LEARNING ABOUT THE TIDES

BY
DAN SKELTON and DELLA McCAUGHAN

Illustrations By
Joe Moran, Tommy Moran,
Dan Skelton, Mary Ellen Turcotte,
William F. Mitzel

Book XII: MARINE DISCOVERY SERIES

PRODUCED BY
DELLA McCAUGHAN, MARINE EDUCATION SPECIALIST
BILOXI SENIOR HIGH SCHOOL, BILOXI, MISSISSIPPI

AND

DEPARTMENT OF WILDLIFE, FISHERIES, AND PARKS
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JERRY MITCHELL
MISSISSIPPI COASTAL ZONE MANAGEMENT PROGRAM

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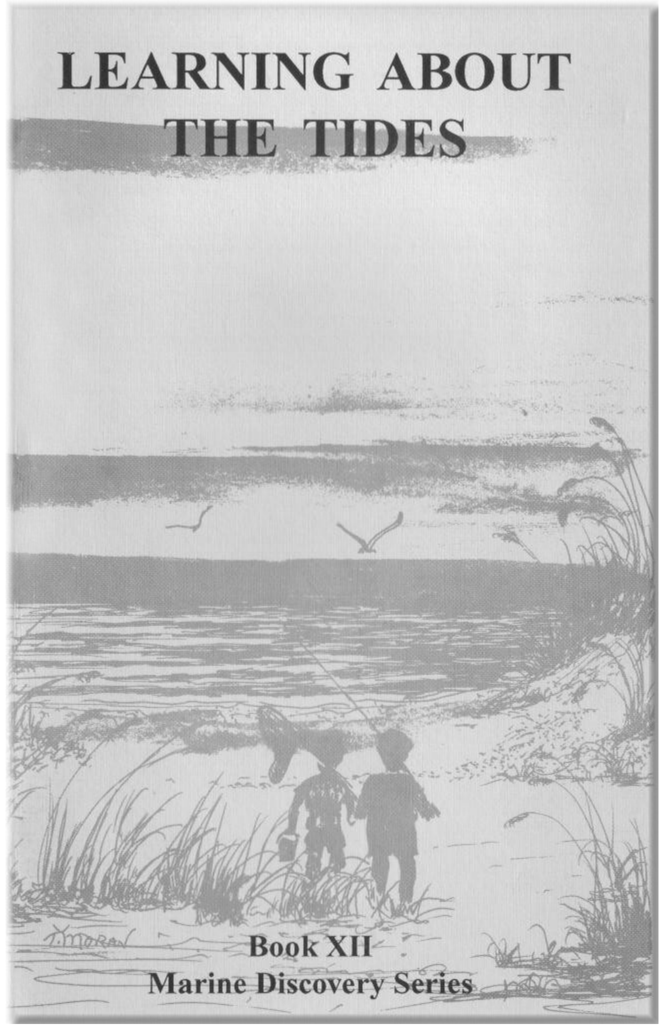


Learning About The Tides, like the other eleven books in the Marine Discovery Series, is intended to help young people learn about the resources, environment, heritage, and history of the Gulf Coast. And in learning important facts that will increase their knowledge and enrich their lives, these elementary students (and others who may read the books) will also learn to respect the unique and beautiful environment of the Mississippi Gulf Coast and to take better care of the wonderful world in which we live.

Dan Skelton

LEARNING ABOUT THE TIDES

When the twins were twelve years old, they lived in a small neat house on a wide, shaded avenue in Biloxi, Mississippi, with tall oaks liming the narrow sidewalks leading to the beach. The word most people used when they wanted to describe their street was always the same: neat. Sometimes they added other words--like clean and quiet and pretty.

"Sometimes I think we live on the most beautiful street in the whole world," Paul told his sister.

"Maybe not in the whole world. You've never seen the whole world," Jennifer said matter-of-factly. Sometimes Paul--what was the word--exaggerated--that was it. "Sometimes," she said, "you exaggerate!"

He laughed. Both of them were dark-tanned and dark-complexioned and brown-eyed and quick to laugh. They liked being twins and always having someone nearby to talk with.

"Well, maybe not in the entire world," he grinned, "but in the United States, I'm pretty sure."

"Not in the whole country, either," she said firmly, continuing to tease him. "Think of all the towns you've never visited."

"In Mississippi, then," he said. It was a game they played sometimes.

"The entire state?"

"Well, maybe just the coast--"

"The prettiest street in the whole world," Paul told Jennifer.

"You've been everywhere on the coast?"

"In Biloxi, then."

"Have you seen all the streets in Biloxi?" When she looked at him, it was hard to keep a serious look on her face. He ought to learn not to exaggerate so much, she thought.

"Well, anyway," he conceded finally, looking to see whether she would agree, "it's the prettiest street in this part of town."

"Have you seen all the streets in this part of town?"

"Stop!" He said, holding up a hand. "I give up. It's a neat quiet, shaded, clean, pretty street--okay?"

"Okay," she laughed, and then they jumped up and ran inside, where they found their parents watching the evening news on WLOX-TV.

The date was August 28, 1985, and the Jacksons were listening intently to the weather report.

