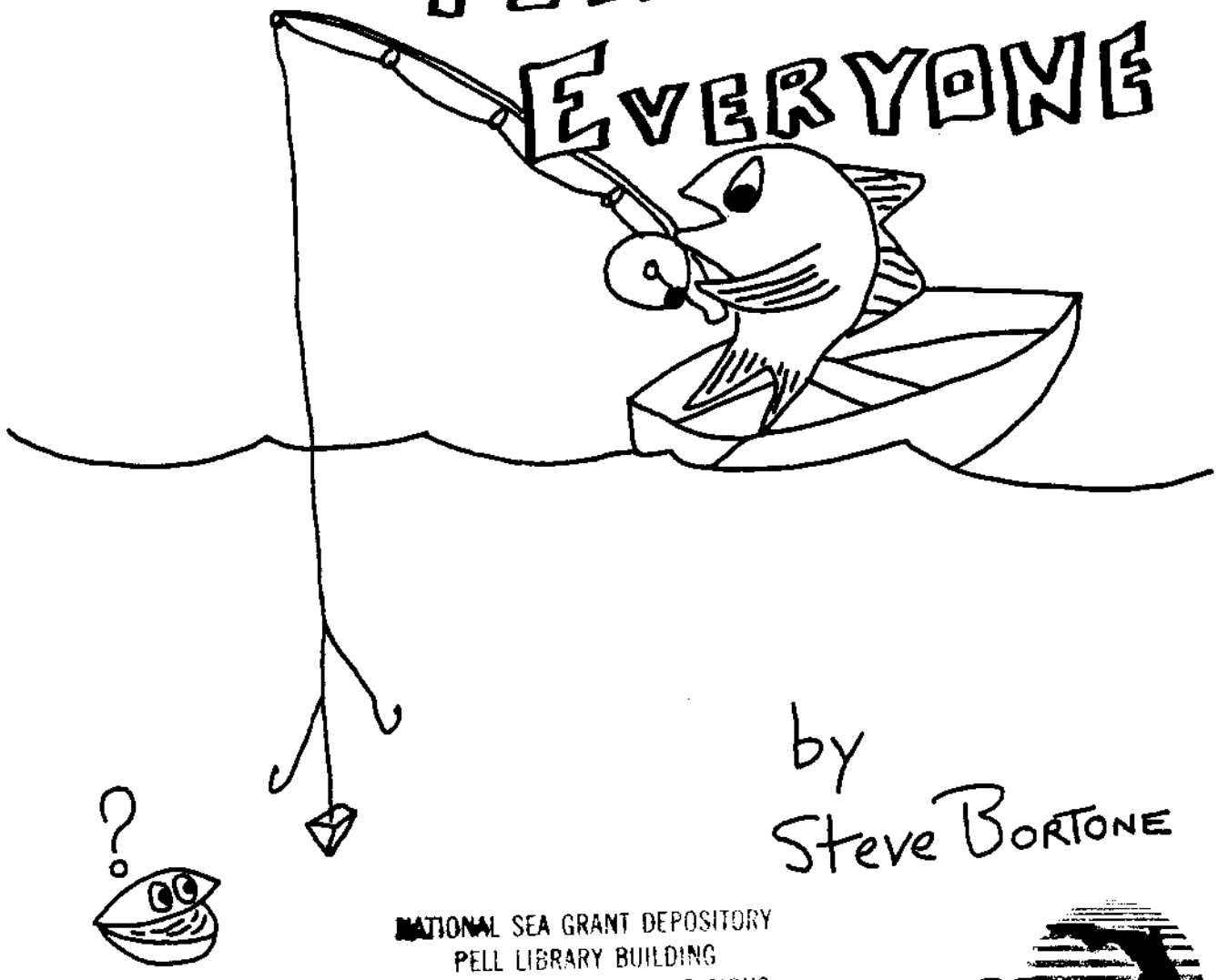
Fisheries Biology For Everyone



by Steve Bortone

SEA GRANT

Florida Cooperative Extension Service

April 1986

Fisheries Biology for Everyone

Stephen A. Bortone

Biology Department
University of West Florida
Pensacola, Florida 32514

Sea Grant Project No. E/M-7
Grant No. NA80AA-D-00038

Sea Grant Extension
Bulletin SGEB-11

Florida Sea Grant College
April 1986
Price $3.00

... FOR MY CHILDREN,
KARA AND DANTE,
SO THEY MAY HAVE
SOMETHING TO CATCH.

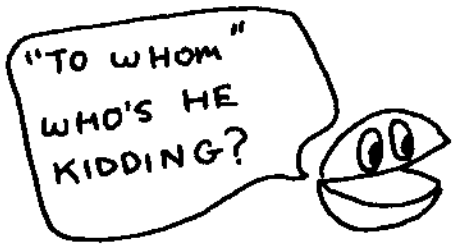
TABLE OF CONTENTS

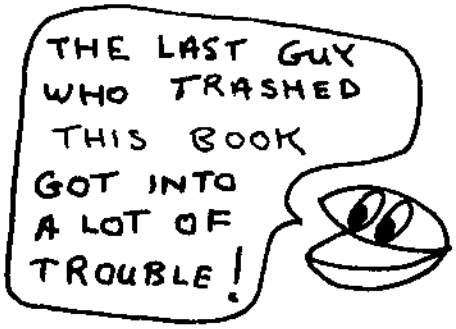
TABLE OF CONTENTS (CONT.)

List of Figures:

~~PREFACE~~ --- INTRODUCTION

WELL IT'S NOT REALLY AN INTRODUCTION BUT IT SEEMS THAT HARDLY ANYONE EVER READS A PREFACE AND IN THIS BOOK IT IS VERY, VERY VERY ETC. IMPORTANT THAT THE REASONS FOR WRITING IT, AND UNDERSTANDING TO WHOM IT'S WRITTEN, BE MADE 'PERFECTLY CLEAR' FROM THE BEGINNING

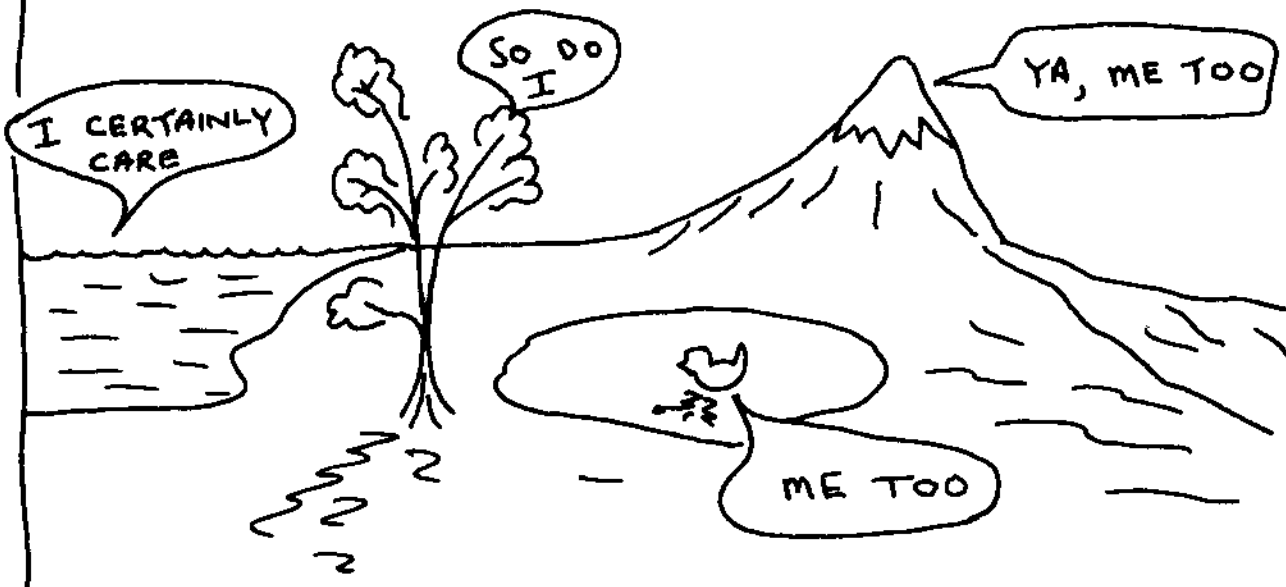




OUR ENVIRONMENT INCLUDES ALL OUR LIVING AND NON-LIVING SURROUNDINGS.

"IT'S EVERYWHERE! ---
IT'S EVERYWHERE!"

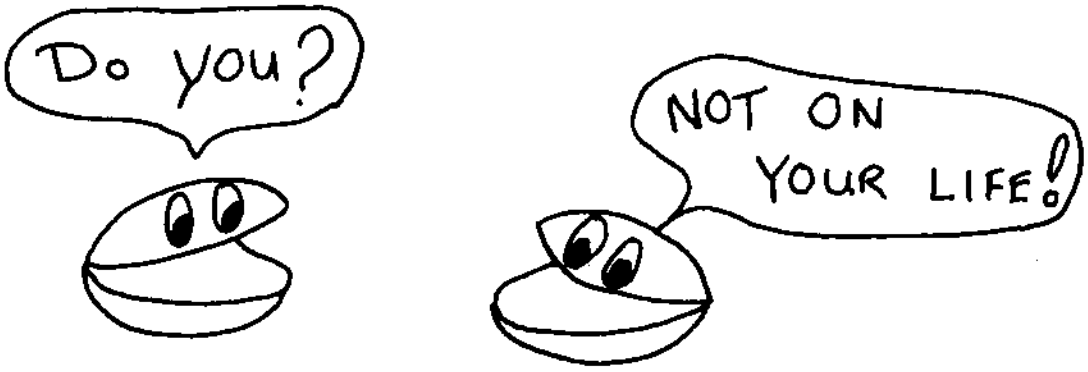
CERTAINLY EVERYONE SHOULD CARE ABOUT THE ENVIRONMENT AND MOST EVERYONE CARES ABOUT A VALUABLE PART OF OUR ENVIRONMENT --- ITS **FISHERIES!**



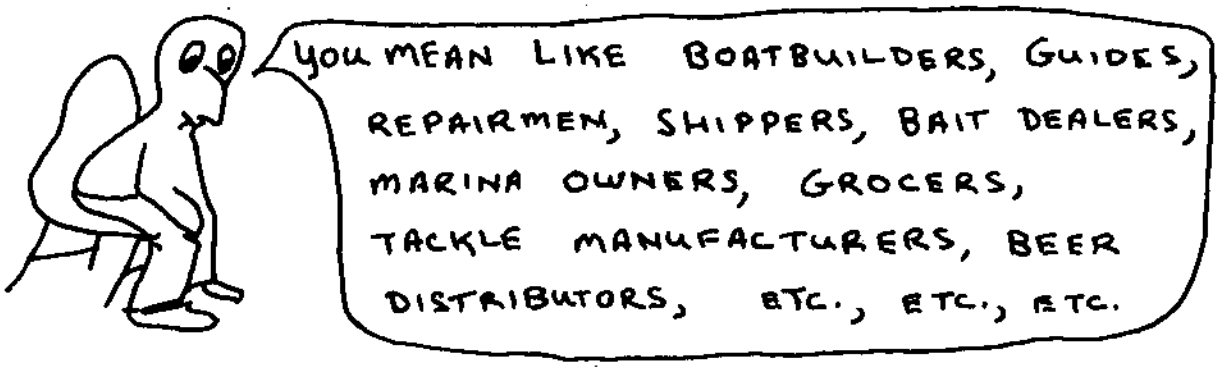
SO WE'RE ALL CONCERNED ---,

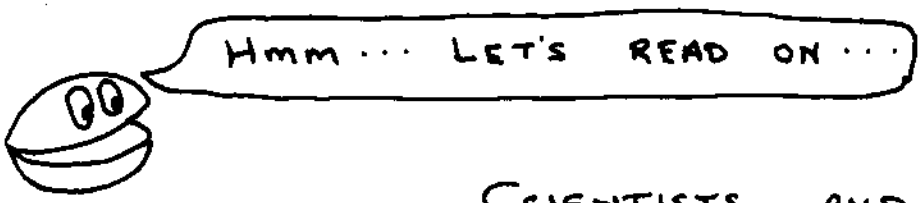
SO WHAT?---

BUT WHO CARES ABOUT THE INDIVIDUAL RECREATIONAL AND COMMERCIAL FISHERMEN AND WOMEN WHO DEPEND ON THESE FISHERIES RESOURCES FOR THEIR ENTERTAINMENT AND THEIR LIVELIHOOD?

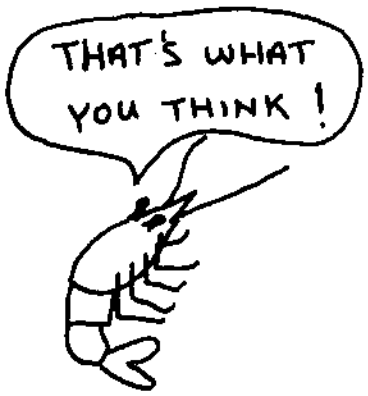


- - - AND DON'T FORGET ALL THE OTHER FOLKS WHO PROVIDE MATERIALS, SUPPLIES, AND HAMBURGERS TO ALL THOSE FISHERMEN.

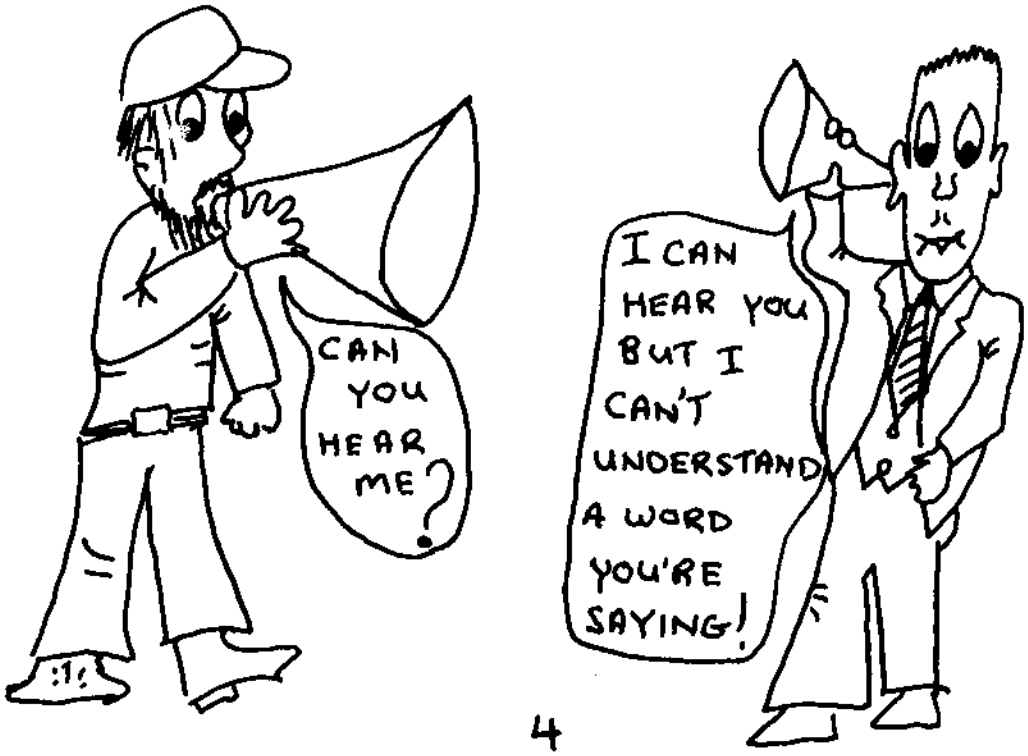




SCIENTISTS AND GOVERNMENT ADMINISTRATORS HAVE TRIED TO USE THE VIEWS, EXPERIENCE, KNOWLEDGE, AND EXPERTISE OF FISHERMEN WHEN THEY CONSIDER THE MANAGEMENT OF OUR FISHERIES.



HOWEVER, WHEN THEY DO TRY TO INTERACT WITH FISHERMEN IN ATTEMPTS TO SOLVE PROBLEMS RELATED TO FISHERIES WHAT GENERALLY RESULTS IS A "FAILURE TO Communicate."



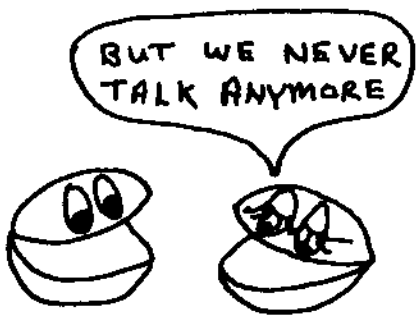
THERE ARE SEVERAL REASONS FOR THIS "FAILURE TO COMMUNICATE".

1. A LACK OF RESPECT FISHERMEN AND NON-FISHERMEN HAVE FOR EACH OTHER, EACH GROUP REFERRING TO THE OTHER WITH THE WORDS "THEM" OR "THEY".

2. A LONG STANDING TRADITION OF ANTAGONISM THAT EXISTS BETWEEN FISHERMEN AND ADMINISTRATORS (AT ANY LEVEL), SCIENTISTS (OR "FISH DOCTORS", ESPECIALLY THOSE WHO WEAR WHITE COATS), AND ANYONE ELSE WHO HAS REAL OR APPARENT AUTHORITY OVER FISH, FISHERIES, FISHERMEN, OR THE ENVIRONMENT.

AND OF COURSE . . .

3. IGNORANCE!



IGNORANCE SHOWS ITSELF IN MANY WAYS BUT BASICALLY CAN BE CATEGORIZED BY 4 ATTITUDES:

1. THOSE WHO THINK THEY KNOW ABOUT FISHERIES --- BUT DON'T.

2. THOSE WHO DO KNOW BUT WON'T TELL ANYBODY WHAT THEY KNOW.

3. THOSE WHO DON'T KNOW AND DON'T WANT TO KNOW.

4. THOSE WHO EITHER:

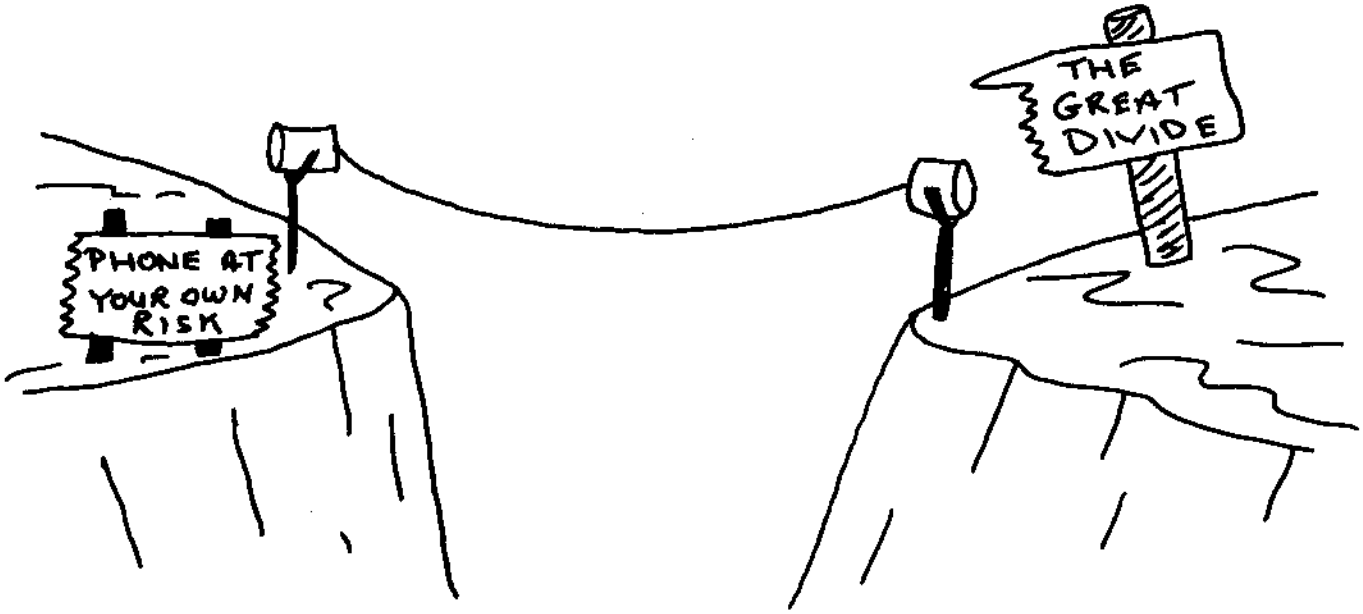
   A. THINK THEY KNOW A "THEM" OR A "THEY" WHEN THEY SEE ONE.

OR

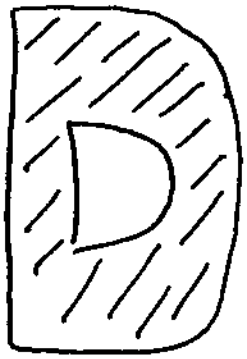
   B. ACT LIKE A "THEM" OR A "THEY".

TAKE HEED - WE ALL FIT INTO ONE OR MORE OF THE ABOVE CATEGORIES. THIS BOOK THEN IS WRITTEN FOR EVERYONE, EVEN THOSE IN CATEGORY 3!

AFTER LOTS + LOTS OF CONVERSATIONS, DISCUSSION, DIALOG, AND TALK WITH A WHOLE BUNCH OF "THEM'S" AND "THEY'S" AROUND THE UNITED STATES, BUT ESPECIALLY IN FLORIDA, IT BECAME APPARENT THAT AN "INFORMATION GAP" EXISTS BETWEEN THE "REAL WORLD" OF FISHERMEN AND THE "IDEAL WORLD" OF FISHERIES SCIENTISTS AND GOVERNMENT ADMINISTRATORS.

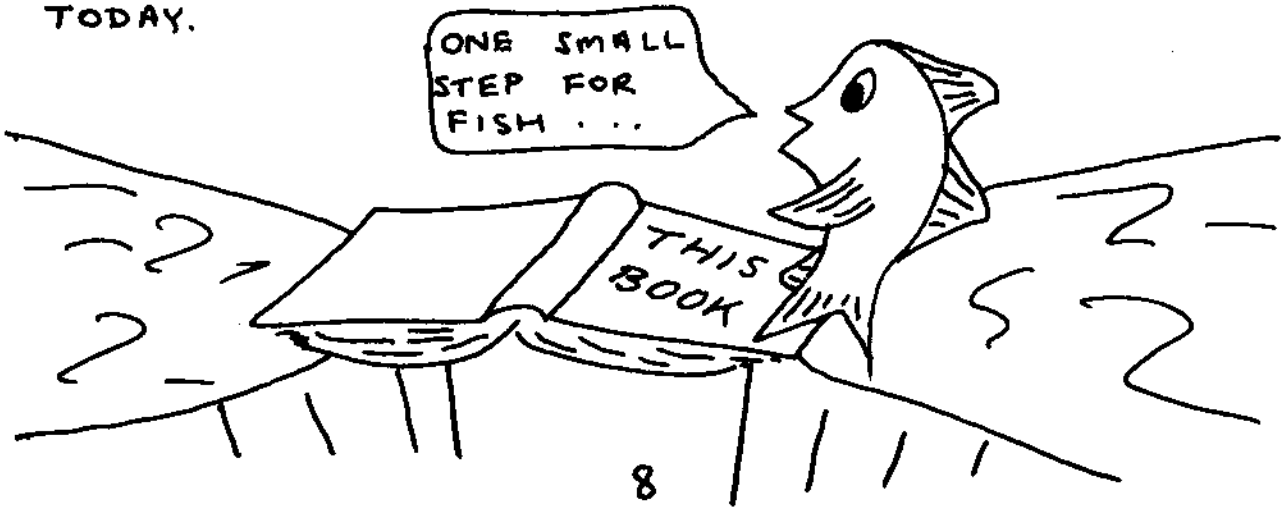


THERE ARE, OF COURSE, REASONS FOR THIS GAP WHICH EXISTS BETWEEN FISHERMEN AND NON-FISHERMEN — WE'LL CALL THESE THE BIG D'S.

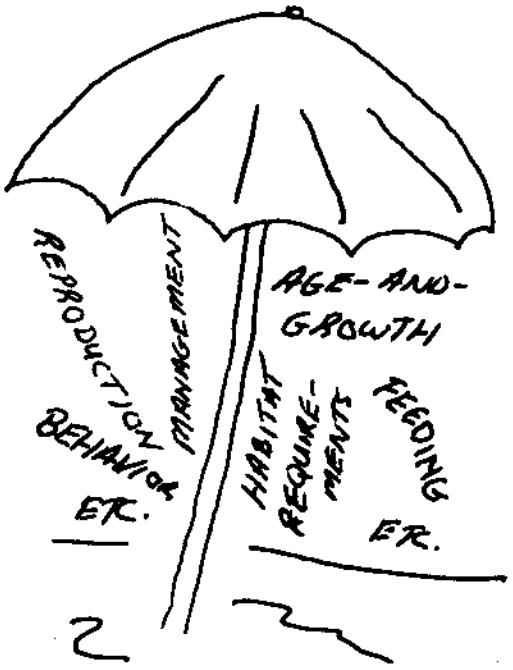


IFFERENCES IN ATTITUDE
" " INFORMATION
" " UNDERSTANDING

IT IS MY EXPECTATION THAT WHEN BOTH SIDES ARE FULLY INFORMED ABOUT WHAT THE OTHER IS DOING, THINKING, AND HOPING CAN WE THEN BEGIN TO SOLVE SOME OF THE PROBLEMS FACING OUR FISHERIES TODAY.



THIS BOOK CAN + WILL PROVIDE AN OPPORTUNITY FOR THE GENERAL PUBLIC, ESPECIALLY THOSE WITH CONCERNS AND INTERESTS IN FISHERIES, TO BECOME INFORMED ABOUT THE BASIC PRINCIPLES AND PROCEDURES USED IN **FISHERIES BIOLOGY.**



LOTS + LOTS OF THINGS WILL BE COVERED IN A RATHER LIMITED SPACE. IF YOU NEED MORE DETAIL OR INFORMATION ON A SUBJECT CHECK THE BOOKS + PAPERS LISTED AT THE END OR SEE YOUR LOCAL "THEM" OR "THEY" NOW PLAYING AT A UNIVERSITY, COLLEGE, OR RESEARCH FACILITY NEAR YOU.

THE OVERALL GAINS OR BENEFITS FROM THIS ENDEAVOR WILL BE TO BEGIN TO BUILD A RELATIONSHIP AMONG ALL OF US ASSOCIATED WITH FISHERIES AS A RESOURCE AND AN INDUSTRY. THIS WILL INEVITABLY SERVE ALL CONCERNED AS THERE WILL BE A COMMON POINT FROM WHICH TO WORK TOWARD UNDERSTANDING AND SOLVING EACH OTHER'S FISHERIES RELATED PROBLEMS.

---READY? - LET'S GO!

Asking Some Reasonable Questions
(and some that don't seem quite so reasonable - - - yet!):

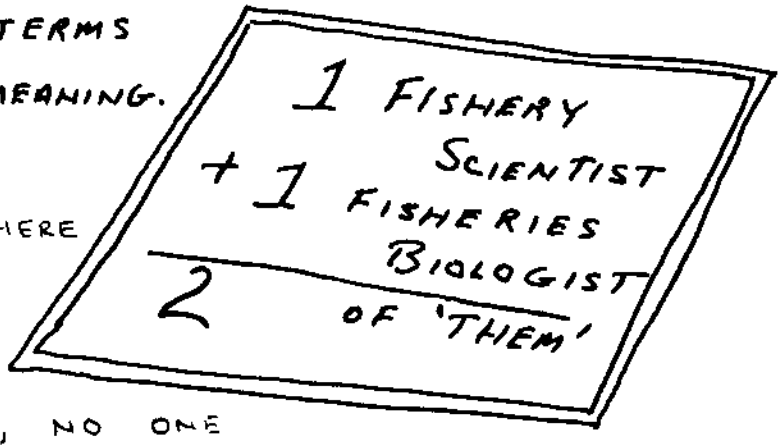
Exactly what is Fisheries Biology- anyway?

Literally 'Fisheries Biology' means the biological study of fisheries - but you already knew that!

In its shorter scope it is the study of the many life features of the organisms which comprise a fishery.

In its longer scope it includes the social, economic & management aspects as well.

SOMETIMES THIS BROADER FIELD, WHICH INCLUDES ALL THE ASPECTS RELATED TO FISHERIES BIOLOGY, IS CALLED 'FISHERIES SCIENCE'. FOR THE MOST PART THESE TWO TERMS HAVE THE SAME MEANING.



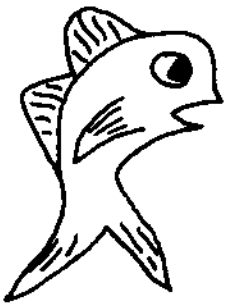
(NOTE: ALTHOUGH THERE MAY BE A DIFFERENCE BETWEEN THE TERMS, FISHERY + FISHERIES, NO ONE REALLY KNOWS OR CARES WHAT THE DIFFERENCE IS, SO THEY ARE OFTEN USED INTERCHANGEABLY - BOTH HERE AND EVERYWHERE.)

WHEN WE TALK ABOUT A 'FISHERY' WE MEAN A GROUP OF AQUATIC ORGANISMS (THINGS THAT LIVE IN THE WATER) THAT ARE, WILL BE, OR HAVE BEEN USED FOR COMMERCIAL AND/OR RECREATIONAL PURPOSES. THE USES INCLUDE NOT ONLY THOSE FOR HUMAN CONSUMPTION BUT ALSO THINGS LIKE INDUSTRIAL (CAT FOOD + FISH MEAL) AND TOURISM (DECORATIVE SHELLS, ETC.)

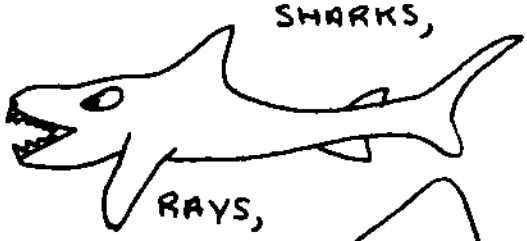
THE AQUATIC ORGANISMS THEMSELVES INCLUDE A WIDE VARIETY OF GROUPS :o

THE COLD BLOODED VERTEBRATES (CAN'T REGULATE THEIR BODY TEMPERATURE BUT THEY DO HAVE BACKBONES) LIKE

FISH,

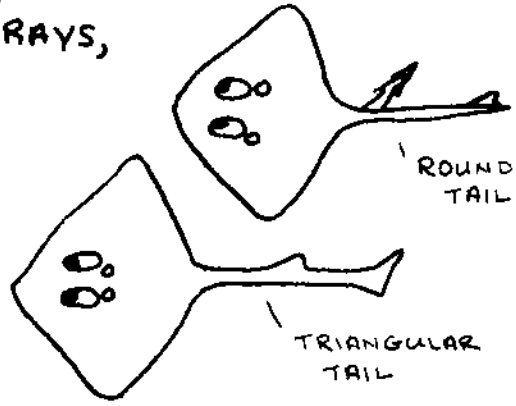


SHARKS,

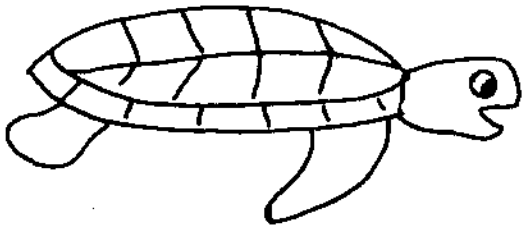


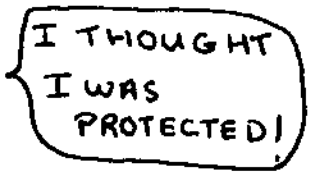
RAYS,

SKATES,



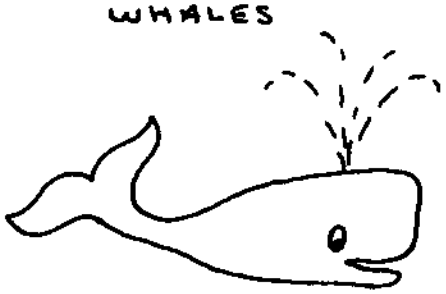
AND SEA TURTLES :o)





WARM BLOODED VERTEBRATES (THEY CAN CONTROL THEIR BODY TEMPERATURE QUITE NICELY - LIKE YOU AND ME) SUCH AS

WHALES

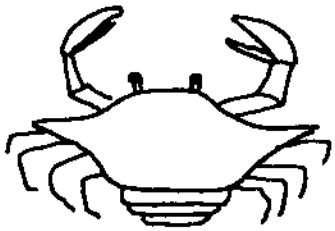


AND

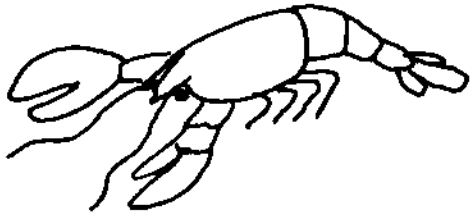
SEALS :o)

LASTLY, THEY INCLUDE A WIDE VARIETY OF INVERTEBRATES (NO BACKBONES) SUCH AS SHRIMP,

CRABS,

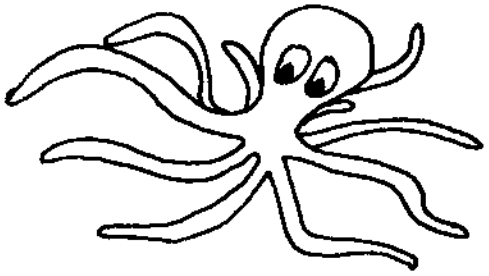


CRAYFISH + LOBSTER,

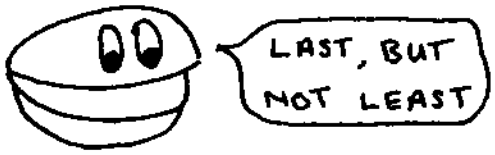


SQUID + OCTOPUS

AND



CLAMS + OYSTERS.



NOT TO LEAVE OUT ANY GROUP, WE MIGHT ALSO INCLUDE CORALS (USED IN MAKING JEWELRY) AND SOME PLANTS SUCH AS SEAWEED (USED IN MAKING ICE CREAM!).

ALL THE ABOVE GROUPS HAVE FISHERIES ATTRIBUTED TO THEM. THE TERMS FISH + FISHES WILL BE USED WHEN REFERRING TO THE ORGANISMS COMPRISING A FISHERY. I WON'T ALWAYS MEAN "FISH", OF COURSE, BUT IT WILL MAKE READING (AND WRITING) A WHOLE LOT SIMPLER (AND HOPEFULLY CLEARER). AS YOU HAVE PROBABLY ALREADY GATHERED, THE GENERAL PRINCIPLES OF FISHERIES BIOLOGY CAN BE APPLIED TO ANY FISHERY.

Why should we want to know something about Fisheries Biology?

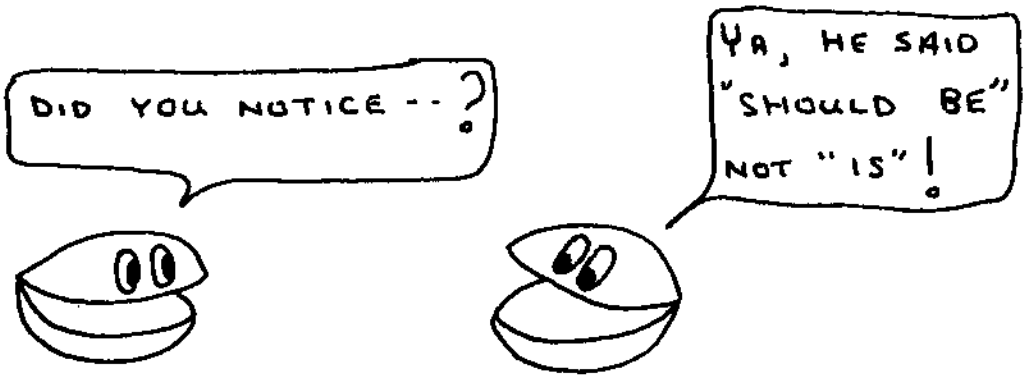
The above question roughly translates to:

What are the objectives of Fisheries Biology?

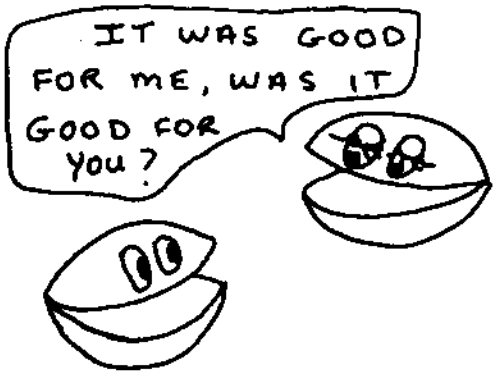
The reason is: if we have an idea what the field is trying to do then it follows that we will have the answer to both questions.

