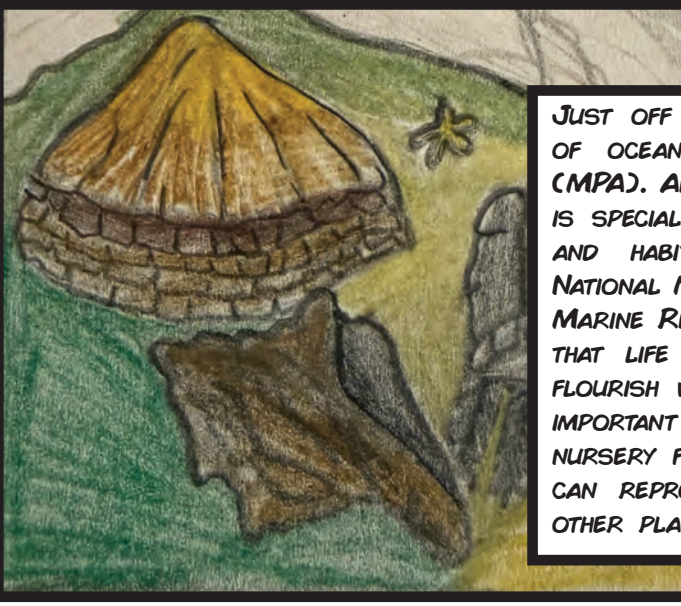


DETECTIVE CRABRILLO
AND THE MYSTERY OF
THE DISAPPEARING
SHELLS

ON THE VERY SOUTHERN TIP OF THE POINT LOMA PENINSULA IN SAN DIEGO, CALIFORNIA, LIES CABRILLO NATIONAL MONUMENT. NATIONAL MONUMENTS ARE PART OF THE NATIONAL PARK SYSTEM, A PLACE PRESERVED AND PROTECTED BY THE NATIONAL PARK SERVICE.



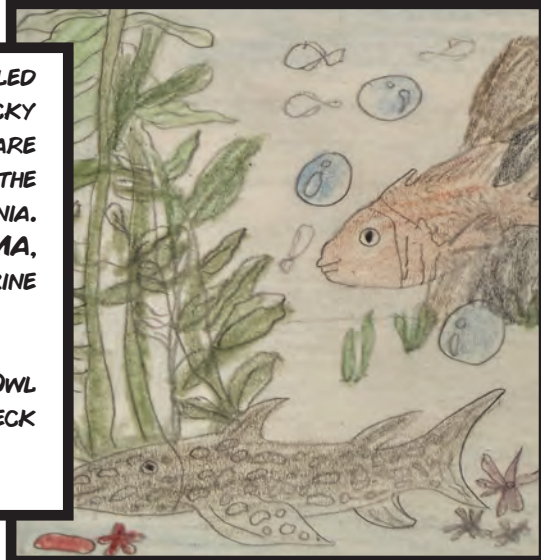
CABRILLO OFFERS HIKES THROUGH DIVERSE HABITATS, EPIC VIEWS OF SAN DIEGO AND THE PACIFIC OCEAN, BEAUTIFUL AND BIODIVERSE TIDEPOOLS, AND A RICH HISTORY TO LEARN ABOUT.



JUST OFF THE COAST FROM CABRILLO IS AN AREA OF OCEAN CALLED A MARINE PROTECTED AREA (MPA). AN MPA IS A LOCATION IN THE OCEAN THAT IS SPECIALLY PROTECTED TO PRESERVE MARINE LIFE AND HABITATS. THE MPA NEXT TO CABRILLO NATIONAL MONUMENT IS CALLED THE CABRILLO STATE MARINE RESERVE (SMR) AND WAS ESTABLISHED SO THAT LIFE IN THE GIANT KELP FOREST THERE CAN FLOURISH WITH LITTLE HUMAN INTERACTION. THIS IS IMPORTANT BECAUSE THE KELP FOREST ACTS AS A NURSERY FOR MARINE LIFE, WHERE LOTS OF SPECIES CAN REPRODUCE AND MATURE BEFORE MOVING TO OTHER PLACES IN THE PACIFIC OCEAN.

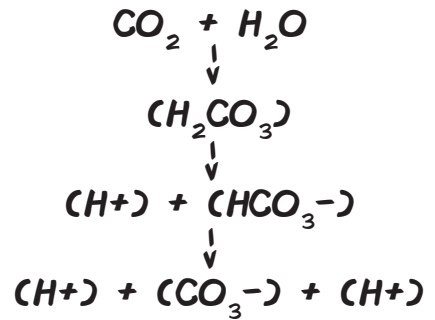
TIDEPOOLS AND THE AREA AROUND THEM ARE CALLED THE ROCKY INTERTIDAL ZONE, WHICH IS THE ROCKY AREA WHERE LAND AND SEA MEET. BECAUSE THEY ARE PROTECTED BY LAW, CABRILLO'S TIDEPOOLS ARE THE MOST BIODIVERSE IN ALL OF SOUTHERN CALIFORNIA. AND THESE TIDEPOOLS CONNECT TO THE CABRILLO SMA, PROVIDING A CONTINUOUS SAFETY ZONE FOR THE MARINE ORGANISMS THAT LIVE IN THE AREA.

SOME OF THIS BIODIVERSITY INCLUDES GIANT OWL LIMPETS (*LOTTIA GIGANTEA*) AND GOOSENECK BARNACLES (*POLLICIPES POLYMERUS*).