"What's happening?" Paul interrupted, sitting beside his father on the large couch in their family room.

"Wait," his father said, motioning toward the TV set. "This is important."

That was the first time Jennifer and Paul became aware of a hurricane moving north of Cuba in the Gulf. The Jackson family had moved to Biloxi only the summer before, coming from Meridian. Both their parents were employed at Keesler Air Force Base. They had often talked about the hurricanes which sometimes threatened the coastal areas. Their neighbors had told them of Hurricane Frederick, which came ashore near the Mississippi-Alabama border east of Biloxi in 1979. And several families on their street had been in Biloxi on August 17, 1969, when the most powerful storm ever recorded in the United States, Hurricane Camille, had struck the Mississippi Coast, leaving behind a trail of destruction and loss of life resulting from the enormous forces of both wind and water.

The weatherman reported that Hurricane Elena was moving in a northwest direction, with the Mississippi Coast among the possible sites where the storm would eventually move inland.

Later, when the twins remembered the next week, everything seemed to move in super-fast motion. First, the hurricane appeared to be headed directly for Mississippi. That was on August 29, when suddenly the storm system took an unexpected turn, moving east toward the Florida coast. People in Biloxi were relieved to know that the unwelcome weather had moved away from them--when, almost as if it were playing a game, Hurricane Elena made a complete circle in the Gulf off the Florida shore and started northwest again on August 31, with forecasters finally predicting that it would probably move inland on the Mississippi Coast.

This time, most of the people on Jennifer's and Paul's street decided to leave the area, because they lived on the low sections of the city. "The part of the street nearer the shore was underwater in Hurricane Camille," a friend told them. "It didn't get up this far, but it could; you never know. Water in a hurricane is a treacherous thing."

That was the first time the twins remembered hearing about storm surges connected with the huge weather systems. The WLOX weatherman had mentioned several possibilities in regard to the water, and then he had said: "A lot depends on what time the storm makes landfall. The surge could be as much as twelve feet, depending on the tidal situation."

Neither of the twins understood what he meant, and their father was too busy to answer their questions then. The only thing he said was that a storm surge so high would mean real problems in the low-lying areas of the Coast.

The Jackson family left Biloxi at noon on September 1, driving to Meridian to stay with the twins' grandparents. That evening they listened closely to radio reports and watched TV news about Hurricane Elena. After the storm hit Biloxi and the Gulf Coast on the morning of September 2, the first reports were disturbing, though there were no reports of loss of life.

The Jacksons found their home undamaged after Hurricane Elena

Even the twins were quiet when the family drove back to Biloxi on September 3, none of them feeling very confident. The TV pictures had been frightening.

And fin-ally, when they turned from Howard Avenue south onto their street, all of them were dismayed at the number of trees that had fallen, the occasional roofs destroyed, fences down, trash in the streets, limbs thrown into houses.

"I can't bear to look!" Jennifer said, closing her eyes as her father drove slowly down what once had been the neat, clean, shaded pretty street where the Jacksons lived.

And that was when Paul saw their house, still standing, undamaged, though there were so many oak branches and pine limbs scattered across their lawn that he could hardly see the front steps.

When it was finally over, and their lives had settled back into the pleasant routine they had known before, Jennifer and Paul heard a neighbor tell their parents: "It could have been so much worse if it had come in on the tide. The impact of the storm surge was only eight to ten feet, because we had what people call a 'negative tide' before the surge reached the coast. The actual surge was the twelve feet predicated by Civil Defense officials, but it didn't come in conjunction with the high tide, which would have been a devastating combination."

"People who live here ought to know more about the water," Mr. Jackson had said. "The sea affects everyone's life here, and most people don't know much about the tides. All of us ought to learn more."

When Paul and Jennifer had an opportunity, they liked to spend time listening to stories their neighbor told them about what he called the "old days in Biloxi." Because he was almost the same age as the twins' father, Mr. Jackson laughed abut it when he heard the phrase.

"You make it sound as if it were in the last century," he joked with his friend. The man had been a fisherman when he was young, working for his father, who had been born in Biloxi.

"Well, my family has been here since the mid-1800s," Thomas Alfred said, "so my knowledge goes back a long time." Mr. Alfred owned his own business, but he remembered when times had been harder, and life, for his family, had been dependent upon the sea.

His sea stories were what the twins enjoyed most. And when Paul asked him one day to tell them all you know about the tides...

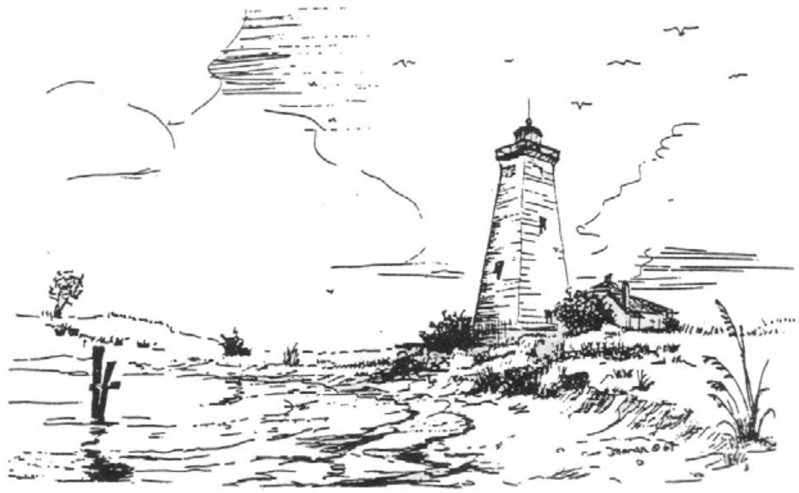
"And storm surges," Jennifer added, using the phrase she had heard in reference to the hurricane.