The main objective of Fisheries Biology should be to:

"Create and maintain the best possible fishing experience for everyone"



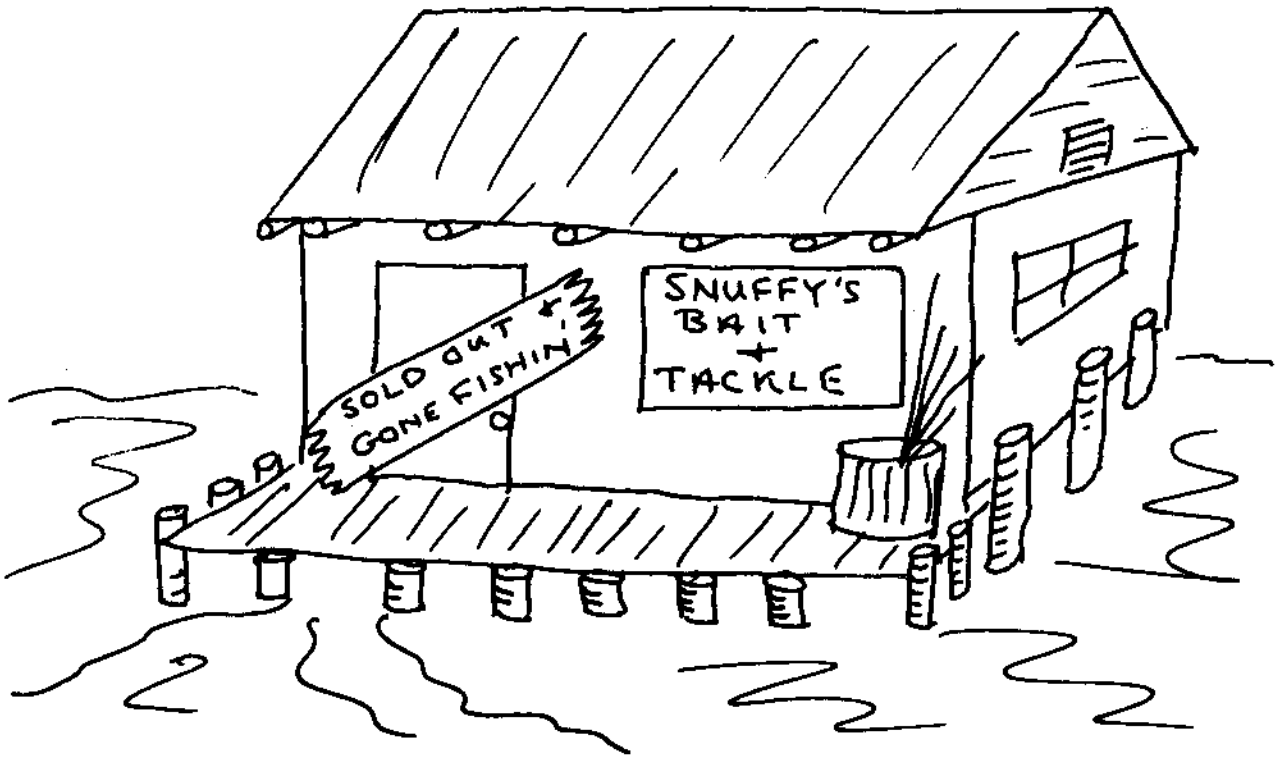
ROBERT LACKEY WROTE THE PREVIOUS QUOTE IN HIS BOOK "INTRODUCTION TO FISHERIES SCIENCE." IT'S IMPORTANT FOR US TO EXAMINE THIS STATEMENT, ESPECIALLY TO UNDERSTAND THE TERMS "BEST" AND "EVERYONE". WE ALL KNOW THAT WHAT IS BEST FOR SOMEONE MAY NOT NECESSARILY BE WHAT'S BEST FOR SOMEONE ELSE. MOREOVER, WE ALSO NEED TO RECOGNIZE THAT THE "EVERYONE" REFERS NOT JUST TO EVERYONE PRESENT HERE AND NOW, BUT ALSO TO THE EVERYONES WHO WILL BE HERE IN THE FUTURE AS WELL.



THIS BECOMES QUITE AN OBJECTIVE THEN WHEN YOU CONSIDER THE HUNDREDS OF FISHERIES (SOME OF WHICH HAVEN'T EVEN BEEN DEVELOPED OR DISCOVERED YET), EACH WITH ITS OWN VERY SPECIAL FEATURES, AND THE MULTITUDES OF PARTICIPANTS EACH WITH THEIR OWN IDEA OF WHAT'S "BEST" FOR THEM (AND EVERYONE ELSE!).

LET'S EXAMINE THE NUTS + BOLTS OF THIS OBJECTIVE EVEN FURTHER ~ - - -

THE DIVERSITY OF FISHING PARTICIPANTS AS WELL AS THOSE CLOSELY OR EVEN REMOTELY ASSOCIATED WITH FISHERIES ALL HAVE A VESTED INTEREST IN DERIVING THE "--- BEST possible FISHING EXPERIENCE ---." THE VALUE OF THIS EXPERIENCE IS OBVIOUSLY IN THE EYE OF THE BEHOLDER AND INCLUDES MORE (OR BIGGER) FISH IF YOU ARE A COMMERCIAL FISHERMAN, MORE LOST LURES AND TACKLE IF YOU OWN A BAIT + TACKLE SHOP, STRANGER AND MORE PICTURESQUE FISH IF YOU'RE A SPORT DIVER, OR LOWER PRICES IF YOU ARE A CONSUMER.



THEN THERE IS, OF COURSE, A MAJOR CONFLICT THAT ARISES UNDER THE TERM "BEST". WHAT IS BEST FOR SOME (LOWER PRICES FOR EXAMPLE) IS NOT NECESSARILY THE BEST FOR OTHERS (IF YOU HAPPEN TO BE A COMMERCIAL FISHERMAN). ONCE A CONFLICT OCCURS MOST OF US PREFER TO DIVORCE OURSELVES FROM THE NICE, HARMONIOUS GROUP. AS SOON AS THAT HAPPENS IT'S "EVERYONE FOR THEMSELF".

IN ESSENCE WHAT FISHERIES BIOLOGY IS ALL ABOUT IS PROVIDING THE BEST POSSIBLE FISHING EXPERIENCE FOR EVERYONE WHILE MINIMIZING THE CONFLICTS BETWEEN EVERYBODY.

THOSE OF US INTERESTED IN OUR FISHERIES RESOURCES NEED TO LEARN HOW TO MAINTAIN, IMPROVE, AND DEVELOP THEIR QUALITY AND QUANTITY. THIS IMPLIES THAT WE OUGHT TO KNOW, OR AT LEAST UNDERSTAND, HOW TO ACHIEVE THE OBJECTIVES OF FISHERIES BIOLOGY. EVEN MORE IMPORTANTLY, WE NEED TO KNOW WHEN OUR OBJECTIVES HAVE BEEN MET SO THAT WE'LL KNOW IF OUR MANAGEMENT STRATEGY HAS BEEN SUCCESSFUL. SO - - - THE MAIN EMPHASIS IN THE NEXT FEW SECTIONS WILL BE ON DISCOVERING:

WHAT A FISHERIES BIOLOGIST DOES,

HOW HE OR SHE DOES IT,

AND - - -

WHY ALL THIS ACTIVITY AND RESEARCH IS NECESSARY.

LATER ON WE'LL EXAMINE HOW THE SPECIFIC OBJECTIVES FOR EACH FISHERY ARE DETERMINED. BUT FIRST - - -

THE QUESTION ALSO ARISES:

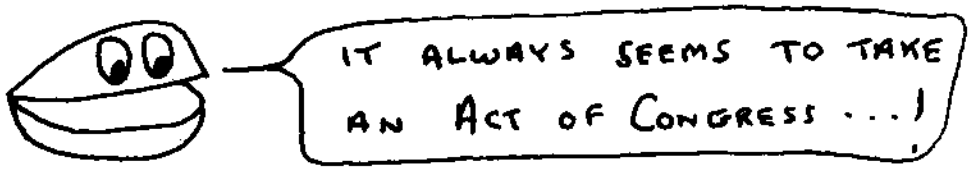
WHAT YARDSTICK DO WE USE TO MEASURE WHAT IS "BEST" AND DO WE KNOW WHEN "BEST" HAS BEEN ATTAINED?

IN THE RECENT PAST AND EVEN TO THE PRESENT DAY, ONE OF THE MAJOR OBJECTIVES OF FISHERIES BIOLOGISTS WAS TO MAINTAIN A FISHERY AT ITS MAXIMUM SUSTAINABLE YIELD (OR MSY FOR SHORT).

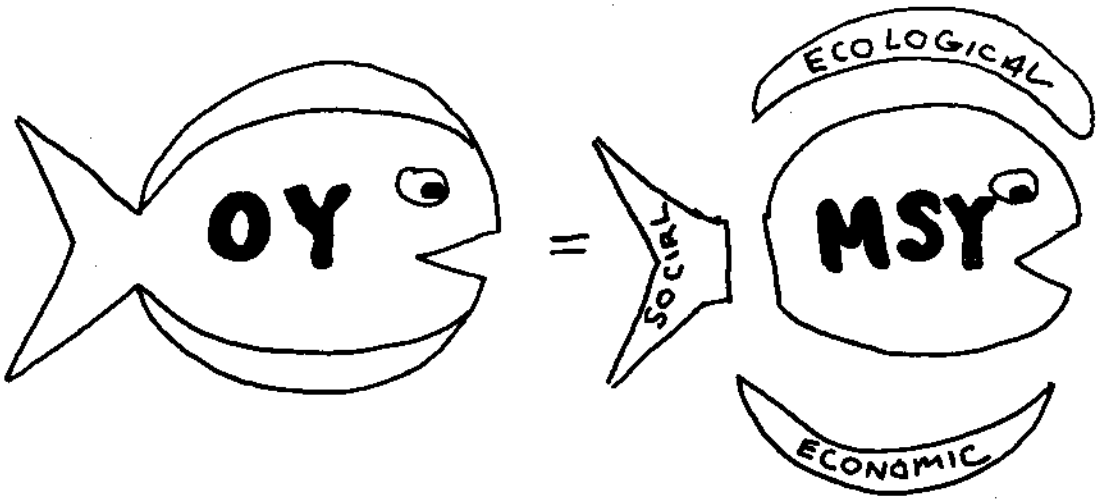
MSY IS DEFINED PURELY ON A BIOLOGICAL BASIS. BRIEFLY, MSY MEANS... THE HIGHEST YIELD OR CATCH OF FISH WHICH CAN BE TAKEN WITHOUT CAUSING A DECLINE IN FUTURE CATCHES. IN OTHER WORDS, THE CATCH WE CAN TAKE FROM A FISHERY WITHOUT DEPLETING THE NUMBER IN THE GROUP OR STOCK.

As stated previously the MSY for any fishery is established purely as a biological problem. Calculating MSY requires no information of any of the economic or social factors which we know can greatly affect the fishing industry and its participants. If the goal of Fisheries Biology were merely to determine and maintain the MSY for each species or kind of fish in the various fisheries then there would certainly be many problems. These problems would occur because the level of catch taken from the pool or stock would be made without any reference or consideration for the personal lives of the people involved with it.

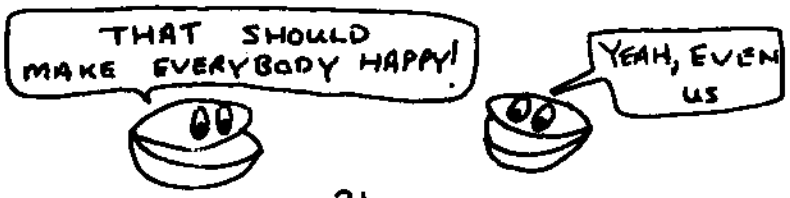
The Fishery Conservation Management Act (abbreviated to FCMA, of course) of 1976 was passed by the U. S. Congress with one of its purposes being to get away from a strictly biological goal of fisheries management.



A NEW GOAL FOR FISHERIES MANAGERS WAS ADOPTED AS PART OF THE FCMA CALLED OPTIMUM YIELD. OPTIMUM YIELD (OR OY) IS BASED ON THE MAXIMUM SUSTAINABLE YIELD BUT AS IT (THE MSY) IS "... MODIFIED BY RELEVANT SOCIAL, ECONOMIC, OR ECOLOGICAL FACTORS."



WE'LL GET TO JUST EXACTLY HOW THIS PUZZLE IS PUT TOGETHER LATER BUT THE IMPORTANT POINT TO REALIZE IS THAT FISHERIES BIOLOGISTS MUST NO LONGER BE ONLY CONCERNED WITH BEING ABLE TO MANAGE A FISHERY FROM A BIOLOGICAL POINT OF VIEW. THEY MUST NOW LEARN TO MANAGE IT FROM A PEOPLE POINT OF VIEW.



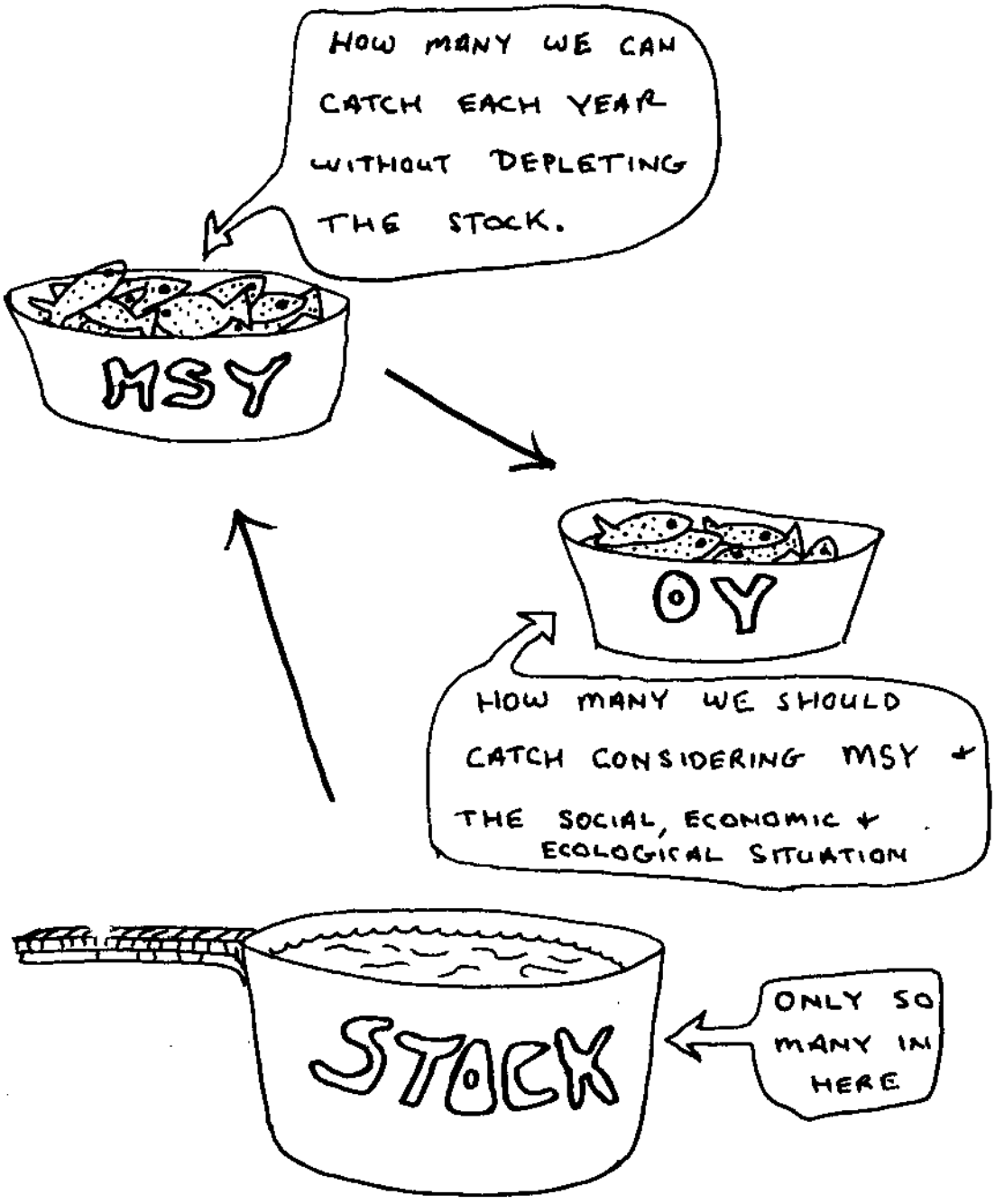
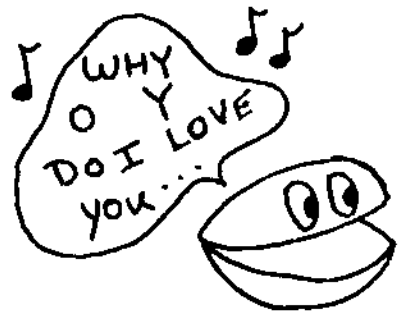


FIGURE 1. THE RELATIONSHIP BETWEEN MSY, OY, AND STOCK

A FISHERIES BIOLOGIST MUST BE ABLE TO ASSESS AND DETERMINE THE IMPACT THE MAJOR ENVIRONMENTAL & BIOLOGICAL FACTORS HAVE ON A FISHERY. THAT MAY SOUND LIKE A DIFFICULT, IF NOT IMPOSSIBLE, TASK BUT IT SOUNDS EVEN MORE DIFFICULT ONCE YOU REALIZE THAT OFTEN EVEN THE FACTORS THEMSELVES MAY INTERACT WITH EACH OTHER. FOR EXAMPLE, TEMPERATURE MAY INFLUENCE A FISHERY, NOT ONLY BY ACTING DIRECTLY ON THE FISH IN A FISHERY, BUT ALSO BY AFFECTING THE AVAILABILITY OF A FOOD ITEM ESSENTIAL TO *THEIR* GROWTH OR SURVIVAL. STUDYING AND DETERMINING THE IMPORTANCE OF THESE FACTORS, THEIR INTERACTION, AND HOW THEY EACH, IN TURN, AFFECT THE FISHERY IS THE RESPONSIBILITY OF FISHERY BIOLOGISTS. IT IS THROUGH A CAREFUL AND CORRECT UNDERSTANDING OF THESE RELATIONSHIPS THAT HE OR SHE IS ABLE TO CALCULATE MSY AND SUBSEQUENTLY EXAMINE THE SOCIAL AND ECONOMIC FACTORS TO DETERMINE OY.



In order to set the goals for fisheries management and to determine if and when these goals have been met we must be able to view the fishery in its total perspective. . . . .

Aquatic organisms are not isolated from themselves or anything else. The fact is that fisheries are affected by just about everything. In Figure 2. the major factors which influence fisheries have been broken down into two groups. There is a group of <u>environmental</u> or <u>physical</u> factors which influence fisheries such as: Temperature, Salinity, Oxygen, & Bottom Type or Substrate In addition, there is a group of other factors which are <u>biological</u> such as: Competition, Food, Parasites, Diseases, and Predators (in a way you might think of fishermen as predators on the fish in a fishery!).

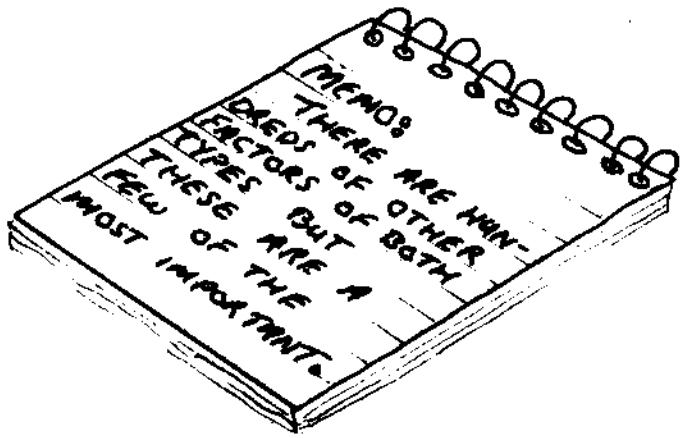
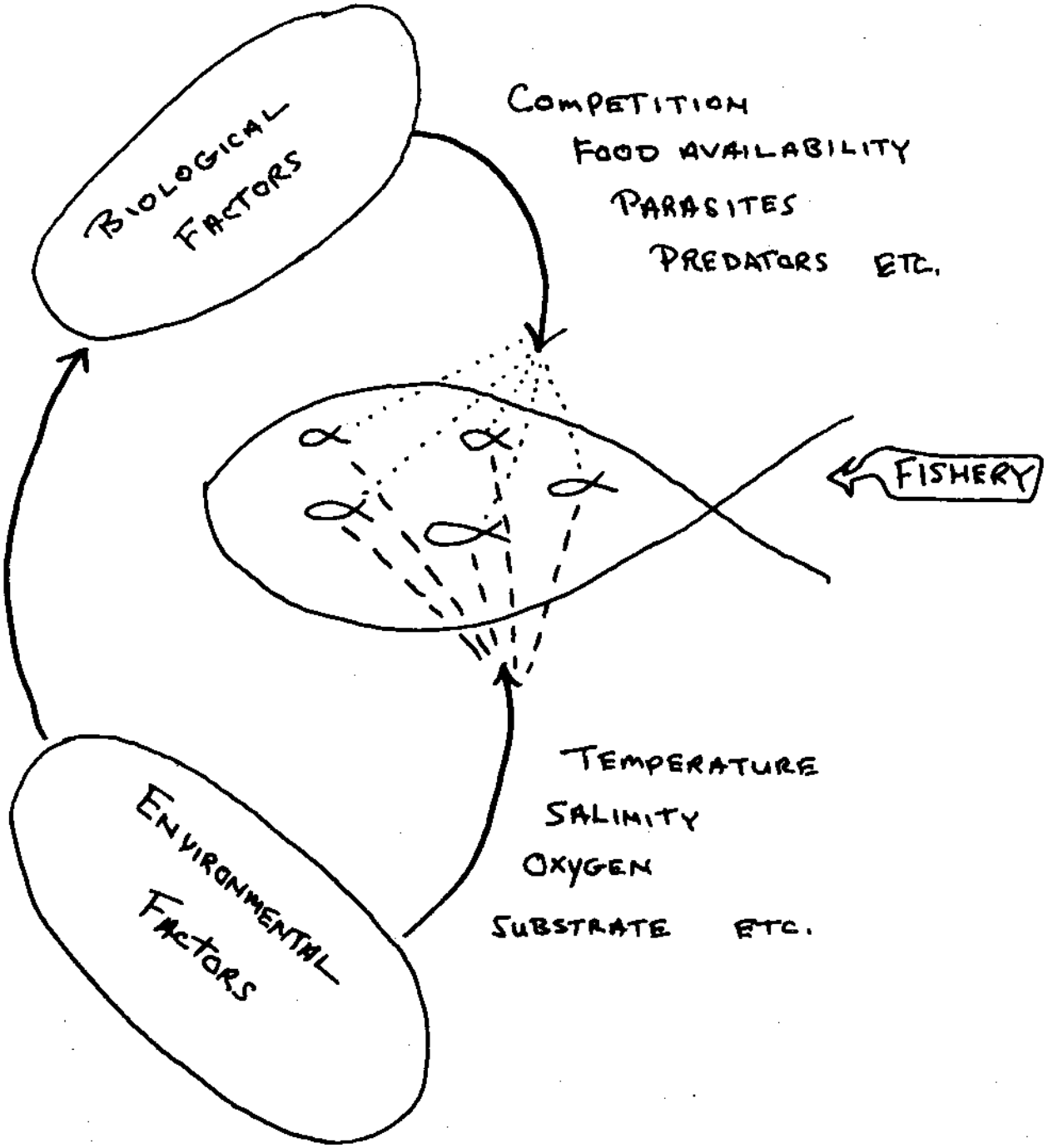
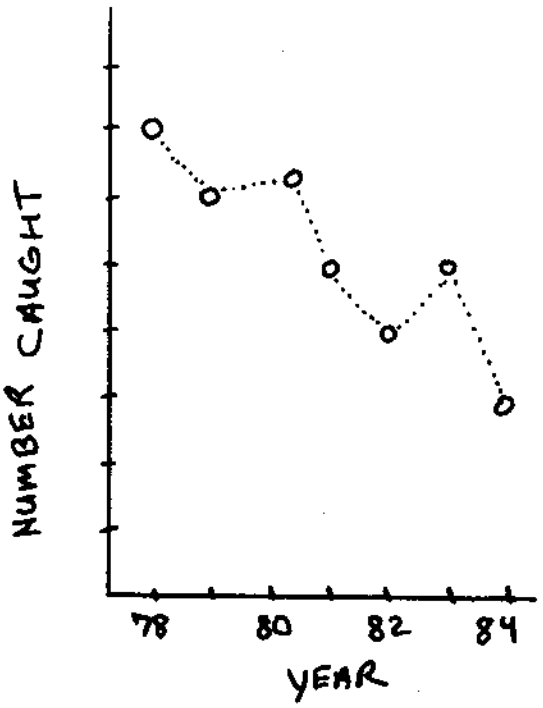


FIGURE 2. FACTORS WHICH MAY INFLUENCE A FISHERY AND THE CONCEPT THAT A FISHERY IS COMPOSED OF INDIVIDUALS WHICH ARE EACH, IN TURN, INFLUENCED BY THESE FACTORS.



In Figure 3. a diagram is presented which indicates the general procedures used in Fisheries Biology (at least in an ideal situation). This general procedure is no different than that used in any other field oriented toward problem solving. It requires an <u>input</u> of information, an <u>analysis</u> of the information, an appropriate <u>response</u> to the situation, and an <u>assessment</u> of the response.



Above all, however, we should begin with a question. This usually means that some inquiry has been made into the current status of a "stock" (we'll define this term later). For example, it may be noted that a fishery seems to be declining in the past few years (..sounds familiar!!!). The question then is raised:

Has the stock really declined?

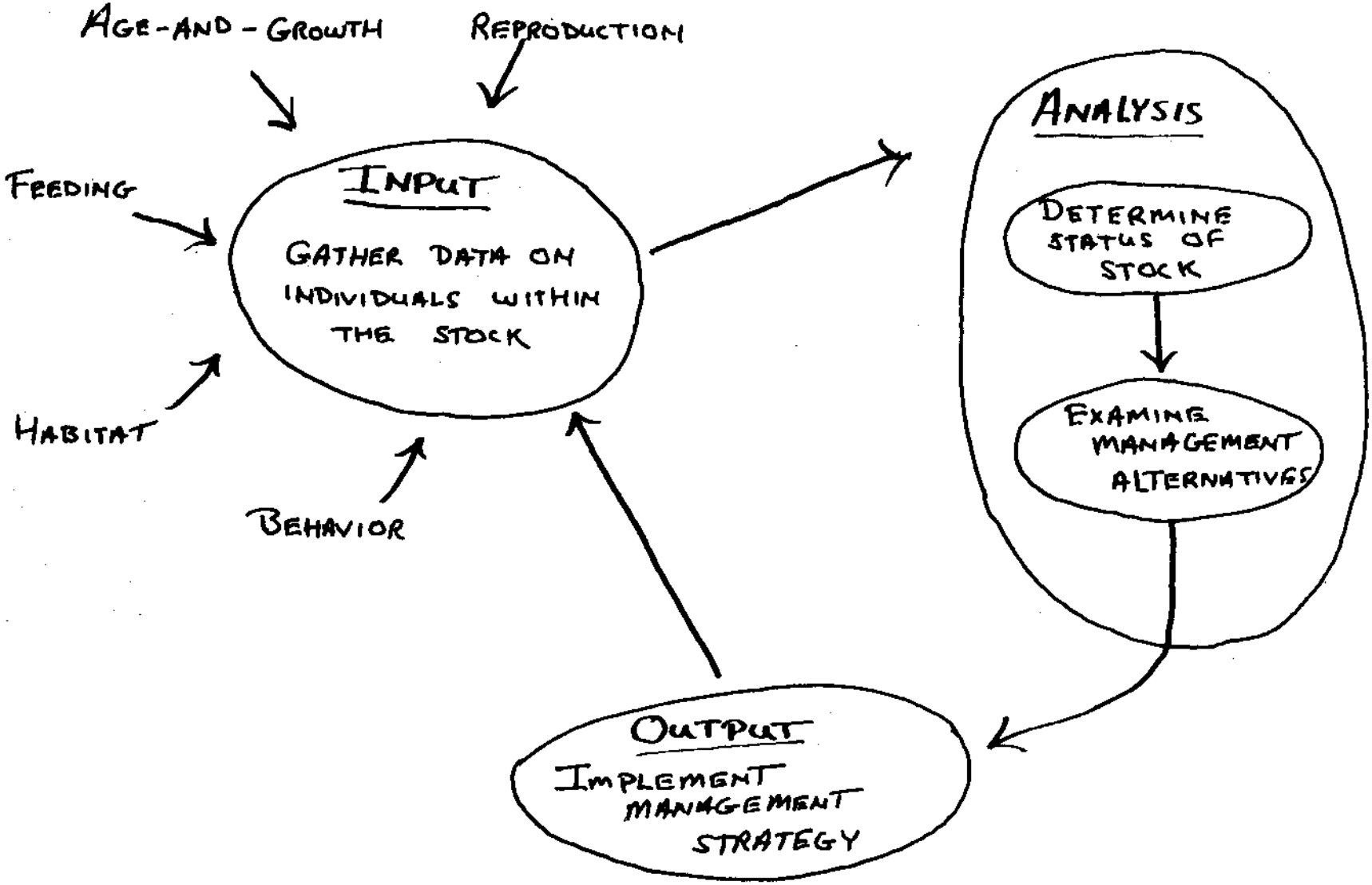
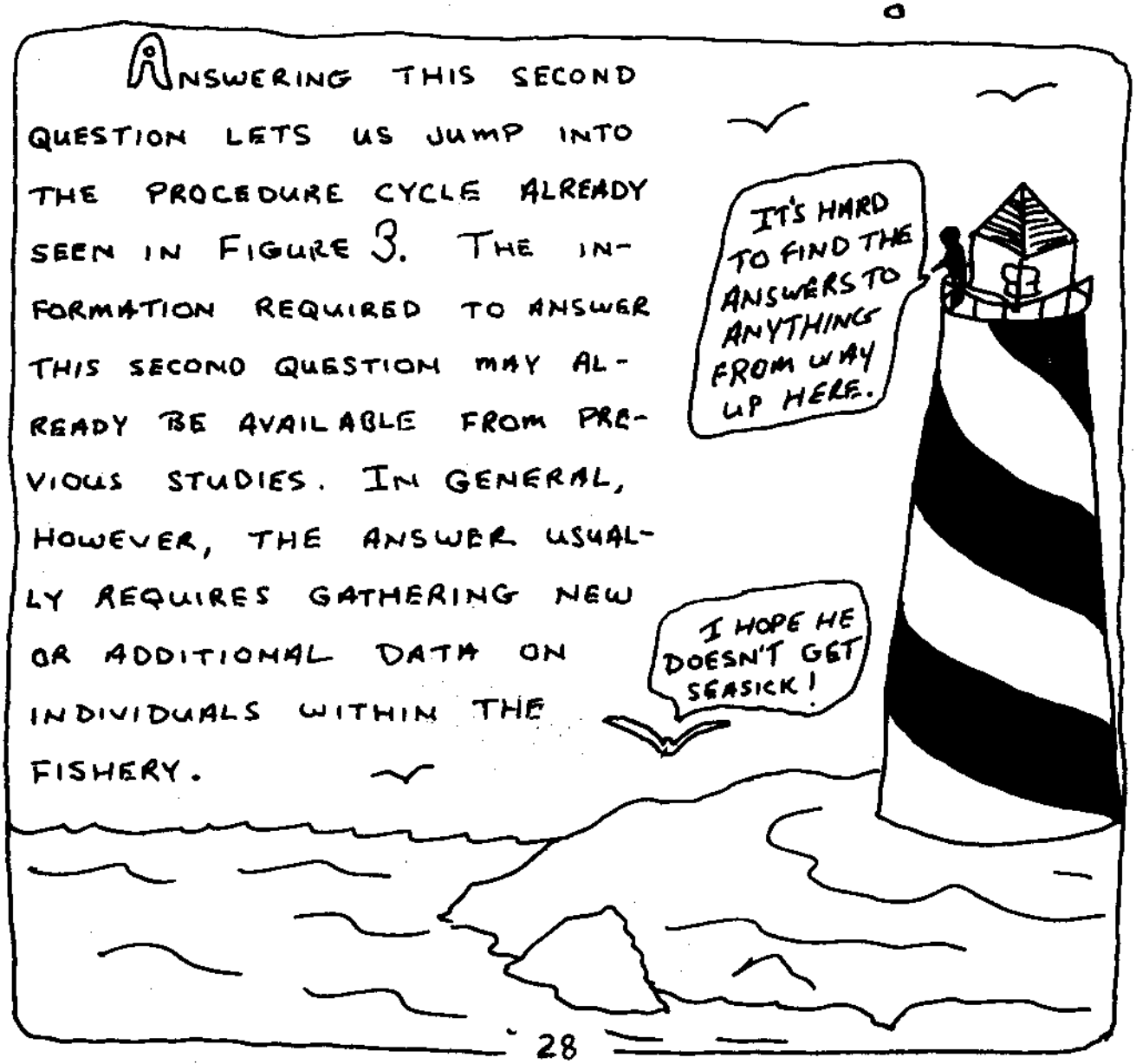


FIGURE 3. FLOW CHART OF THE GENERAL PROCEDURE USED IN FISHERIES BIOLOGY.

WE WOULD BEGIN BY EXAMINING THE AVAILABLE DATA. IF THE DATA INDICATE THAT THE ANSWER TO OUR QUESTION IS A 'YES' (OR A PROBABLE 'YES') AS OPPOSED TO A 'NO' (OR PROBABLE 'NO') THEN A SECOND QUESTION MUST BE ASKED:

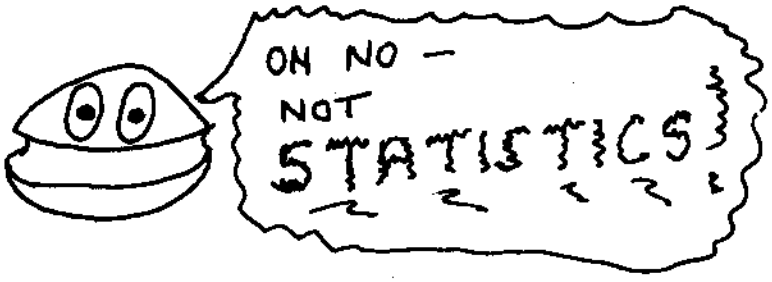
WHAT IS THE CAUSE OF THE DECLINE IN THE FISHERY?

ANSWERING THIS SECOND QUESTION LETS US JUMP INTO THE PROCEDURE CYCLE ALREADY SEEN IN FIGURE 3. THE INFORMATION REQUIRED TO ANSWER THIS SECOND QUESTION MAY ALREADY BE AVAILABLE FROM PREVIOUS STUDIES. IN GENERAL, HOWEVER, THE ANSWER USUALLY REQUIRES GATHERING NEW OR ADDITIONAL DATA ON INDIVIDUALS WITHIN THE FISHERY.



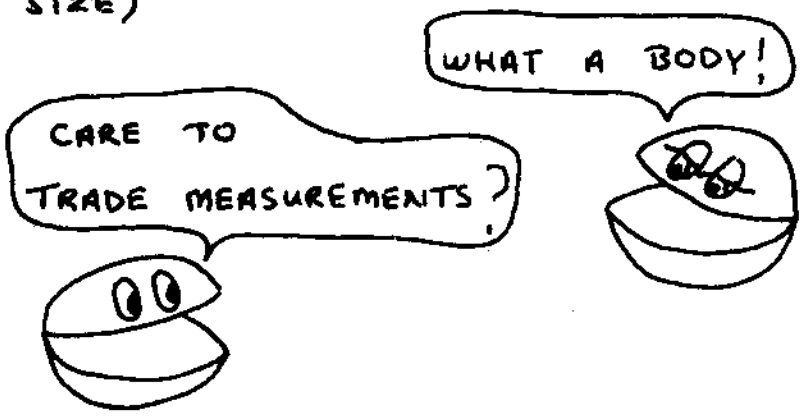
WHILE IT IS TRUE THAT A FISHERY IS COMPOSED OF MANY INDIVIDUAL ORGANISMS, WE NEED TO REALIZE BEFORE WE GO OUT AND GATHER DATA ON THEM THAT NOT ALL INDIVIDUALS IN THE FISHERY HAVE EXACTLY THE SAME CHARACTERISTICS. FOR EXAMPLE, SOME MEMBERS OF THE FISHERY MAY BE LONGER OR PRODUCE MORE EGGS THAN OTHERS OF THE SAME AGE. SOME MAY DIFFER IN WHAT THEY EAT OR WHERE THEY OCCUR.

IN ORDER TO ACCOUNT FOR THESE DIFFERENCES (WHICH COULD HAVE A MAJOR IMPACT ON THE FINAL ANSWER TO A QUESTION) IT IS ESSENTIAL TO DESCRIBE A FISHERY ON A <u>STATISTICAL</u> BASIS.



DON'T GET PUT OFF. WHAT IS MEANT BY A STATISTICAL DESCRIPTION IS REALLY QUITE EASY TO UNDERSTAND. IN ITS SIMPLEST FORM WE MEAN USING AN <u>AVERAGE</u> LENGTH OR WEIGHT TO REPRESENT THAT CHARACTERISTIC OF THE MEMBERS OF A FISHERY (THE AVERAGE THEN IS THE VALUE FOR A "TYPICAL" MEMBER OF THE GROUP).

ALSO - IT IS IMPORTANT TO REALIZE THAT THE ANSWERS TO OUR QUESTIONS MAY REQUIRE THAT NOT ONLY WILL A LOT OF FISH HAVE TO BE MEASURED FOR A SINGLE CHARACTER -- (LIKE BODY SIZE)

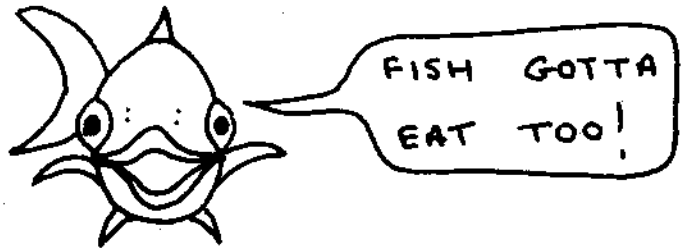


--- BUT MOST ANSWERS WILL REQUIRE THAT WE STUDY (SOMETIMES IN ELABORATE STATISTICAL DETAIL) MANY DIFFERENT BODY CHARACTERS OF THE ORGANISMS AS WELL AS MANY DIFFERENT FACTORS OR FEATURES OF THE ENVIRONMENT WHICH PERTAIN TO THE FISHERY.

FOR EXAMPLE, TO KNOW WHAT MAY HAVE CAUSED THE DECLINE OF A FISHERY WE MAY HAVE TO KNOW THE

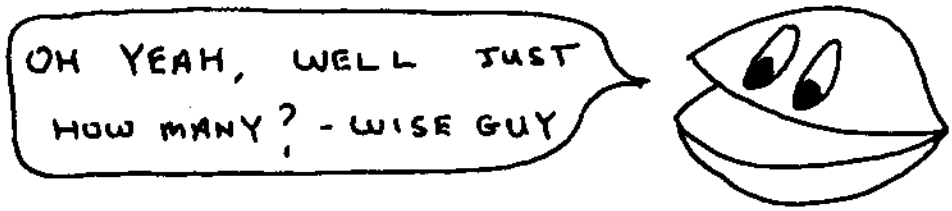
1. FISHING PRESSURE IN THE AREA
2. MIGRATION PATTERN OF THE FISH &
3. THEIR GROWTH RATES.