CLIMATE CHANGE IS THE LONG-TERM CHANGE OF EARTH'S TYPICAL WEATHER PATTERNS. THIS GLOBAL CHANGE IS A MAJOR DISRUPTOR TO ECOSYSTEMS AND THE ORGANISMS THAT LIVE IN THEM (INCLUDING HUMANS!), CAUSING INCREASED TEMPERATURES AND EXTREME EVENTS LIKE WILDFIRES, HURRICANES, AND DROUGHTS THAT MAKE IT INCREASINGLY CHALLENGING FOR SPECIES TO SURVIVE AND THRIVE. FOR CABRILLO'S ROCKY INTERTIDAL ZONE AND THE CABRILLO SMR, CLIMATE CHANGE IS CAUSING SEA LEVELS TO RISE, THE WATER TEMPERATURE TO CLIMB, AND A PHENOMENON THAT AFFECTS PH, TERMED OCEAN ACIDIFICATION.



OCEAN ACIDIFICATION IS A CHEMICAL REACTION IN THE WATER THAT CAN WREAK HAVOC UPON OCEAN ORGANISMS, LIKE THOSE IN THE CABRILLO SMA AND ROCKY INTERTIDAL ZONE. HERE'S HOW:

SURROUNDING PLANET EARTH IS A LAYER OF GASES CALLED THE ATMOSPHERE. THESE GASES - LIKE OXYGEN AND WATER VAPOR - ARE ESSENTIAL FOR LIFE ON EARTH. ONE OF THESE GASES IS CALLED CARBON DIOXIDE (CO_2), WHICH IS THE GAS THAT IS RELEASED BY NATURAL PROCESSES LIKE HUMANS (AND OTHER ANIMALS) EXHALING.

SOME OF THIS CO_2 IN THE ATMOSPHERE WILL SINK DOWN INTO THE OCEAN DURING A PROCESS CALLED THE CARBON CYCLE. THE CO_2 REACTS WITH THE WATER TO CREATE A SUBSTANCE CALLED CARBONIC ACID. AS A RESULT OF THIS PROCESS, HYDROGEN IONS (H^+) ARE RELEASED INTO THE WATER. THIS IS ALL FINE AND NORMAL. SO, WHAT'S THE PROBLEM? THERE'S TOO MUCH CO_2 IN THE ATMOSPHERE!

WHEN HUMANS BURN GASOLINE, COAL, AND OTHER FOSSIL FUELS, CO_2 IS RELEASED INTO EARTH'S ATMOSPHERE. BECAUSE HUMANS HAVE BEEN BURNING A LOT OF FOSSIL FUELS FOR MANY YEARS, THERE IS AN EXCESS AMOUNT OF CO_2 IN EARTH'S ATMOSPHERE; THIS MEANS THERE'S AN EXCESS OF CO_2 SINKING INTO OUR OCEANS.

THIS EXCESS CO_2 IS HURTING
ENDANGERED SPECIES LIKE THE
BLACK ABALONE (HALIOTIS
CRACHERODII) AND ECOSYSTEM
ENGINEERS LIKE THE GIANT
OWL LIMPET WHO ARE
INCREDIBLY IMPORTANT TO
CABRILLO'S TIDEPOOLS AND
MPA. HOW DOES IT HURT
THESE IMPORTANT OCEAN
ANIMALS? IT'S A MYSTERY!
AND ONE THAT DETECTIVE
CRABRILLO AIMS TO SOLVE ...



CABRILLO'S TIDEPOOLS AND MPA ARE FULL
OF LIFE, WITH LOTS OF ACTIVITY FROM
SHELLFISH, FISH, AND OTHER ANIMALS
ROAMING AROUND THE NEIGHBORHOOD.



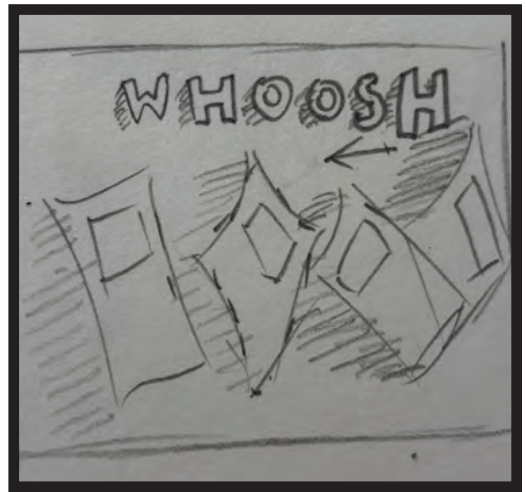
YET TODAY WAS DIFFERENT, AS THE BUSY
ECOSYSTEM BECAME STRANGELY QUIET AND
EMPTY.



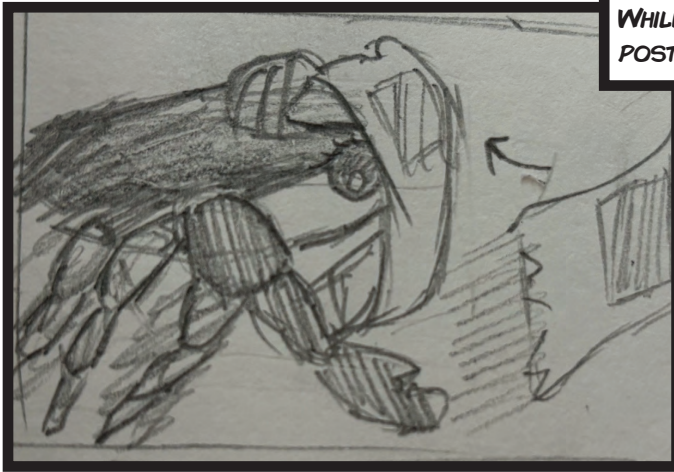
WHAT'S DIFFERENT BETWEEN
THESE IMAGES?



