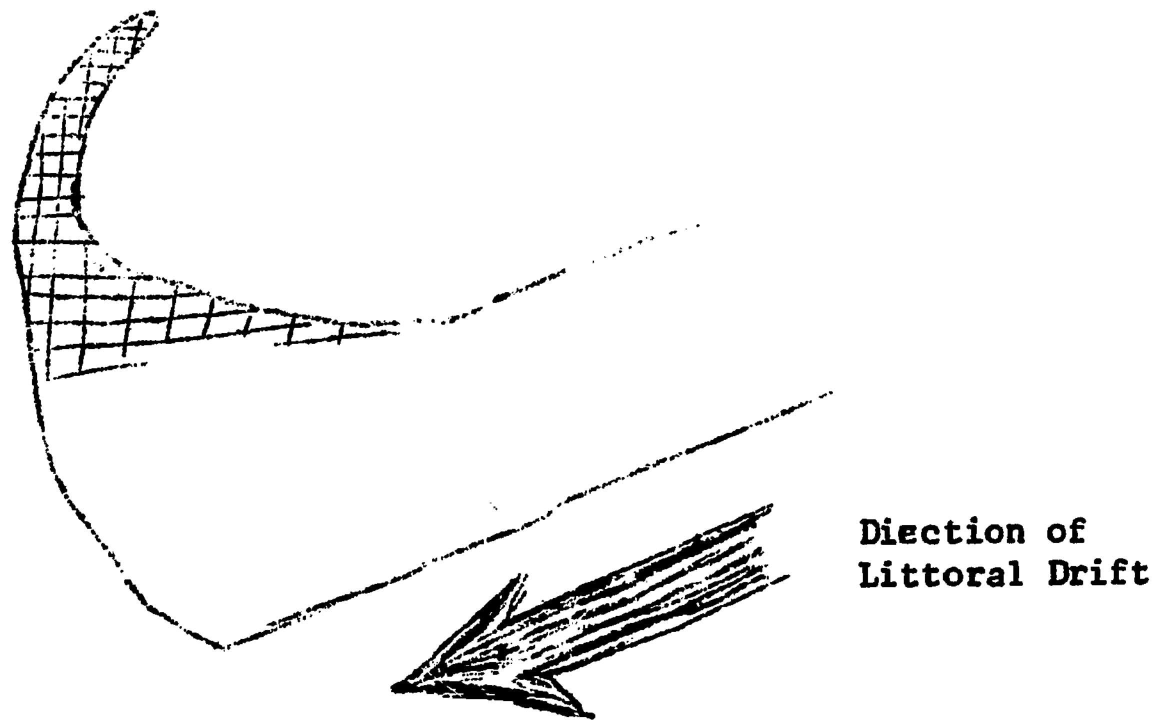


Fig. 16: Island with a sand spit deposited on the end by the littoral drift.