WE MIGHT EVEN NEED TO KNOW THE AMOUNT OF FOOD THAT'S AVAILABLE BECAUSE THAT CAN CERTAINLY INFLUENCE GROWTH RATES



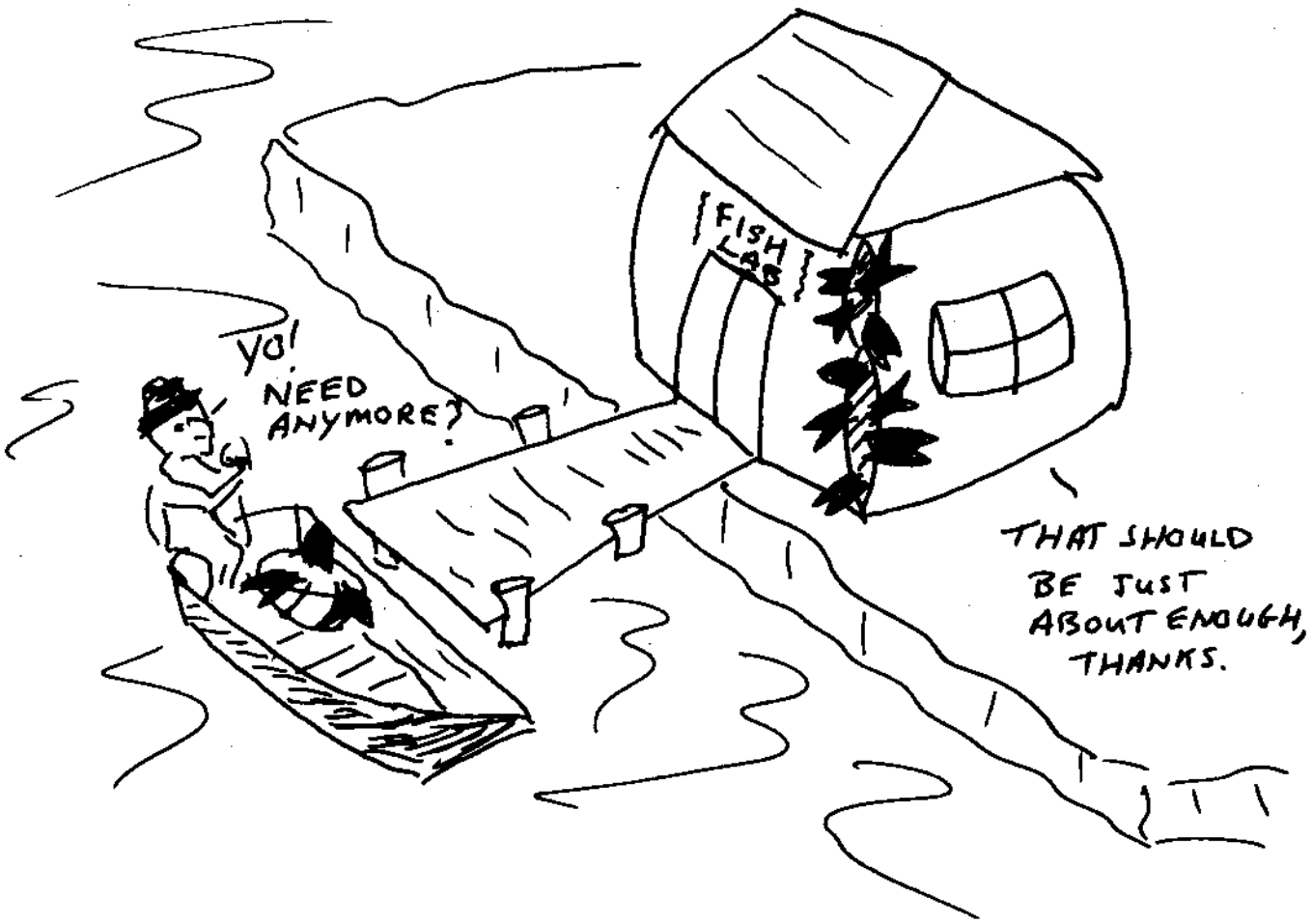
RULE #1 ↓

A LOT OF DIFFERENT CHARACTERS FROM A LOT OF DIFFERENT FISH MUST BE EXAMINED IN ORDER TO ACCURATELY ANSWER QUESTIONS IN FISHERIES



"AS MANY AS IT TAKES, YOU LITTLE CLAM"

THIS RESPONSE MAY SEEM A BIT SILLY BUT THERE IS A LOT OF TRUTH TO IT. GENERALLY, FISHERY BIOLOGISTS GATHER DATA OF THE TYPE AND IN AMOUNTS THAT THEIR EXPERIENCE, EQUIPMENT, AND FUNDS ALLOW.

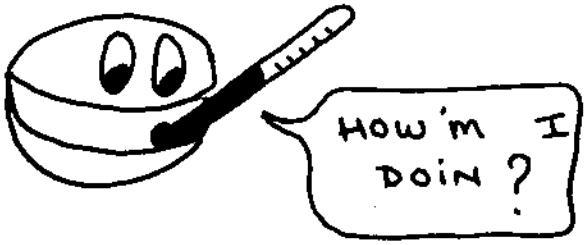


UPON FURTHER STUDY IT MAY BE DETERMINED THAT TOO MUCH OF ONE TYPE OF DATA WERE COLLECTED, NOT ENOUGH OF ANOTHER, OR SOME USELESS DATA WERE GATHERED. PERHAPS SOME REALLY IMPORTANT INFORMATION WAS NOT COLLECTED AT ALL.

RULE #2 →

ONLY BY COLLECTING DATA, ANALYZING IT, AND ASSESSING IT, CAN WE EVER REFINE THE DATA TO THE POINT WHERE OUR QUESTION CAN BE CORRECTLY ANSWERED.

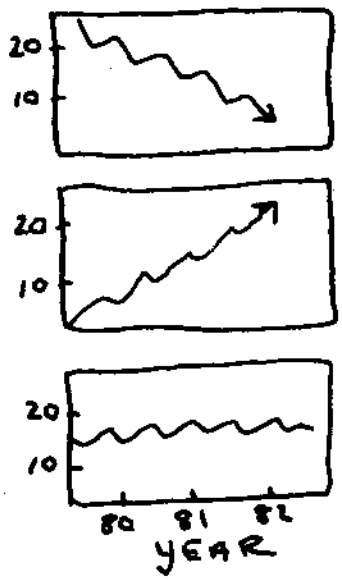
ONCE ENOUGH OF THE 'RIGHT' KIND OF DATA ARE GATHERED AN ANALYSIS IS CONDUCTED TO DETERMINE THE STATUS OF THE FISHERY. . .



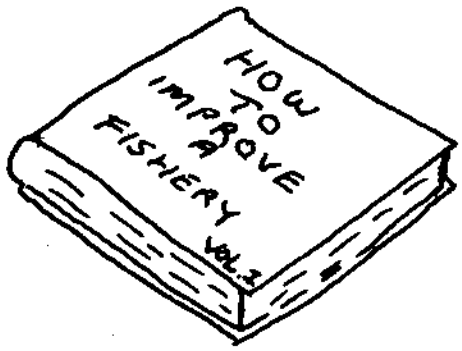
NOTE: THE WORD 'DATA' IS PLURAL AND REFERS TO MORE THAN ONE NUMBER OR PIECE OF INFORMATION. THE WORD 'DATUM' IS THE SINGULAR FORM.

ANOTHER NOTE: HARDLY ANYBODY USES IT CORRECTLY.

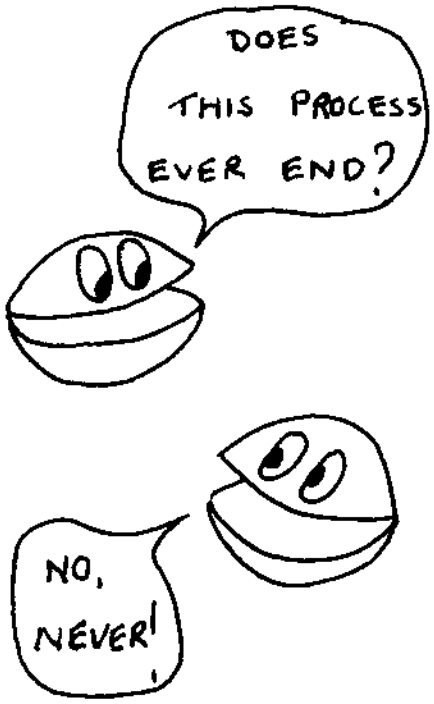
. . . THE ANALYSIS MIGHT INDICATE THAT THE FISHERY IS DECLINING, INCREASING, OR STABILIZING AND (DEPENDING ON THE KIND OF ANALYSIS) INDICATE THE PROBABLE CAUSE (OR CAUSES) FOR THE CURRENT STATUS OF THE FISHERY.



SOMETIMES BY USING THE SAME DATA, IT IS POSSIBLE TO EXAMINE THE EFFECTS THAT VARIOUS MANAGEMENT OPTIONS (MANAGEMENT OPTIONS ARE ESSENTIALLY THE SAME THING AS POTENTIAL SOLUTIONS) MIGHT HAVE ON A FISHERY. FOR EXAMPLE, IF OUR ANALYSIS INDICATES THAT LOW REPRODUCTIVE EFFORT IS THE REASON SUSPECTED AS CAUSING THE DECLINE OF A FISHERY, ONE SUGGESTION FOR ITS IMPROVEMENT MIGHT BE TO STOP OR REDUCE FISHING PRESSURE DURING THE PEAK REPRODUCTIVE SEASON. THERE ARE NUMEROUS OTHER OPTIONS OR STRATEGIES THAT COULD BE APPLIED AS WELL BUT BY USING THE DATA FROM THE FISHERY AND SOME ANALYTICAL TECHNIQUES IT IS POSSIBLE TO DEVELOP MANAGEMENT STRATEGIES THAT WILL LEAD TO IMPROVEMENT OF THE FISHERY WHILE CAUSING THE LEAST INCONVENIENCE TO THE FISHING COMMUNITY.



ONCE A STRATEGY FOR A FISHERY IS ADOPTED AND IMPLEMENTED IT IS ABSOLUTELY NECESSARY TO REASSESS THE STATUS OF THE FISHERY TO DETERMINE IF THE MANAGEMENT TECHNIQUE HAS BEEN EFFECTIVE. THIS, OF COURSE, REQUIRES THAT ADDITIONAL DATA ON THE FISHERY BE GATHERED AND REANALYZED. SUBSEQUENT TO A REANALYSIS SEVERAL QUESTIONS SHOULD BE ASKED:



"WAS THE MANAGEMENT STRATEGY EFFECTIVE?"

"DO WE NEED TO SUBSTITUTE OR ADD ANOTHER MANAGEMENT STRATEGY?"

"IS FURTHER MANAGEMENT NECESSARY?"...

THE PROCESS OF GATHERING DATA, ANALYZING IT, OFFERING MANAGEMENT OPTIONS, AND EVALUATING THE STATUS OF THE FISHERY IS WHAT FISHERIES BIOLOGY IS ALL ABOUT. IN THE NEXT FEW SECTIONS WE WILL EXAMINE SOME OF THE LIFE HISTORY DATA THAT ARE OFTEN NEEDED. LATER WE'LL SEE WHAT THESE CAN BE ABLE TO TELL US.

THE PARTS OF THE CRITTER'S LIFE WE NEED TO KNOW ABOUT

IT'S APPROPRIATE NOW TO GET AN OVERVIEW OF THE TOTAL PICTURE OF THE KINDS OF QUESTIONS WE NEED TO ASK OF THE FISH (OR OTHER KINDS OF ORGANISMS) THAT MAKE UP A FISHERY. IN FIGURE 4. WE SEE THE PICTURE OF A "TYPICAL" FISH WHICH REPRESENTS MANY OF THE ORGANISMS THAT COMPRISE A FISHERY. THE FIGURE INDICATES THE VARIOUS PARTS OF THE ANIMAL WE NEED TO STUDY IN ORDER TO HELP ANSWER SOME BIGGER QUESTIONS ABOUT THE FISHERY AS A WHOLE.

IN SHORT WE NEED TO ASK (AND FIND ANSWERS TO) THE FOLLOWING QUESTIONS:

A. WHAT KIND OF FISH IS IT?
B. WHERE DOES IT LIVE?
C. HOW OLD IS IT?
D. HOW FAST DOES IT GROW?
E. IS IT IN GOOD SHAPE?
F. WHAT DOES IT EAT?
G. HOW MANY YOUNG WILL IT PRODUCE?
H. WHEN WILL IT PRODUCE THOSE YOUNG?
I. WHERE HAS IT BEEN AND WHERE WILL IT GO?

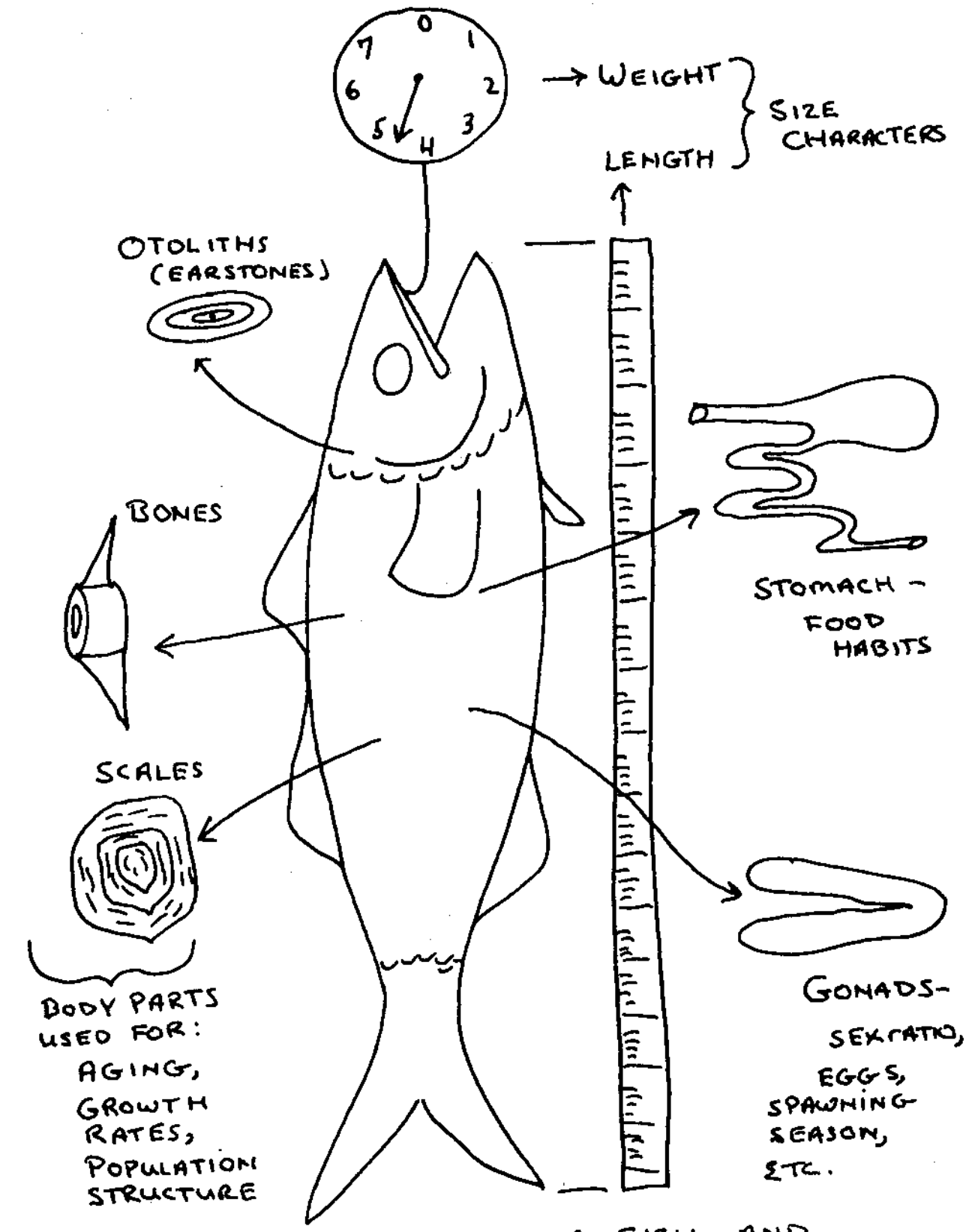


FIGURE 4. THE PARTS OF A FISH AND SOME OF THE KINDS OF DATA WE CAN GET.

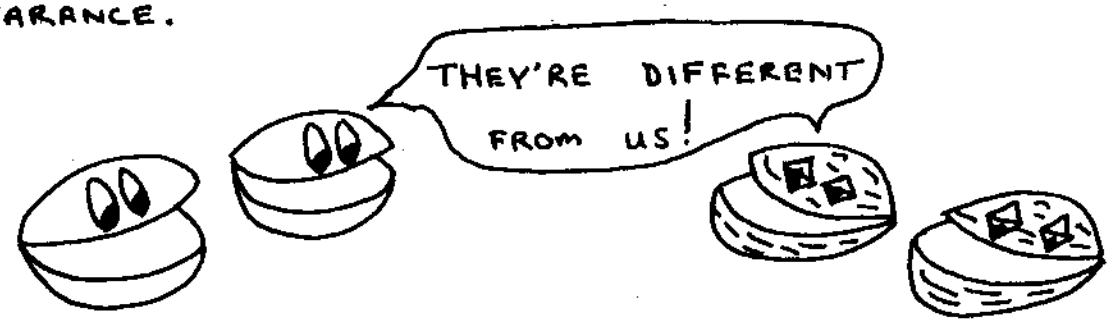
IN THESE NEXT SECTIONS WE WILL EXAMINE EACH OF THESE QUESTIONS AND CAREFULLY EXPLAIN HOW STUDYING THE VARIOUS PARTS AND ATTRIBUTES OF THE ORGANISMS CAN GIVE US A PRETTY GOOD IDEA AS TO WHAT THE ANSWER IS. WE'LL ALSO OUTLINE THE REASONS FOR KNOWING THE ANSWERS TO THESE QUESTIONS AS WELL AS GIVE AN INTRODUCTION ON HOW A FISHERIES BIOLOGIST GOES ABOUT GATHERING THE DATA.

A. WHAT KIND OF FISH IS IT?

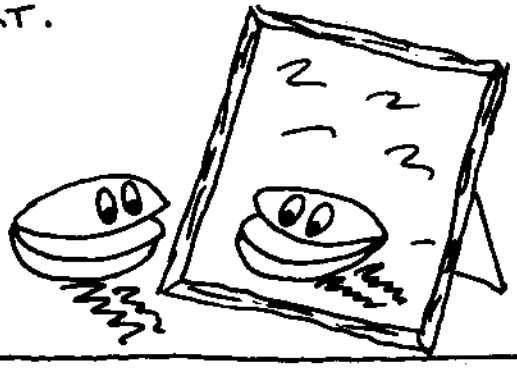
SOME FISHERIES ARE COMPOSED OF A SINGLE KIND OF ORGANISM WHILE OTHERS ARE COMPOSED OF SEVERAL DIFFERENT KINDS. FOR EXAMPLE:

- AN OYSTER FISHERY CONSISTS OF ONLY ONE KIND OF OYSTER,
- THE KING MACKEREL FISHERY GENERALLY INCLUDES ONLY KING MACKEREL,
- A GROUPER FISHERY MAY CONSIST OF SEVERAL DIFFERENT MARINE SEABASSES WHICH ARE CLOSELY RELATED,
- A SHRIMP FISHERY MAY INCLUDE DIFFERENT KINDS OF SHRIMP SUCH AS PINKS, BROWNS, AND WHITES.

EACH OF THE DIFFERENT KINDS OR TYPES OF ORGANISMS ARE KNOWN TO SCIENCE AS DIFFERENT <u>SPECIES</u>. SPECIES ARE USUALLY RECOGNIZED AND DISTINGUISHED FROM EACH OTHER BY THEIR APPEARANCE.



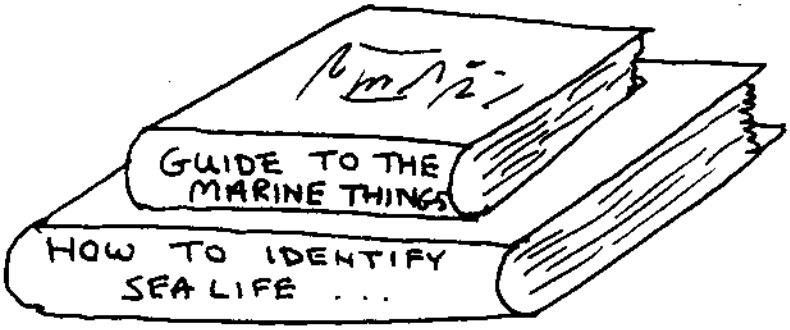
Some different species, however, can resemble each other very closely and careful examination may be necessary to tell them apart.



Another feature of species other than looking different from one another is that they usually don't reproduce or mate with other kinds of species. Grey snapper, for example do not mate and produce young with Red snapper. Occasionally some different species will mate and produce young. This is called <u>Hybridization</u>. It is an exception to the rule, although as we will see later, some aspects of hybridization can serve as a useful management technique.

ANOTHER FEATURE OF A SPECIES IS THAT EACH ONE HAS ITS OWN WAY OF MAKING A LIVING OR ROLE THAT IT PLAYS IN THE ENVIRONMENT. THIS SPECIAL ROLE OR LIFE STYLE FOR EACH SPECIES IS REFERRED TO AS IT'S NICHE AND IS UNIQUE OR SLIGHTLY DIFFERENT FOR EACH SPECIES. THIS UNIQUENESS MAY BE OBVIOUS. SOME SPECIES, FOR EXAMPLE, OCCUPY A CERTAIN ZONE OR HABITAT IN THE ENVIRONMENT THAT NO OTHER SPECIES OCCUPIES. SOMETIMES TWO OR MORE SPECIES MAY OCCUPY THE SAME ZONE BUT WHEN WE LOOK AT THEIR FOOD HABITS WE FIND THAT THEY DON'T EAT EXACTLY THE SAME THINGS. SOMETIMES WE MIGHT FIND THAT THEIR FOOD HABITS ARE THE SAME BUT THEY EACH FEED AT DIFFERENT TIMES OF THE DAY. PRESUMABLY THE RESULT IS THAT COMPETITION BETWEEN SPECIES IS REDUCED. WE COULD GO ON WITH THIS, BUT THE MAIN POINT SHOULD BE CLEAR — EACH SPECIES HAS ITS OWN SPECIAL ROLE IN THE TOTAL COMMUNITY AMONG ALL THE OTHER SPECIES.

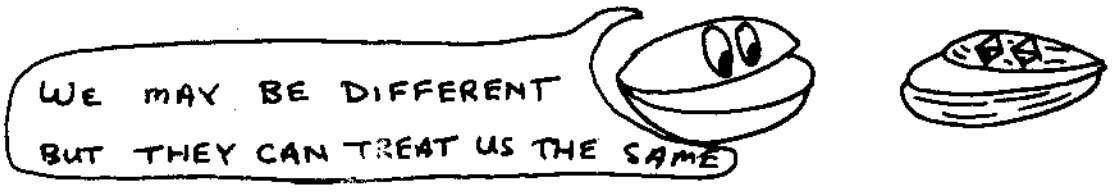
THE USUAL WAY WE DETERMINE WHAT SPECIES AN ORGANISM IS, IS TO FIRST LOOK CAREFULLY AND NOTE ITS PHYSICAL FEATURES OR EXTERNAL APPEARANCE. THIS SHOULD ALLOW US TO CORRECTLY IDENTIFY IT EITHER FROM PAST EXPERIENCE OR BY USING ANY OF A NUMBER OF GUIDES OR BOOKS ON IDENTIFYING AQUATIC ANIMALS THAT ARE AVAILABLE.



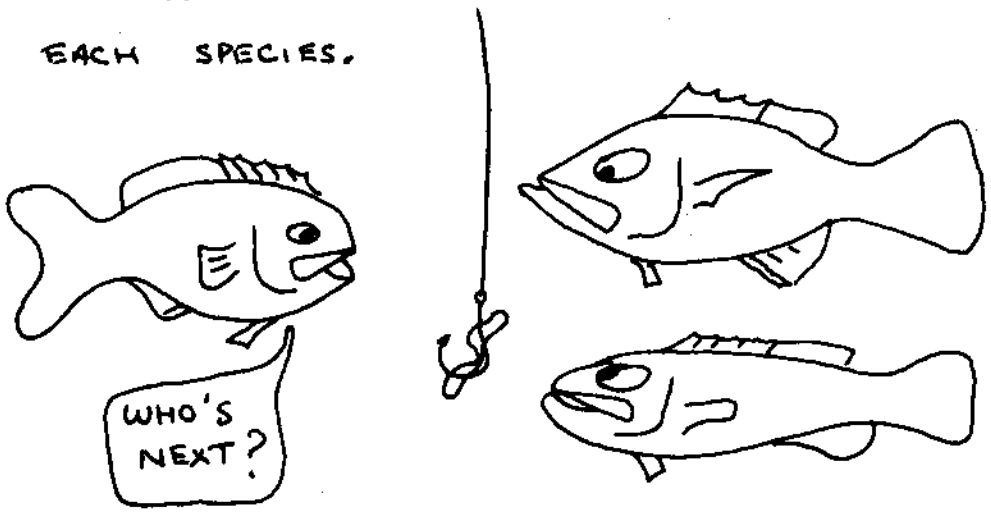
IF WE NEED ADDITIONAL HELP IT MAY BE NECESSARY TO CALL IN A TAXONOMIST. THEY ARE RESEARCHERS WHO SPEND A LOT OF TIME STUDYING THE DIFFERENT KINDS AND VARIETIES OF CRITTERS. THE RESULTS OF THEIR WORK ALLOW US TO PUT THE SPECIMEN (INDIVIDUAL CRITTER) INTO A CATEGORY OF WHAT KIND OF SPECIES IT IS. ANY UNIVERSITY OR AQUATIC RESEARCH FACILITY SHOULD BE ABLE TO SUGGEST THE NAME OF SOMEONE THAT CAN BE CONTACTED FOR HELP WITH IDENTIFYING AN UNKNOWN BEAST.

OKAY, SO NOW WE KNOW THERE ARE DIFFERENT KINDS OF SPECIES. EACH ONE IS PHYSICALLY DISTINCT (ALTHOUGH WE MIGHT HAVE TO LOOK VERY CAREFULLY IN SOME CASES), AND EACH OCCUPIES A NICHE (ROLE OR WAY OF MAKING A LIVING IN THE ENVIRONMENT) THAT IS DIFFERENT. GREAT! ... BUT WHY IS IT IMPORTANT FOR US TO KNOW THIS ABOUT THE ORGANISMS THAT MAKE UP FISHERIES? ...

SINCE EACH SPECIES IS DISTINCT WITH REGARD TO IT'S LIFE OR LIFE HABITS, IT IS ONE OF THE GOALS OF A FISHERY BIOLOGIST TO DETERMINE THE ENVIRONMENTAL LIMITS WITHIN WHICH EACH SPECIES LIVES. SUBSEQUENTLY, HE OR SHE MUST DECIDE WHAT ASPECTS OF THE TOTAL LIFE OF THE ANIMAL ARE IMPORTANT RELATIVE TO IT'S ROLE IN A FISHERY. LASTLY, IT MIGHT BE DETERMINED THAT MORE THAN ONE SPECIES' "LIFE HISTORY" (IT'S THE SAME THING AS LIFE STYLE) FEATURES ARE, FOR ALL PRACTICAL (= STATISTICAL) PURPOSES, THE SAME.



THE MANAGEMENT OF A FISHERY CAN BE SIMPLIFIED ESPECIALLY IF IT IS COMPOSED OF SEVERAL SPECIES. AN EXAMPLE OF THIS MIGHT BE IN A DEMERSAL (THAT MEANS BOTTOM ASSOCIATED) GROUPER FISHERY. THE SEVERAL SPECIES WHICH COMPRISE IT COULD BE MANAGED THE SAME WAY IF EACH SPECIES' LIFE HISTORY FEATURES ARE SIMILAR ENOUGH NOT TO WARRANT A SEPARATE MANAGEMENT STRATEGY FOR EACH SPECIES.

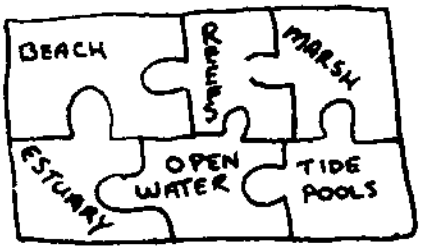


YOU CAN EASILY APPRECIATE THE COMPLEXITY AND NEAR IMPOSSIBILITY A FISHERIES MANAGER'S TASK WOULD BE IF EACH SPECIES HAD TO BE MANAGED SEPARATELY. ESPECIALLY WHEN THEY CAN ALL BE CAUGHT IN THE SAME AREA, AT THE TIME, WITH THE SAME BAIT, FROM THE SAME BOAT, AT THE SAME DEPTH . . .

WHEW!

B. WHERE DOES IT LIVE?

MOST OF US WILL IMMEDIATELY RESPOND AND SAY - AN ORGANISM LIVES IN A HABITAT. THAT'S CORRECT, OF COURSE, BUT LET'S PUT THE TERM 'HABITAT' IN PERSPECTIVE. THERE ARE MANY DIFFERENT KINDS OF HABITATS. SOME EXAMPLES OF THESE ARE: ESTUARIES, SALT MARSHES, CORAL REEFS, SANDY BEACHES, ROCKY SHORES, ETC. IN A WAY, EACH HABITAT IS A UNIQUE PLACE WITH ITS OWN CHARACTERISTICS. LATER WE'LL DESCRIBE SOME OF THE CHARACTERISTICS WHICH ARE IMPORTANT FOR US TO KNOW ABOUT BUT FIRST WE NEED TO SEE HOW ALL THE HABITATS FIT TOGETHER.



THE TERM USED TO DESCRIBE THE TOTAL OF ALL HABITATS IS THE **ECOSYSTEM**. WE COULD BREAK DOWN THE AQUATIC ECOSYSTEM INTO IT'S VARIOUS HABITATS BUT LET'S LOOK AT IT ANOTHER WAY. THE ECOSYSTEM IS COMPOSED OF TWO MAJOR INTERRELATED PARTS OR COMPONENTS: ① THE PHYSICAL ENVIRONMENT AND ② THE BIOLOGICAL ENVIRONMENT (SEE FIGURE 2. AGAIN).

THE PHYSICAL ENVIRONMENT IS USUALLY WHAT WE THINK OF WHEN USING THE TERM HABITAT, BUT AS WE'LL SEE, THIS IS ONLY PART OF ITS MEANING. IN ADDITION THERE ARE SEVERAL MAJOR FEATURES OF THE PHYSICAL ENVIRONMENT THAT MUST BE UNDERSTOOD AS WELL.

WATER QUALITY IS ANOTHER WAY OF SAYING WATER CONDITIONS. IT'S PERHAPS THE SINGLE MOST IMPORTANT ASPECT OF AN AQUATIC HABITAT, BECAUSE THE ORGANISM WE ARE CONCERNED WITH SPEND THEIR ENTIRE LIVES SURROUNDED BY WATER AND ABSOLUTELY DEPEND ON IT FOR THEIR SURVIVAL. IN A SENSE YOU COULD SAY THAT WATER QUALITY IS TO A FISH AS AIR IS TO A HUMAN. PERHAPS EVEN MORE SO!

ALL AQUATIC ORGANISMS HAVE A TOLERANCE LIMIT TO JUST ABOUT EVERYTHING IN THE ENVIRONMENT. THAT MEANS THEY CAN LIVE ONLY WITHIN A CERTAIN RANGE OR LIMIT OF WHATEVER FEATURE OF THE WATER WE WERE TO CONSIDER. SOMEWHERE IN THIS RANGE IS THE OPTIMAL OR BEST PLACE TO BE. IF AN INDIVIDUAL IS AT THE EDGE OF ITS LIMIT FOR A PARTICULAR ENVIRONMENTAL FEATURE WE COULD SAY IT WAS STRESSED.

WHEN A FISH IS STRESSED IT CAN DO SEVERAL THINGS:

(1) IT CAN ADAPT TO THE STRESS. THIS IS USUALLY DONE BY THE ANIMAL MAKING A PHYSIOLOGICAL (HOW IT FUNCTIONS), BEHAVIORAL (HOW IT ACTS), OR MORPHOLOGICAL (HOW IT APPEARS, ITS SHAPE, ITS COLOR, ETC.) RESPONSE;

(2) IF IT IS NOT POSSIBLE TO ADAPT, THE FISH COULD REDUCE OR ELIMINATE THE STRESS BY MOVING OR MIGRATING TO A LESS STRESSFUL PLACE;

OR LASTLY ③ IF IT CAN'T ADAPT OR MOVE IT COULD DIE. USUALLY SUCH A DRASTIC ALTERNATIVE SUCH AS DEATH DOESN'T OCCUR BUT WE CAN ALL THINK OF SOME CIRCUMSTANCES WHERE IT HAS!

MOST OFTEN WHEN THE ORGANISMS IN A FISHERY ARE STRESSED THEY ARE ONLY SUBJECTED TO THE STRESS FOR A SHORT PERIOD OF TIME IF THE STRESS IS SEVERE. SOMETIMES THEY CAN BE UNDER STRESS FOR A LONG PERIOD IF THE STRESS IS NOT TOO HARSH. FROM A FISHERIES POINT OF VIEW WE WOULD WANT TO ASSURE THAT OUR FISHERIES ARE ALWAYS UNDER OPTIMAL CONDITIONS SO THAT THE FISH MIGHT GROW FASTER OR BE MORE FIT IN OTHER ASPECTS OF THEIR LIFE HISTORY (LIKE PRODUCING LOTS OF NICE HEALTHY YOUNG!).

THEREFORE, IT'S IMPORTANT NOT ONLY TO KNOW THE WATER QUALITY FEATURES THAT MAY LIMIT EACH SPECIES BUT ALSO TO KNOW THEIR OPTIMAL WATER QUALITY CONDITIONS SO THE ORGANISMS CAN NOT ONLY SURVIVE BUT THRIVE.

THERE ARE VIRTUALLY AN UNLIMITED NUMBER OF WATER QUALITY CHARACTERISTICS THAT COULD BE EXAMINED BUT OFTEN THERE ARE ONLY A FEW OF THEM WHICH, THROUGH THE YEARS, HAVE PROVEN TO HAVE AN EFFECT ON FISHERIES. AMONG THESE ARE TEMPERATURE, SALINITY, TURBIDITY (WATER CLARITY), OXYGEN, AND WATER CURRENTS. THERE ARE, OF COURSE, MANY OTHERS SUCH AS VARIOUS PESTICIDES, HEAVY METALS, AND OTHER FORMS OF POLLUTION WHICH MIGHT HAVE TO BE STUDIED CAREFULLY AS WELL. BY THE WAY, SOME SPECIES CAN HAVE VERY BROAD LIMITS (A WIDE TOLERANCE) FOR SOME OR ALL OF THE WATER QUALITY FEATURES WHILE OTHERS CAN HAVE VERY NARROW LIMITS FOR SOME OR ALL OF THEM.

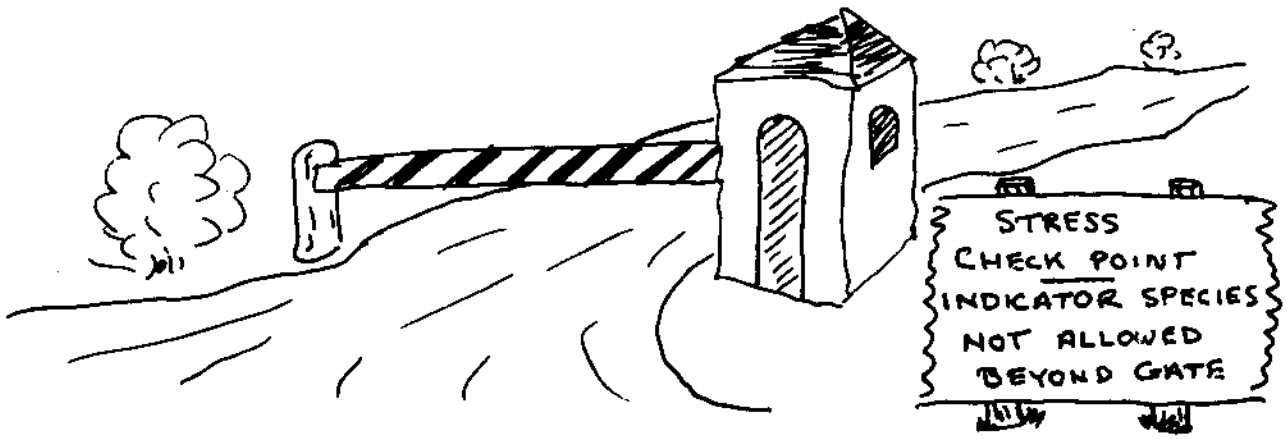
REMEMBER: THE LIMITS AND RANGE OF LIMITS CAN BE DIFFERENT FOR EACH SPECIES!

WHILE CHANGES IN WATER QUALITY CAN CERTAINLY HAVE DRAMATIC EFFECTS ON THE HEALTH AND SURVIVABILITY OF A FISH, WE SHOULD REALIZE THAT THERE ARE A HOST OF OTHER ASPECTS OF WATER QUALITY THAT CAN DIRECTLY OR INDIRECTLY CAUSE MAJOR CHANGES IN A FISHERY.

FOR EXAMPLE, OYSTERS AND OTHER SHELL-BUILDING ANIMALS MAY REQUIRE 'SUPER' AMOUNTS OF CERTAIN MINERALS. WITHOUT THESE THEY CAN'T BUILD A SHELL ADEQUATE ENOUGH TO PROTECT THEMSELVES OR MAKE A SHELL FAST ENOUGH TO KEEP UP THEIR NORMAL GROWTH.

LATELY (AND RIGHTLY SO) THERE HAS BEEN A LOT OF EMPHASIS ON STUDYING AND MONITORING (STUDYING FOR A LONG PERIOD OF TIME) THE AMOUNT AND EFFECTS THAT VARIOUS HUMAN INTRODUCED SUBSTANCES SUCH AS PESTICIDES, FERTILIZERS, AND INDUSTRIAL AND COMMUNITY WASTES MAY HAVE ON AQUATIC ORGANISMS. IF THESE SUBSTANCES ARE ADDED TO THE WATER AT LOW LEVELS OVER A LONG PERIOD OF TIME AND BROAD AREA WE WOULD PROBABLY SEE VERY LITTLE HARMFUL EFFECT ON OUR FISHERIES FROM THEM. THE ORGANISMS WOULD PROBABLY BE ABLE TO MODIFY THEIR INTERNAL FUNCTIONING CAPABILITIES (PHYSIOLOGY) OR MAKE OTHER SUBTLE ADJUSTMENTS TO THEIR LIFE STYLE AND SURVIVE THE SITUATION QUITE WELL. THE PROBLEM ARISES WHEN THESE SUBSTANCES BECOME CONCENTRATED IN THE WATER OR IN THE TISSUES (BODY PARTS) OF THE FISH AND ATTAIN LEVELS WHICH BEGIN TO CAUSE STRESS.