DETECTIVE CRABRILLO RECENTLY HEARD ABOUT THE SILENT CONDITIONS OF THE TIDEPOOLS AND CAME TO INVESTIGATE.

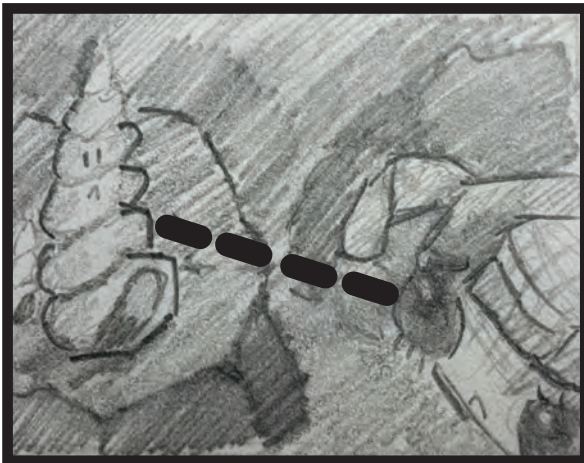


WHILE SEARCHING FOR A CLUE, A MISSING POSTER WAS WASHED INTO HER FACE.



THIS SPARKED HER CURIOSITY: WHO WAS THIS GIANT OWL LIMPET, AND WHY DID SHE DISAPPEAR WITHOUT A TRACE? DOES IT HAVE SOMETHING TO DO WITH HER ALLEGED WEAKNESS LISTED ON THE POSTER?

LITTLE DID DETECTIVE CRABRILLO KNOW, THIS WANTED POSTER WAS ONLY JUST THE BEGINNING



LOOKING AROUND HER,
DETECTIVE CRABRILLO NOTICED
AN UNHAPPY WAVY TURBAN
SNAIL (*MEGASTRAEA UNDOSA*).
PERHAPS THIS SNAIL COULD
SHED SOME LIGHT ON WHAT'S
HAPPENING IN THE TIDEPOLS ...



SOMETHING'S NOT RIGHT. TELL
ME, WHAT HAS BEEN GOING ON IN
YOUR NEIGHBORHOOD?

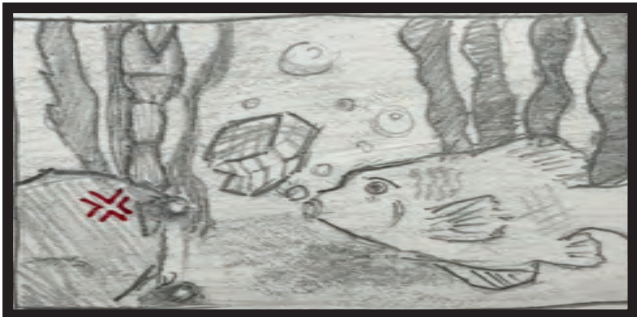
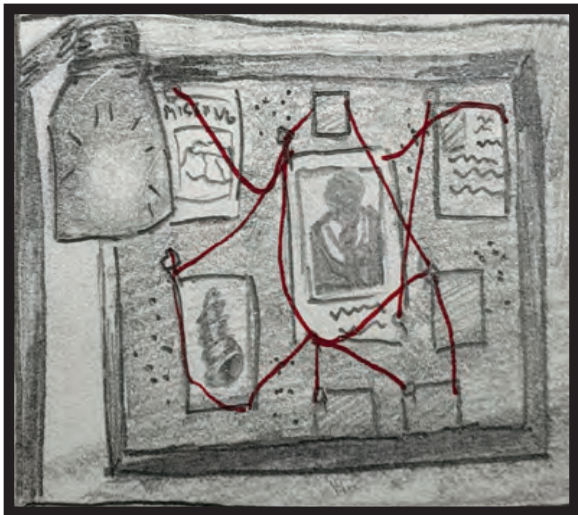
SOMETHING HAS CHANGED AND
THE WATER DOESN'T FEEL ...
RIGHT. MY LITTLE ONE ISN'T
DOING SO WELL, EITHER.



THEIR SHELL SEEMS VERY THIN
AND WEAK.. THE WATER FEELS
DIFFERENT. LIKE THERE'S SOMETHING
MENACING HIDDEN WITHIN.

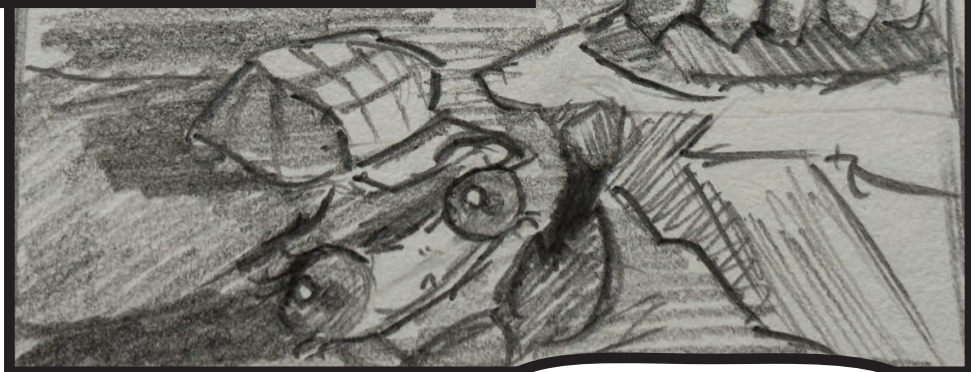
WHAT DO YOU MEAN BY
'CHANGE'?