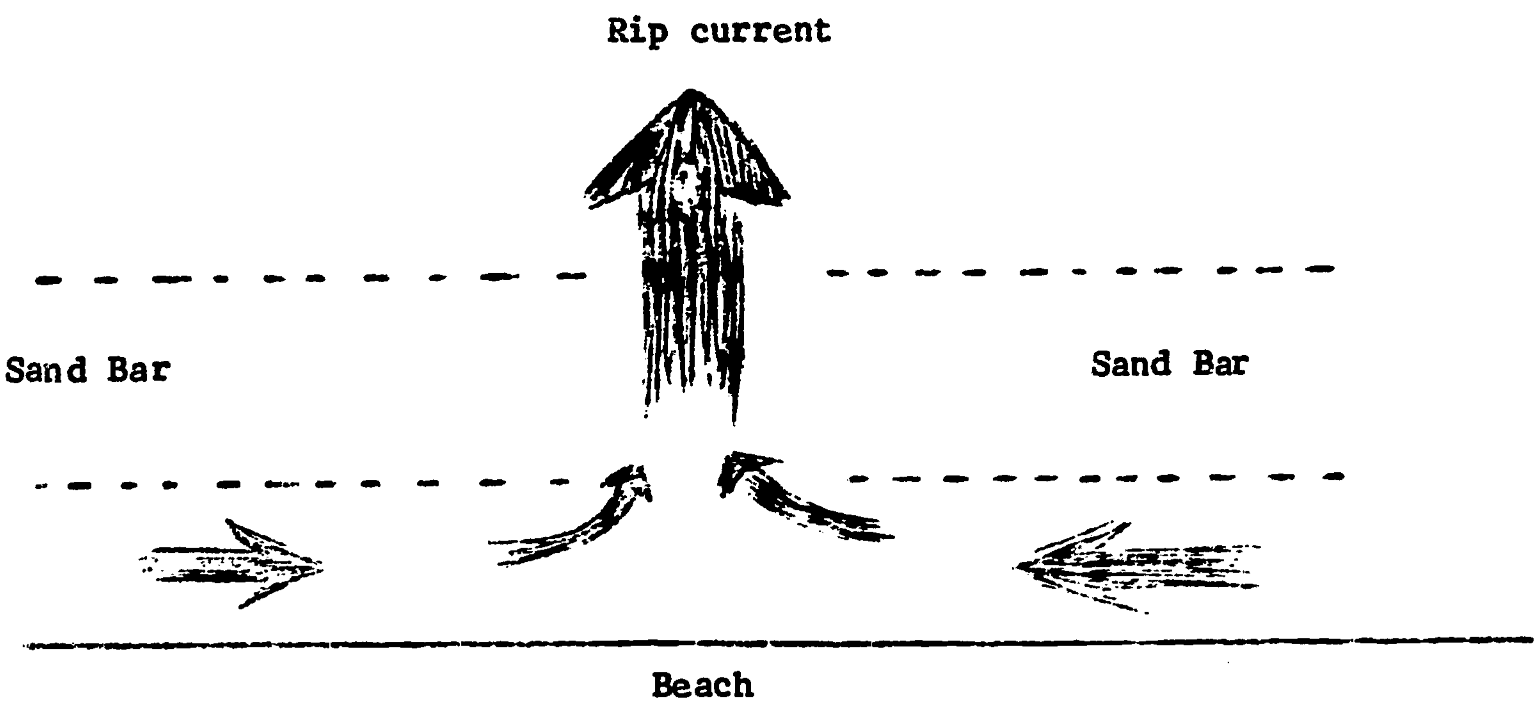


Fig. 17: Water getting trapped between a sand bar and the beach can escape through a hole in the bar. This may produce a strong current running away from the beach. This current is called a rip current.

away. The upcurrent section would become much wider. Although it may be harmful to some area of beach, it may be more important to build certain barriers.

Many materials have been tried, but large rocks are the cheapest and easiest to obtain. Ther material is used to form JETTYS, GROINS, and BREAKWATERS. Jettys are structures that extend into the ocean at the entrance of rivers or bays (See Fig. 18). They restrict the flow of water out of the river to a narrow channel. This tends to prevent SHOALS (sand mounds in rivers or lagoons) from accumulating at the river mouth (See Fig. 18).

Groins are similar to jettys but are usually placed perpendicular to the shore. They are usually grouped in a series, at critical points, to catch or hold sand.

Breakwaters are used outside of a beach to break up the waves hitting shore. This creates a calm area for small boats to anchor. Although this sounds like a good idea, it does have some serious consequences. If the waves no longer strike the shore, the energy creating the long-shore current is gone. When the longshore current encounters the calm water of the breakwater, the sand it carrys will be deposited. The area will then become shallower and shallower. The area on the down current side will continue to be eroded and will not receive sand from above. It will become very narrow (See Fig. 19).

If shoals build up in a shipping lane, they can be removed. This is usually done by a boat, called a dredge, which is specially designed for the purpose. Some dredges suck the material off the bottom and transport it to spoils areas through long pipes. Another type dredge, called a hopper dredge, picks up the material and carries it offshore to be dumped in the ocean.