"And why the hurricane wasn't as bad as it might have been, if it had hit at another time," Paul said.

"And why we have tides in the first place," Jennifer continued. "It's as if they're on some kind of schedule..."

That day was the beginning of their learning about the tides. They could not have had a better teacher, because Mr. Alfred had spent so much of his early life working on his father's boat and listening to the Biloxi fishermen tell their stories and asking almost as many questions as the twins asked. Later that fall they went out on Mr. Alfred's boat, large enough to hold the two families comfortably. Mr. and Mrs. Alfred's son Tony was only a year younger than the twins. He already knew a lot about boats, and his parents had taught him water safety rules that he helped Jennifer and Paul to learn.

The boat was anchored near Ship Island, about twelve miles south of Biloxi, and while the others were fishing, Mr. Alfred gave Jennifer and Paul their first lessons about the tides. "It's almost," Jennifer told her father later, "as if Mr. Alfred were an encyclopedia."



A string of offshore islands lies south of the Mississippi coastline

"He knows everything in the book about the ocean!" Paul said admiringly, exaggerating a bit and waiting for Jennifer to correct him. "And he doesn't mind at all when we ask questions. He said that someone wrote that tides are 'the heartbeat of the ocean.'"

One of the first things Mr. Alfred told them was about the effect that large storms have on tides. High winds blowing toward shore can push the water farther inland as the hurricane nears land. But in its counterclockwise movement, the winds may also push the water back out, depending on the location of a particular site and the section of the storm nearest land.

"The height of the water can be greatly influenced by the wind force, and if the tide is coming in at the same time the wind is pushing the water inland, the storm surge can be more damaging. In other words, the height of the water when the storm hits land can be several feet greater, and the water can reach far deeper into land. We were lucky in this storm," Mr. Alfred said. "At the time the storm winds hit us, if the winds had been blowing hardest from the south into land at the same time we were having high tide, we'd have been in much greater trouble. The storm surge would have been several feet higher and more houses and property would have been destroyed."

"Are all tides the same?" Jennifer asked.

"There are different names for different kinds of tidal situations," Mr. Alfred said. "When the water moves in toward shore, it's called 'flood tide.' When it stops rising, it is 'high tide.' And when it reaches the point that it stops going out, it's called 'low tide.'"

"Why do we have tides in the first place?" Paul asked. "I remember reading somewhere that the tides are caused by the moon, but I didn't understand that, either."

"I still don't understand," Jennifer said.

Though the twins stopped him frequently with their questions, Mr. Alfred carefully led them through the sometimes very complex explanations surrounding the movements of the oceans that are called tides.

Correctly used, the word tide refers only to the periodic rising and falling of the ocean surface due to the gravitational forces of the moon and the sun on the rotating earth. It does not include waves caused by wind or the piling up of water along the shore during storms. Tidal current is used to refer to the horizontal movement of the water accompanying the tide.

"It has been estimated that the earth holds 300-million cubic miles of ocean water," Mr. Alfred told them, shaking his head at the wonder of it, "and none of it is ever still. It's always moving."

They were fascinated by the incessant motion of the sea. The enormous sea basins are like gigantic pans, with water sloshing from side to side. The levels rise and fall; waves beat against the sand or rocks; winds whip across the surface; froth forms and waves crest and break and splash. High tides come in and fill small pools and low areas along the shore. The ebb tide slowly reveals the land mass near the shore and leaves it uncovered until the waters reach their lowest point, and the inevitable process starts again.

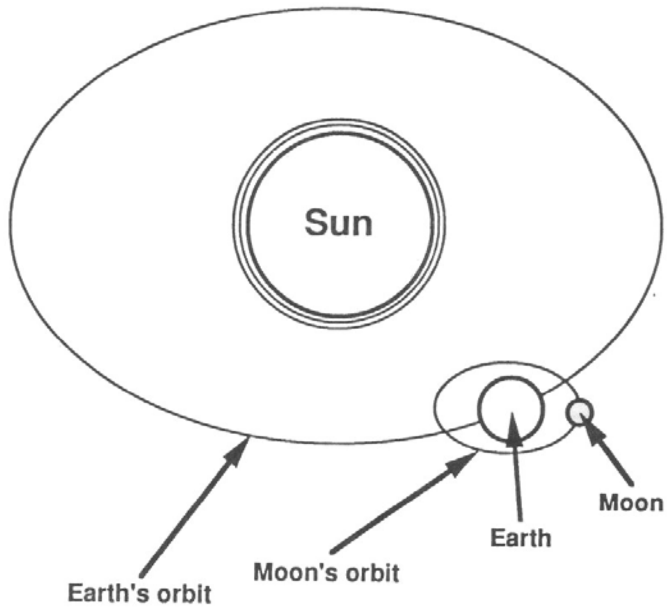
On most coasts, the tide comes in and then moves back twice a day. These are called semidiurnal tides. In other places, however, as in the Gulf of Mexico, there is only one low tide and one high tide every twenty-four hours and fifty minutes. These are called the diurnal tides. It is a process that must have been well-observed by ancient tribes near coastal waters everywhere.