THANK YOU FOR YOUR
COOPERATION MA'AM. I HOPE
YOUR LITTLE ONE GETS
BETTER.

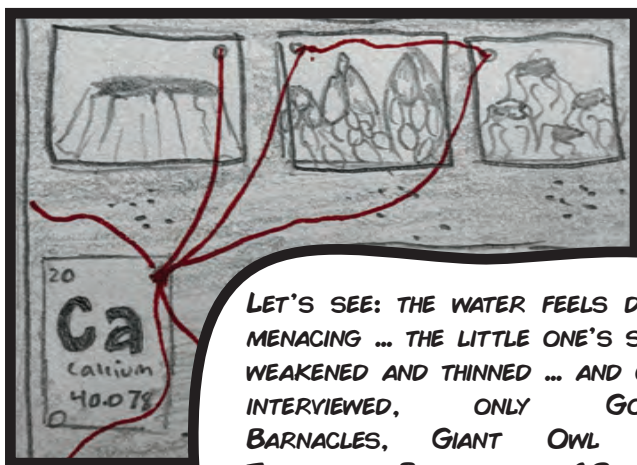


DETECTIVE CRABRILLO DECIDES TO INTERVIEW
MORE ANIMALS TO FIND THE DEMOGRAPHIC OF
WHO IS GETTING AFFECTED. LIKE CHITONS,
GARIBALDI, AND MUSSELS.

RECOGNIZING THE PATTERN OF ORGANISMS WITH A CALCIUM CARBONATE SHELL BEING IMPACTED, THE DETECTIVE REMEMBERS WHAT THE MOTHER SAID TO THEM EARLIER. THAT THE WATER HAD FELT DIFFERENT, LIKE SOMEHOW IT HAD CHANGED.



I KNOW! MAYBE IT HAS SOMETHING TO DO WITH THE PH OF THE WATER ... ? LET'S START THERE ...



LET'S SEE: THE WATER FEELS DIFFERENT, MENACING ... THE LITTLE ONE'S SHELL HAS WEAKENED AND THINNED ... AND OF THOSE INTERVIEWED, ONLY GOOSENECK BARNACLES, GIANT OWL LIMPETS, THATCHED BARNACLES (SEMIBALANUS CARIOSUS), AND BLUE BAND HERMIT CRABS (PAGURUS SAMUELIS) ARE FEELING SIMILARLY. Hmm ...

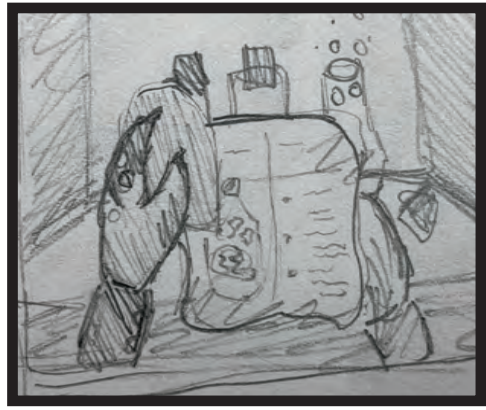
WITH A NEW LEAD, THE DETECTIVE GETS TO WORK. SHE STARTS COLLECTING SHELL PIECES AND CONTAINERS TO GET SAMPLES OF THE WATER.

LET'S SEE WHAT THE WATER'S HIDING. SAME SHELLS, DIFFERENT WATER, THIS'LL BE INTERESTING.





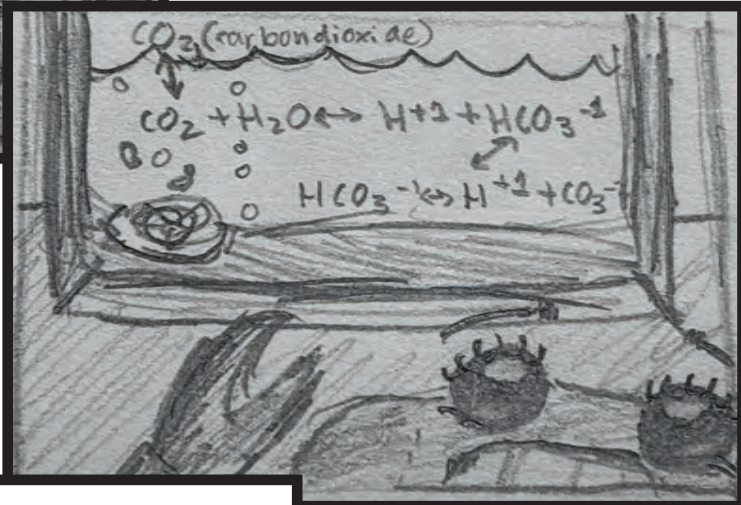
EACH BOTTLE CONTAINS SALT WATER WITH DIFFERENT AMOUNTS OF DISSOLVED CO_2 , WHICH AFFECTS THE PH OF THE WATER. THE MORE CO_2 , THE LOWER THE PH ...