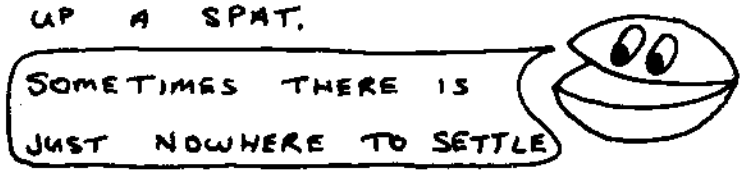
Some species can 'feel' the effects of stress more easily than others. Often these more easily stressed or susceptible organisms are watched more closely by fisheries scientists as they can serve as indicators of potential stress to the remainder of the community. These species are referred to as <u>indicator species</u>; each species serving as an 'indicator' of stress from one or more environmental hazards or conditions.



Overall every species has it's own very special set of limits for each aspect of water quality (remember the concept of niche!). There is, however, another important aspect of habitat especially significant to organisms* that live in association with the bottom (<u>demersal</u> areas).

*Species associated with the bottom are called demersal species.

SUBSTRATE OR BOTTOM TYPE IS ANOTHER FEATURE OF THE PHYSICAL ENVIRONMENT WHICH CAN GREATLY INFLUENCE NOT ONLY DEMERSAL SPECIES BUT BENTHIC (THOSE THAT LIVE DIRECTLY ON THE BOTTOM) SPECIES AS WELL. BENTHIC SPECIES CAN INCLUDE ORGANISMS THAT ARE SEDENTARY (RELUCTANT TO MOVE) OR SESSILE (ATTACHED TO THE SUBSTRATE AND UNABLE TO MOVE) IN NATURE. JUST AS THERE ARE LIMITS TO THE WATER QUALITY A SPECIES CAN TOLERATE, THERE ARE LIMITS TO THE KIND OF BOTTOM OR SUBSTRATE A SPECIES CAN TOLERATE. WHEN THE PREFERRED SUBSTRATE IS NO LONGER AVAILABLE OR IS CHANGED (PERHAPS DUE TO CHANGES IN WATER CURRENTS OR SEDIMENT RUNOFF) THE LIFE STYLE OF A SPECIES CAN BE DISRUPTED TO THE POINT WHERE IT'S SURVIVAL MAY BE AFFECTED. FOR EXAMPLE, IF THE SUBSTRATE IN AN AREA CHANGES FROM FINE SAND TO COARSE GRAVEL THEN A SHRIMP SPECIES MAY BE INHIBITED FROM BURROWING TO AVOID PREDATORS. IN ANOTHER EXAMPLE, A CHANGE FROM A HARD SUBSTRATE TO A SOFTER ONE COULD KEEP AN OYSTER LARVA FROM BEING ABLE TO SET UP A SPAT.



WATER QUALITY AND SUBSTRATE ARE THEN OBVIOUSLY IMPORTANT FEATURES OF THE ENVIRONMENT WHICH CAN INFLUENCE A SPECIES' PRESENCE AND ABUNDANCE. WE SHOULD ALSO BE AWARE, HOWEVER, THAT GATHERING DATA ON THESE FEATURES, IN ONE AREA, AT ONE POINT IN TIME, IS NOT GOING TO BE ENOUGH IF WE ARE GOING TO HELP OUR FISHERIES. WATER QUALITY AND SUBSTRATE CAN VARY CONSIDERABLY FROM PLACE TO PLACE OR EVEN IN ONE PLACE EVERY YEAR OR EVEN EVERY MONTH. EXTREMELY STRONG STORMS CAN CAUSE HIGH ENERGY WAVES AND CURRENTS TO MIX, CHURN AND INEVITABLY ALTER THE LOCAL CONDITIONS. LIKEWISE, SEASONAL CHANGES SUCH AS RAINFALL AND WINDS CAN AFFECT RUNOFF AND CURRENT PATTERNS, ESPECIALLY ALONG COASTAL AREAS.

Local weather conditions are an important factor as well as climatic conditions which are essentially long term weather conditions. Heavy rainfall for several months followed by hot dry periods, if they occur consistently over many years, will have a definite impact on the ecosystem being subjected to this 'weather' and consequently influence the habitats within the ecosystem.

Generally, climatic effects are consistent enough so that the individuals within the biological communities in the habitats adjust to these long term weather or climatic conditions. Changes in climate usually occur slowly enough so that changes in the community occur only gradually as well. We should be aware, however, that climates are always in a state of slow change. Knowing this alone may let us appreciate the fact that some changes in our fisheries may be due to long, slow (almost unobservable) changes in climatic conditions.

Weather conditions can have a direct and severe impact on a fishery. For example, unseasonably cold weather can often kill aquatic organisms if the water temperature drops too rapidly.

ALONG WITH WEATHER AND CLIMATIC EFFECTS ON WATER AND BOTTOM CONDITIONS, IN SOME AREAS, TIDES CAN HAVE THE DOMINANT INFLUENCE. TIDES ARE BASICALLY CAUSED BY THE GRAVITATIONAL PULL OF THE MOON ON THE EARTH. THE REASON TIDES ARE IMPORTANT IS THAT WHEN THE TIDE CHANGES, SO DOES THE SEA LEVEL HEIGHT. THIS IN ITSELF MAY NOT SEEM IMPORTANT BUT REMEMBER ANY TIME THE SEA LEVEL CHANGES, WATER FLOWS. WHEN WATER FLOWS, BOTTOM AND SURFACE CURRENTS MAY DEVELOP. IT'S ALL RELATED TO THE MOON'S PHASE!

NEW (HIGHEST TIDES) | FIRST QUARTER | HALF (LOWEST TIDES) | LAST QUARTER | FULL (HIGHER TIDES)

A DIAGRAM OF THE OVERALL ECOSYSTEM, EMPHASIZING THE FACTORS WHICH MOST OFTEN INFLUENCE THE HABITAT IS SHOWN IN FIGURE 5. OVERALL THERE IS AN ECOSYSTEM AFFECTED BY CLIMATE. WATER CONDITIONS AND SUBSTRATE INTERACT TO HELP DETERMINE THE TYPE AND CONDITION OF THE HABITATS.

IT'S ALL VERY SIMPLE AND YET VERY COMPLEX AT THE SAME TIME!

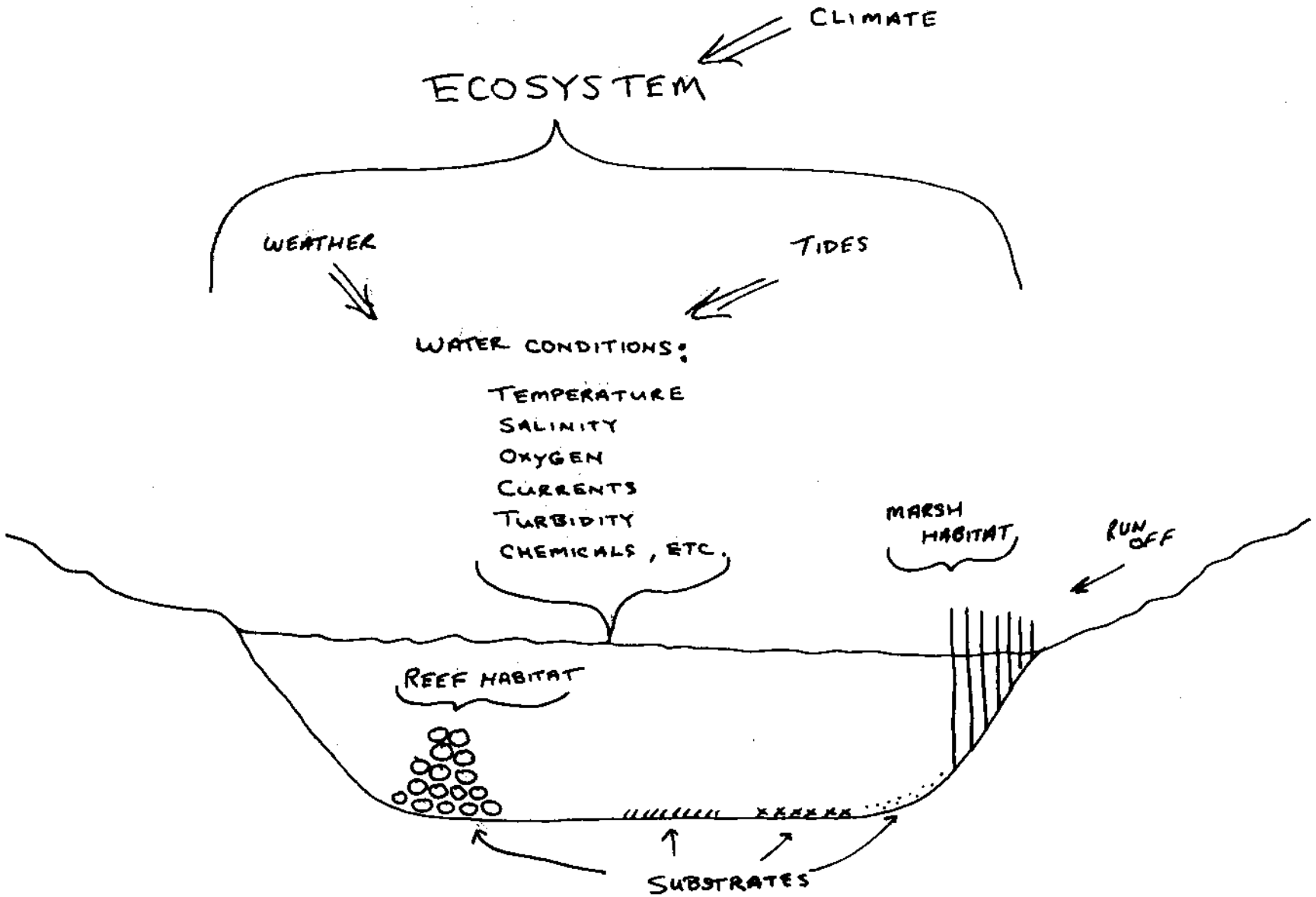
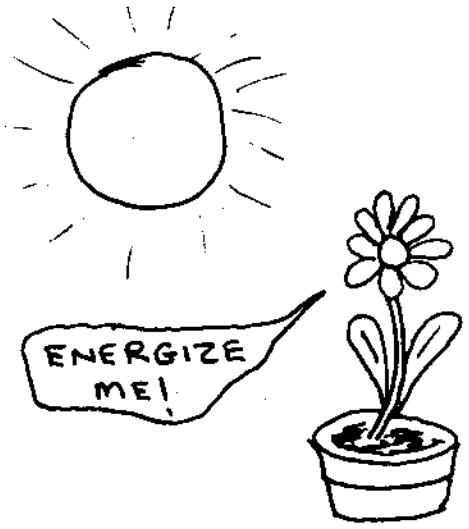


FIGURE 5. AN ATTEMPT AT UNCOMPLICATING THE COMPLICATED!

In water as well as on land, plants (better known to scientists as Primary Producers) are responsible for converting light energy from the sun along with some basic chemical compounds, elements, and minerals (such as water, carbon dioxide, nitrates, and phosphates) into more plant material. In other words, plants get their energy from the sun and combine it with other materials to make more of themselves (the process used by plants to get their energy from the sun is called photosynthesis and organisms that do not eat other organisms to obtain energy (like plants) are called autotrophs).



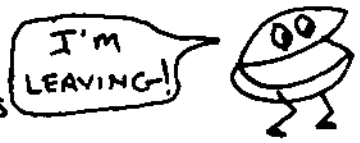
The vast majority of plants in the water are almost microscopic and float freely, usually at or near the surface. These plants are mostly single celled algae and are referred to as phytoplankton (phyto- because they are plants, and plankton- because they are not attached to anything and are small).

PHYTOPLANKTON SERVE TWO MAJOR ROLES IN AQUATIC HABITATS: THEY PRODUCE OXYGEN (NECESSARY FOR ALMOST ALL ANIMAL LIFE); AND THEY SERVE AS A SOURCE OF ENERGY (FOOD!) FOR SMALL FREE SWIMMING ANIMALS CALLED ZOOPLANKTON (ZOO- FOR ANIMALS) AND SOME LARGER ANIMALS CAPABLE OF FEEDING ON THEM SUCH AS SHRIMP, ANCHOVIES, THE LARVAE (TINY YOUNG) OF ALMOST ANY MARINE ANIMAL, AND, OF COURSE, CLAMS.

THE ORGANISMS CAPABLE OF FEEDING ON PLANKTON (BOTH PHYTO- AND ZOOPLANKTON) ARE FILTER FEEDERS. WHILE THEY INCLUDE THE VARIETY OF ANIMALS LISTED ABOVE, SOMETIMES FILTER FEEDERS CAN BE LARGE BEASTS LIKE THE BASKING SHARK!

OBVIOUSLY SOMETHING EATS THE FILTER FEEDERS. THESE ARE USUALLY SMALL PREDATORS (ALTHOUGH THE GREAT WHALES, WHICH FEED ON SMALL SHRIMP-LIKE CREATURES CALLED KRILL ARE AMONG THE EXCEPTIONS). THE SMALLER PREDATORS SUCH AS SMALL INDIVIDUALS OF SOME SPECIES AND ADULTS OF OTHERS CAN, IN TURN, BE FED UPON BY THE LARGER PREDATORS.

HUMANS OCCUPY A RATHER UNIQUE POSITION IN THIS PREDATORY PATHWAY (BETTER KNOWN AS THE FOOD CHAIN OR FOOD WEB)*. HUMANS TEND TO CONSUME AQUATIC ORGANISMS AT EVERY LEVEL. WE EAT A HOST OF LARGE PREDATORS SUCH AS TUNA, SHARKS, AND GROUPER; A VARIETY OF SMALLER PREDATORS SUCH AS HERRING, CRABS, AND SQUID; AND A NUMBER OF DIFFERENT FILTER FEEDERS SUCH AS SHRIMP, OYSTERS, ANCHOVIES, AND CLAMS. THERE HAVE EVEN BEEN SOME ATTEMPTS TO TAP THE FOOD CHAIN (OR THE FOOD WEB) AT THE PRIMARY PRODUCER LEVEL BY COLLECTING PLANKTON, TREATING IT, AND PUTTING IT IN OTHER FOODS AS A PROTEIN ADDITIVE OR SUPPLEMENT.



THIS ENTIRE NETWORK OF A LARGE NUMBER OF ORGANISMS IN A HABITAT IS CALLED A COMMUNITY. EACH SPECIES IN THE COMMUNITY WITHIN THE HABITAT FORMS A UNIT CALLED A POPULATION (AS WE WILL SEE LATER A WORD FOR THE CATCHABLE PORTION OF A POPULATION IN A FISHERY IS A STOCK). PREDATION OCCURS WITHIN THIS NETWORK WHEN ONE ORGANISM EATS ANOTHER. COMPETITION FOR FOOD OCCURS WHEN TWO OR MORE ORGANISMS TRY TO EAT THE SAME FOOD.

* SEE FIGURE 6 FOR A DIAGRAM OF A FOODWEB.

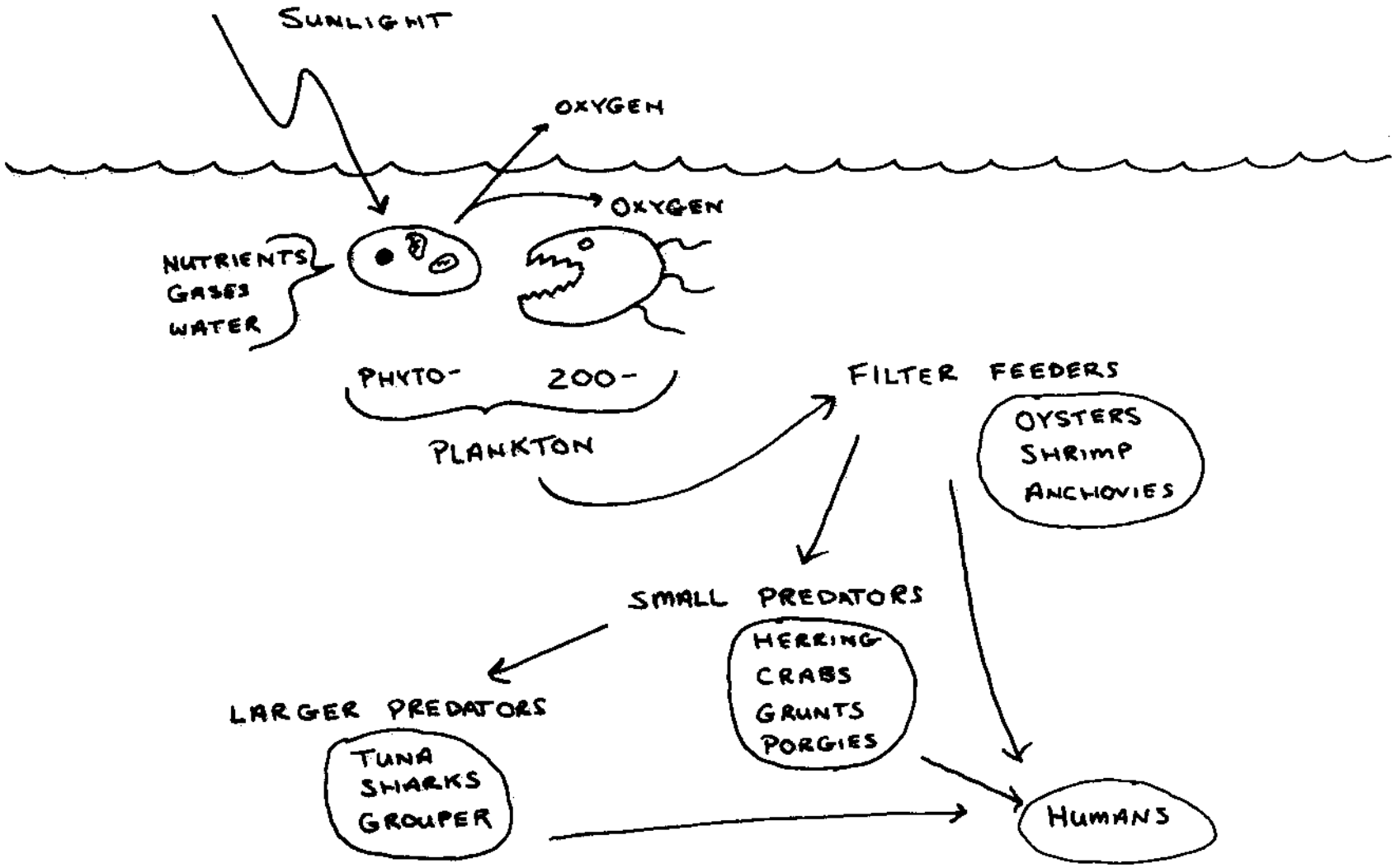


FIGURE 6. YOUR BASIC, TYPICAL, EVERYDAY, AQUATIC FOOD WEB.

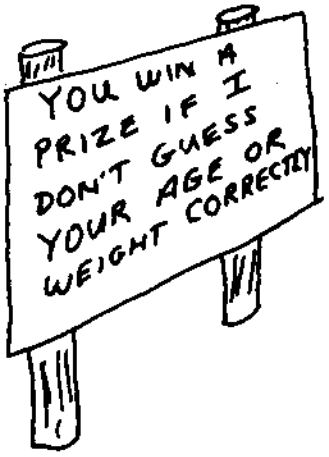
THE WHOLE ECOSYSTEM IS JUST AS SIMPLE AND, IN SOME WAYS, JUST AS COMPLICATED AS YOU CAN IMAGINE. UNDERSTANDING THE BASIC FLOW OF ENERGY INTO THE SYSTEM, THROUGH THE VARIOUS ORGANISMS, AND (FROM A FISHERIES POINT OF VIEW) ENDING WITH HUMANS, IS A RATHER STRAIGHTFORWARD CONCEPT. WHAT REALLY MAKES THE FISHERIES BIOLOGISTS' LIFE DIFFICULT IS THAT ALL THE VARIOUS COMPONENTS OF THE PHYSICAL ENVIRONMENT AND BIOLOGICAL COMMUNITY ARE INTERRELATED AND DEPEND ON ONE ANOTHER. FOR EXAMPLE, OYSTERS NEED A SUITABLE PLACE TO SETTLE (SUBSTRATE), A CERTAIN AMOUNT OF FOOD (PLANKTON), AND A CERTAIN QUALITY OF WATER TO LIVE IN (TEMPERATURE, SALINITY, OXYGEN ETC.). MEANWHILE THE OYSTERS THEMSELVES, BY THEIR VERY PRESENCE, CREATE A NEW SUBSTRATE (OYSTER SHELL) WHICH, IN TURN, MAY LEAD TO THE GATHERING OR COLONIZATION OF OYSTER BED ASSOCIATED ORGANISMS. IN TOTAL THIS WOULD BE CALLED AN OYSTER COMMUNITY. ANOTHER EXAMPLE IS THE CORAL REEF COMMUNITY BUILT AROUND CORAL ORGANISMS THAT SECRETE A HARD SUBSTANCE THAT BUILDS UP THE REEF STRUCTURE THAT EVENTUALLY ATTRACTS AND MAINTAINS A WHOLE COMMUNITY OF ITS OWN.

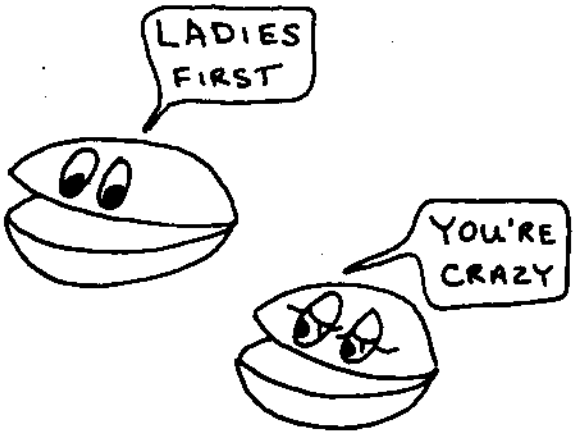
DISCOVERING THE FACTORS WHICH CONTROL OR HAVE THE MOST SIGNIFICANT IMPACT ON A COMMUNITY IS IMPORTANT BUT, AS YOU MIGHT GATHER, IT'S EXTREMELY DIFFICULT TO DO. IT REQUIRES OBTAINING YEARS AND YEARS OF DATA (TO ALLOW FOR VARIATION DUE TO SEASONS AND WEATHER), FROM A NUMBER OF DIFFERENT PLACES (TO ACCOUNT FOR LOCAL EFFECTS), ON MANY ENVIRONMENTAL FEATURES (SO WE WON'T MISS OUT ON ANY ASPECTS THAT WE INADVERTENTLY THOUGHT WERE UNIMPORTANT). ONCE WE HAVE A "HANDLE" ON THESE FEATURES IT IS THEN POSSIBLE TO ANSWER A WHOLE SERIES OF QUESTIONS RELATED TO THE STATUS OF OUR FISHERIES AND TO GO ABOUT MAINTAINING OR IMPROVING THEM.

REMEMBER: ALL THE FACTORS, FEATURES, AND ORGANISMS ARE INTERDEPENDENT!

WHY WE NEED TO KNOW HOW OLD THEY ARE, HOW FAST THEY GROW, AND WHAT KIND OF SHAPE THEY ARE IN.

THE ANSWERS TO THESE QUESTIONS COULD BE VERY COMPLICATED OR VERY SIMPLE. LET'S TRY SIMPLE! REMEMBER WAY BACK IN THE **INTRODUCTION** WHEN WE TALKED ABOUT THE GOALS AND OBJECTIVES OF FISHERIES MANAGEMENT? ONE OF OUR OBJECTIVES WAS TO "PROVIDE THE 'BEST' POSSIBLE FISHING EXPERIENCE FOR EVERYONE." MANY OF US MIGHT THINK OF BEST IN TERMS OF HAVING <u>MORE</u> FISH OR THE <u>LARGEST</u> FISH OR EVEN HAVING <u>MORE</u>, <u>LARGER</u> FISH. IF THESE ARE INDEED WHAT WE MEAN BY THE WORD 'BEST' THEN WE'RE GOING TO HAVE TO KNOW ABOUT GROWTH, AGE AND CONDITION.





ORGANISMS TAKE IN FOOD AND THEN USE SOME OF THE ENERGY IN THE FOOD FOR: (1) GROWING; (2) MAKING EGGS OR SPERM FOR REPRODUCTION; AND (3) KEEPING THEMSELVES ALIVE (SOME OF THE ENERGY IN THE FOOD IS WASTED AND GIVEN OFF AS HEAT OR ELIMINATED BY WAY OF FECES). THE FASTER THE GROWTH, THE SOONER WE GET LARGER FISH. ALSO THE FASTER THEIR GROWTH, THE SOONER THEY GET LARGE ENOUGH TO REPRODUCE AND PRODUCE MORE FISH. TO PUT IT ANOTHER WAY, WE STUDY THE AGE, GROWTH, AND CONDITION OF FISH IN ORDER TO KNOW HOW TO INCREASE OR MAINTAIN THE SIZE AND/OR NUMBER OF INDIVIDUALS IN THE FISHERY.

ULTIMATELY, IF WE KNOW THE AGE, GROWTH, AND CONDITION OF THE SPECIES WE ARE CONCERNED WITH, THEN WE WILL BE ABLE TO PREDICT THE BIOMASS (WEIGHT) THAT CAN BE EXPECTED AS YIELD (CATCH) FROM THE FISHERY. ALSO, IF WE CAN IDENTIFY THE FACTORS RESPONSIBLE, WE MIGHT BE ABLE TO CONTROL THEM IN THE FUTURE AND GET FASTER GROWTH AND MORE FISH. THIS COULD LEAD TO LARGER CATCHES IN WEIGHT PER INDIVIDUAL FISH OR HIGHER CATCH FOR THE SAME AMOUNT OF FISHING EFFORT. HIGHER CATCHES OR YIELD PER EFFORT CERTAINLY COULD BE CONSIDERED A DESIRABLE GOAL OF ANY FISHERY PLAN.

C. How old is it?

The age of individual fish in a stock or population is an important character because from this information the 'typical' or 'average' age of the stock members can be determined. Once determined we might examine the stock further to note any changes in its age composition. For example, let's say the average age of the fish in a stock was three years old but, over a few seasons, the average age drops to two. This would be important to note especially if the species is known to reproduce only after it is three years old.

Knowing the age of a fish also gives us a standard reference point from which we can compare potential changes in its life history. Thus the length of time an animal has been alive, when used in conjunction with other data such as length or weight, can tell us about the fitness of the organism. In addition, it is often possible to determine its past growth history from age information.

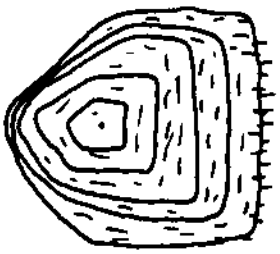
FIRST, LET'S EXAMINE HOW AGE IS DETERMINED AND THEN WE'LL LEARN HOW TO USE THIS AGE INFORMATION.

MOST AQUATIC ORGANISMS GROW CONTINUOUSLY (EXCEPT THE MARINE MAMMALS LIKE WHALES + SEALS). BY THIS WE MEAN THAT IF THEY COULD LIVE FOREVER THEY WOULD ATTAIN AN INFINITE SIZE! THEIR GROWTH RATE (HOW FAST THEY GROW) IS INFLUENCED BY FACTORS SUCH AS TEMPERATURE (THEY MAY NOT EAT AS MUCH WHEN IT GETS COLD), BEHAVIOR (WHILE MIGRATING THEY WILL USE MORE ENERGY SWIMMING AND LESS FOR GROWING), + REPRODUCTIVE CONDITION (IT TAKES ENERGY TO MAKE EGGS). ALL THESE FACTORS OR SITUATIONS (AND MORE) CAN INFLUENCE A SPECIES' RATE OF GROWTH. BECAUSE FISH GROW CONTINUOUSLY, THEY ARE CONSTANTLY ADDING TO THEIR BODY SIZE. AS A BODY INCREASES IN SIZE, TRACES OF ITS GROWTH HISTORY ARE OFTEN SEEN IN THE HARD BODY PARTS SUCH AS SCALES, BONES, SHELLS, OR OTHER STRUCTURES LIKE <u>OTOLITHS</u> (FOUND IN THE INNER EAR AREA OF BONY FISH).

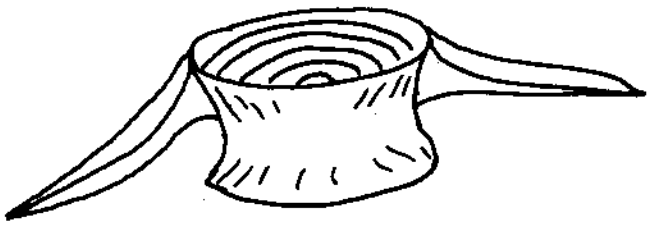
IN GENERAL — THE LARGER THE AQUATIC ANIMAL, THE OLDER IT IS.

P.S. — THERE ARE ALWAYS EXCEPTIONS!

When growth is fast, a fish often adds deposits of bone or other material to it's body faster than when growth is slow. With hard body parts it's possible to see permanent evidence of it's growth history by examining for thicker or thinner (dense or less dense) tissue deposits. These differences in tissue deposition can be seen as rings or bands similar to those seen in a cross-section of a tree trunk. By counting the rings and knowing what time of the year and how many rings are laid down per year we can tell it's age.



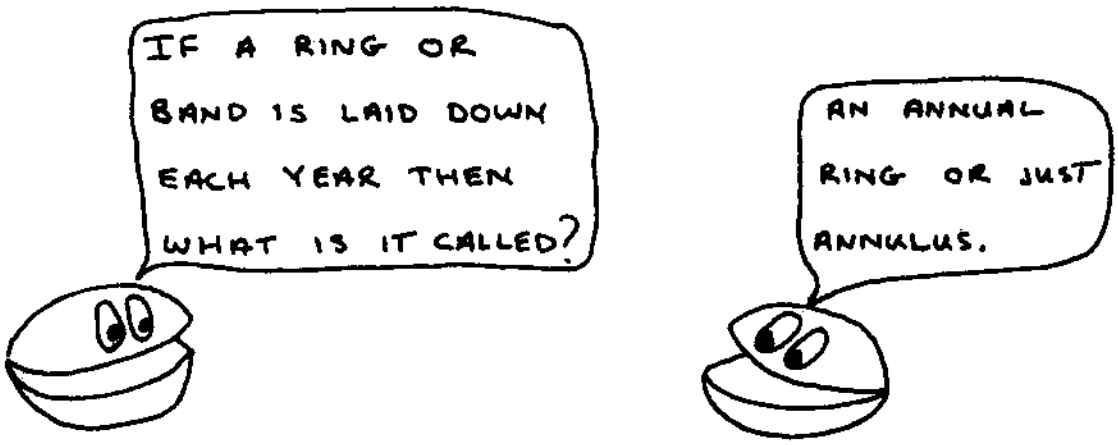
Scale - 4 years old



Vertebra - 5 years old

By measuring the radius of the rings (distance from the central point to each ring) we can calculate the fish's size at a previous age. Once we know the sizes at previous ages we can determine it's rate of growth (growth rate is just how much bigger a fish gets with time; inches per year).

FIGURE 7. ILLUSTRATES THIS RELATIONSHIP. IN THIS FIGURE THE GIANT, MAGNIFIED OTOLITH HAS THREE RINGS OR BANDS. LET'S SUPPOSE THAT FROM PREVIOUS STUDIES WE LEARNED THAT A FISH WITH ONE RING ON ITS OTOLITH IS ONE-YEAR OLD. SINCE THIS OTOLITH HAS THREE RINGS, WE MIGHT CONCLUDE THAT IT IS NOW AT LEAST THREE YEARS OLD. WE SHOULD BE CAREFUL HERE, BECAUSE SOMETIMES THERE ARE 'EXTRA' OR 'FALSE RINGS' DUE TO A CHANGE IN THE FISH'S ENVIRONMENT OR BEHAVIOR. BY LOOKING AT A LOT OF FISH OF MANY DIFFERENT SIZES WE CAN CONSTRUCT A GRAPH LIKE THAT IN FIGURE 7. FROM THIS GRAPH IT IS POSSIBLE TO DETERMINE THE AVERAGE RATE OF GROWTH OF FISH IN THE STOCK. ALSO, NOTICE THAT EVEN THOUGH A FISH GROWS CONTINUOUSLY, ITS GROWTH RATE IS USUALLY GREATER IN ITS EARLIER YEARS.



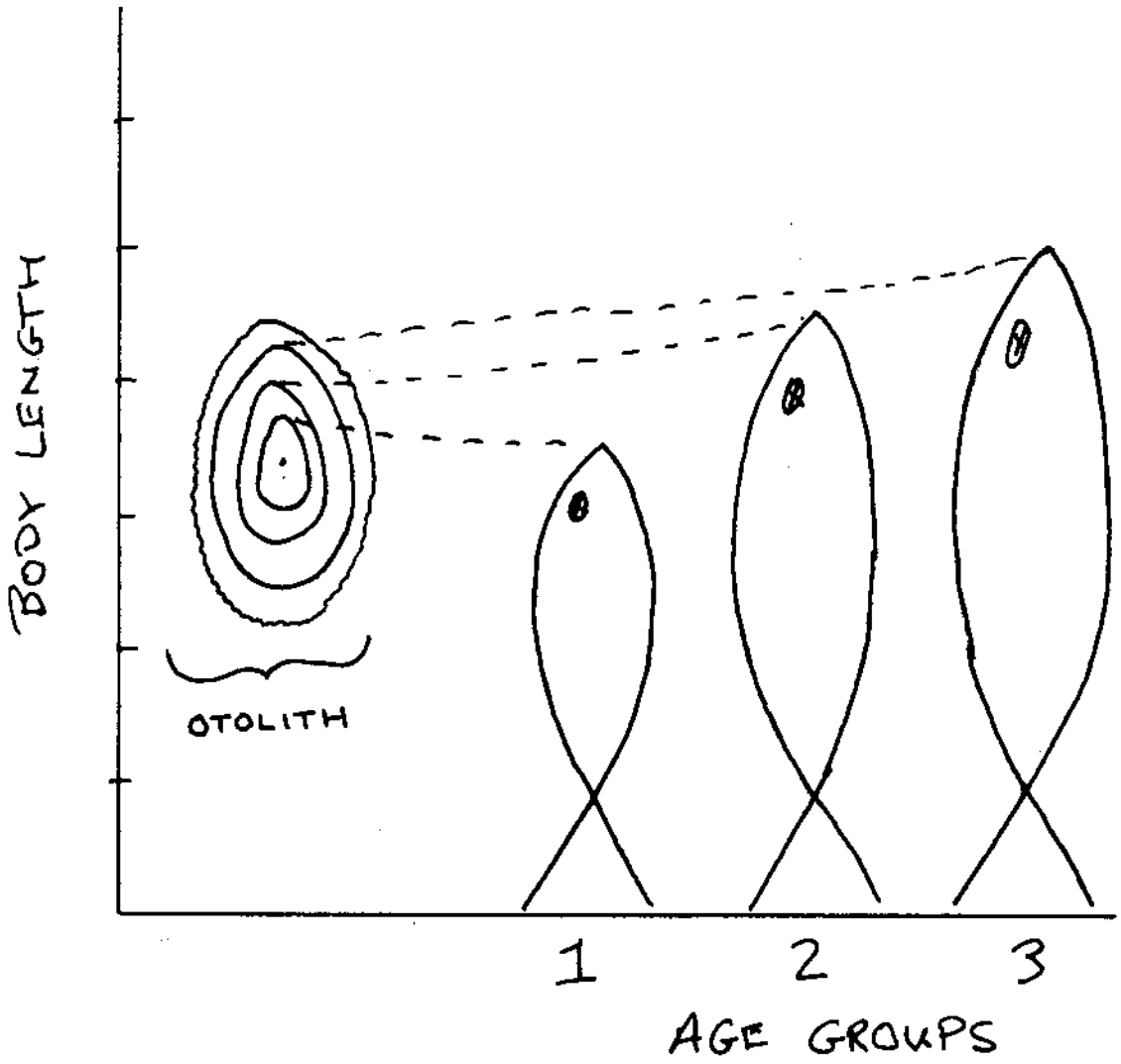
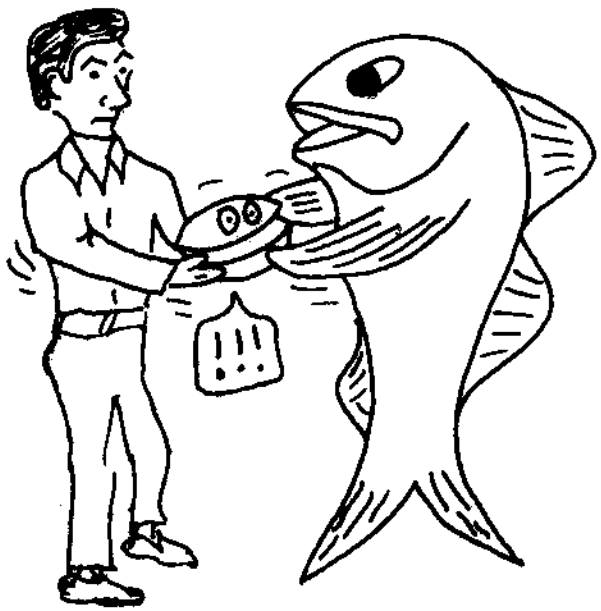


FIGURE 7. AVERAGE SIZE OF FISH IN A STOCK AS DETERMINED BY LOOKING AT OTOLITHS.

D. How fast does it grow?

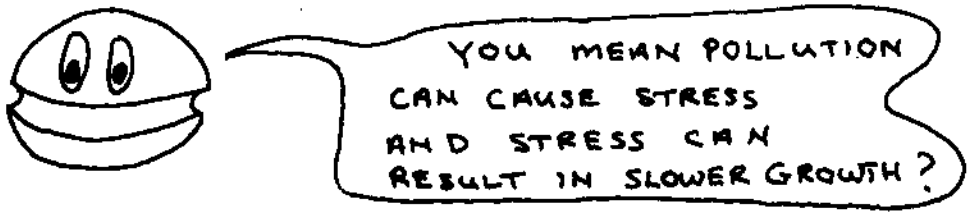
As we have already indicated, growth in aquatic organisms is often quite variable. This variability can be affected by a number of factors such as the animal's life stage (larval, juvenile, or adult), it's age, it's reproductive condition as well as competition for food or space from other animals (even humans!).