The rising and falling action comes in a cycle that is about fifty minutes later each time, and those ancient peoples must have learned to associate tides with the moon, which rises about fifty minutes later each day, as the moon is over any given location on earth every twenty-four hours and fifty minutes. In 1687, tides were seen as the result of laws of gravitation after publication of the discoveries of the great scientist Isaac Newton. Even today, after all those years, people are still studying and learning new facts about tides every year.

Over the next few weeks the twins listened to Mr. Alfred and read a book about tides and watched a program on Mississippi ETV about the effects of tides in strange places like the Bay of Fundy on the east coast of Canada, where the tides can measure fifty feet from high to low. In most places, the differences in height between high and low tide is not very great, but in other places, the tides are affected by narrow channel opening or other factors that cause large fluctuations in height.

It is not enough to say simply that tides are responses to the gravitational pull of the moon. Much more is involved in the tides.

In fact, as Jennifer and Paul soon learned, they needed to know more about the earth and its relation to the sun and the moon if they were to understand the governing forces surrounding tidal movements. They reviewed some of the information they had learned in their science class the year before in order to fill in the background for their understanding, beginning with the movement of the earth around the sun and on its axis.



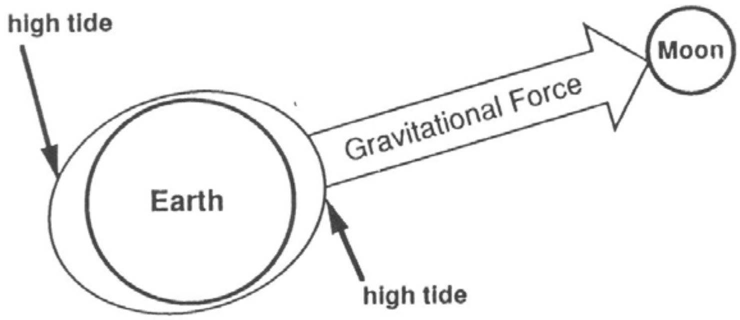
The earth orbits the sun in an elliptical movement. At the same time, the moon orbits the earth in an elliptical movement. When the earth is closest to the sun, it is said to be at **perihelion**; farthest away, it is at its **aphelion**. When the moon is closest to the earth, it is at its **perigee**; farthest away, it is at it **apogee**.

The earth orbits (moves around) the sun in a journey that takes 365 ¼ days, the basis for determining a calendar year. The sun is about 93-million miles from earth. At the same time the earth is moving around the sun, it is rotating on what scientists call its axis, an imaginary line that runs from the North Pole to the South Pole through the earth's center. The movement around the sun--together with the constant tilt of the earth on its axis--results in the seasons. The rotation of the earth on its axis causes day and night. At the same time the earth is moving on its loop around the sun and rotting on its axis, the moon--about 239,000 miles away--is also moving. It moves around the earth, taking about 29 ½ days for its revolution, which is the basis for a calendar month.

Working to hold the moon and earth and sun in place is the awesome force that scientists have named gravity.

Fundamentally, tides are big waves resulting from the forces of gravity exerted upon the earth by the moon and the sun and affected also by the centrifugal forces resulting from the revolutions of earth and moon and of earth and sun around common centers of gravity (mass).

The moon exerts its greatest gravitational effect on the part of the earth closest to it, and, in high tide, the water bulges toward the moon. This occurs because the moon's gravity pulls on the center of mass of the earth. On the other side of earth, high tides are also taking place, as the center of mass of the earth is closer to the moon than the water on the far side (the side farthest away from the moon), and the earth is actually pulled away from the water, causing the bulge.



The moon exerts its greatest gravitational pull on the side of the earth nearest the moon, resulting in high tide, but high tide is also occurring on the opposite side of earth.

At the same time, low tides are occurring at right angles to the moon's pull.