THE DETECTIVE SITS PATIENTLY, A SLATE ROCK AND LIMESTONE IN HAND AS SHE OBSERVES THE SPECIMENS WITH QUIET SCRUTINY. SLOWLY AND SURELY, IN SPECIMEN ONE AND TWO, A GREAT CHASM FORMS IN THE SHELLS' GAPS, AND IT SHATTERS INTO MULTIPLE, DESOLATE PIECES LIKE A BROKEN CHINA PLATE.

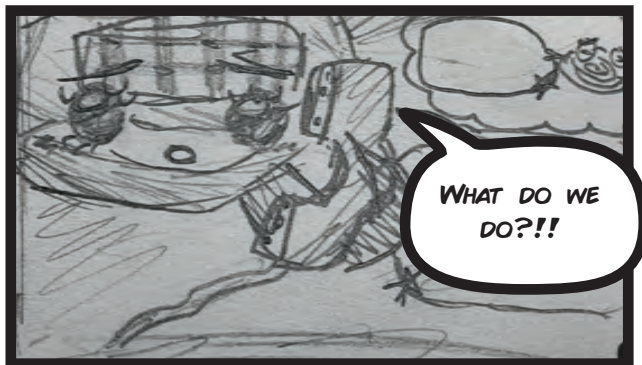


THE DETECTIVE'S LIPS CURL INTO A PLEASED SMILE. THERE IT WAS. EVERYTHING WAS ADDING UP.

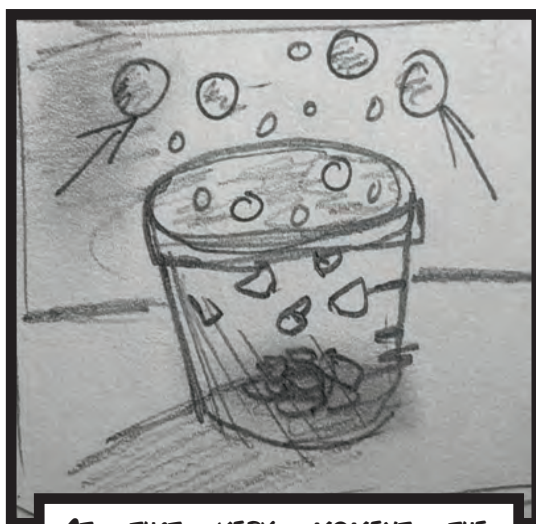


DETECTIVE GRABRILLO RECALLS HER CHEMISTRY CLASS, REMEMBERING CO_2 CAN AFFECT THE STRUCTURE OF SHELLS.

SHE GRABS THE SHELL-PHONE AND CALLS ALL THE LOCAL SHELLFISHES TO WARN THEM ABOUT CO_2 ...



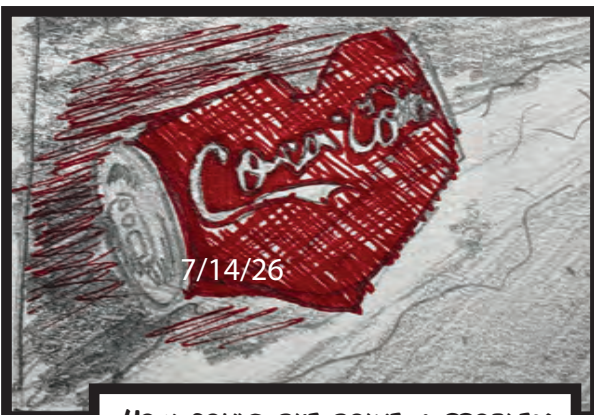
WE MUST LOOK FOR A WAY TO CAPTURE CO_2 AND REMOVE IT FROM THE OCEAN WATER THAT SURROUNDS US." BUT WHAT DETECTIVE CRABRILLO DIDN'T KNOW WAS THAT CO_2 ITSELF WASN'T WHAT WAS CAUSING THE PROBLEM. IT WAS HUMANS BURNING FOSSIL FUELS AND PUTTING TOO MUCH CARBON DIOXIDE INTO THE ATMOSPHERE.



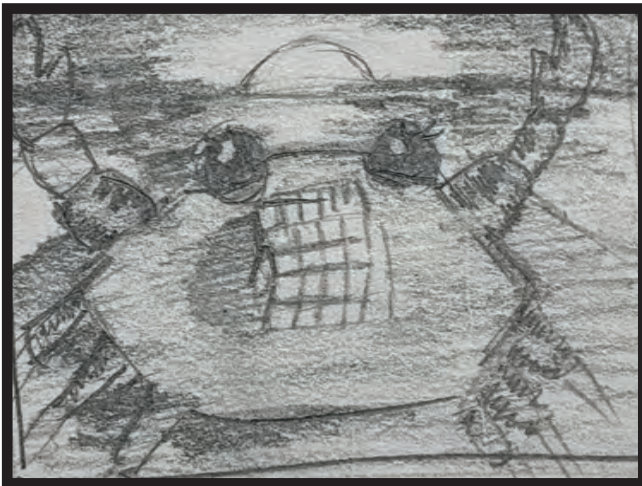
AT THAT VERY MOMENT THE INFAMOUS GAS HURLED ITSELF OUT OF THE SEA-GLASS BEAKER IN A HOP, SKIP AND A JUMP!