Many environmental factors are also known to have an influence on growth rates. For example, any change in water quality could cause a change in the availability of food or affect a fish's ability to extract energy from the food (this is called <u>metabolism</u> - if anyone should ever ask!). By examining the factors which influence growth rates we can also figure out what caused old growth rates (remember that past growth rates are often recorded on hard body parts) and predict future growth rates as well.

LET'S LEARN MORE ABOUT GROWTH RATES AND THEIR SIGNIFICANCE BY LOOKING AT FIGURE 8. IN THIS DIAGRAM THE SIZES OF THE FISH REPRESENT THE TYPICAL OR AVERAGE LENGTH OF FISH WHEN THEY ARE 1, 2, OR 3 YEARS OLD. THERE ARE TWO GROUPS OF FISH ALSO; A SLOWER GROWING GROUP (A - ABOVE), AND A FASTER GROWING GROUP (B - BELOW). FISH IN BOTH GROUPS START OUT AT THE SAME SIZE WHEN THEY ARE 1 YEAR OLD, BUT AFTER A COUPLE OF YEARS, WE NOTE THAT FISH IN GROUP A ARE SHORTER THAN THOSE IN GROUP B.

AS FISHERY BIOLOGISTS, IT MIGHT BE OUR TASK TO STUDY THIS SITUATION AND FIGURE OUT WHAT MIGHT HAVE CAUSED THIS DIFFERENCE IN GROWTH RATES IN THE TWO GROUPS. FOR EXAMPLE, UPON FURTHER STUDY WE MIGHT FIND THAT THE FISH IN GROUP B CAME FROM A STOCK THAT LIVES IN A SHRIMP GROUND. THIS COULD MEAN MORE AVAILABLE FOOD AND HENCE A FASTER GROWTH RATE. LIKEWISE, THE SLOWER GROWING FISH IN GROUP A COULD HAVE COME FROM A STOCK THAT WAS LOCATED IN A POLLUTED BAY.



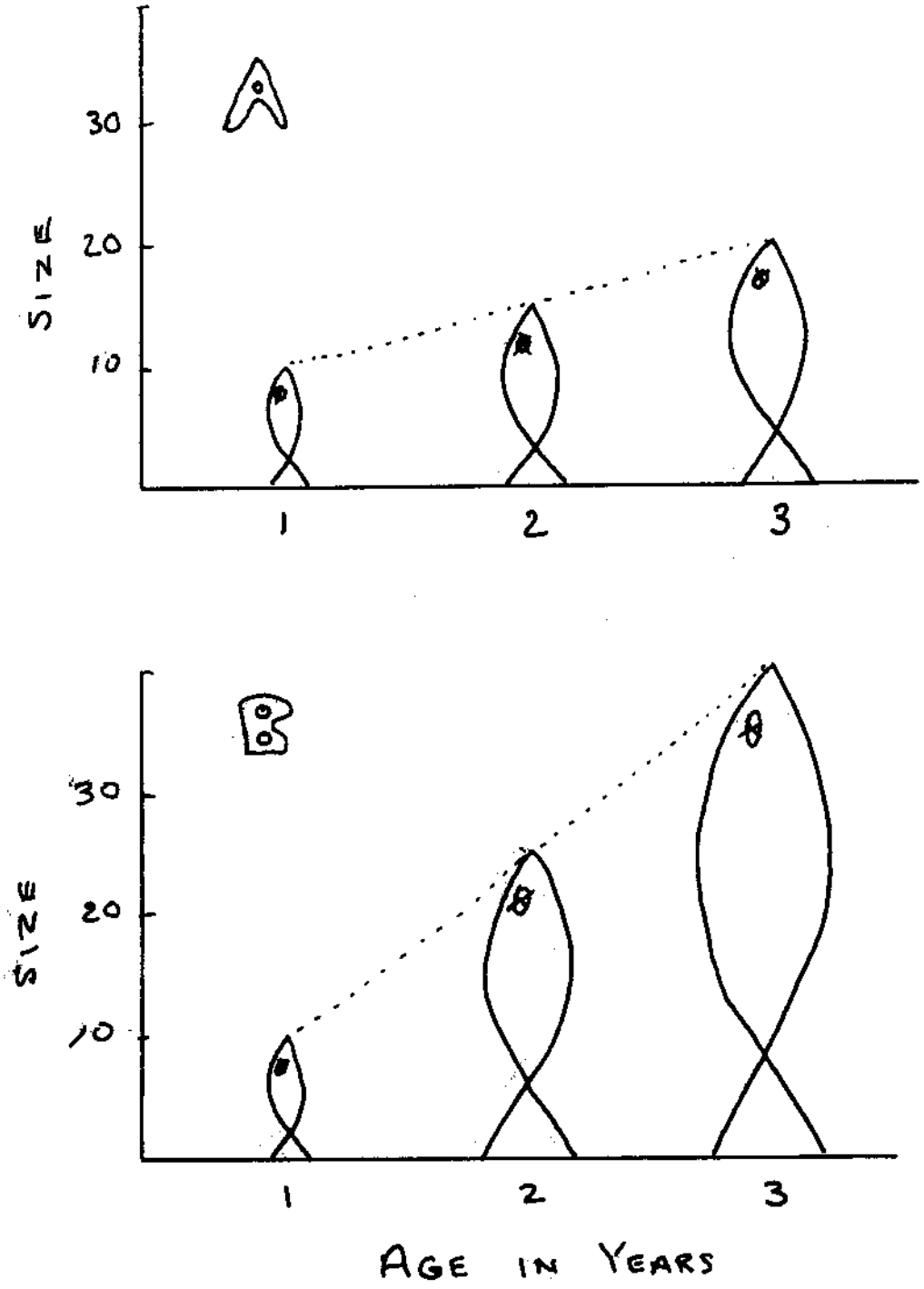
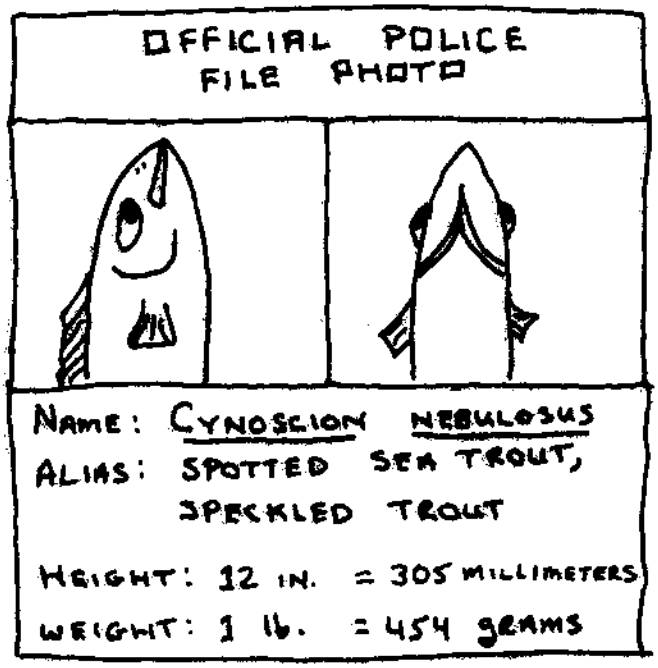


FIGURE 8. TWO GROUPS - THEY START OUT THE SAME BUT BECAUSE THEIR GROWTH RATES DIFFER THEY END UP AS DIFFERENT SIZES AT THE SAME AGE

THE MAIN POINT HERE IS THAT DIFFERENCES IN THE ENVIRONMENT COULD LEAD TO DIFFERENCES IN GROWTH RATES. IF WE ARE GOING TO MAKE AN ATTEMPT AT IMPROVING OUR FISHERIES WE NEED TO KNOW HOW THE ENVIRONMENT AFFECTS GROWTH. ALSO BY STUDYING GROWTH, WE CAN USE IT AS A WAY OF ASSESSING THE 'HEALTH' OF THE STOCK.

B. Is it in good shape?

One of the things a fishery biologist is interested in is the relative health, fitness, or condition of the organisms in a fishery. We have already seen some ways of judging this but another way is to compare the length and weight of a large number of fish from a stock.



The graph on top in Figure 9. shows what a length vs. weight comparison might look like.

SEE FIGURE 9 THIS WAY PLEASE

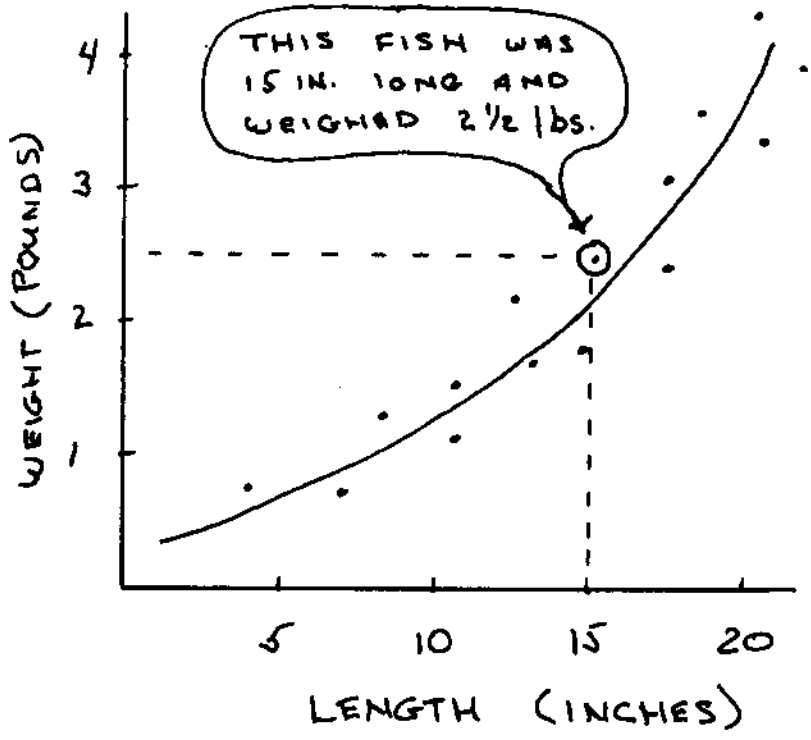


FIGURE 9. A GRAPH SHOWING THE POINTS OF THE LENGTH AND WEIGHT OF 15 FISH.

AT FIRST GLANCE THIS FIGURE MIGHT CONFUSE ANYONE, SO AN EXPLANATION IS IN ORDER. ALL I'VE DONE IS PLOT THE LENGTH AND CORRESPONDING WEIGHT OF 15 FISH ON GRAPH PAPER. THE CURVED LINE WAS DRAWN — IN JUST TO MAKE THE GENERAL TREND OF THE DOTS EASIER TO FOLLOW. AS YOU CAN SEE, LONGER FISH TEND TO WEIGH MORE THAN SHORTER FISH. OF COURSE YOU ALREADY KNEW THAT - - - BUT THERE'S MORE - - -.

We can tell a lot about the fitness or condition that fish in a fishery are in by looking at the shape of the curve created from length and weight data. To see an example of this let's look at Figure 10. In graph 10A (above), the fish represented by the length vs. weight curve tend to be much heavier at a given length than those represented in graph 10B (below). Note that a 20-inch fish in graph A weighs about 3 lbs. while a 20-inch fish in graph B weighs about 1 1/2 lbs.

Would you rather catch a 20-inch fish from group A or group B?

Well, that in itself is useful but we can do more with it than that. If we were to follow a fishery for several years we might notice changes in the health (fitness or condition) of the stock members by comparing the length-weight data (the shape of the curve, that is) from a few years ago

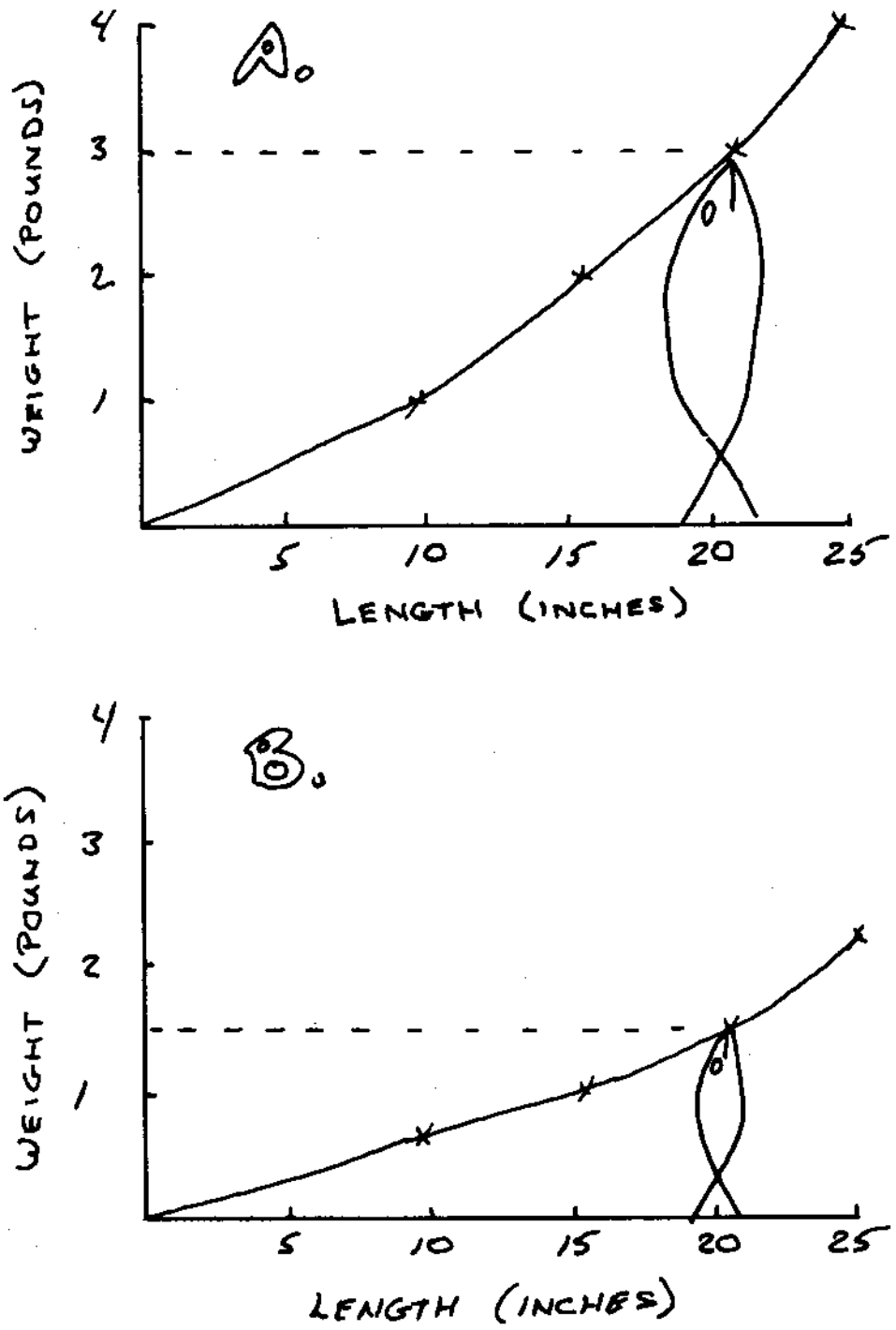
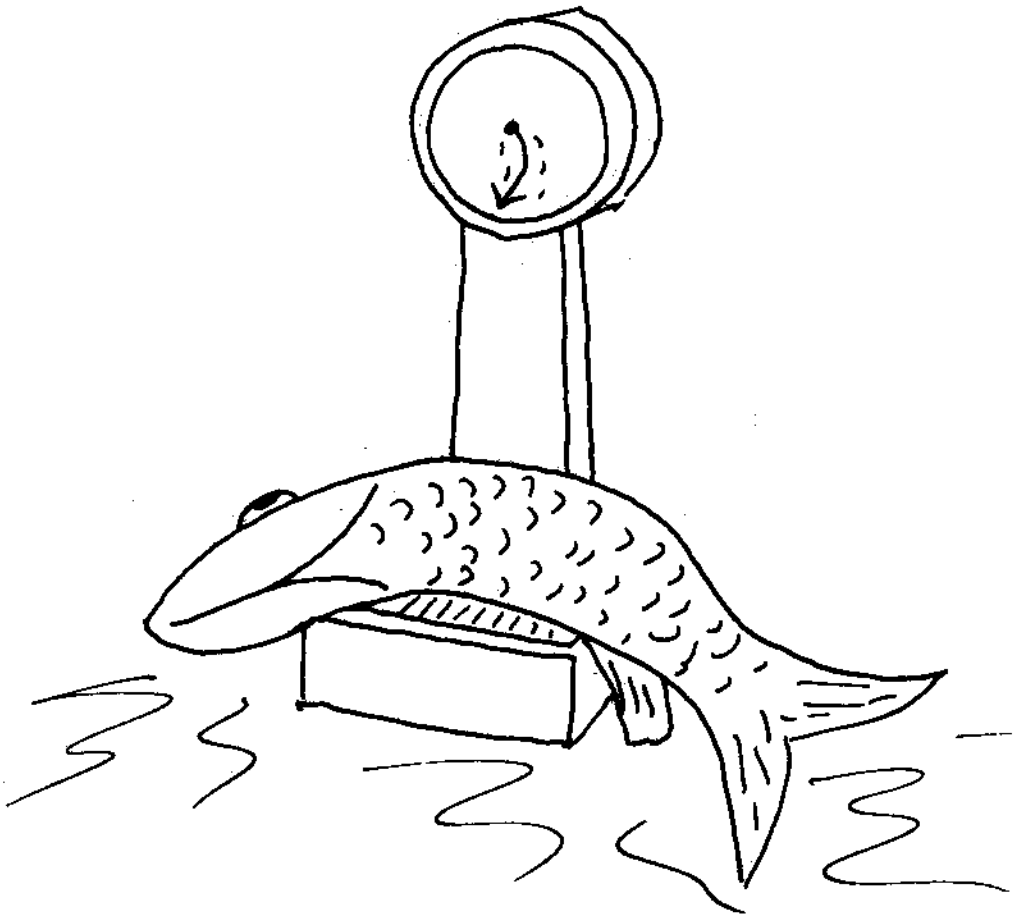


FIGURE 10. THESE GRAPHS SHOW THE LENGTH VS. WEIGHT RELATIONSHIP BETWEEN TWO DIFFERENT GROUPS.

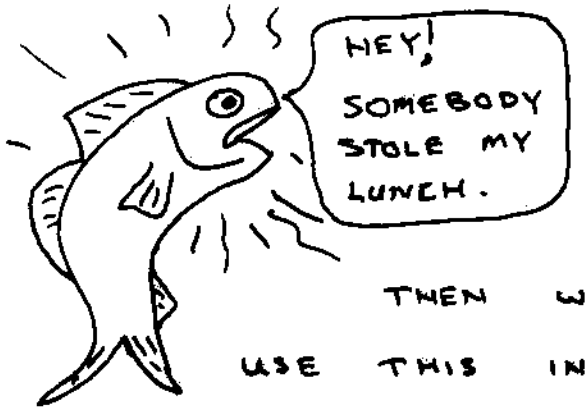
WITH THOSE OF TODAY. A CHANGE COULD MEAN THAT THE ENVIRONMENTAL CONDITIONS SURROUNDING THE FISHERY MAY HAVE CHANGED. FOR EXAMPLE, POLLUTION LEVELS COULD BE BETTER OR WORSE OR A COMPETING SPECIES MAY HAVE MOVED INTO THE AREA. SIMILARLY, AN EXAMINATION OF LENGTH VS. WEIGHT DATA MAY GIVE US A QUICK WAY OF DECIDING IF OUR MANAGEMENT STRATEGY HAS BEEN SUCCESSFUL.



P. WHAT DOES IT EAT?

THIS QUESTION IS AN IMPORTANT ONE FOR A FISHERY BIOLOGIST TO ANSWER ALTHOUGH INITIALLY IT MAY SEEM RIDICULOUS TO CARE WHAT A WHITE GRUNT OR A PINK SHRIMP HAD FOR DINNER! IF YOU RECALL OUR PREVIOUS DISCUSSION ABOUT A SPECIES' NICHE (AGAIN - THAT'S THE ROLE IT PLAYS IN THE ENVIRONMENT) THEN YOU'LL ALSO RECALL THAT EACH SPECIES' ROLE OR NICHE IS UNIQUE. QUITE OFTEN A SPECIES IS UNIQUE BY HAVING ITS OWN FEEDING STRATEGY. IDENTIFYING THIS FEEDING STRATEGY IS, IN ITSELF, AN IMPORTANT REASON FOR STUDYING FEEDING HABITS. EACH SPECIES OCCUPIES A POSITION IN THE FOOD WEB (OR LINK IN THE FOOD CHAIN IF YOU PREFER). ENERGY IS CAPTURED FROM THE SUN AND TURNED INTO A POTENTIAL FOOD SOURCE BY PRIMARY PRODUCERS (MAINLY PHYTOPLANKTON IN AN AQUATIC ECOSYSTEM) WHICH ARE THEN CONSUMED BY HERBIVORES (PLANT EATERS) WHICH ARE THEM CONSUMED BY ANIMAL EATERS (CARNIVORES).

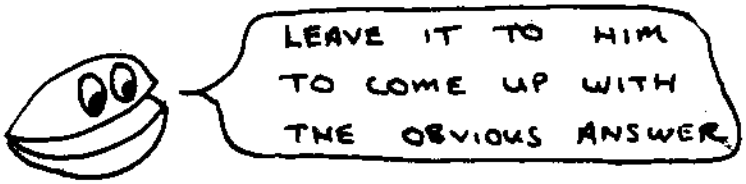
ALL THIS CONSUMING RESULTS IN A TRANSFER OF ENERGY THROUGH THE FOOD WEB. KNOWING HOW, WHEN, AND AT WHAT RATE THIS TRANSFER TAKES PLACE WILL LET US ACCURATELY DETERMINE EACH SPECIES' POSITION IN THIS GREAT SCHEME OF THINGS. ADDITIONALLY, WE CAN IDENTIFY THE SOURCE OF PROBLEMS IF THE FOOD WEB IS DISRUPTED TO THE POINT WHERE WE NOTICE THAT OUR FISHERIES ARE AFFECTED.



FIRST, LET'S BRIEFLY EXAMINE HOW THE FOOD HABITS OF A SPECIES ARE DETERMINED AND THEN WE'LL SEE HOW WE CAN USE THIS INFORMATION.

Q. HOW DO YOU DETERMINE FOOD HABITS?

A. WELL FIRST YOU HAVE TO CATCH SOME OF THE FISH WHOSE FOOD HABITS YOU WANT TO STUDY.



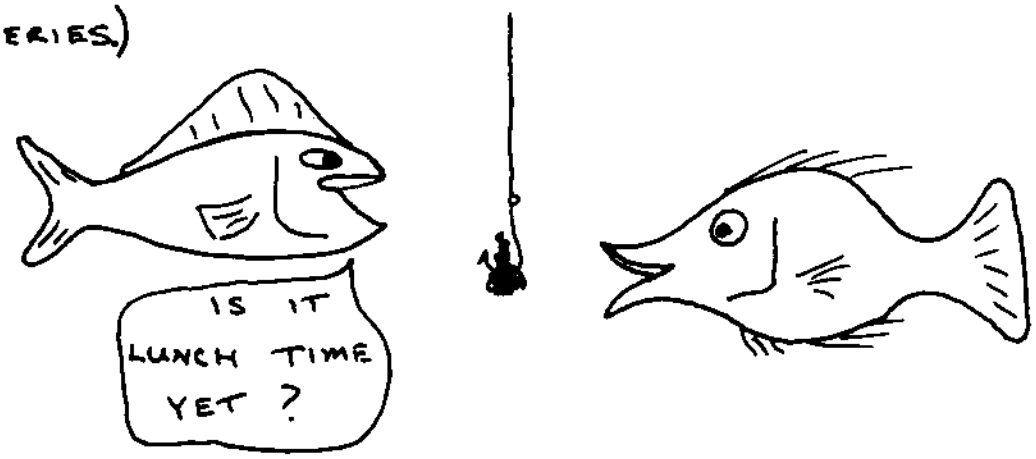
SAMPLING OR THE COLLECTION OF SPECIMENS FOR FOOD HABIT STUDIES IS IMPORTANT FOR A COUPLE OF GOOD REASONS. FIRST, IT'S NECESSARY TO HAVE LARGE NUMBERS (SAY AT LEAST THIRTY) OF INDIVIDUALS OR SPECIMENS OF EACH SPECIES OR GROUP IN THE FISHERY. AS YOU MIGHT GATHER, NOT ALL INDIVIDUALS EAT EXACTLY THE SAME THING ALL THE TIME (JUST LIKE HUMANS!).

PIZZA'S GREAT BUT WHO EATS IT EVERY DAY?

BY LOOKING AT THE FOOD HABITS OF LOTS OF INDIVIDUALS WE CAN GET AN IDEA OF THE VARIATION IN THE DIET.

SECOND, THE SPECIMENS SHOULD COME FROM EACH OF THE AGE AND SEX GROUPS. THIS IS BECAUSE THERE ARE OFTEN DIFFERENCES BETWEEN JUVENILES AND ADULTS, OR MALES AND FEMALES, IN THEIR FOOD HABITS. ALSO THERE MAY EVEN BE DIFFERENCES IN A SPECIES' FOOD HABITS BECAUSE OF LOCAL DIFFERENCES IN HABITAT (HABITAT VARIATION). ADDITIONALLY, WE SHOULD KNOW ABOUT SEASONAL DIFFERENCES OR SHIFTS IN DIET. MOREOVER, IF WE REALLY WANT TO KNOW WHAT'S GOING ON IN A SPECIES' FEEDING STRATEGY WE WOULD

EVEN EXAMINE A SPECIES' FOOD HABITS OVER A 24-HOUR PERIOD TO FIND OUT WHAT TIME OF DAY IT FEEDS. (THIS IS ESPECIALLY IMPORTANT TO DETERMINE ACTIVITY PATTERNS IN SPECIES ASSOCIATED WITH HOOK-AND-LINE OR TRAP FISHERIES.)



ONCE WE HAVE THE SPECIMENS CAPTURED, THE STOMACHS (OR AT LEAST THEIR CONTENTS) MUST BE <u>QUICKLY</u> REMOVED AND PRESERVED IN A SOLUTION OF ALCOHOL OR (PREFERABLY) FORMALDEHYDE. SPEED IS ESSENTIAL BECAUSE DIGESTION CONTINUES EVEN AFTER A FISH IS CAUGHT (EVEN IF IT HAS BEEN PUT ON ICE OR FROZEN!) AND IF YOU DON'T HURRY, THE STOMACH CONTENTS WILL BE DIGESTED BEYOND RECOGNITION. IN OTHER WORDS - THEY WILL BE A SOUPY MUSH! THE QUICKER THE STOMACHS ARE PRESERVED THE BETTER.

IDENTIFYING, COUNTING, AND WEIGHING THE FOOD ITEMS FOR SOME SPECIES IS EASIER THAN IT IS FOR OTHERS. SOME SPECIES (LIKE MULLET) GRIND THEIR FOOD IN THEIR STOMACHS TO THE POINT THAT ALL THAT'S REMAINING IS A PULVERIZED MESS. OTHER SPECIES ARE MORE COOPERATIVE AND SWALLOW THEIR FOOD WHOLE (LIKE TUNA) THUS MAKING IDENTIFICATION OF THEIR FOOD ITEMS A SNAP.

AFTER IDENTIFYING THE STOMACH CONTENTS WE WOULD THEN PROCEED TO DETERMINE HOW MANY FISH IN OUR SAMPLE ATE THE FOOD ITEM. THIS BIT OF INFORMATION IS USUALLY REPORTED AS A PERCENT OF THE SAMPLE AND IS CALLED <u>PERCENT OCCURRENCE</u>. A PERCENT OCCURRENCE VALUE OF 10%, FOR EXAMPLE, MEANS THAT THE FOOD ITEM WE'RE REFERRING TO OCCURRED IN 10% OF THE SPECIMENS IN OUR SAMPLE.

WE MIGHT ALSO DETERMINE HOW MANY OF THE FOOD ITEMS OCCUR IN A TYPICAL FISH IN OUR SAMPLE. THIS IS CALLED <u>FREQUENCY</u>. IT IS ALSO OFTEN REPORTED AS A PERCENT. FOR EXAMPLE, IF THE PERCENT FREQUENCY OF CRABS IN A FISH WAS 20%, WE WOULD SAY, THAT OF THE TOTAL ITEMS PRESENT, 20% WERE CRABS.

ALSO WE WOULD WANT TO HAVE SOME IDEA AS TO THE IMPORTANCE EACH FOOD TYPE SERVES IN THE SPECIES' TOTAL DIET BY ITS WEIGHT (OR VOLUME). EACH FOOD ITEM IS WEIGHED AND THE PERCENTAGE OF THE WEIGHT OF THE ENTIRE STOMACH CONTENTS IS CALCULATED. A PERCENT WEIGHT OF 25% MEANS THAT THE PARTICULAR FOOD ITEM WE ARE TALKING ABOUT MAKES UP 25% OF THE TOTAL DIET BY WEIGHT.

WITH THESE THREE PIECES OF INFORMATION (1. PERCENT OCCURRENCE, 2. PERCENT FREQUENCY, AND 3. PERCENT WEIGHT) TAKEN FROM THE VARIOUS AGE AND SEX GROUPS AND DIFFERENT SEASONS, WE CAN GET A PRETTY GOOD IDEA AS TO THE SIGNIFICANCE EACH FOOD ITEM HAS ON THE LIFE AND FEEDING NICHE OF THE SPECIES COMPRISING OUR FISHERIES.

Q. WHAT CAN INFORMATION ON A SPECIES' FEEDING HABITS TELL US AND HOW CAN WE USE THIS INFORMATION?

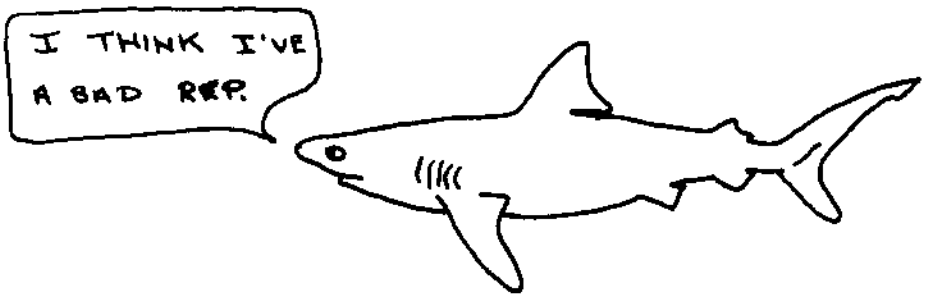
(THE ANSWER WILL APPEAR BEFORE YOUR EYES ON THE NEXT FEW PAGES - - -) ➡

THERE IS ACTUALLY QUITE A LOT THAT WE CAN LEARN FROM FEEDING STUDIES OR "STOMACH ANALYSES". AS STATED ALREADY, A SPECIES' "PLACE" IN THE FOOD WEB CAN BE DETERMINED. THIS PLACE OR POSITION CAN BE DESCRIBED BASED ON THE RELATIVE IMPORTANCE OF A FEW OR ALL OF THE FOOD ITEMS IN THE DIET. FISHERIES BIOLOGISTS & ECOLOGISTS HAVE DEVELOPED A VARIETY OF TERMS TO DESCRIBE OR CHARACTERIZE A SPECIES' FEEDING HABITS ESPECIALLY AS IT PERTAINS TO ITS USUAL FEEDING STRATEGY :

PLANKTIVORE - PRIMARILY EATS PHYTO- AND ZOOPLANKTON. EXAMPLES - SHRIMP, ANCHOVIES, OYSTERS, CLAMS, AND BASKING SHARKS.

HERBIVORE - EATS PLANTS (USUALLY THOSE ATTACHED TO THE BOTTOM). EXAMPLES - SOME CRABS, PARROT FISH, AND GREEN SEA TURTLES.

CARNIVORE - EATS ANIMALS (OTHER THAN ZOOPLANKTON). EXAMPLES - BLUE CRABS, OCTOPUS, GROUPER, AND OF COURSE ....



PISCIVORE - THIS IS A MEAT EATER THAT TENDS TO EAT ONLY FISH. EXAMPLES - TUNA, BARRACUDA ETC.

DETRITIVORE - THEY EAT DETRITUS WHICH IS A NICE WORD FOR: DEAD PARTS OF PLANTS, PARTIALLY DECOMPOSED PLANT MATERIAL AND SOME DEAD ANIMAL MATTER (DELICIOUS!) EXAMPLES - SOME CRUSTACEANS AND MULLET.

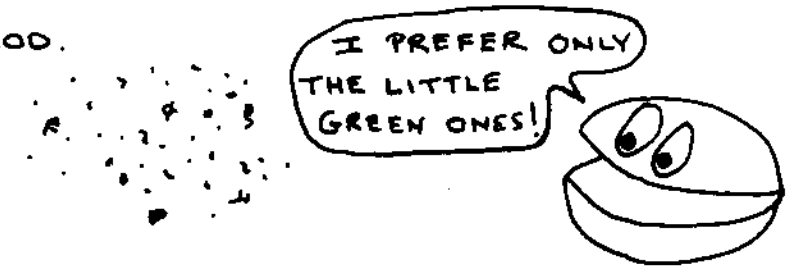
OMNIVORE - EATS A LITTLE BIT OF EVERY-THING (REMINDS ME OF A FRIEND OF MINE !) EXAMPLES - PINFISH AND SOME CRUSTACEANS.

WE MIGHT ALSO BE ABLE TO CLASSIFY OR DESCRIBE AQUATIC ORGANISMS ACCORDING TO THE VARIETY OF ITEMS THEY EAT.

GENERALIST - TENDS TO EAT A WIDE VARIETY OF DIFFERENT FOOD ITEMS.

OR

SPECIALIST - THEY ARE VERY SELECTIVE AND EAT ONLY A CERTAIN TYPE OF FOOD.



WE COULD ALSO FIND IT USEFUL TO IDENTIFY THE WAY IN WHICH AN ORGANISM EATS.

FILTER FEEDERS STRAIN OR "SIFT" THE WATER FOR FOOD ITEMS. FILTER FEEDERS CAN BE AS LARGE AS THE GREAT BLUE WHALE AND BASKING SHARKS OR AS SMALL AS SHRIMP AND BARNACLES. THEY CAN BE PASSIVE FILTER FEEDERS SUCH AS OYSTERS AND JUST SIT THERE AND LET THE WATER FLOW ON BY OR THEY CAN BE ACTIVE AND MOVE THROUGH THE WATER LIKE ANCHOVIES.

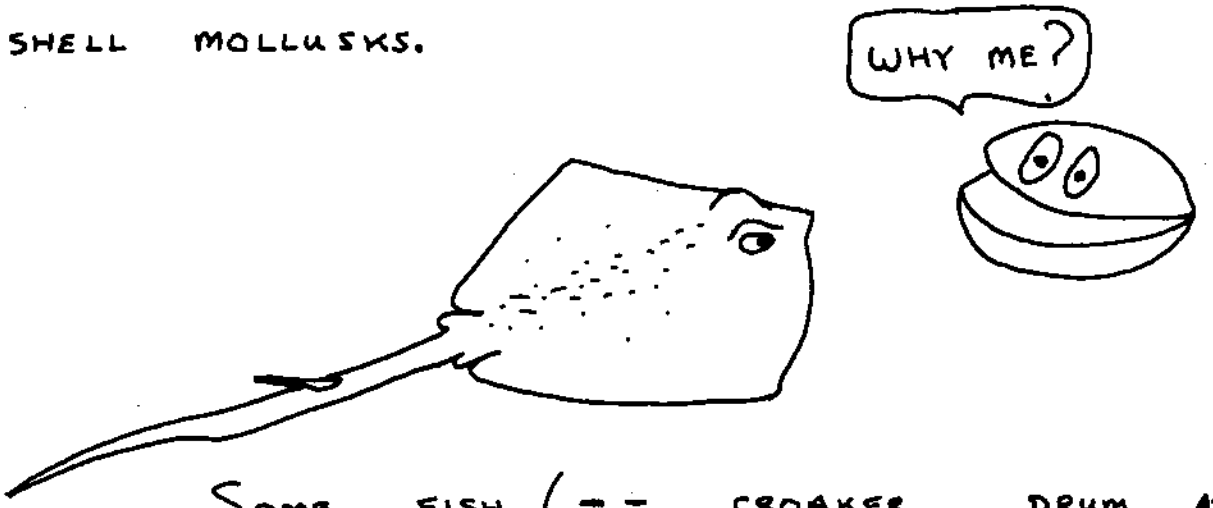
FILTER FEEDING USUALLY INVOLVES A SPECIAL FILTER STRUCTURE LIKE BALEEN (IN WHALES) OR A FINE COMB-LIKE STRUCTURE (THE GILL RAKERS IN AN ANCHOVY)

PICKERS ARE SPECIES WHICH ARE USUALLY ASSOCIATED WITH A SUBSTRATE LIKE A REEF OR A GRASSBED. THEIR FEEDING BEHAVIOR INVOLVES DARTING OUT FROM COVER AND "PICKING" AT SMALL FOOD ITEMS THAT ARE EITHER IN THE WATER OR CLOSE TO THE SUBSTRATE. THE FOOD ITEMS THIS GROUP FEEDS ON OFTEN CONSIST OF EGGS, LARVAE, OR JUVENILES OF OTHER SPECIES AND ALSO SMALL CRUSTACEANS SUCH AS AMPHIPODS AND COPEPODS.

GRAZERS TEND TO BITE OFF PIECES OF CORAL, SPONGE, GRASSES, OR OTHER PLANTS. SOMETIMES THEY ARE FEEDING ON THE PIECE ITSELF, BUT OFTEN THEY ARE REALLY AFTER THE SMALL ORGANISMS THAT LIVE ON THE CORAL, SPONGE, OR PLANT. EXAMPLES OF GRAZERS ARE PARROT FISH. SEA URCHINS ARE ALSO GRAZERS.

(I FORGOT TO MENTION IT ABOVE BUT EXAMPLES OF PICKERS ARE DAMSELFISH, CARDINAL FISH, AND WRASSES.)

OF COURSE THERE IS THE GENERAL CATEGORY OF **PREDATOR**. PREDATORS ARE ADAPTED FOR EATING OTHER ANIMALS BUT WHAT THEY FEED ON IS OFTEN A FUNCTION OF THEIR SIZE, JAW STRUCTURE, AND ATTACK STRATEGY. SOME PREDATORS HAVE POWERFUL CRUSHING STRUCTURES THAT ARE PRESENT EITHER AS JAWS OR CLAWS. STING RAYS, FOR EXAMPLE, HAVE LARGE FLAT TEETH ESPECIALLY DESIGNED FOR CRUSHING HARD SHELL MOLLUSKS.