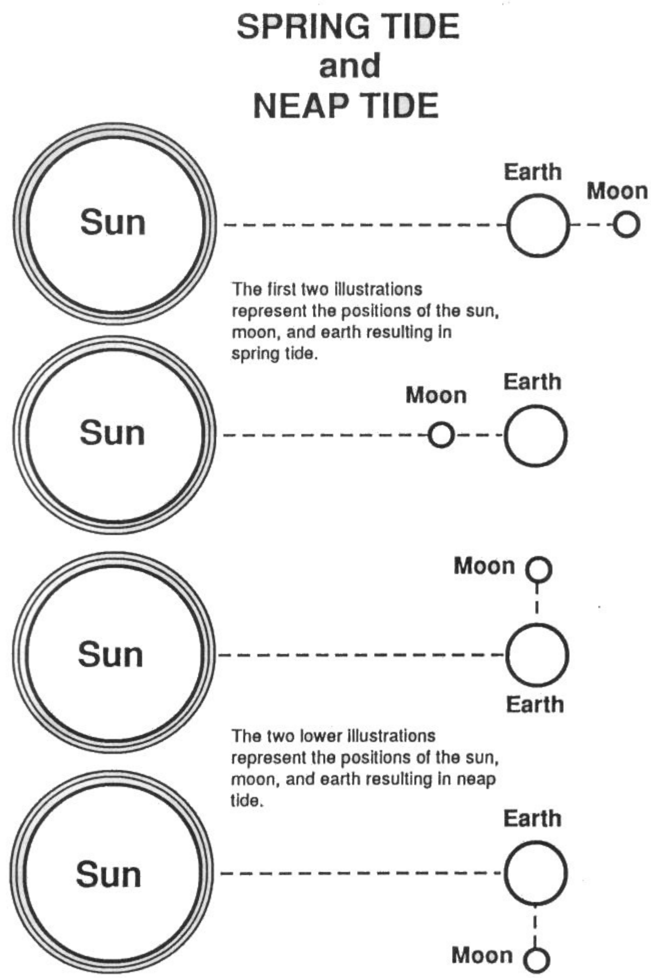
But the sun also has a gravitational effect on the ocean's waters. And other factors are involved in determining the force and shape of tides. The land formation along the coast; the seabeds themselves; the size, depth, and shape of ocean basins...all these help to determine the speed of the great traveling bulges of water that are the tides.

Scientists have determined that each part of an ocean has its own revolving tide action, as the tidal forces move up one side of the ocean and down another. The movement is clockwise in the Northern Hemisphere and counterclockwise in the south of the Equator. If there were no huge land masses like the continents on earth, the tidal bulges would travel around the earth without impediment, following the revolutions of the moon in an uninterrupted race.

When the sun and the moon are in line with each other and the earth, the rise and fall of tides is greatest. These are called "spring tides," and they take place about twice a month. The word <u>spring</u> does not refer to the season but to the upward movement. When the sun and the moon pull at right angles, when the three bodies are aligned in an "L" shape, their gravitational forces work against each other, and tides have smaller ranges. These are called "neap tides." <u>Neap</u> means <u>scanty</u> or <u>lacking</u>. They come in the first and third quarters of the moon. Some people mistakenly think that low tides and neap tides are synonymous; but neap tides are simply those periods one could call "the lowest high tide."

As they read and talked with Mr. Alfred about the tides, Jennifer and Paul also learned something of the currents of the world's oceans. While tides involve the vertical movement of water, currents are horizontal movements.

Currents include both surface and underwater currents. Winds move the surface waters and cause wind-driven currents. The surface currents flow generally clockwise in the northern half of the world, counterclockwise in the southern half. The movement sees warm water from the warmer areas move toward the cold north or south polar regions, while cold waters from those areas move toward the tropics.



Underwater currents may not flow in the same patterns, since those currents may flow in opposite directions from the surface currents. This deep-sea drift may move icy cold water from polar regions to areas hundreds or thousands of miles away.

One of the great currents is part of the Gulf Stream called the Loop Current, which passes between Cuba and Mexico and loops up and then east and south again. The world's great currents include the Gulf Stream, the Japan Current (Kuroshio), the Equatorial Current, and cold water currents like the Labrador, which starts in the Atlantic and flows into the North Atlantic toward Labrador, Newfoundland, and the Northeast United States.

The cold water currents generally move toward the Equator. When the Labrador Current meets the warm Gulf Stream, the cold waters of the Labrador sink toward the bottom and continue toward the Equator.

All they learned about the oceans and the movements of ocean waters fascinated Jennifer and Paul, and Mr. Alfred told them he was amazed by the way they had--as he said--"got into the subject and kept at it." It was his way, Paul laughed about it later, of telling them that he appreciated the hundreds of questions they had asked.

People who live on the sea or near it need to understand currents and tides and wave motions, Mr. Alfred repeated. The knowledge is invaluable to them. Sailors can ride out storms on high seas without losing control of their boats, if they know how to handle their vessels in storms. Boaters and swimmers and fishermen know that often waters move in one direction while the currents and tides are going in the opposite direction. Waves come in toward shore and lift swimmers of boats up and then let them down--and they may then continue to be moved away from land. Waves are beautiful as they roll in, the highest part--the crest--white with froth and the low part of the wave--the trough--hidden between crests; but they may also be dangerous.

The twins learned that knowledge of tides and currents is important to navigation along the coastal waterways to seamen working in harbors, to owners who take their boats out on pleasure trips, or to fishermen who seek their livelihood on the oceans, to people who like to use their boats for recreation or who like surfing, to families using the beach area for vacations, and to people who build bridges on deep-water channels. Knowledge of tides and currents is important especially today in Mississippi, for instance, to courts and landowners trying to determine legal boundaries for public and private ownership of land, which under legislation and judicial ruling, is affected by tidal action and tidal histories.