IT FLEW PAST THE SHARP DETECTIVE, COLORLESS AND UNDETECTABLE. IN PURSUIT, DETECTIVE CRABRILLO ATTEMPTED TO CAPTURE IT WITH A JAR, BUT IT WAS FUTILE. SHE STOOD THERE WITH THE JAR IDLY CLUTCHED WITH HER CLAW, HER EXPRESSION DOWNCAST AS SHE FINALLY LOOKED AROUND HER. FROM THE DISINTEGRATING SHELLS, TO THE MISSING POSTERS HUNG IN EVERY DIRECTION.



HOW COULD SHE SOLVE A PROBLEM THAT WAS SO COMPLICATED? THE DETECTIVE LOOKED OVER HER SHOULDER, AND RIGHT AT A SCARLET RED, ALUMINUM CAN WITH MINIMALISTIC WHITE CURSIVE WRITING LAYING INTO THE SAND AS THE TIDE WASHED IT INTO ITSELF. IT WAS IMPOSSIBLE TO CATCH IT. IT'S IMPOSSIBLE TO SEE IT. AND IMPOSSIBLE TO BLAME IT AS IT WAS JUST FOLLOWING ITS INSTINCT TO REACT WITH WATER.



THE CULPRIT WAS HUMANS CAUSING OCEAN ACIDIFICATION BY BURNING FOSSIL FUELS. EVER SINCE HUMANS STARTED BURNING COAL AND OIL IN THE INDUSTRIAL REVOLUTION, OUR CITY WAS DOOMED. AND THAT WAS A STARTLING REVELATION. THE CASES SHE DEALT WITH ALWAYS HAD A SATISFYING ENDING. BUT, THERE WAS ALWAYS A FIRST TIME FOR EVERYTHING. SOMETIMES THE VILLAIN ISN'T CAUGHT, BUT THAT DOESN'T MEAN THE EFFORTS TO STOP IT ARE FUTILE.



AS IT TURNS OUT, EXCESS CO_2 IN EARTH'S ATMOSPHERE AND OCEANS REALLY DOES CAUSE A LOT OF PROBLEMS - IT'S LIKE A DOMINO EFFECT, WHERE ONE SYSTEM GETS OUT OF BALANCE, AND STARTS DISRUPTING ALL THE OTHER SYSTEMS AROUND IT. AND THE BREATHTAKING BIODIVERSITY OF EARTH'S ECOSYSTEMS, INCLUDING THE ONES AT CABRILLO'S TIDEPOLS AND MPA, ARE SUFFERING BECAUSE OF IT. HOWEVER, NOT ALL HOPE IS LOST.

IT GIVES US GREAT SADNESS BUT ALSO HOPE THAT WE CAUSED THIS GREAT DILEMMA OF CLIMATE CHANGE. BECAUSE IF WE STARTED IT, WE CAN END IT. THIS SEEMS LIKE AN OVERWHELMING TASK, BUT IF EVERYONE DID THEIR PART, WE WOULD BE WELL ON OUR WAY TO SOLVING THIS DIFFICULT PROBLEM.



HERE ARE SOME SIMPLE BUT EFFECTIVE
WAYS TO COMBAT CLIMATE CHANGE
THAT YOU CAN EASILY IMPLEMENT INTO
YOUR LIFESTYLE TODAY:



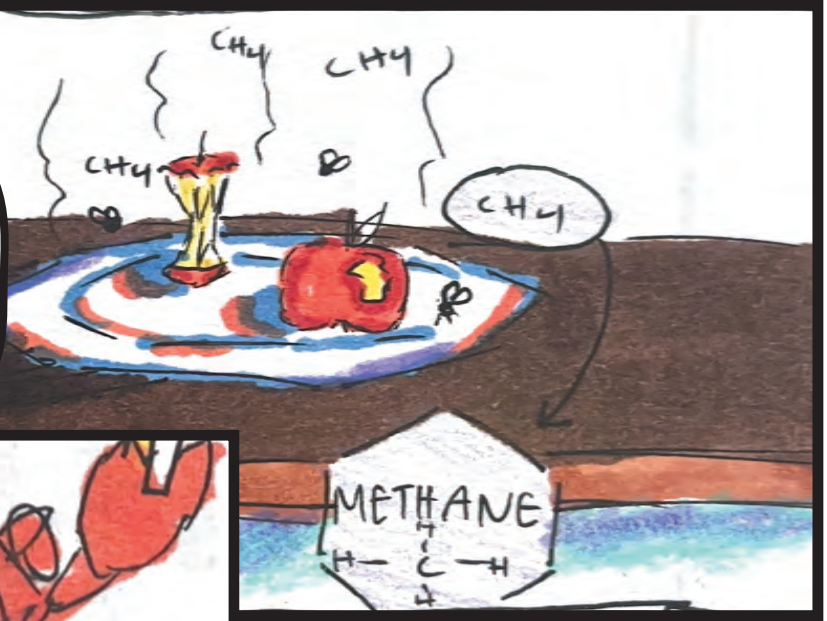
TAKE PUBLIC TRANSPORTATION OR BIKE AND WALK
MORE. EVEN DRIVING TOGETHER INSTEAD OF
SEPARATELY CAN HELP! WHEN CARS BURN
GASOLINE, THEY RELEASE CO_2 INTO THE AIR SO THE
LESS WE DRIVE, AND THE FEWER CARS ON THE
ROAD, THE BETTER.