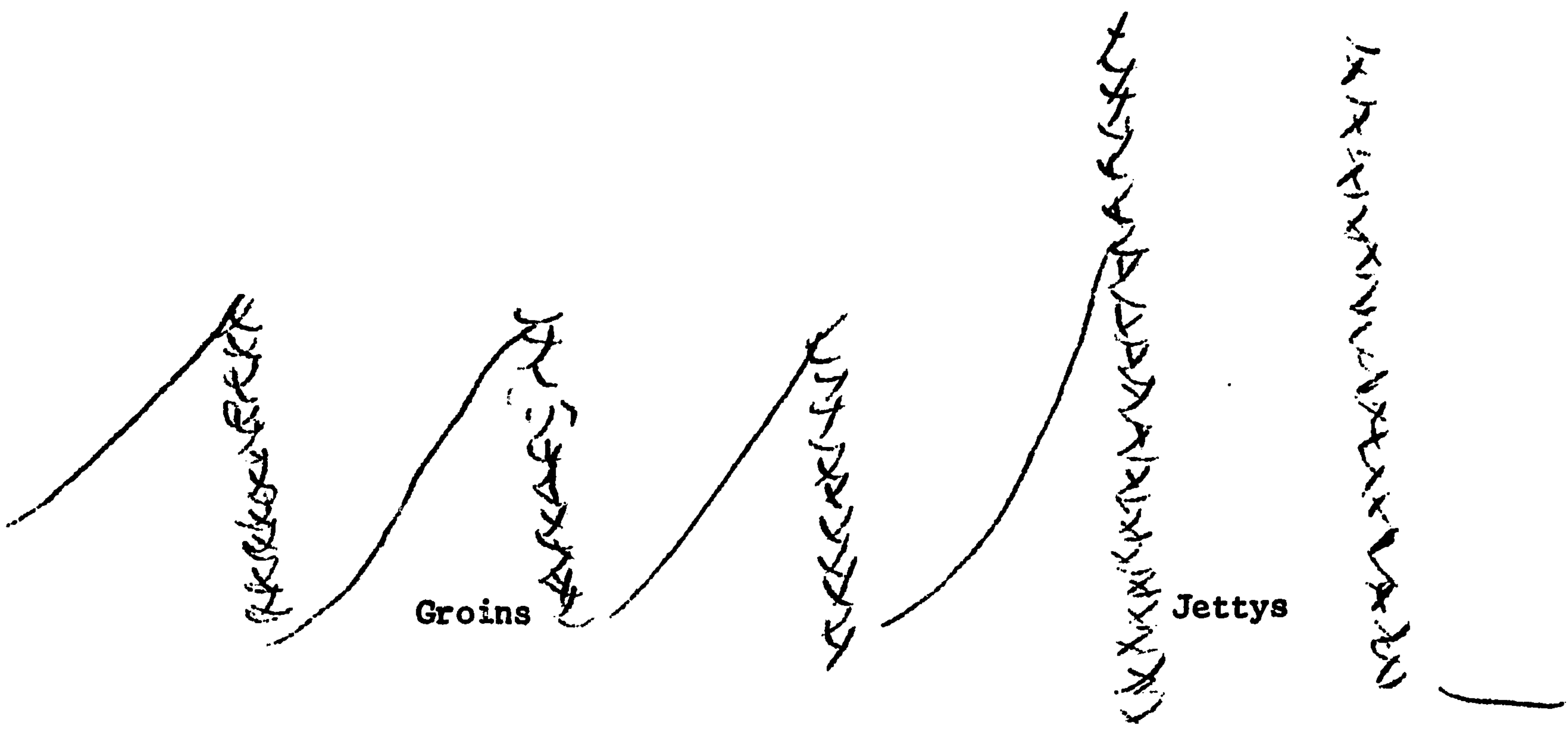


Fig. 18: System of groins and jettys. The groins are perpendicular to the beach and used for catching and holding sand from the littoral drift. The jettys are found on each side of the mouth of the inlet or river. Its purpose is to keep sand from "shoaling up" in the entrance..

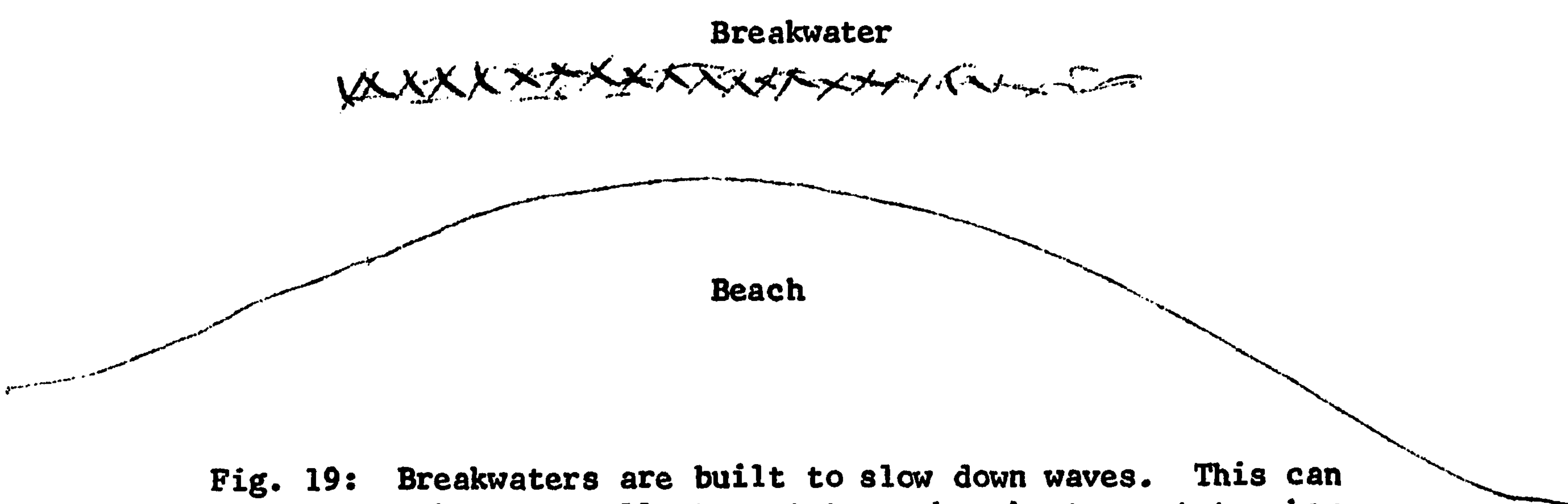


Fig. 19: Breakwaters are built to slow down waves. This can make an excellent spot to anchor boats next to shore. Since they slow the waves down, sand is deposited behind them, ruining the beach.