Fishermen learn to use the tidal movements to increase their catches. They follow local tide charts published in local papers, and they learn to take into account the other factors involved in tidal conditions, like the precise location where they will fish, winds and currents, and other variables.

They also learned many fascinating stories about important events that had happened in the world's history connected with the seas and the tides.

People who depend on the sea for their livelihood
need to know a great deal about the tides

One of the curious words they found was a Japanese word: tsunami. The name is given by scientists to waves that have been set off by forces underneath the sea--earthquakes or volcanic eruptions underwater. They can move as fast, some accounts report, as 500 miles an hour. A ship out in the ocean might not even know that a tsunami was passing if the water level was not very high; but it is possible for a tsunami to enter a shallow bay at heights up to 200 feet.

One of the world's great disasters occurred in 1883 when the great volcano Krakatoa erupted in the East Indies. One result of the eruption was a tsunami that killed thirty-six thousand people along the Java and Sumatra coasts, as the waters reached as much as 115 feet in height.

Today's scientists have set up a warning system in Hawaii to provide forewarning of tsunami movements.

Jennifer and Paul learned some things they would never forget because they involved safety in recreational enjoyment of the water.

Tide ranges--variations in height--differ from one coast to another or from one area to another on the same coast, so the twins learned that they should not expect the water levels to be the same when they were in unfamiliar areas. The variations may come because of differences in coastlines, for example, of from narrow places near the ocean where creeks and small rivers and narrow bays join the sea. Here the tide turns quicker and moves with greater force, and the unwary swimmer may be caught off-guard.

It is impossible to know far ahead of time how strong the winds may be on a given day--and winds affect tide levels--so it is also impossible to forecast exact tide levels for long periods in the future. It is possible, however, to forecast approximate high and low tide heights, and people should be aware of the tide tables carried by local newspapers or on local weather reports, particularly if they plan to swim or fish in local waters.

In addition, people ought to know about what has been called "a longshore current." This type of current is the swift movement of water as it runs along some shoreline until is can head back toward the sea. When it moves back toward deeper waters, the fast-moving current is called a "rip." Some people erroneously call it a "rip-tide"--or undertow. Many people who study the oceans do not believe that an undertow can actually pull a swimmer down, but rip currents are dangerous. They can cause a swimmer to lose footing or control. Close to shore, they extend to the bottom; as they get farther out, they become surface currents.

Tide ranges (variations in height) differ from one coast or from one area to another on the same coast

Swimmers who realize that they are caught in a rip current should drift with the current or swim across it until they reach the shallow water or are out of the current, according to some of the studies Jennifer and Paul read. By swimming parallel to the beach, one can usually get out of the rip current into calmer water, they read. The swimmer should try not to be frightened or to fight the water, because the rips are usually not wide. Knowing the area where one swims is important, and one should obey the signs that warn of deep water or rip currents or unusual tide, Mr. Alfred told them several times.

Learning about the tides for Jennifer and Paul involved learning about the oceans, so great a part of the earth's surface, scene of its greatest explorations and most far-reaching commerce, and source of much of the world's food.

"The more you know about the world you live in, the more you will respect it and want to take care of it," their father told them one day as they repeated one of Mr. Alfred's stories.

"You're fortunate to live here, where the waters stretch out as far as you can see and the tides come in and go out in that timeless cycle. It is a wonderful, beautiful part of the natural world, and nothing could be better evidence of the great forces of nature which are at work around us every moment. I love the sea. Sometimes I like to sit on the beach and watch the movements of the tides and listen to the peaceful sounds of the water--and it fills me with wonder at the mystery and beauty of it all. You're lucky," he told Jennifer and Paul, "to make that kind of discovery when you're young. Some people go through their entire lives and never learn to appreciate the things closest to them. I'm proud of you," he said.

"I'm proud of us, too," Paul said, grinning and knowing what Jennifer would say. "Now we know everything there is to know about tides!"

"Well, anyway, we know something about the tides," Jennifer corrected, "and we plan to learn a lot more." She couldn't help laughing at her brother's exaggerating. "You've never seen all the tides," she said, "nor read all the books."

"Well, everything about tides in North America," he grinned.

"You haven't read everything about the tides in North America--"

"In the United States," he said.

"No--not in the United States--"

"Well, on the Gulf Coast."

"You don't know everything about the tides on the Gulf Coast," she said. "You haven't been all along the Gulf Coast."

"In Biloxi, then."

"No, not even in Biloxi."

"Well, we do know some things about tides," he conceded. "Here and in other places. And we have whole libraries to visit and books to read. And then maybe we'll know everything there is to know about the tides and the currents and the way the waters move. Everything we always wanted to know about tides!"

Jennifer laughed with him. Even if he did exaggerate, Paul always made it fun to learn new things. There were so many things to learn; the world was full of so many things to study, and it would make life interesting and exciting.

"Everything!" She said then, surprising her twin. "Everything!" She said again. And they walked down the quiet, shaded, neat, pretty street in Biloxi toward the house where their friend Tony lived. If Mr. Alfred was at home, they would ask more questions.

"Questions, questions!" Mr. Alfred would say, shaking his head. "Was there ever anybody else in the whole world with more questions!"