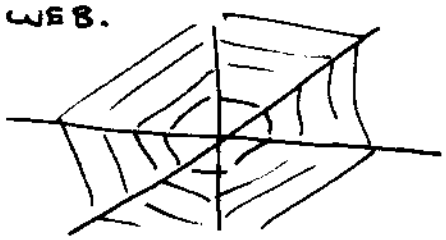
SOME FISH (-- CROAKER, DRUM, AND RED FISH) HAVE THEIR CRUSHING TEETH LOCATED IN THEIR THROATS. THEY'RE CALLED <u>PHARYNGEAL TEETH</u>, AND THEY FIT INTO THIS CATAGORY AS WELL.

SOME PREDATORS HAVE SHARP, LONG TEETH (SUCH AS MACKEREL) AND THESE ANIMALS USE THEIR SPEED, MANEUVERABILITY, AND BITE TO CATCH THEIR FOOD. OTHER PREDATORS SUCH AS

FLOUNDERS, WHICH HIDE ON THE SUBSTRATE, LIE-IN-WAIT, AND QUICKLY ENGULF A PREY THAT COMES WITHIN RANGE BY RAPIDLY OPENING, AND CLOSING, THEIR JAWS.

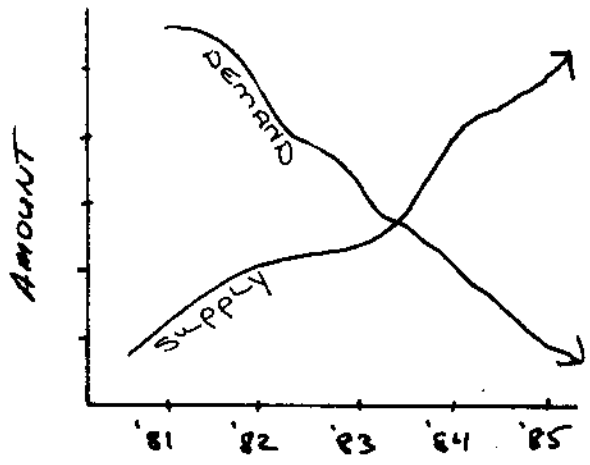
DID YOU KNOW THAT MANY ORGANISMS ACTIVELY FEED AT ONLY SPECIFIC TIMES OF THE DAY. THOSE THAT FEED IN THE DAYTIME ARE CALLED **DIURNAL** SPECIES. THOSE THAT FEED AT NIGHT ARE CALLED **NOCTURNAL** SPECIES. MOST SPECIES FEED AT DUSK AND AT DAWN AND ARE REFERRED TO AS **CREPUSCULAR**.

THE TERMS ABOVE INDICATE SOME OF THE VARIETIES OF FEEDING MODES THAT ARE KNOWN AND JUST ABOUT ALL POSSIBLE COMBINATIONS OF THESE TYPES OCCUR IN NATURE. FOR EXAMPLE, A SPECIES MAY BE A NOCTURNAL CARNIVORE, THAT IS A GENERALIST, WHILE ANOTHER MAY BE A DIURNAL FILTER FEEDING SPECIALIST. GIVEN ALL THE POSSIBLE COMBINATIONS OF FEEDING MODES AND THE VARIETY OF POTENTIAL FOOD ITEMS AVAILABLE IT'S EASY TO SEE THAT EACH SPECIES OFTEN OCCUPIES A UNIQUE POSITION IN THE FOOD WEB.



WHEN TWO OR MORE SPECIES OCCUPY THE SAME PLACE IN THE FOOD WEB, THEY COMPETE FOR FOOD ITEMS. COMPETITION IN ITSELF IS NOT NECESSARILY DETRIMENTAL TO THESE SPECIES ESPECIALLY IF THE FOOD ITEMS THEY ARE COMPETING FOR ARE RELATIVELY ABUNDANT. IT'S WHEN THE FOOD ITEMS BECOME RARE (AS THEY OFTEN DO IN SOME LOCATIONS OR AT CERTAIN TIMES OF THE YEAR) OR THE CONSUMERS OF THE ITEMS BECOME ABUNDANT THAT COMPETITION BECOMES IMPORTANT.

FISHERY BIOLOGISTS, THEREFORE, NEED TO KNOW THE FEEDING STRATEGY AMONG THE SPECIES IN THE COMMUNITY. KNOWING THIS WILL ALLOW THEM TO ASSESS THE RELATIVE POSITION EACH SPECIES OCCUPIES IN THE "GREAT WEB" OF THINGS. ADDITIONALLY, IT IS ESSENTIAL THAT FISHERY BIOLOGISTS BE ABLE TO RECOGNIZE POTENTIAL PROBLEMS POSED BY COMPETITION FROM A NON-PREFERRED SPECIES IN THE FISHING AREA. THIS ABILITY TO RECOGNIZE THOSE POTENTIAL PROBLEMS WILL ENABLE FISHERIES MANAGERS TO ADJUST THEIR STRATEGIES, ONCE AGAIN TO INSURE A "BETTER" USE OF THE RESOURCE FOR EVERYONE.



ULTIMATELY THE PROBLEM OF STUDYING THE FOOD HABITS AND FOOD RESOURCES IN A FISHERY BECOMES ONE OF "SUPERMARKET" ECONOMICS. BY THIS WE MEAN THE SUPPLY AND DEMAND OF FOOD ITEMS AVAILABLE TO THE ORGANISMS IN A FISHERY. IN FIGURE 11. WE SEE HOW THE FOOD AVAILABLE TO THE SPECIES IN A FISHERY AFFECTS THE LIFE OF THE INDIVIDUALS COMPRISING THE SPECIES. FOOD IS CAPTURED BY A FISH USING A BEHAVIORAL 'ATTACK' PLAN AND ITS LONG DEVELOPED CAPTURING AIDES (LIKE JAWS, SWIMMING SPEED, CAMOUFLAGE, ETC.). A 'CONSUMER' THEN USES THE ENERGY IN THE FOOD TO:

1) MAINTAIN ITS LIFE
2) PRODUCE MORE OF ITSELF BY GROWING
AND ... 3) MAKE MORE OF ITSELF BY REPRODUCING.

IN GENERAL, THE MORE THAT AQUATIC ORGANISMS EAT, THE FASTER THEY GROW AND/OR THE MORE YOUNG THEY PRODUCE.

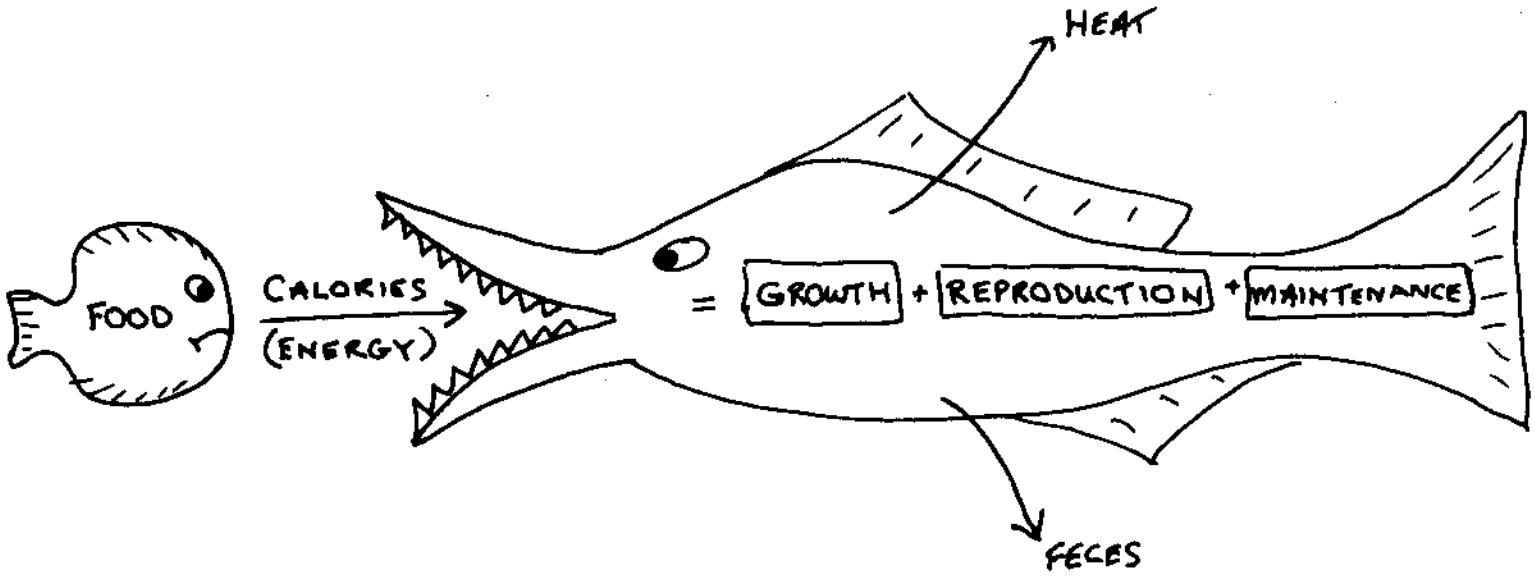
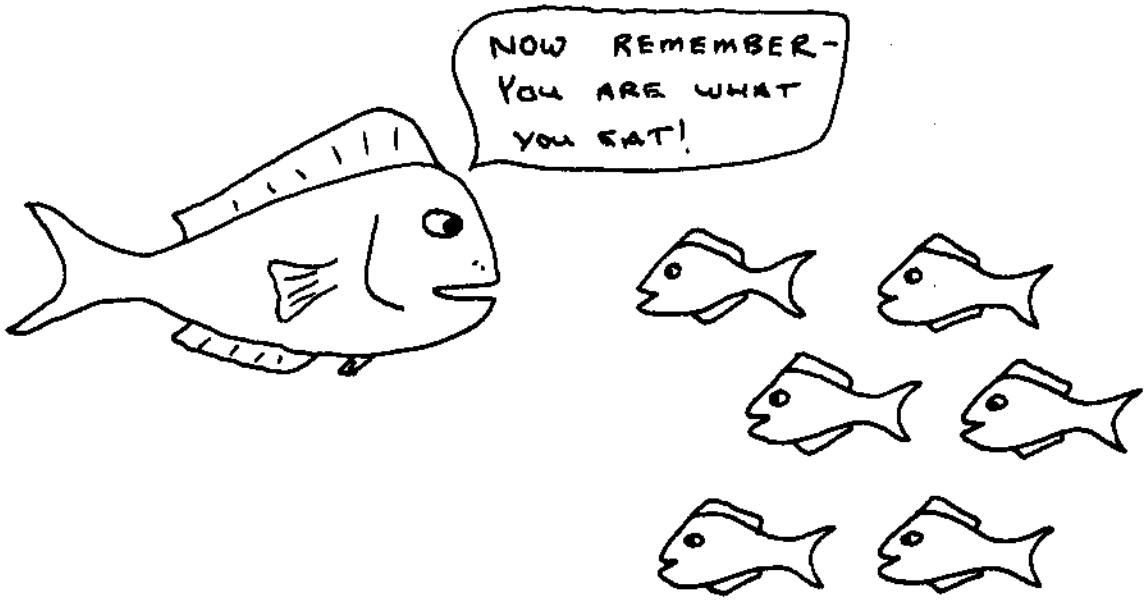


FIGURE 11. IN THE GREAT SCHEME OF THINGS, THE ENERGY AN ORGANISM DERIVES FROM ITS FOOD IS USED FOR: 1) GROWTH, 2) REPRODUCTION, AND 3) KEEPING ITSELF ALIVE (MAINTENANCE). SOME OF THE ENERGY IN THE FOOD IS TOTALLY WASTED, HOWEVER. IT'S EITHER LOST AS HEAT OR NEVER EVEN DIGESTED AND LOST IN THE FORM OF FECES.

IF CHANGES OCCUR IN THE ENVIRONMENT WHICH RESULT IN A CHANGE IN FOOD AVAILABILITY THEN WE PROBABLY SEE AN EFFECT ON EITHER ONE, TWO, OR ALL THREE OF THE ABOVE ASPECTS OF A FISH'S LIFE FUNCTION. WE'VE ALREADY EXAMINED THE USEFULNESS OF LOOKING AT AGE AND GROWTH. LATER WE'LL EXAMINE REPRODUCTION IN THE SAME WAY. FOR NOW WE MUST REALIZE THAT FEEDING STRATEGIES AMONG SPECIES DIFFER AND THAT CHANGES (EITHER INCREASES OR DECREASES) IN FOOD AVAILABILITY AND QUALITY CAN AFFECT THE SIZE AND ABUNDANCE OF THE INDIVIDUALS IN A FISHERY.



G. How many young will it produce - - -

and - - -

H. When will it produce them?

Before we get to these and other questions, let's find out why they want to reproduce or breed in the first place. Multicellular animals (such as any of those found in a fishery) do not live forever. This is perhaps a dramatic statement but since their lifespan is limited, the only way they can "live" forever is by passing on their genetic traits to their offspring. This is usually done by <u>sexual</u> <u>reproduction</u>. This means combining half the genetic traits from an individual of one sex with half the traits from another.

THERE ARE SEVERAL REASONS FOR COMBINING THE GENETIC TRAITS OF TWO INDIVIDUALS IN ORDER TO PRODUCE YOUNG. THE MOST OFFERED EXPLANATION RELATES TO COMBINING THE GENETIC CHARACTERS OF BOTH PARENTS TO CREATE OFFSPRING WHICH ARE AT LEAST AS GOOD, AND HOPEFULLY BETTER, THAN EITHER OF THE PARENTS AT SURVIVING IN THE GREAT WIDE WORLD.

WE'RE GETTING OFF TRACK A LITTLE, BUT THE MAIN POINT IS - ANY ORGANISM WOULD LIKE TO LIVE FOREVER. IT CAN'T DUE TO LIMITS ON CELL LIFE AND CELL DIVISION, SO IT FORMS A POTENTIALLY BETTER REPLACEMENT IN THE FORM OF OFFSPRING BY SHARING TRAITS WITH ANOTHER INDIVIDUAL OF THE OPPOSITE SEX.

IT WOULD APPEAR THAT MOST SPECIES PRODUCE MANY MORE YOUNG THAN ARE ACTULLY NECESSARY TO REPLACE THE ORIGINAL ADULTS IN THE POPULATION. —

THE REASON FOR THIS IS THAT THERE IS OFTEN A VERY HIGH MORTALITY AMONG THE YOUNG. FOR A GIVEN SET OF ENVIRONMENTAL CONDITIONS, IF THE PARENTS DO NOT PRODUCE ENOUGH YOUNG, THE SPECIES MAY DECLINE IN ABUNDANCE. SIMILARLY, IF THEY PRODUCE TOO MANY YOUNG, THE POPULATION MAY INCREASE. WHAT'S WRONG WITH PRODUCING TOO MANY? NOTHING - AT FIRST, BUT EVENTUALLY IF FAR TOO MANY ARE PRODUCED AND SURVIVE TO ADULTHOOD THEY COULD USE UP TOO MUCH OF THE FOOD AVAILABLE TO THE OTHER MEMBERS OF THE POPULATION. IN OTHER WORDS: - - -

"THE NICHE SPACE BECOMES CROWDED."

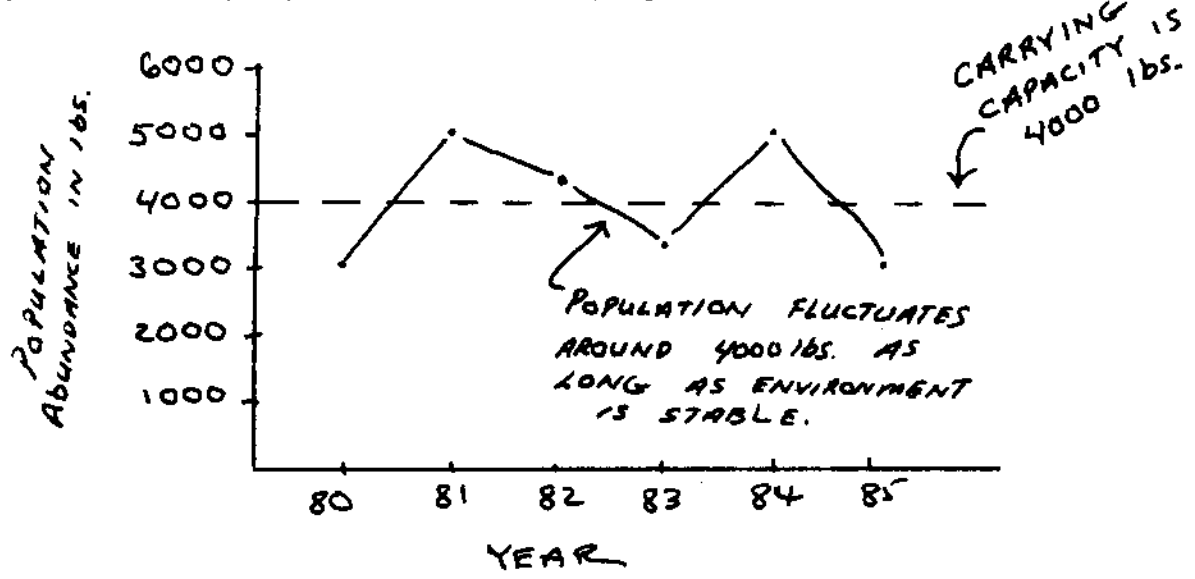
OVERCROWDING CAN LEAD TO SLOWER GROWTH AND REDUCED FITNESS DUE TO A LOWER FOOD SUPPLY. LESS FIT ADULTS MAY PRODUCE OFFSPRING WHICH HAVE A LOWER PROBABILITY OF SURVIVAL. ALSO, LESS FIT ADULTS MAY NOT BE ABLE TO OUT COMPETE INDIVIDUALS OF OTHER SPECIES FOR THE REMAINING FOOD. A "CRASH" IN SPECIES ABUNDANCE WOULD OCCUR IF A SPECIES "OVER ATE" THE AVAILABLE FOOD SUPPLIES. THE POPULATION WOULD GO THROUGH A SERIES OF WILDLY FLUCTUATING UPS AND DOWNS IN ABUNDANCE.

TO AVOID THESE FLUCTUATIONS AND TO MORE EFFECTIVELY EXPLOIT THE AVAILABLE ENVIRONMENT, MOST SPECIES HAVE DEVELOPED (OVER THOUSANDS OF YEARS) A LIFE STYLE AND REPRODUCTIVE STRATEGY THAT ALLOWS A SPECIES TO MAINTAIN A POPULATION ABUNDANCE AT A CERTAIN LEVEL. THIS LEVEL IS CALLED THE **CARRYING CAPACITY.** LOOKING AT IT ANOTHER WAY, WHEN THE POPULATION'S REPRODUCTIVE EFFORT IS JUST HIGH ENOUGH TO REPLACE ITSELF AND NOT INCREASE TO THE POINT OF STRAINING THE AVAILABLE FOOD RESOURCES, WE SAY THAT THE POPULATION HAS STABILIZED OR HAS ATTAINED ITS CARRYING CAPACITY.

THINK OF IT ANOTHER WAY - THE CARRYING CAPACITY IS THE POPULATION LEVEL THAT THE ENVIRONMENT CAN SUPPORT.

IDEALLY THE CARRYING CAPACITY DOES NOT FLUCTUATE VERY MUCH FROM YEAR-TO-YEAR ALTHOUGH IT IS SPECIFIC FOR CERTAIN HABITATS. FOR EXAMPLE, THE CARRYING CAPACITY FOR GROUPER MAY BE MUCH HIGHER ON ONE CORAL REEF THAN IT IS ON ANOTHER. {HOWEVER}, IF THE ENVIRONMENTAL CONDITIONS IN THE HABITAT CHANGE (YOU GUESSED IT),

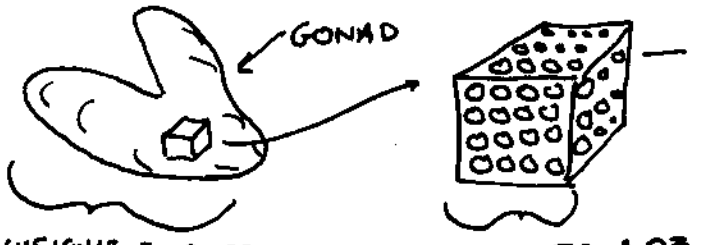
THE CARRYING CAPACITY CHANGES AS WELL. IN GENERAL, HOWEVER, A SPECIES HAS DEVELOPED AN OVERALL REPRODUCTIVE STRATEGY WHICH IS TAILORED TO MAINTAIN ITS POPULATION AT AN ABUNDANCE WHICH IS <u>CLOSE</u> TO ITS 'AVERAGE' CARRYING CAPACITY YEAR AFTER YEAR.



LATER WE WILL EXAMINE CONCEPTS SUCH AS "STOCK SIZE" AND "YEAR CLASS STRENGTH" BUT KEEP IN MIND THAT INDIVIDUALS IN A SPECIES ARE TRYING TO PRODUCE THE MOST YOUNG THEY CAN WITHOUT PUTTING TOO MUCH STRESS ON THEMSELVES. AT THE SAME TIME THEY ARE AT LEAST TRYING TO REPLACE THEMSELVES (EACH PAIR ULTIMATELY TRYING TO PRODUCE A PAIR) OVER THE LONG HAUL OF THEIR LIFE HISTORY.

EARLIER WE SAW WHAT HAPPENED TO ENERGY (IN THE FORM OF FOOD) AS IT ENTERED AN ORGANISM. SOME OF THE AVAILABLE ENERGY WENT TO MAINTAIN THE ANIMAL ITSELF, SOME OF IT WAS USED FOR GROWTH, SOME WAS LOST IN THE FORM OF HEAT, BUT SOME PORTION WENT TO MAKE EGGS OR SPERM SO THE ANIMAL COULD REPRODUCE. FROM A FISHERIES' VIEWPOINT IT IS POSSIBLE TO GET AN IDEA OF FUTURE INCREASES OR DECREASES THAT A POPULATION MAY GO THROUGH BY LOOKING AT ITS REPRODUCTIVE POTENTIAL (THAT MEANS - HOW MANY YOUNG THE POPULATION IS CAPABLE OF PRODUCING). IT IS SOMETIMES POSSIBLE TO PROJECT HOW MANY YOUNG WE CAN EXPECT TO BE ADDED TO THE FISHERY BY LOOKING AT REPRODUCTIVE POTENTIAL. LIKEWISE, KNOWING A LOT ABOUT THE CONDITIONS UNDER WHICH A SPECIES REPRODUCES MIGHT BE USEFUL WHEN DEVELOPING A MANAGEMENT PLAN. THIS IS ESPECIALLY TRUE FOR PLANS WHICH CALL FOR INCREASING A SPECIES' REPRODUCTIVE CAPACITY.

THE ABILITY OF A FISH TO PRODUCE YOUNG IS CALLED **FECUNDITY**. A FISH CAN HAVE A HIGH OR LOW (OR ANYTHING IN BETWEEN) FECUNDITY BASED ON A NUMBER OF FACTORS. MEASURING THE NUMBER OF YOUNG ANY PAIR OF FISH PRODUCES CAN BE ALMOST AN IMPOSSIBLE TASK. HOWEVER, WE CAN GET A PRETTY GOOD ESTIMATE OF FECUNDITY BY COUNTING THE NUMBER OF MATURE EGGS THAT A FEMALE PRODUCES. WE DO THIS BY COUNTING THE NUMBER OF EGGS IN THE BODY OF A FEMALE. IN A SPECIES WHICH PRODUCES ONLY A FEW EGGS (LESS THAN 100) WE WOULD PROBABLY COUNT THEM DIRECTLY. SOME SPECIES PRODUCE 1,000 TO 1,000,000 EGGS PER FEMALE (A COD IS KNOWN TO PRODUCE OVER 9,000,000). IN THIS CASE WE WOULD GET AN ESTIMATE OF THE NUMBER OF EGGS (AND THEREFORE AN ESTIMATE OF ITS FECUNDITY) BY COUNTING THE NUMBER OF EGGS IN PART OF THE GONAD (A PART IS A SUBSAMPLE) AND EX-PANDING OUR ESTIMATE. FOR EXAMPLE,



200 EGGS IN SUBSAMPLE = 200 EGGS PER OZ.

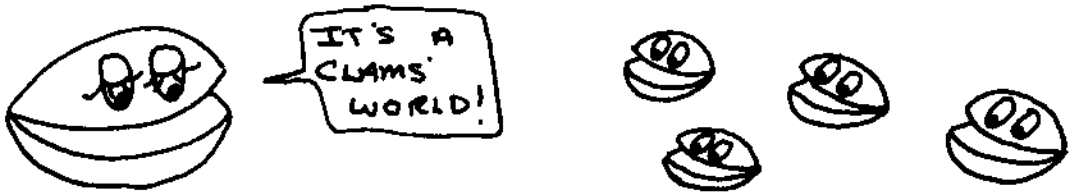
So: $10 \times 200 = \boxed{2000}$ EGGS IN GONAD.

IN CASE YOU'RE WONDERING WHY WE LOOK AT EGGS IN FEMALES INSTEAD OF SPERM IN MALES: COUNTING SPERM WOULD BE TOO TIME CONSUMING AND IT WOULD YIELD LITTLE INFORMATION BECAUSE A SPECIES' REPRODUCTIVE CAPACITY IS USUALLY LIMITED BY THE NUMBER OF EGGS A FEMALE PRODUCES.

QUESTION: IF YOU HAVE 100 EGGS AND 10,000 SPERM HOW MANY YOUNG COULD YOU POSSIBLY PRODUCE?

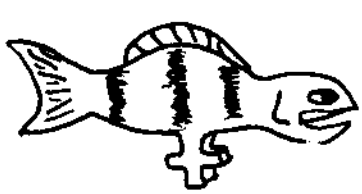
ANSWER: ANY NUMBER OVER 100 WOULD BE WRONG!

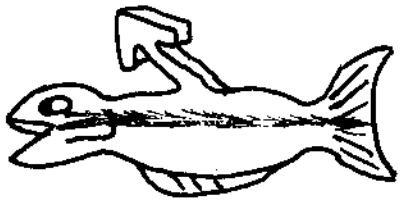
IN ADDITION TO KNOWING HOW MANY YOUNG WILL BE PRODUCED BY AN INDIVIDUAL OR A POPULATION IT WILL ALSO BE USEFUL TO KNOW THE NUMBER OF MALES PER FEMALE (THIS IS CALLED THE **SEX RATIO**). YOU MIGHT SAY THAT EACH SPECIES HAS AN "IDEAL" BALANCE OF MALES AND FEMALES THAT IS NECESSARY FOR COMPLETE FERTILIZATION AND REARING OF THE YOUNG.



INFORMATION ON SEX RATIOS CAN BE EASILY GATHERED BY CAPTURING A SAMPLE OF SPECIMENS, CUTTING OPEN THE BODY CAVITY AND DETERMINING THEIR SEX. WHEN IN REPRODUCTIVE CONDITION, MALES OF MOST SPECIES HAVE GONADS (TESTES) WHICH ARE WHITE AND SMOOTH IN TEXTURE. FEMALES, ON THE OTHER HAND, HAVE GONADS (OVARIES) WHICH ARE USUALLY YELLOW (IT CAN RANGE FROM CREAM TO ORANGE!) AND GRANULAR IN APPEARANCE. IN SOME SPECIES, ESPECIALLY THOSE JUST READY TO SPAWN, YOU CAN MERELY PRESS THE BELLY AND A WHITE, MILKY FLUID (FOR MALES) OR LITTLE ROUND YELLOW BEADS (FOR FEMALES) WILL BE FORCED OUT THE GENITAL OPENING NEAR THE ANUS. THIS CAN ALLOW YOU TO DETERMINE THE SEX QUITE EASILY AND WITHOUT BECOMING A SURGEON!

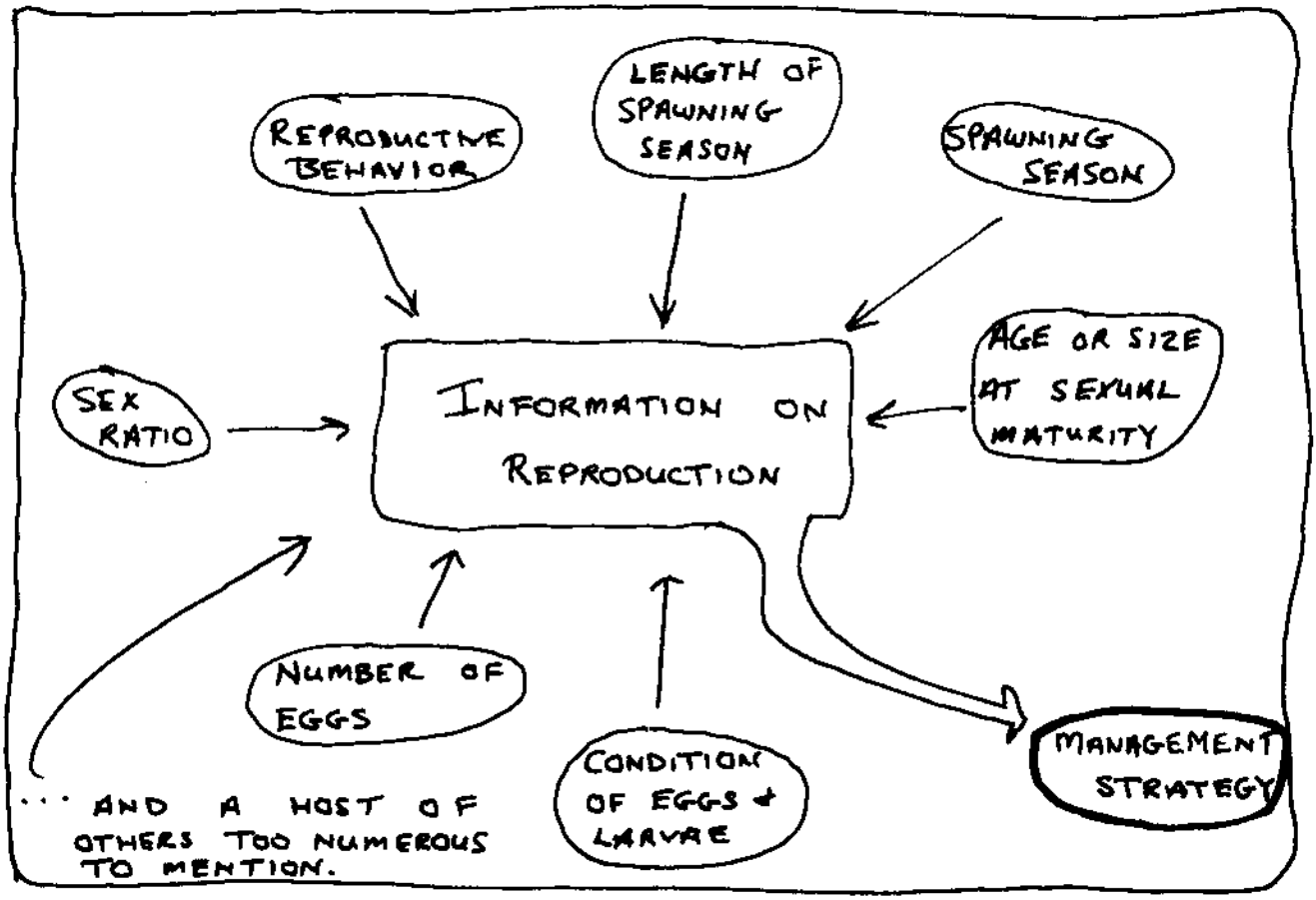
THE SEX IN SOME SPECIES CAN BE DETERMINED OFTEN WITHOUT ANY OF THIS MANIPULATION. SOME SPECIES DISPLAY <u>SEXUAL DIMORPHISM</u> (SEXUAL DIFFERENCES IN SHAPE OR SIZE BETWEEN MALES AND FEMALES) OR <u>SEXUAL DICHROMATISM</u> (DIFFERENCES IN COLOR BETWEEN SEXES) OR BOTH.





ALONG WITH KNOWING THE NUMBER OF EGGS AND SEX RATIO, IT IS OFTEN ESSENTIAL TO HAVE DATA ON ♂♀ 1) THE TIME OR SEASON OF SPAWNING, 2) THE DURATION OF THE SPAWNING PERIOD, AND - - - 3) THE AGE OR SIZE WHEN EACH SEX BECOMES SEXUALLY MATURE.

THESE DATA ARE GATHERED BY CAREFUL EXAMINATION OF LARGE SAMPLES OF INDIVIDUALS IN A FISHERY OVER THE ENTIRE YEAR. AS WE WILL SEE LATER THIS INFORMATION WILL ALSO BE USEFUL IN CONSTRUCTING A MANAGEMENT PLAN FOR ANY FISHERY.



INFORMATION ON REPRODUCTIVE CONDITION AND CAPACITY IS IMPORTANT BUT IT BECOMES EVEN MORE USEFUL WHEN IT IS USED IN CONJUNCTION WITH THE ENVIRONMENTAL FACTORS WHICH INFLUENCE OR CONTROL HOW MANY YOUNG ARE PRODUCED AND WHEN THOSE YOUNG ARE PRODUCED. LOOKING AT FIGURE 12., WE CAN SEE SOME OF THE ENVIRONMENTAL FACTORS WHICH OFTEN INFLUENCE THE REPRODUCTIVE CONDITION (AND ULTIMATELY FECUNDITY) OF AN INDIVIDUAL. FOOD AVAILABILITY IS OBVIOUSLY IMPORTANT BECAUSE THIS IS THE SOURCE OF ENERGY AN ORGANISM USES TO MAKE EGGS AND SPERM (AND TO SWIM AROUND AND MAKE (--AH EM--) ENTICING GESTURES TO MEMBERS OF THE OPPOSITE SEX). LIKEWISE, INCREASED OR DECREASED ENVIRONMENTAL STRESS CAN HAVE AN INFLUENCE ON AN ORGANISM'S REPRODUCTIVE CONDITION.

WHEN IT COMES TO CONTROLLING THE ONSET OF SPAWNING AND THE DURATION OF THE REPRODUCTIVE SEASON MOST ORGANISMS USE A VARIETY OF CUES IN THE ENVIRONMENT. IN FIGURE 13. WE CAN SEE THAT $^{a}_{o}$ DAYLENGTH (AMOUNT OF SUNLIGHT), SUBSTRATE, TEMPERATURE, AMOUNT + TYPE OF FOOD ARE SOME OF THE MORE INFLUENTIAL FACTORS WHICH SERVE AS CUES.

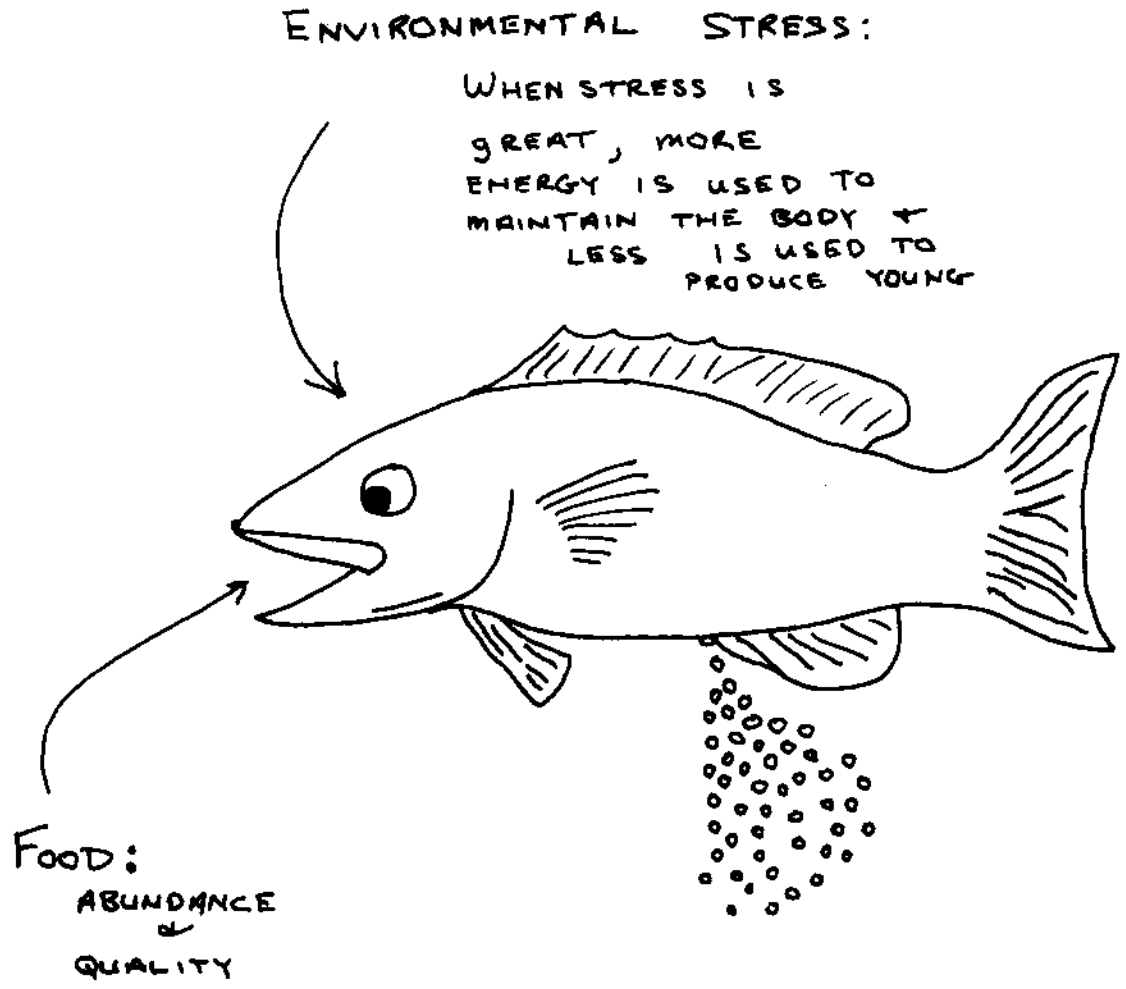


FIGURE 12. FACTORS AFFECTING THE NUMBER AND QUALITY OF EGGS. A RELIABLE COUNT OF EGGS CAN BE USED TO REPRESENT FECUNDITY. FECUNDITY CAN, IN TURN, BE USED TO GAUGE FUTURE CHANGES IN POPULATION SIZE.