Above the water line on the beach, sand is moved by the wind. When the wind hits vegetation or some other barrier it slows down. The sand being carried by the wind then falls to the ground. If this continues for long periods, SAND DUNES are formed. Sand dunes are mounds of sand that pile up on the upper beach. They are very important in keeping storm waves from destroying the land behind them. Since the land along our coasts is valuable, man is now trying to preserve it by building sand dunes. There are several methods man uses to build dunes. One method is to pile sand up with a machine. This is not the best way because the wind will soon blow it away. The best methods are by using snow fences and beach grasses. With this method the wind actually builds the sand dune. The vegetation and snow fences will hold the dune in place. Recent investigation has pointed out that vegetation is the most ideal method to build dunes. In fact, until man came along this was the only way for dunes to become stable (See Fig. 20).

Fig. 20: Snow fence and vegetation built dunes. The vegetation section represents a "cut-away" to demonstrate how the root reaches down in the dune.

VOCABULARY

Bar---------------------A mound of sand found offshore and parallel with the beach.

Beach-------------------An area bordering an ocean that is effected by the waves.

Breaker-----------------A wave in which the crest has fallen off.

Breakwater--------------A wave barrier placed offshore and parallel to the shoreline.

Crest-------------------The uppermost part of a wave.

Groin-------------------Barriers placed perpendicular to a shoreline.

Jetty-------------------A barrier extending into the ocean at the mouth of a river or bay.

Littoral Drift----------The movement of sand along a beach.

Longshore current-------Current of water that moves along a beach.

Neutrally buoyant particle --------A particle that neither floats or sinks but has the same density as water.

Plunging wave-----------A breaker in which the crest is thrown into trough.

Rip current-------------Water currents formed when water moves to sea through a break in the offshore bar.

Shoal-------------------Shallow area caused by the deposition of sand.

Spilling wave-----------A breaker in which the crest slides down itself into the traugh ahead.

Swell-------------------A stable wave that does not carry water from one spot to another.

Trough------------------The low area of a wave between two crests.

Tsunami-----------------A seismic wave that may reach great heights.

Wave heighth------------The vertical distance between a wave trough and a wave crest.

Wave length-------------The horizontaal distance between 2 crests

Wave period-------------The time that elapses between the passing of two crests.

CLASS QUESTIONS

1. The size of wind waves is dependent on the strength of the wind, length of time the wind blows and the ____________________.

2. ________________ are produced by seismic activity on the ocean's bottom.

3. The time it takes for two wave crests to pass an area is called the wave ________________.

4. Breakers carry water from one place to the next and are called by scientists ______________________ waves.

5. Currents of water moving away from shore through a hole in the offshore bar are called _________________________ currents.

6. The ____________________ is a current of water caused by waves striking the coast line of at an angle.

7. The mass movement of sand along a coast is called the _________.

DISCUSSION

1. Discuss how the littorial drift can be important to the seaports of North Carolina.

2. Describe a method of measuring the height of waves.

3. How are sand dunes formed and why are beach grasses important.

THE AREA AWAY FROM LAND

Now that we have seen some of the processes at work along the edge o the sea, lets look at the area away from the shoreline. The relatively shallow area surrounding a continent is called the CONTINENTAL SHELF. It extends from the beach to the point where a relatively steep slope to the deep ocean floor occurs. This slope is called the CONTINENTAL SLOPE. (See Figure 21) The width of the continental shelf is different from place to place. At West Palm Beach, Florida the continental shelf is only about 1 mile wide. At Beaufort, North Carolina it is about 45 miles wide. A continental shelf may have many types of bottom. They may be sandy, muddy, rocky, or a combination of all three. They may also have depressions and hills on them. In fact, some hills stick out of the water as islands. Continental shelves are very important to fishermen. Since they border the continents, minerals washed from the land mixes with the water over the shelf. Mairine plants, mostly phytoplankton (phyto-plant plankton-floating), are able to use these minerals to grow. The plants are then eaten by the fishes and other important marine organisms. On the far edge of the continental shelf is the CONTINENTAL SLOPE. (See Fig. 21) The continental slope drops down to the DEEP OCEAN FLOOR. For many years it was thought that the deep ocean floor was a smooth featureless plain. With improved methods of SOUNDING (testing the depth) it was found that it is not a smooth plain. In fact, it was found to consist of some of the most spectacular mountains and valleys anywhere on earth. The MID-ATLANTIC RIDGE is a system of mountains that extends through the middle of the Atlantic Ocean. On each side of the Mid-Atlantic ridge are DEEP SEA BASINS.