But he would smile when he said it, and the twins knew that he enjoyed their questions--and they would continue to ask them. About everything!

QUESTIONS FOR FURTHER STUDY

These questions may be used by a teacher to stimulate further discussion and individual study and research regarding the tides and related subjects.

1. How can tides be predicted?

The moon can be seen to rise about fifty minutes later each night; therefore, the lunar day is longer than the solar day of twenty-four hours. As the earth rotates on its axis, the moon is also moving in the same direction along its orbit about the earth. During this time, the moon has moved 12.2 degrees to the east, accounting for the fact that the earth must rotate another fifty minutes to have the moon again on the meridian (longitude line) of the observer.

2. Tidal movement affects sediments in the Mississippi Sound. How are sediments in the Sound classified?

Sediments are identified by the composition (what they are made of) and by the size of the sediment, measured in microns. To understand the sizes, we need to know the length of a millimeter (abbreviated mm). If the yard stick, which measures three feet, and about three inches (3.37 inches) added to it, the length would then be a meter. A meter is divided into 1000 millimeters, a unit equal to one-thousandth of a meter. Now, if we take a millimeter and divide it into a thousand slices, each slice would represent the size of a micron.

Sand is larger than 62 microns, or 0.062 mm in diameter. Mud size ranges between sand and clay; mud sediment grains are between 62 microns and 4 microns. Four microns are 0.004 mm. In the Mississippi Sound, sediments are the results of rivers, bays, currents, and tides moving and carrying sediments, break-down of rocks, winds blowing sediments, and chemical reactions, including the decomposition of matter. Gravel is the largest of sediments, consisting of boulders, cobbles, pebbles, and granules. Sand consists of course, medium, fine, and very fine sizes. Mud consists of silt and clay.

3. Are tides at all influential in night fishing?

Yes, particularly in floundering and soft-shell crabbing. Most local fishermen say that they go flounder-gigging on a low-rising tide and in a dark moon phase. Fishermen report that flounders come in on a rising tide and leave the shallow waters on a falling tide. If the water is muddy (too much sediment in the water to prevent one's seeing the bottom clearly), you can't see the flounders. When looking for flounders, you look for the outline or shape of the flounders, because they are generally lightly covered with sediment.

Soft-shell crabbing is, as a rule, best during spring when crabs, especially the young, have come in from deeper waters and are molting. All crabs must molt (shed) to grow larger. Fishermen report that the moon does not have to be in a dark phase. You can collect these crabs during any of the moon phases. The soft-shells are collected during the spring or summer, less in the fall, and not during the winter months. During the winter, the crabs have migrated out into deeper water and return in the spring. the crabs coming in closer to shore to molt are protected from being eaten by larger predators that stay out in deeper waters. A few fishermen reported that they prefer collecting their soft-shell crabs during a bright moon phase and a falling tide.

In general, fishermen, depending on the type of fishing, like a moving tide; some like the tide at its peak just before the fall of a tide; some state that the rising tide is better for some types of fishing and a falling tide is better for other types. the term "slack tide" is used by local fishermen to refer to the period of time between tide changes.

4. How do gravitational attraction and centrifugal force combine to cause tides?

Gravitational attraction is a mutual attraction between massive bodies (the earth and the moon, for example). Centrifugal force is an outward directed force from the center or axis with the body moving along in a curved path. Sir Isaac Newton's universal law of gravitation states that any two bodies attract each other, and to determine this attraction, one must know the masses of the two bodies and the distance between the center of the masses. It is the differences between the forces at the earth's surface and the forces at its center that are mainly responsible for our tides. The moon influences the tides more than the sun does because of its closeness to the earth. The sun is approximately 93-million miles away and has a diameter of about 864,000 miles, with a mass about 330,000 times that of the earth. The moon, having a slightly elliptical orbit, is about 221,600 miles away at its perigee (the point nearest the earth in the orbit of the moon), and about 252,950 miles at its apogee (the point in the orbit of the moon farthest away from the earth). The moon's average revolution around the earth requires 29 days, 12 hours, 44 minutes, and 2.8 seconds.

5. Why does the sun influence our tides more in the winter?

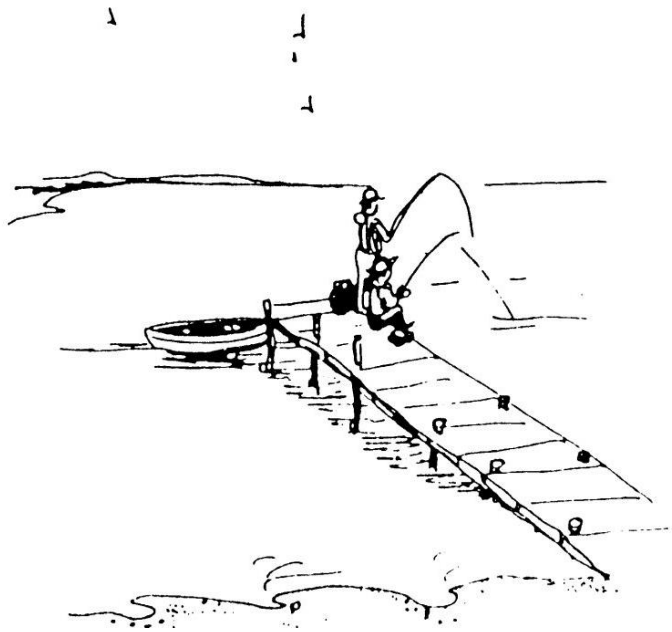
Because the moon's orbit is elliptical and not circular, and the earth's orbit around the sun is also elliptical and not circular, there are times during an orbit when the earth is closer to the sun or the moon than it is at other times. In the northern hemisphere, the earth is closer to the sun in the winter than it is in the summer; therefore, the sun influences tides more in winter than in summer.