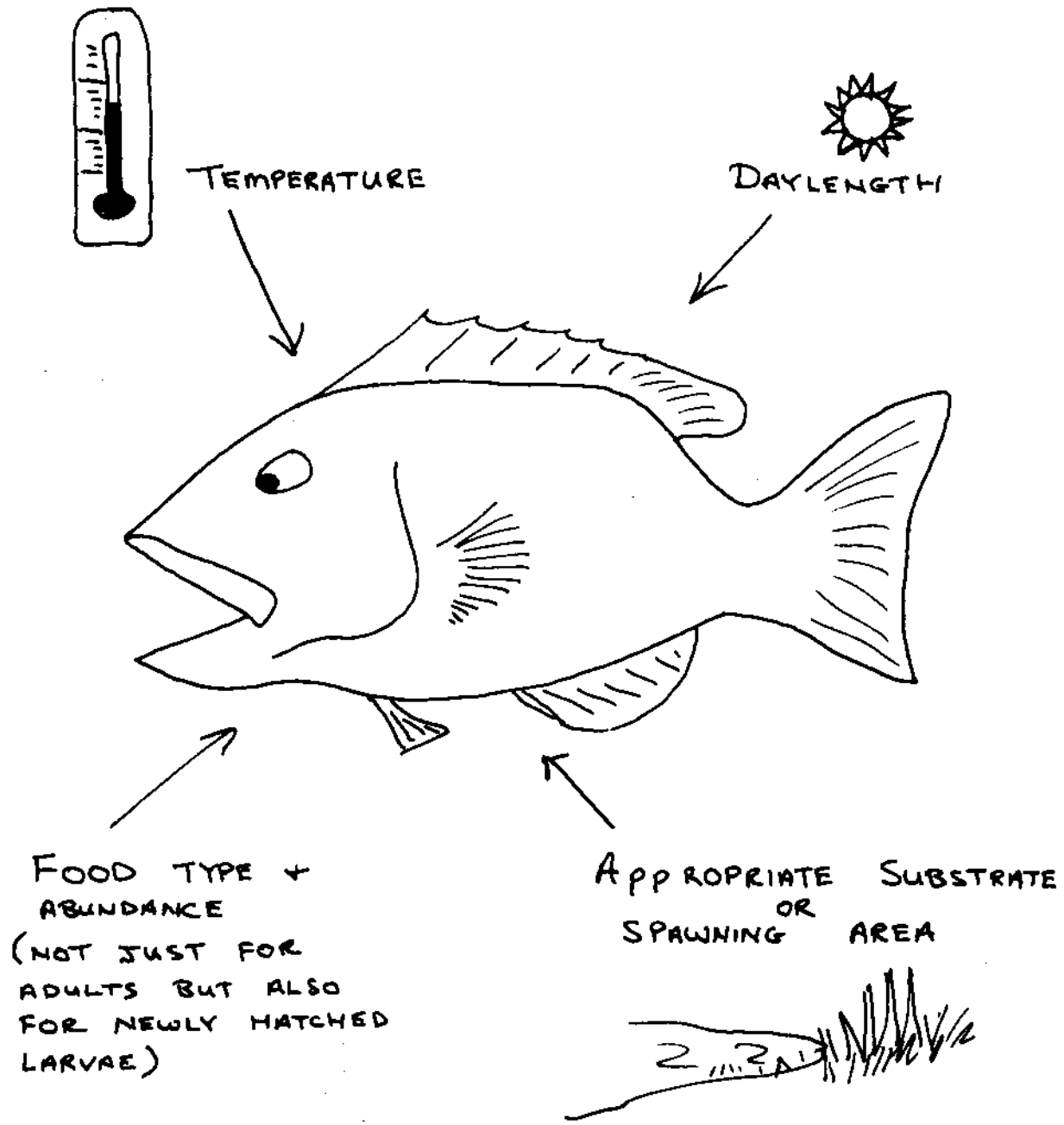


FIGURE 13. FACTORS OFTEN KNOWN TO AFFECT WHEN, WHERE, + HOW LONG SPAWNING OCCURS.

OF COURSE EACH SPECIES CAN BE QUITE DIFFERENT WITH REGARD TO WHAT FACTOR OR FACTORS AFFECT ITS REPRODUCTION. ALSO THE DEGREE TO WHICH EACH FACTOR AFFECTS REPRODUCTION MAY BE DIFFERENT. FOR EXAMPLE, ONE SPECIES MAY ONLY REACH REPRODUCTIVE READINESS AFTER A PERIOD OF RISING WATER TEMPERATURE AND LONGER PERIODS OF DAYLIGHT. THESE SPECIES ARE USUALLY CALLED WARM SEASON SPAWNERS, GROUPER AND SNAPPER ARE GOOD EXAMPLES. ON THE OTHER HAND, ANOTHER SPECIES MAY REQUIRE COLDER TEMPERATURES AND SHORTER PERIODS OF DAYLIGHT IN ORDER TO ATTAIN REPRODUCTIVE READINESS. THESE ARE CALLED COLD SEASON SPAWNERS + MULLET AND CROAKER WOULD BE GOOD EXAMPLES HERE. SOME SPECIES WON'T SPAWN AT ALL UNLESS THE NECESSARY SUBTRATE IS PRESENT WHILE OTHERS REQUIRE JUST THE RIGHT AMOUNT AND KIND OF FOOD. TO COMPLICATE THIS EVEN FURTHER SOME SPECIES MAY NEED UNIQUE COMBINATIONS OF THESE AND OTHER FACTORS. IN OTHER WORDS EACH SPECIES CAN BE QUITE DISTINCT WITH REGARD TO THE ENVIRONMENTAL SITUATION IT NEEDS TO REPRODUCE (OR PERHAPS MAXIMIZE ITS REPRODUCTIVE POTENTIAL).

IF WE ARE TO MANAGE, OR AT LEAST PREDICT, THE SPAWNING POTENTIAL (AND HENCE THE POTENTIAL NUMBER OF FISH IN A FISHERY) WE NEED TO KNOW WHAT THE FACTORS AND THEIR LIMITS ARE.

BY NOW YOU ARE PROBABLY AWARE THAT EACH SPECIES IS OFTEN QUITE DIFFERENT FROM OTHER SPECIES WITH REGARD TO WHAT IS CALLED ITS REPRODUCTIVE STRATEGY. BY REPRODUCTIVE STRATEGY WE MEAN THE SUM TOTAL OF ALL THE FEATURES ASSOCIATED WITH PRODUCING YOUNG. THESE INCLUDE: HOW AND WHEN THEY REPRODUCE, HOW MANY YOUNG, HOW MUCH PROTECTION FOR THE OFFSPRING, MATING BEHAVIOR, MATE SELECTION, AND OF COURSE A HOST OF OTHER FEATURES.

MOST SPECIES HAVE SEPARATE SEXES, THAT IS, THEY EXIST AS EITHER MALES OR FEMALES. YOU MIGHT BE SURPRISED TO LEARN, HOWEVER, THAT MANY SPECIES ARE NOT SO "STRAIGHT!"

HERMAPHRODITISM (WHICH MEANS THAT AT SOME TIME DURING ITS LIFE, AN ORGANISM IS BOTH MALE AND FEMALE - IT CAN CHANGE SEX OR BEAR BOTH GONAD TYPES) OCCURS WIDELY IN AQUATIC ORGANISMS. FOR EXAMPLE, GROUPERS START OUT LIFE AS A FEMALE AND THEN (PROBABLY DEPENDING ON THE LOCAL CIRCUMSTANCES SUCH AS THE SEX RATIO IN THE GROUP) SWITCHES OVER TO BEING A MALE. SOME SPECIES SUCH AS THE SMALLER SEA BASSES CAN FUNCTION AS BOTH MALE AND FEMALE AT THE SAME TIME. THIS REPRODUCTIVE MODE SEEMS EXTRAORDINARY BUT IT OCCURS OFTEN ENOUGH THAT WE MIGHT NEED TO CONSIDER IT IN OUR MANAGEMENT OF SOME FISHERIES.

MOST AQUATIC ORGANISMS DEPOSIT THEIR EGGS OR SPERM IN THE WATER WHEN REPRODUCTION TAKES PLACE. THIS REPRODUCTIVE MODE OF EXTERNAL FERTILIZATION MEANS THAT A NEWLY FORMED YOUNG MUST GET ALL ITS INITIAL FOOD SUPPLY (AT LEAST UNTIL IT HATCHES) FROM ITS YOLK SUPPLY. MANY ORGANISMS HAVE OPTED FOR A MUCH DIFFERENT REPRODUCTIVE MODE. THEY PRACTICE INTERNAL FERTILIZATION WHERE THE MALE DEPOSITS SPERM (OR MILT) INTO THE FEMALE.

THESE INTERNALLY FERTILIZING SPECIES OFTEN RETAIN THE YOUNG DEVELOPING EMBRYOS IN THEIR BODY CAVITIES WHERE IN SOME SPECIES THE EMBRYOS ACTUALLY GET SOME ADDITIONAL FOOD OR NUTRITION FROM THE FEMALE. AS YOU MIGHT SUSPECT, SPECIES WITH INTERNAL FERTILIZATION USUALLY PRODUCE MUCH FEWER OFFSPRING THAN EXTERNALLY FERTILIZING SPECIES. THE GAME PLAN IS THAT WHAT THE PARENTS SACRIFICE BY NOT PRODUCING AS MANY YOUNG, THEY GAIN BY HAVING MUCH HIGHER SURVIVABILITY OF THOSE YOUNG THAT THEY ACTUALLY DO PRODUCE.

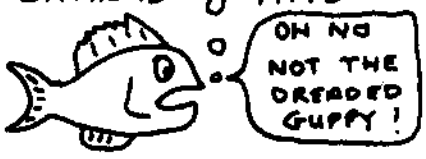
EXAMPLES OF GROUPS WITH INTERNAL FERTILIZATION

INVERTEBRATES	VERTEBRATES
SQUID	SHARKS
OCTOPUS	SKATES
SOME SNAILS	RAYS
SHRIMP	WHALES
CRABS	SEALS
LOBSTER	WALRUS

... AND DON'T FORGET -- GUPPIES!

Some species which fertilize their eggs externally try to help the survivability of their young along by protecting them. This is often done by depositing the eggs in a nest where they remain to be guarded by either or both of the parents. Another way is for one of the parents to "brood" them by gathering up the newly formed young in their mouth (as in sea catfish) or put them in a pouch (as in sea horses + pipe fish).

Internally fertilizing species deliver varying amounts of nutrients to their offspring while they are developing inside the body of the female. Sometimes this development is short-lived and the female gives birth to a fertilized egg. In this case most development will take place in the water. At the other extreme the females may retain the young for considerable periods and supply a large portion of the energy to her young while in her body cavity. The species are known as <u>LIVEBEARERS</u>. Good examples would be some sharks ○ and of course - - -

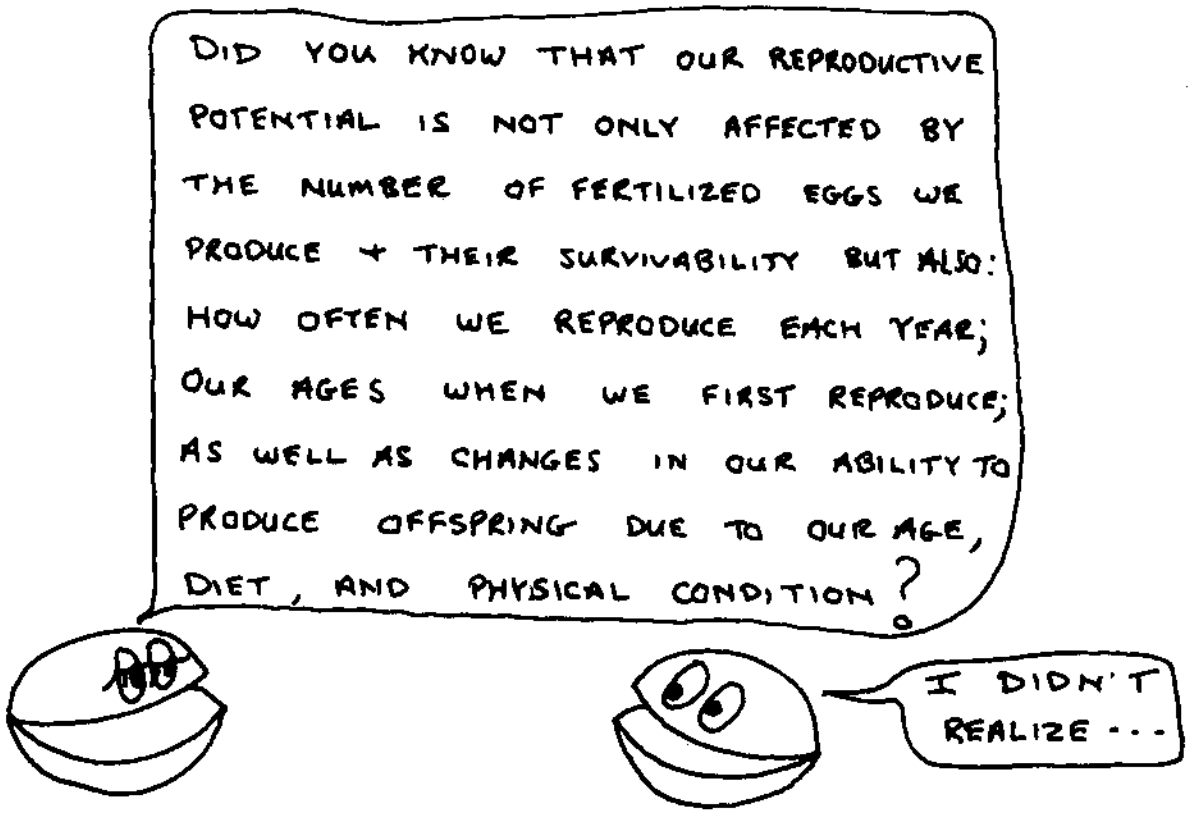


GUPPIES!

We've covered a variety of reproductive modes thus far, but a few other types are important enough to fisheries biologists so we'll consider those as well. Some species reproduce or spawn in a group situation. Depending upon the species, it could consist of a massed spawn involving all the males and females coming together and releasing their eggs and sperm into the water. Herring would be an example of fish with "group" spawning. Sometimes the "group" can resemble a "harem" in that one male mates with several females (or even one female with many males). Other times, especially among reef associated fishes, <u>paired</u> (male + female) spawning is the usual reproductive behavior. This "paired" spawning often involves elaborate prereproductive courtship dances and color displays. The type of 'dance' is often particular to each species.

NOW THAT WE HAVE AN IDEA WHY ORGANISMS REPRODUCE, WHAT FACTORS GENERALLY CONTROL IT, AND HOW WE MEASURE OR MONITOR REPRODUCTIVE POTENTIAL OR CAPACITY, LET'S LOOK BRIEFLY AT HOW THIS INFORMATION CAN BE OF USE IN FISHERIES BIOLOGY.

KNOWING A SPECIES' REPRODUCTIVE POTENTIAL (THAT IS — THE NUMBER OF YOUNG LIKELY TO BE PRODUCED IN ANY GIVEN YEAR) WILL LET US SPECULATE REGARDING THE POTENTIAL YIELD (OR CATCH) THAT CAN BE TAKEN FROM THE FISHERY AT A FUTURE TIME.



ANOTHER REASON FOR GATHERING INFORMATION ON A SPECIES' REPRODUCTION IS TO BE ABLE TO DEVELOP MANAGEMENT TECHNIQUES DESIGNED TO REDUCE THE IMPACT OF FISHING ON THE STOCK SIZE OR IT'S ABILITY TO RECOVER FROM FISHING ACTIVITY. FOR EXAMPLE, WE MIGHT STUDY A SITUATION AND DECIDE THAT CATCH LEVELS IN THE FUTURE MAY NOT BE LOWERED IF WE WAIT UNTIL AFTER A SPECIES' REPRODUCTIVE PEAK OR SPAWNING SEASON. SIMILARLY WE MAY FIND OUT THAT BY CAPTURING MALES AND RELEASING THE FEMALES THAT ACCEPTABLE POPULATION AND CATCH LEVELS CAN BE SUSTAINED. ON THE OTHER HAND WE MIGHT LEARN FROM OUR STUDIES ON REPRODUCTION WHERE A SPECIES' SPAWNING AREA IS LOCATED. THIS COULD MAKE CAPTURING THEM (AND, IN TURN, THE FISHERY) MORE EFFICIENT.

OVERALL - INFORMATION ON REPRODUCTION WILL YIELD AN IMPORTANT SET OF DATA ON THE LIFE HISTORY OF ANY SPECIES. THIS WILL ALLOW US TO WISELY MANAGE AND MORE EFFICIENTLY EXPLOIT OUR STOCKS OF AQUATIC ORGANISMS.

II. WHERE HAS IT BEEN AND WHERE WILL IT GO?

THE MIGRATION OR MOVEMENT PATTERNS AND ROUTES THAT AQUATIC ORGANISMS USE PLAY AN INTEGRAL PART IN THEIR LIFE HISTORY AND THEIR SURVIVAL. THESE MOVEMENTS ARE IMPORTANT AND CONSIDERATION SHOULD BE GIVEN TO WHERE THEY MOVE, HOW THEY MOVE, WHEN THEY MOVE AND ALSO WHY THEY MOVE. MANY SPECIES MAKE DAILY, SEASONAL OR LIFE LONG EXCURSIONS FOR A VARIETY OF REASONS:

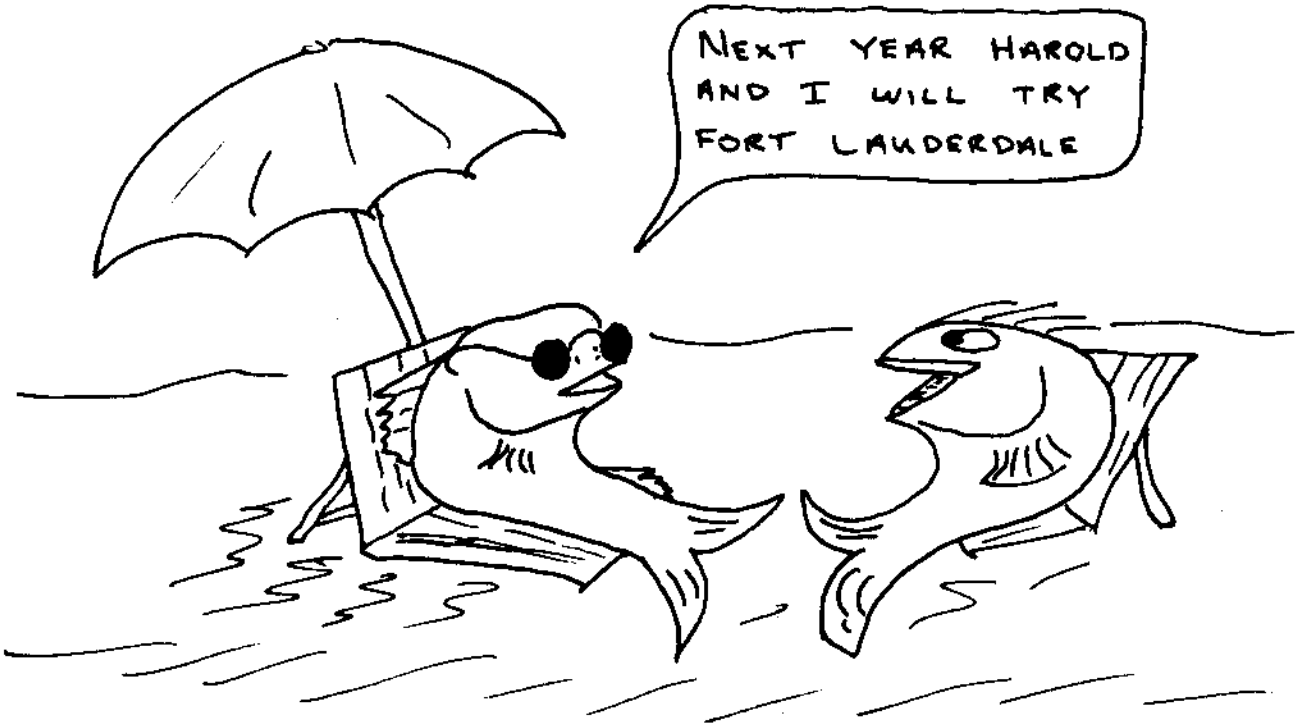
(1) **FOOD** — SEARCHING FOR SPECIFIC FOOD TYPES OR FOLLOWING A FOOD SOURCE WHICH IS ITSELF FOLLOWING A MIGRATORY PATTERN.

(2) **TEMPERATURE** — SINCE MOST AQUATIC ANIMALS (EXCEPT THE BIRDS AND MAMMALS) ARE COLD BLOODED, THEY MAY MOVE IN AN ATTEMPT TO REGULATE THEIR BODY TEMPERATURE. AS WATER TEMPERATURE CHANGES WITH SEASON OR LATITUDE THEY MOVE TO BE IN THE 'RIGHT' WATER TEMPERATURE.

③ **WATER CONDITIONS** — TURBIDITY, SALINITY, PHYTOPLANKTON PRODUCTIVITY, ETC. CAN VARY SEASONALLY OR DAILY. ANIMALS OFTEN MOVE TO OPTIMIZE THEIR CHANCE OF SURVIVAL.

REMEMBER - WHEN STRESSED AN ORGANISM CAN ADAPT, MIGRATE, OR DIE!

④ **REPRODUCTION** — MOVEMENT OF ADULTS TO A CERTAIN PLACE OR AREA FOR MATING OR TO PROVIDE A GOOD PLACE FOR THEIR YOUNG TO SURVIVE.

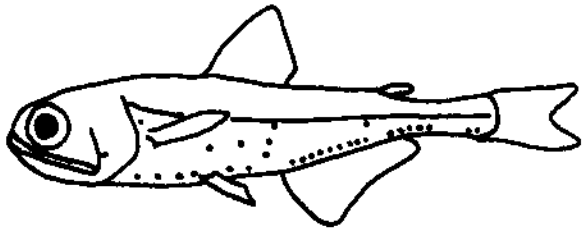


THE EXTENT OF THESE MIGRATIONS CAN BE TREMENDOUS — HUNDREDS OR EVEN THOUSANDS OF MILES, AS IN THE CASE OF THE BLUE FIN TUNA AND SEVERAL SPECIES OF PACIFIC SALMON.

NEWS FLASH - - -

IN THE MARCH 1985 ISSUE OF THE MAGAZINE **SEA TECHNOLOGY** IT WAS ANNOUNCED THAT A BLACK MARLIN CAUGHT OFF BAJA CALIFORNIA WAS RECAPTURED TWO YEARS LATER OFF NEW ZEALAND - OVER 5763 NAUTICAL MILES AWAY!

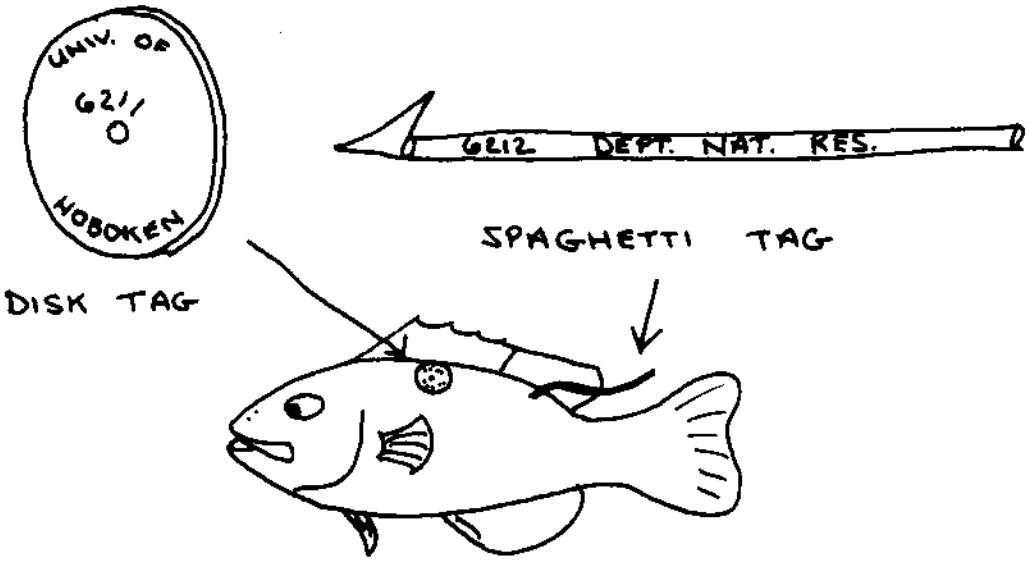
SOMETIMES THE MIGRATIONS MAY BE JUST UP RIVER— DOWN RIVER OR INSHORE — OFFSHORE. SOME SPECIES' MOVEMENTS INCLUDE EXTENSIVE VERTICAL MIGRATIONS IN THE WATER COLUMN. THE BEST EXAMPLE OF THIS TYPE OF MIGRATION WOULD BE THE STRANGE AND RARELY SEEN LANTERN FISH (WHOSE BODIES ARE COVERED WITH LIGHT PRODUCING ORGANS) WHICH CAN MAKE DAILY UP-AND-DOWN MOVEMENTS OF OVER 2000 FEET!



OFTEN THE MIGRATION PATTERNS HAVE TO DO WITH CHANGES IN SOME ASPECT OF A SPECIES' LIFE HISTORY. FOR EXAMPLE, EGGS MAY BE DEPOSITED IN ONE AREA, LARVAE MAY DRIFT TO ANOTHER AREA, YOUNG ADULTS TO ANOTHER, AND FINALLY SEXUALLY MATURE ADULTS MAY MOVE BACK TO THE SPOT WHERE THEY WERE ORIGINALLY DEPOSITED AS EGGS.

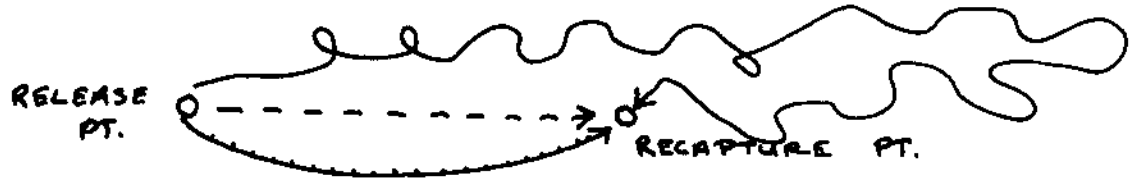
THERE ARE MANY WAYS USED TO LEARN ABOUT THE MOVEMENTS OR MIGRATORY PATTERNS OF AQUATIC ORGANISMS. THE MOST OFTEN WAY IS BY REMEMBERING WHERE AND WHEN THEY'VE BEEN CAUGHT. THIS MAY NOT SEEM SCIENTIFIC, BUT THROUGH THE ACCUMULATION OF COMMERCIAL AND RECREATIONAL FISHERY STATISTICS AND MENTAL (AND WRITTEN) NOTES MADE BY FISHERMEN OVER THE YEARS, — — A PICTURE OF WHERE AND WHEN CERTAIN SPECIES OR STOCKS OCCUR EMERGES.

ANOTHER WAY TO LEARN ABOUT THEIR MIGRATORY PATTERNS IS TO 'TAG' OR 'MARK' THEM IN SOME FASHION. TYPICALLY TAGS ARE PLASTIC DISKS OR STRANDS WHICH HAVE AN IDENTIFICATION NUMBER AND SOME OTHER INFORMATION SO THE FINDER CAN SEND IN DATA RELEVANT TO THE CAPTURE OF THE ORGANISM.



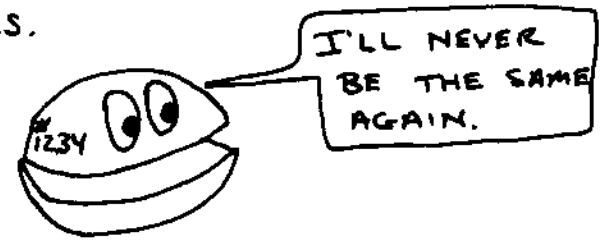
SINCE THE FISHERY BIOLOGIST HAS ALREADY RECORDED THE SPECIMEN'S SPECIES TYPE, ITS SIZE, + WHERE, AND WHEN IT WAS RELEASED, HE OR SHE CAN COMPARE THE SAME INFORMATION OBTAINED FROM A FINDER OF THE WAYWARD ORGANISM. FROM THE DATA GATHERED WE CAN GET SOME IDEA AS TO HOW FAR IT MOVED, HOW LONG IT TOOK TO GET THERE AND HOW MUCH IT GREW IN THE MEANTIME.

BY THE WAY --- TAGGING STUDIES ONLY LET US KNOW THE RELEASE AND RECAPTURE POINTS, THE EXACT PATH TAKEN BETWEEN THE TWO POINTS CAN ONLY BE GUESSED AT.



ALL THREE ROUTES COULD HAVE BEEN TAKEN!

OTHER MEANS OF 'MARKING' OR 'TAGGING' ORGANISMS ARE ALSO USED SUCH AS: MAGNETIC OR METAL STRIPS (INSIDE OR OUTSIDE THE BODY), HOT OR COLD BRANDING IRONS, COLORED DYES, AND SEVERAL SIMPLER METHODS SUCH AS CLIPPING FINS FROM FISH OR WRITING WITH PERMANENT INK ON MOLLUSK SHELLS.



SO-CALLED BIOLOGICAL OR NATURAL TAGS ARE ALSO USED. THE STOCK IS "RECOGNIZED" OR IDENTIFIED BY ITS PHYSICAL CHARACTERS SUCH AS COLOR PATTERN, NUMBER OF SPINES, NUMBER OF SCALES, OR BODY SHAPE. OTHER CHARACTERS CAN ALSO BE USED SUCH AS A UNIQUE SET OF BLOOD PROTEINS, OR EVEN THE TYPE OF PARASITES SOME GROUPS HAVE.

IN RECENT YEARS MINIATURE RADIO TRANSMITTERS HAVE BEEN PLACED ON (OR IN) SOME ANIMALS AND THEIR MOVEMENTS ARE THEN MONITORED. THIS TYPE OF 'TAG' OBVIOUSLY GIVES US COMPLETE INFORMATION REGARDING AN INDIVIDUAL'S MOVEMENT, BUT AS YOU CAN IMAGINE, IT TAKES BIG BUCK$ TO CONDUCT THESE STUDIES.

KNOWING THE MIGRATION PATTERN FOR A SPECIES IS A DEFINITE ADVANTAGE FOR FISHERMEN AND FISHERY BIOLOGISTS. IF WE ARE TO EFFECTIVELY MANAGE A STOCK, WE HAVE TO BE SURE IT'S THE SAME STOCK WE ARE ALWAYS TALKING ABOUT. LIKEWISE THERE ARE SOME ASPECTS OF A SPECIES' MIGRATION PATTERN THAT MAY REQUIRE SPECIAL MANAGEMENT CONSIDERATIONS. FOR EXAMPLE, IN FLORIDA, THERE IS SOME EVIDENCE INDICATING THAT MULLET STOCKS ARE DECLINING. SOME COUNTY GOVERNMENTS HAVE SOUGHT TO REDUCE THIS DECLINE BY HALTING FISHING WHILE MULLET MAKE THEIR MIGRATION OFFSHORE TO SPAWN. THIS SOUNDS GREAT EXCEPT THAT WE HAVE NO IDEA WHERE THE LARVAE FROM THESE MULLET GO AFTER THEY HATCH. THEY MAY COME BACK TO THEIR "HOME" ESTUARY OR THEY MAY NOT. STUDIES ON THE MIGRATION OF THE LARVAE WOULD HELP RESOLVE THE EFFECTIVENESS OF THE PROPOSED MANAGEMENT STRATEGY.

THOUGHT WE WERE FINISHED?

HOW ABOUT A FEW MORE QUESTIONS JUST TO ROUND THINGS OUT? . . . LIKE . . .

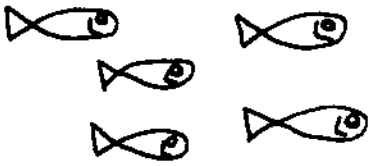
WHAT CAN STUDYING THEIR BEHAVIOR TELL US?

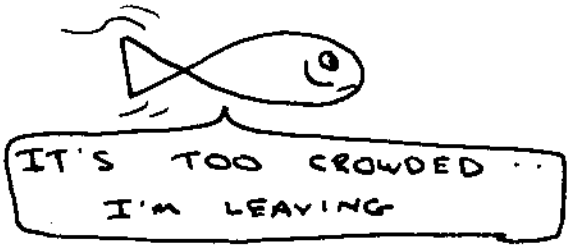
STUDYING AN ANIMAL'S BEHAVIOR (OR ITS **ETHOLOGY**, AS IT IS KNOWN TO THE GUYS IN THE WHITE LAB COATS) IS A WAY OF GATHERING IMPORTANT INFORMATION ABOUT SPECIES WHICH COMPRISE A FISHERY. JUST AS IMPORTANT AS KNOWING THE GROWTH RATE OF A FISH, KNOWING ITS BEHAVIOR CAN GIVE US A PICTURE AS TO <u>WHAT</u> IT'S DOING AND HOW IT DOES IT. THIS IN ITSELF MAY NOT SEEM SO EARTH-SHAKING BUT WHEN WE RELATE THE SPECIES' BEHAVIOR TO ITS ROLE IN THE AQUATIC COMMUNITY OR FISHERY, IT MAKES SUCH INFORMATION WORTHWHILE.

We have already looked at the impact and significance of one type of behavioral information called MIGRATION, but there are many other aspects of a species' behavior that should be considered as well. These can include: competition, habitat choice, response to a stress, or even mating behavior + mate choice.

Competition for food or space with another species or even with members of the same species is certainly one aspect of behavior we should know about. Many people think that COMPETITION, or how different organisms behaviorally interact, is one of the most important aspects in the life of a species. The effects of competition can certainly be far reaching. If competition for food, for example, becomes great then some individuals may not have

AS MUCH FOOD ENERGY AVAILABLE TO THEM TO GROW OR REPRODUCE. THIS COULD MEAN THAT THE SIZE OR NUMBER OF INDIVIDUALS IN A FISHERY MAY BE REDUCED. SIMILARLY, A SPECIES UNDER THE PRESSURE OF STRESS CREATED BY COMPETITION MAY MOVE OR MIGRATE TO ANOTHER AREA TO AVOID THE COMPETITION.





BOTH THESE TYPES OF RESPONSES TO STRESS CAUSED BY COMPETITION (THAT IS, CHANGES IN LIFE HISTORY FEATURES SUCH AS GROWTH - AND - REPRODUCTION AND MIGRATION) WOULD BE IMPORTANT TO KNOW AND PREDICT. THIS WOULD BE ESPECIALLY TRUE IF WE WERE THINKING OF INTRODUCING A NEW SPECIES INTO AN AREA. ADDING ANOTHER SPECIES WOULD PROBABLY INCREASE COMPETITION. IT WOULD BE NICE TO BE ABLE TO PREDICT, BASED ON PAST EXPERIENCE AND DATA, WHAT CHANGES IN LIFE HABITS WE COULD EXPECT BECAUSE OF OUR NEW ADDITION.

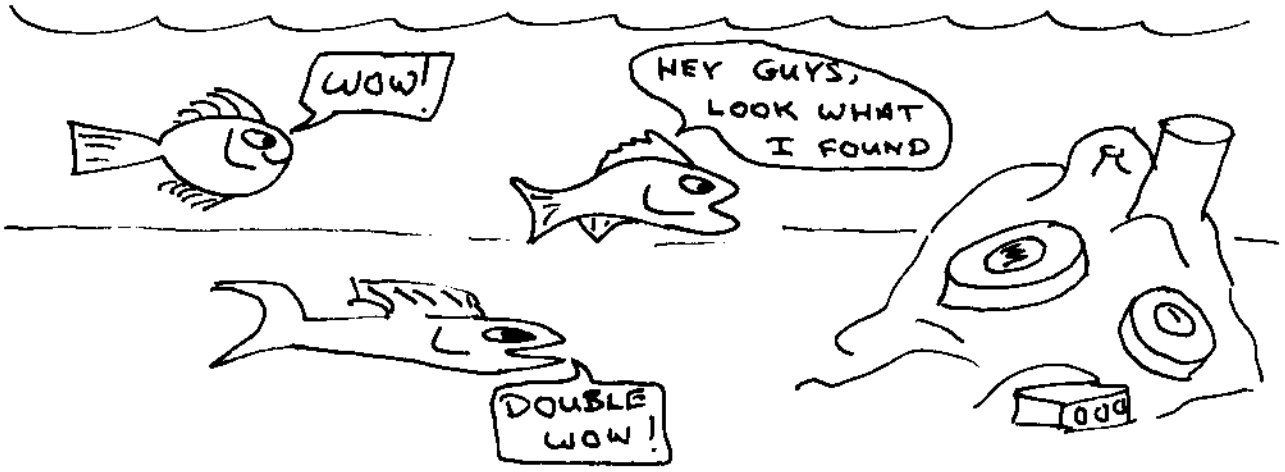
EARLIER WE LEARNED THAT THE ENVIRONMENT CONSISTS OF A NUMBER OF FEATURES OR FACTORS. WHEN ONE OR SOME OF THESE FACTORS CHANGE, THE NET EFFECT ON THE ORGANISMS MIGHT BE SEEN AS A CHANGE (FOR BETTER OR WORSE - JUST LIKE A MARRIAGE!) IN THE WAY THEY BEHAVE. IN ORDER TO PREDICT HOW AN ANIMAL RESPONDS TO AN ENVIRONMENTAL CHANGE OR STRESS, SCIENTISTS CONDUCT LABORATORY EXAMINATIONS. THESE STUDIES CAN OFTEN GIVE A GOOD INDICATION OF HOW A SPECIES WILL RESPOND IN A "REAL WORLD" SITUATION.