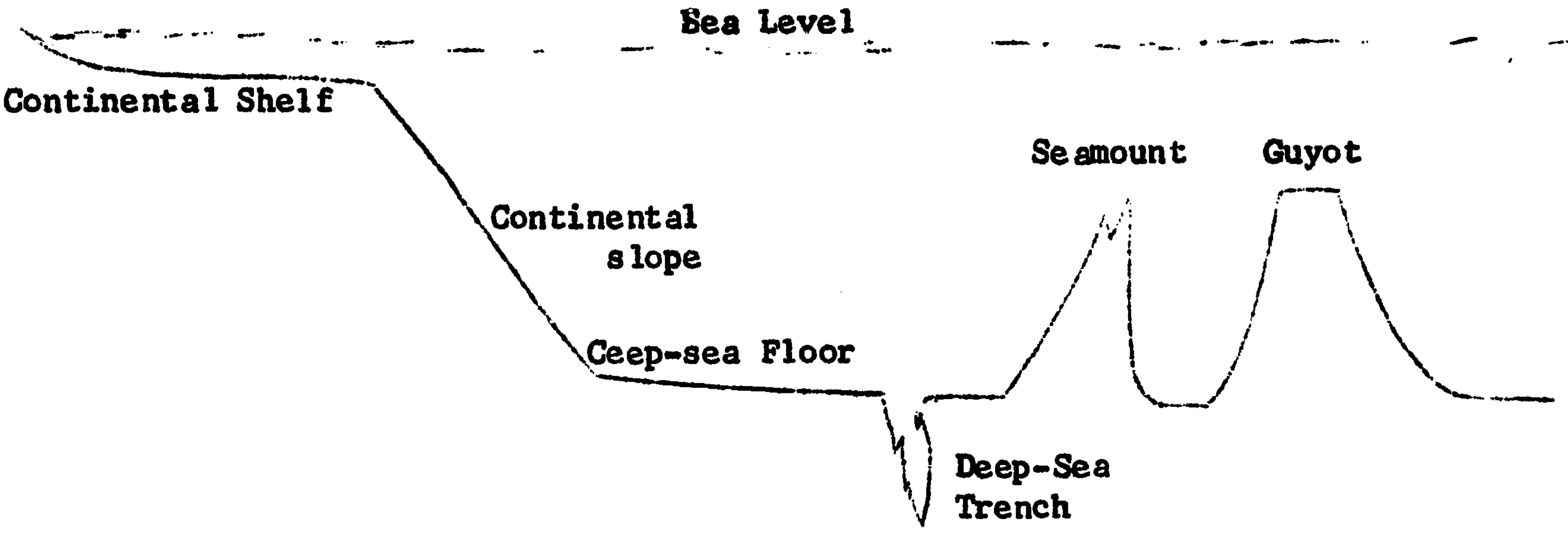


Fig. 21: Profile of the Ocean Bottom.

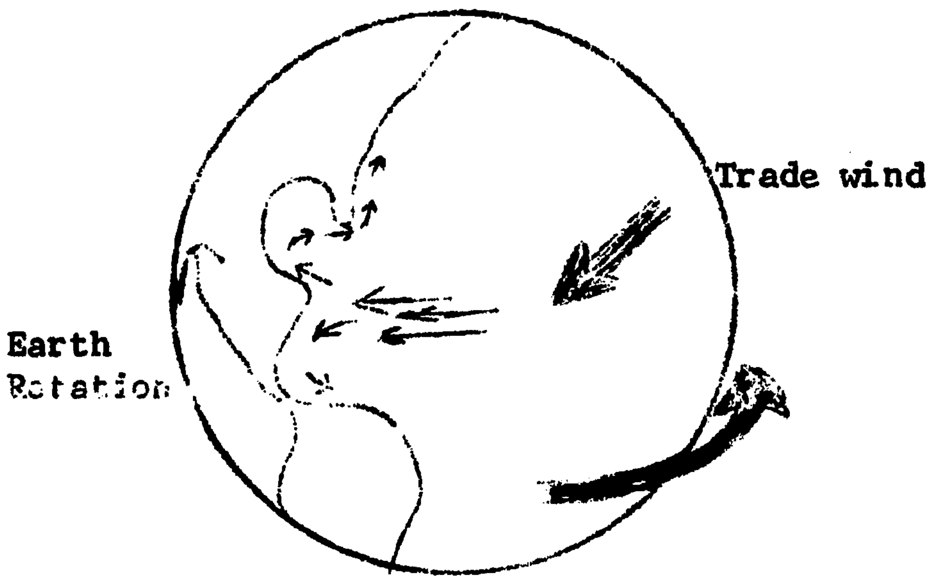


Fig. 22: Ocean currents are the results of two main factors. The earths rotation and the trade winds. The trade winds tend to push water along with them. The earths rotation has a different effect. The water tends to remain in place as the earth turns. Just as if the water was a separate shell and did not turn. This is seen by us as a current that is turned as it encounters land.