PLANT MORE TREES AND VEGETATION,
AS THEY TAKE IN CO_2 DURING
PHOTOSYNTHESIS, MUCH LIKE THE OCEAN
DOES DURING THE CARBON CYCLE.



BE MINDFUL OF FOOD WASTE. WHEN FOOD ROTS, IT RELEASES A POWERFUL GREENHOUSE GAS CALLED METHANE, WHICH CONTRIBUTES TO CLIMATE CHANGE.



BUY MORE SECOND-HAND ITEMS. MANUFACTURING IS DONE BY BURNING FOSSIL FUELS LIKE COAL, WHICH CONTRIBUTES TO CLIMATE CHANGE AND OCEAN ACIDIFICATION.

THANK
YOU!



REMEMBER FOLKS, YOU HAVE THE POWER TO CHANGE THE WORLD!

GLOSSARY

NATIONAL MONUMENT - PROTECTED AREAS DESIGNATED BY PRESIDENTIAL PROCLAMATION THAT PROTECT NATURAL, CULTURAL, HISTORIC OR SCIENTIFIC RESOURCES. LARGELY MANAGED BY THE NATIONAL PARK SERVICE.

NATIONAL PARK SYSTEM - COLLECTION OF PROTECTED LAND AND WATER AREAS MANAGED BY THE NATIONAL PARK SERVICE.

NATIONAL PARK SERVICE - FEDERAL AGENCY OVERSEEING THE NATIONAL PARK SYSTEM.

MARINE PROTECTED AREA (MPA). A DESIGNATED SECTION OF THE OCEAN WHERE HUMAN ACTIVITY IS RESTRICTED TO PROTECT NATURAL AND CULTURAL RESOURCES.

BIODIVERSE - CONTAINING A HIGH VARIETY OF SPECIES.

ECOSYSTEM - GEOGRAPHIC UNIT OF BIOTIC AND ABIOTIC FACTORS, OFTEN FOCUSING ON THE FLOW OF ENERGY AND MATTER.

ORGANISM - LIVING INDIVIDUAL ENTITY THAT GROWS, SURVIVES AND REPRODUCES ON ITS OWN.

ROCKY INTERTIDAL ZONE - COASTAL ECOSYSTEMS WHERE THE LAND MEETS THE OCEAN. SUBJECT TO CHANGING TIDES AND THE HARSH CONDITIONS THAT COME WITH THAT.

OCEAN ACIDIFICATION - DECREASE IN THE PH OF THE OCEAN CAUSED BY THE ABSORPTION OF EXCESS CO_2 FROM THE ATMOSPHERE.

STATE MARINE RESERVE (SMR) - THIS IS A TYPE OF MARINE PROTECTED AREA THAT IS SPECIFICALLY A "NO-TAKE" ZONE.

CARBON CYCLE - THE CONTINUOUS MOVEMENT OF CARBON BETWEEN THE ATMOSPHERE, OCEANS, LIVING ORGANISMS AND THE SOIL. THIS IS A PRIME EXAMPLE OF THE LAW OF CONSERVATION OF MASS, WHICH STATES THAT MATTER IS NEITHER CREATED NOR DESTROYED, JUST TRANSFERRED AND REARRANGED.

ATMOSPHERE - MIXTURE OF GASES SURROUNDING EARTH, HELD BY GRAVITY.

FOSSIL FUELS - NONRENEWABLE HYDROCARBON RESOURCES FORMED FROM BURIED, PREHISTORIC ORGANIC (CONTAINING CARBON) MATTER. OFTEN IN FORMS OF COAL, OIL AND GAS.

HYDROGEN - COLORLESS, ODORLESS CHEMICAL ELEMENT.

CALCIUM CARBONATE SHELLS - SHELLS FORMED MAINLY FROM CALCIUM CARBONATE (CaCO_3). ACTS AS PROTECTION FROM THE ENVIRONMENT AND CRUCIAL TO THE SURVIVAL OF MANY MARINE ORGANISMS.

DETECTIVE CRABRILLO'S WORD SEARCH MYSTERY



NATIONAL MONUMENT
CARBON CYCLE
STATE MARINE RESERVE
MPA
FOSSIL FUELS
ECOSYSTEM

BIODIVERSE
ORGANISM
SMR
ATMOSPHERE
HYDROGEN

CALCIUM CARBONATE SHELLS
NATIONAL PARK SERVICE
MARINE PROTECTED AREA
ROCKY INTERTIDAL ZONE
NATIONAL PARK SYSTEM
OCEAN ACIDIFICATION

ECOLOGIK

THE MISSION OF THE ECOLOGIK INSTITUTE IS TO EMPOWER YOUTH TO BE CHAMPIONS FOR NATURE, INNOVATORS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS, WARRIORS FOR ENVIRONMENTAL STEWARDSHIP, LEADERS IN THEIR COMMUNITIES, AND CHANGEMAKERS WHO CREATE A POSITIVE IMPACT ON THE WORLD AROUND THEM.

LEADERSHIP ACADEMY

THE ECOLOGIK LEADERSHIP ACADEMY CREATES A CONTINUUM OF SUPPORT FOR THE YOUNG WOMEN AND GENDER-MARGINALIZED YOUTH WHO HAVE PARTICIPATED IN OUR INSPIRING CAMPS, APPRENTICESHIP PROGRAM, OR APPLIED SEPARATELY BY OFFERING ONGOING LEARNING AND INTERNSHIP OPPORTUNITIES, CAREER DEVELOPMENT, MENTORSHIP BY WOMEN-IN-STEM, AND A COMMUNITY OF ALUMNAE.