6. Why does a bulge in the water occur on the opposite side of the earth when one bulge occurs from the gravitational attraction of the moon?

The moon influences our tides because the water on the side of the earth facing the moon is acted upon by the moon's gravitational force. Due to the uniqueness of water, it is easily moved toward the moon. A bulge in the water occurs on the earth. At the same time, a bulge of water on the opposite side of earth occurs due to centrifugal force of the earth-moon system.

7. What is the Intracoastal Waterway?

It is a route for ships and barges around the Gulf which is generally within the shore of the Gulf Coast. It has been developed from a system of canals, lakes, and protected sounds. The U.S. Army Corps of Engineers protects this waterway.



8. Why do our shorelines keep changing?

Our beaches, especially the barrier islands, are subjected to a constant attack of waves. Sand is often added to the beaches during the summer and fall and removed into deeper water during the winter and spring when storm waves are more common. In addition, the strong tidal currents carry sand; therefore, wave action, storm waves, beach drifting, sediment migration, and wind are among the factors which constantly change our beaches and shorelines. Our barrier islands are subject to devastation and great changes during hurricanes. Summer and fall seasons are the times that hurricanes occur on the Mississippi Gulf Coast. The local citizens claim that Hurricane Camille changed our shorelines more than any other recorded hurricane.

GLOSSARY OF TERMS

AXIS	a real or imaginary line on which an object rotates or is regarded as rotating, as in earth's rotation on its axis
BASIN	parts of the ocean bottom, oval, circular, or elliptical shaped, like enormous pools
BREAKER	a wave
CLOCKWISE	moving in the same direction as the hands of a clock move
CONTINENTAL SHELF	land that is underwater at the edge of the exposed portion of a continent, sloping away to the deeper part of the ocean bottom
CREST	the highest part, particularly of a wave
COUNTERCLOCKWISE	moving in direction opposite to the movement of a clock's hands
DIURNAL TIDE	daily tide, only one high and one low tide each tidal day
DRIFT	being carried along, as by air or water, deviating from normal path
EBB TIDE	water movement away from shore
EBBING	moving away; term for tide going out
FLOOD TIDE	water movement toward shore, rising water height
FLOWING	moving in; term for tide coming in
GRAVITY	a natural phenomenon described as an invisible force or attraction that holds objects in the universe in place; a universal law referring to the force dependent upon mass (weight) of each body and distance apart
GYRE	moving in a whirling path; the great loops in which ocean currents flow
HIGH TIDE	the point when the height of the rising tidal movement is greatest
HURRICANE	a violent storm with winds moving in a counterclockwise direction at 73 miles per hour or greater, often accompanied by torrential rains
LONGSHORE CURRENT or LONGSHORE DRIFT	current located along the shore; also called rip current or sometimes undertow; current in surf zones
NEAP TIDES	tide with smallest range, occurring when earth, moon, and sun are at right angles (L-shape)
ORBIT	movement around, as in earth's elliptical movement around the sun or the moon's movement around the earth
RANGE	difference between extremes (as in difference between high and low tide, for instance)
REVOLUTION	movement of a body or object around another body, as in planets' revolution around the sun

RIP CURRENT	strong surface movement of water along the shore and flowing back to deeper water; usually of short duration
ROTATION	to turn around a center point, as on an axis; revolution
SEMIDIURNAL TIDE	two high and two low tides each tidal day
SPRING TIDE	high tide resulting when sun, moon, and earth are in line with one another, iin straight alignment
STORM SURGE	increase in level of water on open coast caused by wind stress on the surface of the water; in hurricanes, also includes the rise in level due to reduction in atmospheric pressure; more severe when occurring in conjunction with high tide
STORM TIDE	water rise during a storm, particularly in a hurricane (scientists prefer the term "storm surge")
STORM TRACK	path followed by a storm system (center of low atmospheric pressure)
SURF	term for water with braking waves near shore
SURGE	tidal current; horizontal movement of waters accompanying tide
TIDE	periodic rise and fall of water elevation (the sea surface)
TIDAL CURRENT	alternating horizontal movement of water associated with the tide
TIDAL WAVE	incorrect name for seismic sea wave or tsunami
TROUGH	the lowest part of a wave; opposite of crest
TSUNAMI	movement of water caused by underwater action like earthquake or volcanic eruption, commonly, but erroneously called a tidal wave
UNDERTOW	inaccurate word used by many people to refer to a rip current

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