These are deep depressions on the ocean floor. Isolated mountains found on the ocean floor are called SEAMOUNTS. Some seamounts are flattopped and are called GUYOTS, (pronounced, gee yoo). (See Fig. 21). No one is sure how seamounts originated. Some oceanologist think they may be old volcanoes. Even if they are old volcanoes, how did some of the seamounts (guyots) get flat tops? They believe that millions of years ago, during the ice ages, these seamounts were above sea level. Above the water, they were eroded by wind and waves. When the many tons of ice melted, the level of the sea became much higher. This submerged the eroded tops of the seamounts. The hypothesis does not completely explain guyots, but it is a step in attempting to understand how they became flat-topped.

The deepest areas in the ocean are the deep sea trenches (See Fig. 21). The deepest trench known is the Mariana trench found in the Pacific Ocean. It has been measured at 35,700 feet deep, almost 7 miles deep. Trenches seem to be caused by volcano activity, but this has not been proven.

In all our studys so far we have failed to consider the water in the sea. After all, this is what we think of when we think of the sea. Water is called the universal solvent by chemists, because it can disolve so many substances. Sea water tastes salty to us because of this. Scientists believe that millions of years ago, ocean water was not salty. With the errosion of the land, minerals were washed into the sea where they were dissolved. Over millions of years, this gave the ocean its present salinity (this term refers to chemicals dissolved in sea water). It should be remembered that most of the sea water is still water. Only about 4% is dissolved minerals and solids. The most common elements, but not all of them, found dissolved in sea

Fig. 22A: Direction of major ocean currents of the world. Notice the direction and extent of the Gulf Stream that occurs along the Eastern Coast of the United States.

water are chlorine, sodium, magnesium, potassium, calcium, iron, and carbon. Two of the most common substances chlorine and sodium can combine to form common table salt, NaCl. During, the civil war sea water was boiled in large pots. When the water was completely evaporated, crystals of salt were left behind in the bottom of the pot.

Salt works were an early attempt at mining the sea. Today bromine is taken from sea salt in large amounts. The cost is very high for removing most minerals from the sea. In fact, it costs more to mine minerals from the sea than a company could make by selling them.

The ability of water to hold heat is very important to coastal dwellers. Land areas of the earth lose and gain heat very rapidly. This is not so with the oceans. During the winter coastal areas usually remain warmer than the inland areas. Often water at different depths will have different temperatures. Sometimes a very distinct line of difference can be found between the different temperatures. This line is called a THERMOCLINE.

The waters of the ocean are always in motion. TRADE WINDS AND THE SPINNING OF THE EARTH are responsible for most of this movement. The most spectacular of the movements are called OCEAN CURRENTS. (See Fig. 22). Ocean currents are caused by winds and the earths rotation. If we took a pan of water and suddenly moved it forward, we would see that the water would spill over the back of the pan. This is very similar to the way the water behaves in relation to the spinning of the earth. If there were no land masses to stop the water, there would be a continuous current from East to West in the sea. But, land masses prevent the ocean waters from doing this. Instead, currents turn away when they encounter a land mass. These currents occur over all oceans. (See Fig. 22A).

The most studied of the ocean currents is the GULF STREAM. The gulf stream carries warm water from the Carribean Sea to the east coast of the United States and the northwest coast of Europe. The warm waters of the Gulf Stream meeting the cold waters of the LABRADOR CURRENT causes great fog clouds on the grand fishing banks of Newfoundland. Another important current in the ocean is the UPWELLING CURRENT. This current is rather slow, but carries cold bottom water to the surface. This water may carry minerals from decayed animals that have sunk to the bottom. Phytoplankton can then use the minerals to grow. The oceanologist uses many methods to study the ocean. One of his most important tools is the RESEARCH VESSEL. These are special built ships. They carry equipment for all phases of ocean study. (See Fig. 23) It takes special instruments to reach the great depths necessary to study the oceans propertys. The insturments are sent down to the depths on a cable and must withstand great pressures. For studies of the bottom, CORING DEVISES are dropped from a ship. These instruments are streamlined and reach high speeds on the way to the bottom. The high speed and great weight of the instrument push a long pipe into the bottom. The whole instrument is then brought to the surface and the material caught in the pipes studied. Another method of bringing up bottom materials is with a CLAM-JAWED GRABBER. When this insturment touches the bottom it closes and a large piece of the bottom is scooped up.

In order to test the salinity of deep water it is necessary to bring some of it up to the surface. NANSEN BOTTLES are one of the best instruments for getting this water. They are lowered to the desired depth, closed up, and the water is brought to the surface for study.