ACKNOWLEDGMENTS

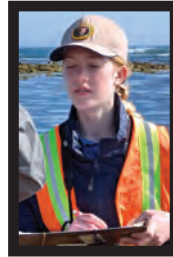
THIS COMIC WAS CREATED BY THE YOUTH APPRENTICES OF THE ECOLOGIK INSTITUTE'S LEADERSHIP ACADEMY.



IZZY S.
VIEV S.



THACH
HIEU TO



SABRINA P.



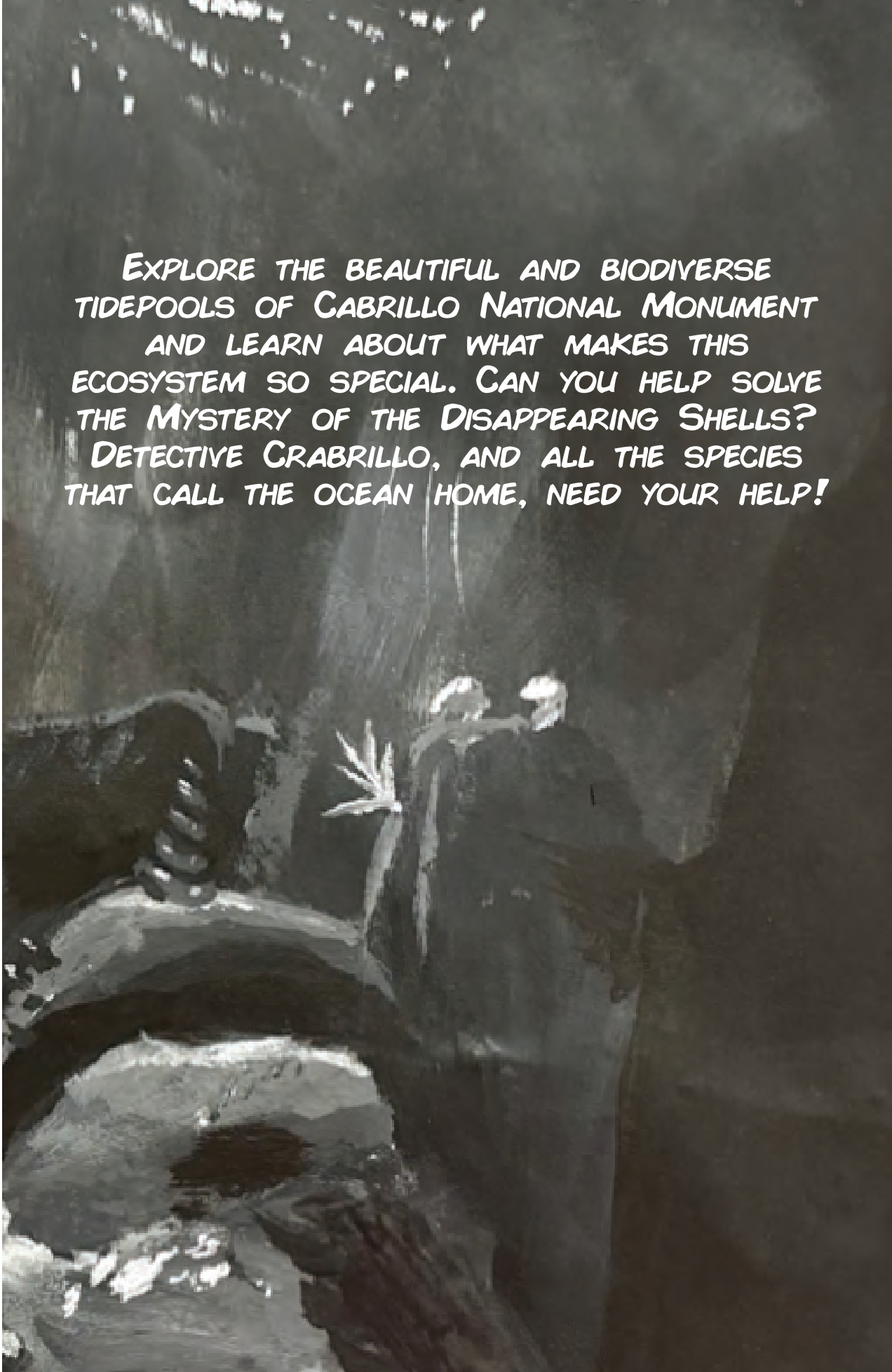
KHOA
TRAN



SAM
WYNNIS

THIS COMIC WAS MADE POSSIBLE THROUGH FUNDING PROVIDED BY THE MARINE PROTECTED AREA COLLABORATIVE NETWORK.



A dark, atmospheric illustration of a rocky coastline. In the foreground, there are tide pools reflecting light. A person is visible in the background, standing near a rocky outcrop. The overall tone is mysterious and naturalistic.

EXPLORE THE BEAUTIFUL AND BIODIVERSE
TIDEPOLS OF CABRILLO NATIONAL MONUMENT
AND LEARN ABOUT WHAT MAKES THIS
ECOSYSTEM SO SPECIAL. CAN YOU HELP SOLVE
THE MYSTERY OF THE DISAPPEARING SHELLS?
DETECTIVE CRABRILLO, AND ALL THE SPECIES
THAT CALL THE OCEAN HOME, NEED YOUR HELP!