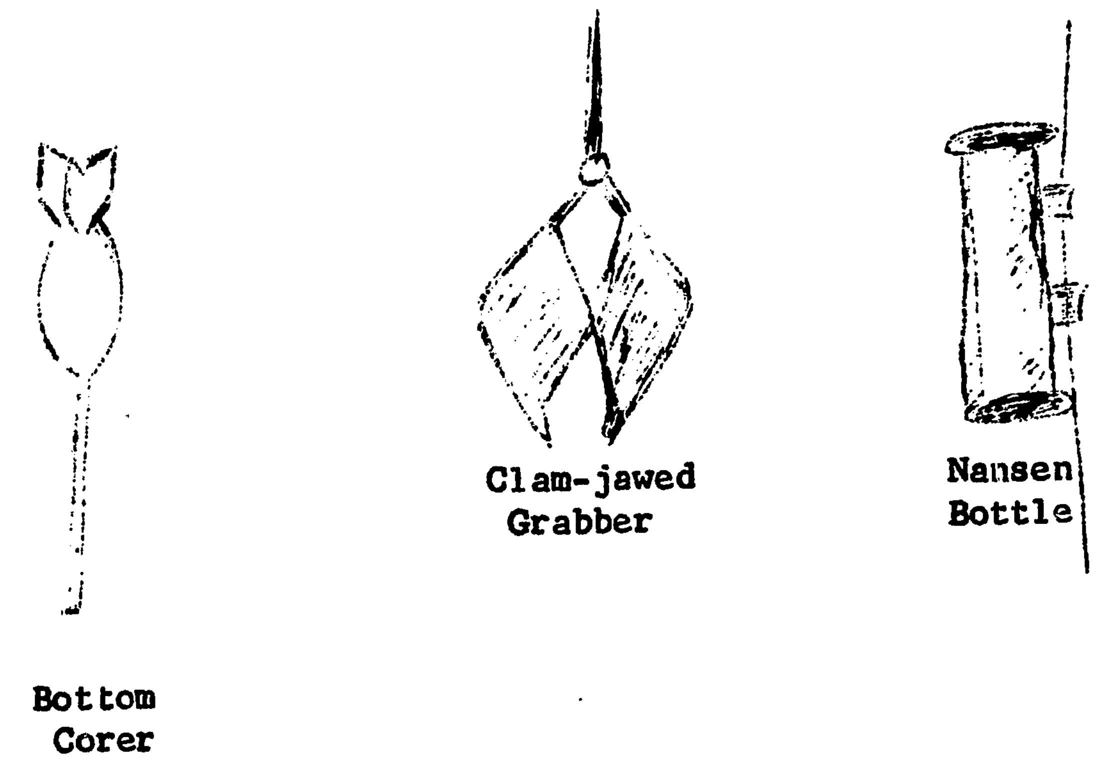


Fig. 23:

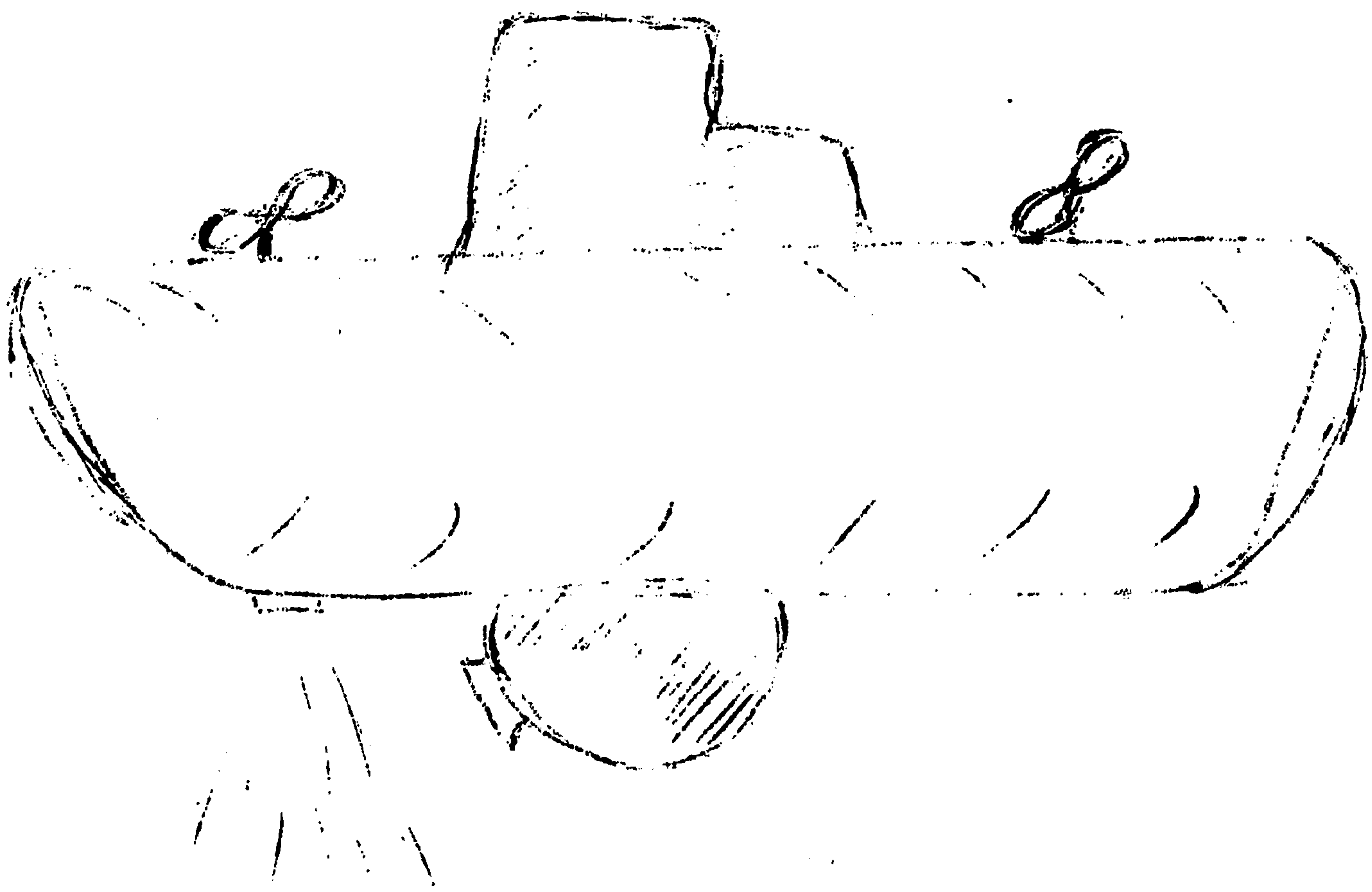


Fig. 24: Bathyscaphe "Trieste", one of the first free diving"Deep Boats".

Thermometers, pressure guages, current meters, and cameras are also lowered into the ocean.

The fathometer is used to determine the depth of the ocean floor. This electronic instrument works by bouncing a sound wave from the ship off the bottom of the ocean. The longer it takes thw wave to reach the ship after bouncing from the bottom, the deeper is the water. Fishermen can use this device for finding fish. Sound waves pounce off the fish just as they do off the bottom. Fishermen can then drop their nets right on the school.

Oceanologists can also observe the bottom directly. If he only wants to go to 150 feet, he can safely use SCUBA GEAR (Self-Contained, Underwater Breathing Apparatus). For deeper observation, the research submarine or BATHYSCAPH is used. Most of the research submarines can dive to about 3,000 feet. The bathyscaph (from Greek meaning "deep boat") is designed for much deeper diving. The deepest dive was in the Challenger deep, 35,700 feet. This was done by Jacques Piccard in his bathyscaph "Trieste". Piccard was able to prove that life exists at this great depth when he saw a fish swim by his window.

Continental Shelf-----------The area surrounding a continent, out to the steep sloped dropoff to the deep ocean basin.

Continental Slope-----------The steep slope that marks the end of the continental shelf.

Deep Sea basin--------------Flat bottom depression that forms the deep ocean floor.

Deep Sea trenches-----------Trenches in the ocean floor believed to be caused by volcanic activity. They are the deepest spots in the ocean.

Guyots----------------------Flat-topped seamounts.

Mid-Atlantic ridge----------Ridge of mountains in the Atlantic ocean.

Ocean Currents--------------Water moving from one place to the other in the open ocean.

Phytoplankton---------------Floating plants in the sea, mostly microscopic.

Salinity--------------------Amount of dissolved minerals in the sea.

Sea mounts------------------Isolated mountains that are believed to be volcanos.

Thermocline-----------------An area in the ocean where the temperature rapidly changes.

Upwelling current-----------A current that moves from the bottom to the top of the oceans waters.

1. Water is called the ______________ because it dissolves so many substances.

2. The ocean current occuring off the coast of North Carolina is called the__________________________.

3. The bathyscaph trieste made its deepest dive to 35,700 feet in the __________________________________.

4. Microscopic floating plants in the sea are called_______________.

5. Isolated flat-topped mountains in the sea are called_____________.

6. The ____________________ is a mountain range in the Atlantic Ocean.

7. The ____________________ is a device used to sample the oceans bottom.

8. The amount of minerals dissolved in Ocean water is called its __________________________.

9. The oceans water is____________________ percent pure water.

10. The term Scuba stands for______________________________________.

Discussion

1. Why are the continental shelf areas of importance to the fisherman.
2. Explain why seamounts have pointed tops and guyots have flat tops.
3. Write down a complete method of studying the continental shelf on the North Carolina coast. Include research ships and instruments you would use.