OFTEN THE VERY FIRST AND MOST NOTICEABLE EFFECT WE'LL NOTE ABOUT A SPECIES' RESPONSE TO ENVIRONMENTAL CHANGE IS ITS BEHAVIOR. THUS, STUDIES ON THE BEHAVIORAL RESPONSES SPECIES MAKE UNDER LABORATORY CONDITIONS CAN ALLOW FISHERY BIOLOGISTS TO

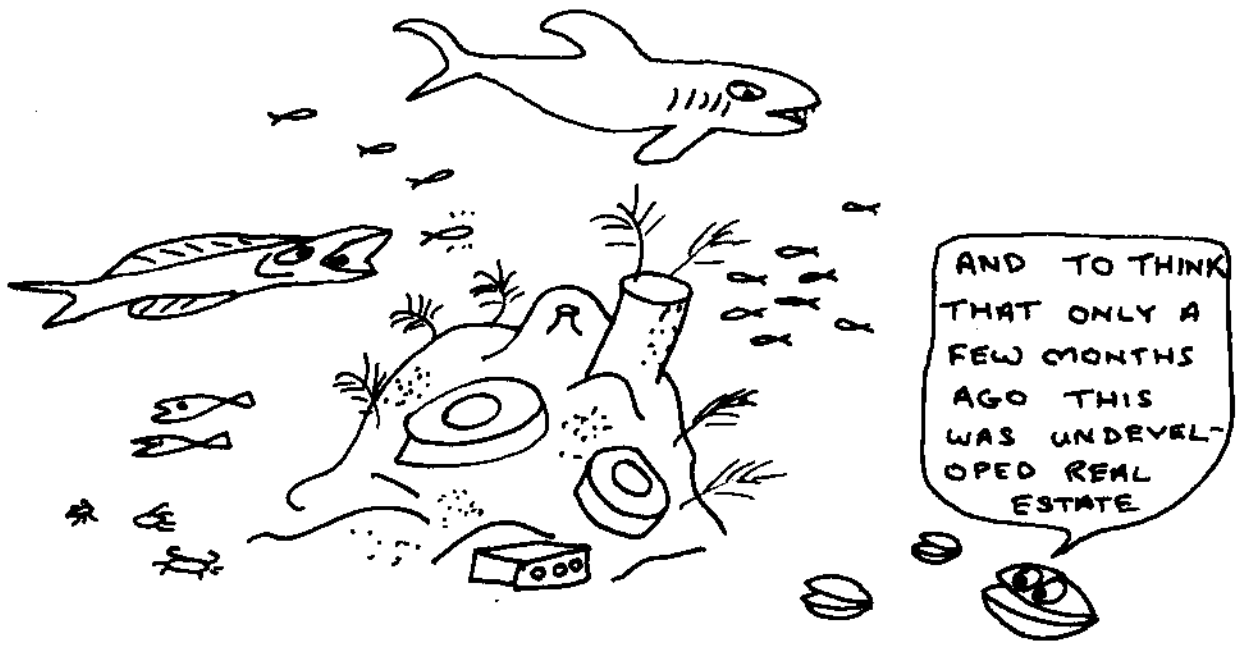
PREDICT THE EFFECTS A CHANGE IN THE ENVIRONMENT COULD HAVE ON THE NATURAL POPULATION.

REMEMBER - THESE CHANGES COULD RESULT IN THE ENHANCEMENT OF A FISHERY AS WELL AS ITS DEMISE!!!

SOME OF THE RECENT RESEARCH ON THE CONSTRUCTION AND EMPLACEMENT OF ARTIFICIAL REEFS INDICATES HOW USEFUL INFORMATION ON A SPECIES BEHAVIOR CAN BE. MOST FISH RESPOND TO THE PRESENCE OF STRUCTURES IN THE WATER BY MOVING CLOSER TO THEM. IN FACT THE TYPICAL RESPONSE OF WANDERING MARINE ORGANISMS IS TO SETTLE ON OR NEAR STRUCTURES WHEN THEY FIND THEM.



FISHERIES SCIENTISTS SUSPECT THAT INITIALLY THESE STRUCTURES SERVE AS A PLACE TO ORIENT AROUND. LATER THE FISH MAY ESTABLISH TERRITORIES ON OR NEAR THE STRUCTURES. EVENTUALLY ENTIRE COMMUNITIES BECOME ESTABLISHED (AND IT ALL STARTED OUT AS A SIMPLE BEHAVIORAL RESPONSE !!!). ONCE THE COMMUNITY ESTABLISHES ITSELF, THEN COMPETITION FOR HIDING AND FEEDING SPACE OCCURS. EVEN MUCH LATER (SEVERAL MONTHS) SOME ANIMALS AND PLANTS (MAINLY ALGAE) WILL ATTACH TO THE STRUCTURES AND ESTABLISH THEMSELVES AS REEF RESIDENTS.



THE SUPPOSITION THAT THERE IS SOME OPTIMAL OR BEST DESIGN FOR ATTRACTING AND MAINTAINING THE PRIZED OR HIGHLY SOUGHT AFTER SPECIES, INSPIRES TODAYS ARTIFICIAL REEF RESEARCH.

BY STUDYING EACH SPECIES' RESPONSE TO A REEF AND ITS WAY OF LIVING ONCE ON THE REEF, WE CAN PERHAPS ONE DAY KNOW HOW, WHERE, AND WHEN TO BUILD ARTIFICIAL REEFS TO IMPROVE OUR CATCHES OF PREFERRED SPECIES AT A MINIMAL COST.

OVERALL STUDIES ON THE BEHAVIOR OF THE SPECIES ON WHICH VARIOUS FISHERIES ARE BASED CAN BE REWARDING FROM SEVERAL VIEW POINTS.

TURN PAGE FOR VIEW POINTS . . .

VIEWPOINT #1 – INFORMATION ON BEHAVIOR CAN GIVE US IMPORTANT CLUES AS TO BETTER WAYS TO MANAGE FISHERIES.

VIEWPOINT #2 – CONSIDERATION OF AN ANIMAL'S BEHAVIOR CAN BE JUST AS IMPORTANT WHEN MAKING MANAGEMENT DECISIONS AS INFORMATION ON ITS GROWTH, AGE, REPRODUCTION, OR FEEDING HABITS.

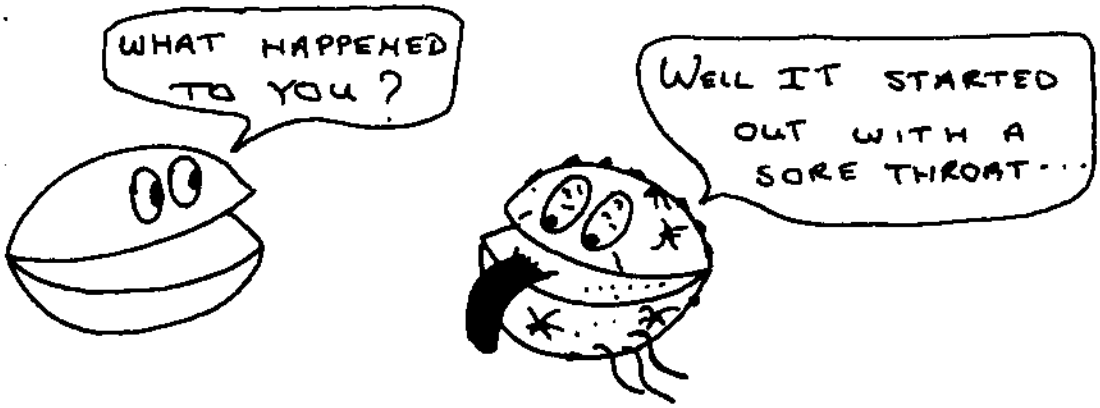
VIEWPOINT #3 – MANAGEMENT DECISIONS AND FISHING PRACTICES MUST TAKE A SPECIES' BEHAVIOR INTO ACCOUNT. FAILURE TO DO SO MAY MEAN DISRUPTION OF THE SPECIES' NORMAL AND NECESSARY BEHAVIORAL ACTIVITIES.

LAST VIEWPOINT – ADDITIONALLY, TAKING A SPECIES' BEHAVIOR INTO ACCOUNT MAY PROVIDE A USEFUL AND ESSENTIAL BIT OF INFORMATION WHICH WILL MAKE THE JOB OF MANAGING THE FISHERY NOT ONLY EASIER BUT 'MORE EFFICIENT.'

AND - - -

WHAT ABOUT DISEASES AND OTHER MEAN AND NASTY THINGS?

AQUATIC ORGANISMS SUCH AS FISH AND SHELLFISH ARE SIMILAR TO YOU AND ME WHEN IT COMES TO DISEASES AND INFECTIONS. THEY ARE SUSCEPTIBLE TO A WIDE RANGE OF BACTERIA AND VIRUSES THAT CAN CAUSE A VARIETY OF PROBLEMS. SOME OF THESE PROBLEMS INCLUDE: SKIN INFECTIONS WHICH CAN LEAD TO BLEEDING, EYE SORES THAT CAN CAUSE BLINDNESS, AND GILL ULCERATIONS THAT CAN INHIBIT BREATHING ABILITY. ALL OF THESE CAN SUBSEQUENTLY LEAD TO ADDITIONAL PROBLEMS AND EVEN LOWER AN ORGANISM'S RESISTANCE TO INFECTION FROM OTHER MEAN AND NASTY THINGS.



ULTIMATELY EVERY PART OF THE BODY IS SUSCEPTIBLE.

THE KINDS OF ORGANISMS THAT ARE OFTEN FOUND ON OR IN AQUATIC ORGANISMS ARE MANY. COPEPODS (ACTUALLY SMALL CRUSTACEANS) ARE OFTEN FOUND ATTACHED TO THE GILLS, SKIN, OR FINS OF FISHES. BECAUSE THEY ATTACH THEMSELVES ON THE OUTER SURFACES OF THE HOST, THEY ARE CALLED **ECTOPARASITES.** IT'S USUALLY THE FEMALE COPEPODS THAT ATTACH THEMSELVES TO THE HOST WITH SPECIAL CLAWS OR LIMBS. THEY OFTEN SUCK A BIT OF BLOOD OR RASP AWAY PIECES OF FLESH WHICH SERVE AS LUNCH!

YOU CAN EASILY SEE THE ECTOPARASITIC COPEPODS ON SOME FISH SPECIES BY LIFTING THE GILL COVER AND LOOKING FOR THE LITTLE FLESH-COLORED ANIMALS (ABOUT 1/8th — 1/16th OF AN INCH LONG) ON THE REDDISH SURFACE OF THE GILLS.

ENDOPARASITES ARE PARASITES WHICH LIVE INSIDE THE BODY OF THE HOST. ROUNDWORMS AND TAPEWORMS ARE JUST TWO EXAMPLES OF THESE. THEY EAT LITTLE BITS OF HOST AS WELL.

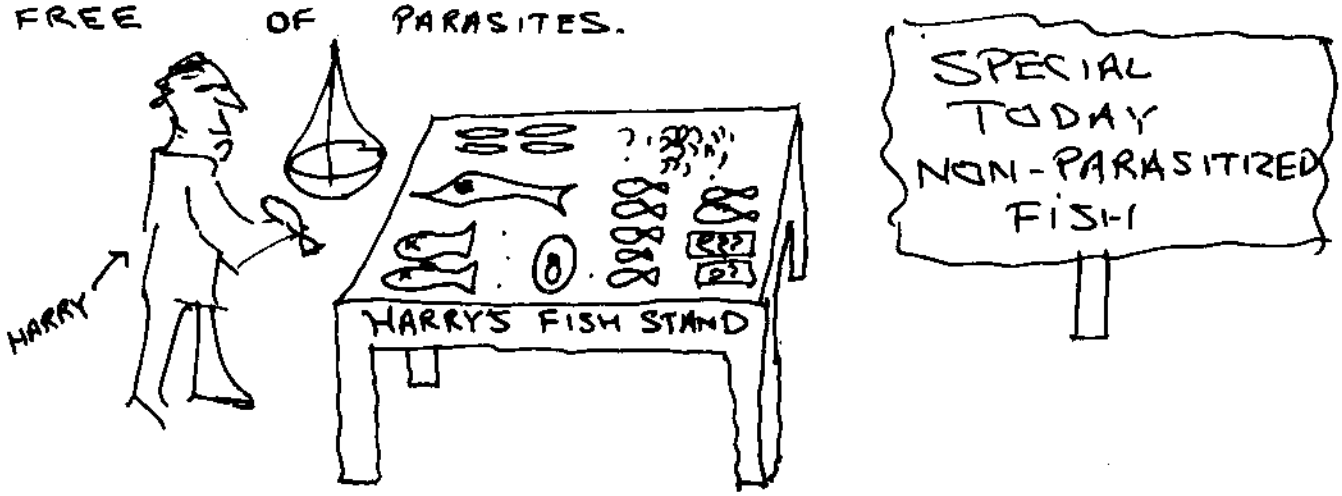
APART FROM BACTERIA AND VIRUSES, AQUATIC ORGANISMS CAN ALSO BE ATTACKED BY FUNGI. THESE MUSHROOM RELATED BEASTS OFTEN ATTACH AND GROW ON EXTERNAL BODY PARTS, ESPECIALLY THOSE AREAS THAT HAVE BEEN PHYSICALLY DAMAGED OR PREVIOUSLY INFECTED BY BACTERIA OR VIRUSES.

. . . . AND THAT'S NOT ALL THEY HAVE TO WORRY ABOUT (AND NEITHER DO YOU) BECAUSE THEY ARE ALSO SUSCEPTIBLE TO A WHOLE ARRAY OF BOTH EXTERNAL AND INTERNAL PARASITES. PARASITES ARE GENERALLY VERY SMALL ORGANISMS THAT EITHER ATTACH THEMSELVES TO SOME PORTION OF THE HOST ANIMAL'S EXTERNAL STRUCTURES SUCH AS FINS, GILLS, OR SKIN OR THEY ARE SWALLOWED AND LIVE INSIDE THE HOST. HERE THEY MAY STAY OR (DEPENDING ON THE EXACT KIND OF PARASITE) BURROW THROUGH OUT THE HOST'S INSIDES AND ENTER INTO OTHER ORGANS SUCH AS THE LIVER OR KIDNEYS.

PARASITES, FOR THE MOST PART, CAUSE LITTLE HARM TO THEIR HOST AQUATIC ORGANISM. MOST PARASITES ARE THEREFORE CONSIDERED TO BE **COMMENSAL**. THAT MEANS THEY GAIN SOMETHING FROM THE HOST (A LIGHT LUNCH!) BUT CAUSE LITTLE DAMAGE OR STRESS TO THE HOST ITSELF. HOWEVER, WHEN A HOST BECOMES HEAVILY INFESTED, WE OFTEN FIND THAT "HUNDREDS" OF LIGHT LUNCHES CAN ADD UP. THE RESULT IS OFTEN STRESSFUL ENOUGH TO KEEP THE HOST FROM LIVING A HEALTHY LIFE. THE EFFECTS FROM THIS STRESS COULD BE SUBTLE IN THAT THE GROWTH RATE MAY DECREASE OR FEWER EGGS MAY BE LAID. HOWEVER, IN SOME INSTANCES THE STRESS CAUSED BY PARASITISM CAN LOWER THE HOST'S RESISTANCE TO BACTERIA OR VIRUSES. THEY MIGHT EVEN INTERFERE WITH A VITAL FUNCTION OF THE HOST. WHEN THIS HAPPENS DEATH IS THE USUAL RESULT.

FROM A FISHERIES VIEW POINT WE WOULD WANT TO INSURE THAT THE PARASITES DON'T GET AN "UPPER HAND" ON THE SPECIES WE'RE INTERESTED IN. 'HEAVILY INFESTED MEMBERS OF A FISHERY' TRANSLATES TO SLOWER GROWTH, LOWER NUMBERS OF EGGS, AND EVENTUALLY TO LOWER PRODUCTIVITY (YIELD) FROM THE FISHERY.

ALSO FROM A FISHERIES VIEW POINT THE ASPECT OF MARKETABILITY IS OFTEN AN IMPORTANT CONSIDERATION. SOME PREFERRED FISH LIKE GROUPER OR SEA TROUT MAY HAVE PARASITIC WORMS IN THE MEAT. THE UNAPPETIZING APPEARANCE OF THESE HARMLESS PARASITES MAY DISSUADE SOME OF US FROM PURCHASING OR ATTEMPTING TO EAT THESE SPECIES. SIMILARLY, ORGANISMS INFECTED WITH PARASITES MAY NOT COMMAND AS HIGH A MARKET PRICE AS THOSE FREE OF PARASITES.



THE PRESENCE AND ABUNDANCE OF CERTAIN DISEASES AND PARASITES IS OFTEN A USEFUL PIECE OF INFORMATION TO THE FISHERIES BIOLOGIST. THE CONDITION OF THE ENVIRONMENT OFTEN CAN BE ASSESSED BY LOOKING AT THE DISEASE AND PARASITE CONDITION OF THE AQUATIC ORGANISMS. GENERALLY SPECIES PEACEFULLY COEXISTING WITH THEIR PARASITES ARE INDICATORS OF A NON-STRESSED ENVIRONMENT. WHEN THE ENVIRONMENT (AND THEREFORE A HOST) BECOMES STRESSED, SUCH AS TOO LITTLE OXYGEN OR TOO HIGH A WATER TEMPERATURE, THEN THE HOST IS LESS ABLE TO FEND OFF INFECTIONS FROM PESTS. AN INDICATION OF HIGH DISEASE OR PARASITISM SHOULD CAUSE US TO TAKE A LOOK AT WHAT THE UNDERLYING CAUSE FOR THE STRESS MIGHT BE.

ANOTHER USEFUL REASON FOR STUDYING PARASITISM AND DISEASE CONDITIONS IN FISHERIES IS THAT IT CAN ALLOW US TO IDENTIFY A STOCK OR POPULATION WITHIN A FISHERY. EACH LOCAL STOCK OR POPULATION MAY OFTEN BE UNIQUE IN THE KIND AND ABUNDANCE OF PARASITES IT HAS. FOR EXAMPLE, LET'S SAY A CERTAIN COPEPOD PARASITE NORMALLY ONLY OCCURS ON THE GILLS OF REDFISH OR CHANNEL BASS FROM TAMPA BAY.

IF REDFISH FROM PENSACOLA BAY BEGIN TO SHOW EVIDENCE OF THIS SAME PARASITE WE MIGHT SUSPECT A MIGRATION OF STOCKS OF REDFISH FROM TAMPA TO PENSACOLA. IN A WAY, THE PARASITE BECOMES KIND OF A NATURAL TAG OR MARKER WHICH CAN AID IN POPULATION IDENTIFICATION.

KNOWING SOMETHING ABOUT THE DISEASES AND PARASITES OF THE ORGANISMS IN OUR FISHERIES CAN BENEFIT OUR UNDERSTANDING OF THEM IN MANY WAYS.

① WE CAN ASSESS THE RELATIVE FITNESS OF THE HOST FISH,

② WE CAN ASSESS THE RELATIVE CONDITION OF THE WATER QUALITY

– AND –

③ WE CAN POTENTIALLY IDENTIFY STOCKS AND THEIR MOVEMENTS

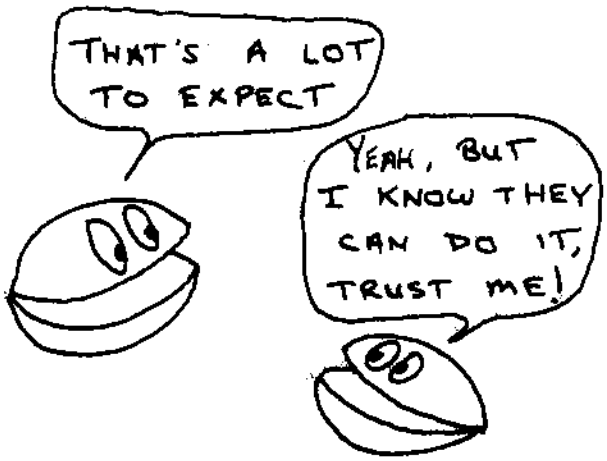
IN THE FUTURE WHEN WE HAVE DEVELOPED ENOUGH INFORMATION ON DISEASES AND PARASITES WE MIGHT EVEN BE ABLE TO "CURE", OR AT LEAST LESSEN, THE STRESS PLACED ON FISH SO THEY CAN GROW FASTER, REPRODUCE MORE, AND EVENTUALLY OBTAIN A HIGHER YIELD.

AND NOW FOR THE BIG QUESTION THAT WE'VE ALL BEEN WAITING FOR:

HOW MANY OF THEM ARE THERE AND HOW MANY OF THEM CAN WE OR SHOULD WE CATCH?

ALL OF THE PREVIOUS MATERIAL PRESENTED WAS ESSENTIAL AND NECESSARY SO THAT WE COULD UNDERSTAND THE BASIS BEHIND THE SCIENTIFIC PROJECTIONS OF YIELD. TO DO THIS WE MUST ALSO KNOW 'HOW MANY' OR AT LEAST 'PROPORTIONALLY HOW MANY' (OR HOW MANY lbs.) ARE AVAILABLE TO BE CAUGHT. IN ORDER TO DETERMINE HOW MANY, WE WOULD FIRST, HOWEVER, HAVE TO ANSWER THE QUESTION: "HOW MANY OF WHAT?" — IN OTHER WORDS - WHAT IS THE UNIT OR GROUP WE WISH TO MANAGE?

AND IT FOLLOWS..'AS THE NIGHT→THE DAY,' THAT ONCE WE DEFINE THE UNIT THAT WE WISH TO MANAGE ⟶ WE CAN DETERMINE ITS SIZE AND THEN ⟶ WE CAN FIGURE OUT HOW MUCH YIELD OR CATCH WE CAN TAKE FROM A FISHERY. MAYBE (IF WE'RE REAL GOOD AT THIS) WE CAN CALCULATE THE AMOUNT OF EFFORT NEEDED TO OBTAIN AND MAINTAIN A CERTAIN CATCH LEVEL.



THIS SECTION THEN IS OBVIOUSLY THE CRUX OF THE FISHERY BIOLOGIST'S JOB. ALL THE TYPES OF DATA WE TALKED ABOUT PRIOR TO THIS WILL BE APPLIED TO THIS CENTRAL PROBLEM. WE TACKLE THIS SECTION BY:

FIRST - ADDRESSING THE PROBLEM OF DETERMINING THE MANAGEMENT UNIT OR STOCK,

SECOND - EXPLORING WAYS TO MEASURE THE SIZE OF THE STOCK, AND...

THIRD - SHOWING YOU HOW TO FIGURE OUT THE YIELD WE WOULD (OR SHOULD) GET.

(COME ON YOU'VE STUCK IT OUT THIS FAR...)

THE CONCEPT OF STOCK
(A.K.A. – UNIT STOCK)

WE ALL HAVE SOME IDEA AS TO WHAT IS MEANT BY THE TERM 'STOCK'. FOR EXAMPLE, EVERYONE GETS A MENTAL PICTURE WHEN THEY HEAR THAT "THE HERRING STOCK IS DECLINING" OR "THE SCALLOP STOCKS ARE ON THE RISE." THERE ARE A NUMBER OF WAYS OF DESCRIBING A STOCK BUT TO BE USEFUL TO US IT MUST BE DEFINED IN TERMS OF ITS APPLICABILITY TO FISHERIES BIOLOGY. ONE WAY TO DEFINE THE WORD STOCK IS TO CALL IT A GROUP OF ORGANISMS THAT CAN BE MANAGED. THAT'S FINE BUT LET'S EXPLORE THIS CONCEPT FURTHER.

GIVEN THAT THE TERM STOCK IS SO WIDELY APPLIED (AND OFTEN MISAPPLIED) FISHERY BIOLOGISTS HAVE COINED A NEW TERM CALLED UNIT STOCK. THIS IS REALLY A MORE SPECIFIC DEFINITION OF STOCK. TO BORROW FROM FISHERIES BIOLOGIST JIM ZUBOY – A UNIT STOCK IS A "GROUP OF FISH THAT CAN BE TREATED AS A SINGLE UNIT FOR MANAGEMENT PURPOSES."

THIS DEFINITION NEEDS FURTHER EXPLANATION. THE PROBLEM COMES WITH THE WORD, GROUP. MANY FISHERIES ARE MULTI-SPECIES FISHERIES. IN OTHER WORDS THERE IS MORE THAN ONE KIND OR SPECIES OF FISH COMPRISING THE FISHERY. FOR EXAMPLE THE GROUPER FISHERY OFF THE SOUTHEASTERN U.S. CONSISTS OF AT LEAST THREE AND POTENTIALLY A DOZEN DIFFERENT SPECIES. GENERALLY EACH SPECIES HAS IT'S OWN DISTINCT BIOLOGICAL TRAITS SUCH AS GROWTH RATE, AGE, SIZE, FOOD HABITS, AND REPRODUCTIVE POTENTIAL. HOWEVER, IN THE CASE OF THE GROUPERS, THEY ALL OCCUR AND ARE CAUGHT TOGETHER AND THEIR LIFE HISTORY FEATURES ARE SIMILAR ENOUGH TO EACH OTHER THAT THE SPECIES CAN BE MANAGED AS A UNIT. AS IT TURNS OUT, IT WOULD BE ALMOST IMPOSSIBLE TO MANAGE EACH SPECIES SEPARATELY ANYWAY!

SO, IN SOME CASES, A UNIT CONSISTS OF SEVERAL DIFFERENT SPECIES. HOWEVER, SOMETIMES ONE SPECIES MAY CONSIST OF SEVERAL MANAGEABLE UNITS.

CONFUSED? - READ ON ⟹

FISHERY BIOLOGISTS CONSIDER THE LIMITS OF A STOCK (OR UNIT STOCK) FROM A BIOLOGICAL BASIS. FOR EXAMPLE, SOMETIMES A GROUP OF INDIVIDUALS IN A FISHERY MAY HAVE DIFFERENT LIFE HISTORY FEATURES IN DIFFERENT PARTS OF ITS RANGE. LET'S SAY A SPECIES OF SNAPPER OFF MIAMI GROWS FASTER AND REPRODUCES AT A YOUNGER AGE THAN DOES THE SAME SPECIES OFF PENSACOLA. FOR MANAGEMENT PURPOSES A SLIGHTLY DIFFERENT STRATEGY OR POLICY MAY HAVE TO BE ADOPTED BECAUSE OF THE DIFFERENCES IN BIOLOGICAL FEATURES. THEREFORE THE MIAMI GROUP MAY BE TREATED AS A UNIT STOCK AND THE GROUP OFF PENSACOLA ANOTHER UNIT STOCK.

ANOTHER PROBLEM WITH UNIT STOCK IS DETERMINING ITS GEOGRAPHICAL LIMITS.

FISHERY BIOLOGISTS HAVE FOUND IT ESSENTIAL TO DETERMINE THE LIMITS OF A UNIT STOCK ON IT'S NATURAL GEOGRAPHICAL RANGE AS WELL. FOR EXAMPLE, A FISH SPECIES DOESN'T STOP OR START ITS NORMAL DISTRIBUTION AT THE NORTH CAROLINA – SOUTH CAROLINA BORDER! MANY OF THEM DO BEGIN OR END THEIR RANGES AT CAPE HATTERAS (OBVIOUSLY THE GULF STREAM WITH ITS UNIQUE TEMPERATURE AFFECTS THEIR DISTRIBUTION IN THIS AREA)

FISHERIES BIOLOGISTS USE NATURAL OR ARTIFICIAL TAGGING OR MARKING DEVICES TO DETERMINE THE LIMITS AND SIZES OF UNIT STOCKS. WE'VE ALREADY COVERED THAT PART.

FROM HERE ON WE'LL USE THE TERM STOCK WHEN WE REALLY MEAN UNIT STOCK. REMEMBER A UNIT STOCK IS A GROUP RECOGNIZED TO MAKE MANAGEMENT EASIER AND MORE EFFICIENT. IT'S ALL PART OF OUR GOAL TO ASSURE MORE FISH FOR FUTURE GENERATIONS.

WHAT AFFECTS THE SIZE OR NUMBER OF FISH IN A STOCK?

FOR FISHERY PURPOSES THE TOTAL NUMBER OF FISH OF THE KIND WE'RE INTERESTED IN IS NOT NECESSARILY THE SAME AS THE NUMBER OF FISH IN THE STOCK. THE REASON FOR THIS IS THAT A FISH IS NOT CONSIDERED TO BE PART OF THE STOCK UNTIL IT BECOMES CATCHABLE. IN OTHER WORDS, A FISH THAT IS TOO SMALL TO BE CAUGHT WILL NOT OFFICIALLY JOIN THE STOCK UNTIL IT GROWS LARGE ENOUGH TO BE CAUGHT. A STOCK THEN IS REALLY A GROUP OF ORGANISMS THAT COULD BE CAUGHT

LATER WE'LL EXAMINE SOME WAYS WE CAN DETERMINE STOCK SIZE BUT FIRST LET'S SEE WHAT FACTORS CAN INFLUENCE THE SIZE OF A STOCK.

In figure 14 there is a large central box (the one with the fringe) which represents the abundance or size of a stock. There are a couple of things which can either lead to a larger or smaller stock.

First the increasers:

A fishery stock can increase only through <u>recruitment</u>. When a fish has been recruited into a stock then it becomes part of the fishery (that is - now it's possible to catch it ... if you can!). There are 2 ways a fish can be recruited:

1) By <u>growing</u> large enough to be caught. It should be noted that a stock can increase in number by producing more young which survive and grow to a size large enough to be caught. Hence, <u>reproduction</u> plus growth can lead to an increase in the stock size.

and

2) By <u>immigrating</u> into the area where the stock is located.

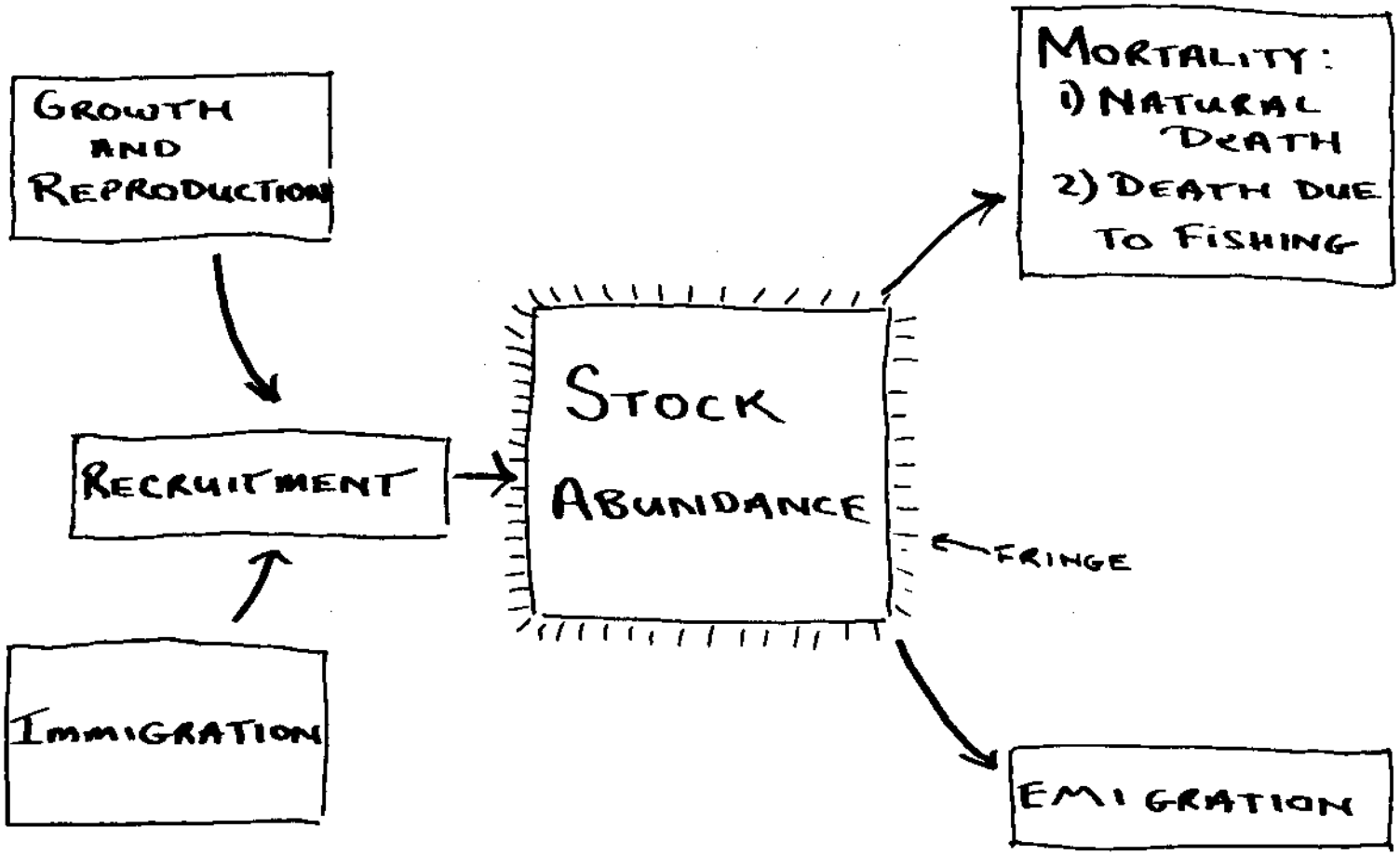


FIGURE 14. FACTORS AFFECTING THE SIZE OF A STOCK.

AND NOW FOR THE DECREASES:

STOCK SIZE CAN DECREASE THROUGH TWO MEANS AS WELL:

1) BY MOVING OUT OF THE AREA WHERE THE STOCK IS LOCATED (BETTER KNOWN AS EMIGRATION) THE OVERALL EFFECT IS TO REMOVE OR REDUCE THE NUMBER OF INDIVIDUALS AVAILABLE TO BE CAUGHT.

AND

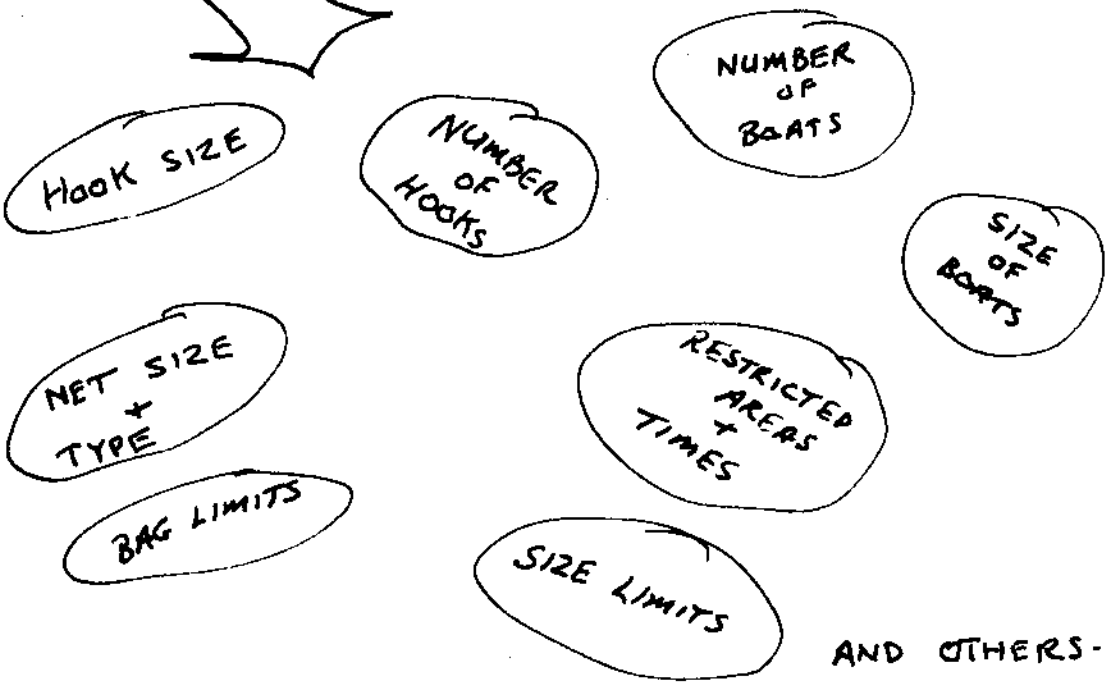
2) BY SOME OF THE INDIVIDUALS DYING!

AS SEEN IN FIGURE 14. THERE ARE TWO WAYS AN ORGANISM CAN DIE. IT CAN DIE A NATURAL DEATH BY WAY OF OLD AGE, DISEASE, ENVIRONMENTAL STRESS, OR PREDATION. DEATH BY WAY OF NATURAL CAUSES IS CALLED **NATURAL MORTALITY**. IT CAN ALSO DIE AT THE HANDS OF FISHERMEN BECAUSE OF BEING CAUGHT. THIS TYPE OF DEATH IS CALLED **FISHING MORTALITY**. THE TOTAL DEATH IS CALLED **TOTAL MORTALITY** AND IT'S THE SUM OF MORTALITY DUE TO NATURAL CAUSES AND FISHING PRESSURE.

TOTAL MORTALITY = NATURAL MORTALITY + FISHING MORTALITY

As you can guess when managing a fishery, it may be difficult to control anything about the factors which affect the increase or decrease of a stock except Fishing Mortality. This is because it's humanly possible to control fishing mortality by controlling fishing effort (either by amount or efficiency!).

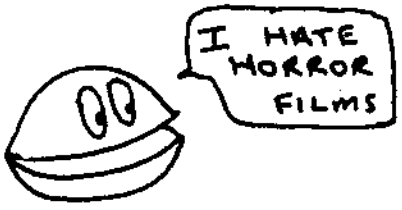
It's possible to control growth, reproduction, and natural mortality (by managing the environment) but most management today relies on managing by way of regulating fishing effort.

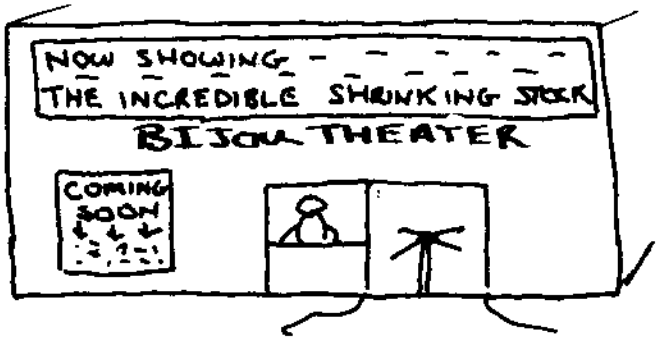


WHY KNOW THE SIZE OF A STOCK?

OBVIOUSLY IF WE WANT TO CATCH MORE FISH IT'S GOING TO BE EASIER TO CATCH THEM WHEN THERE ARE MORE OF THEM IN THE STOCK. SO IF WE KNOW THE STOCK SIZE WE SHOULD KNOW HOW MANY WE COULD EXPECT TO CATCH OR (IF WE'RE TRYING TO MANAGE THE FISHERY) HOW MANY WE SHOULD CATCH. ALSO IF WE CAN RECOGNIZE CHANGES IN STOCK ABUNDANCE (WHETHER IT'S AN INCREASE OR DECREASE) IT MIGHT BE POSSIBLE TO FIND OUT WHAT CAUSED THE CHANGE. IT MIGHT MEAN CONTINUING TO DO WHAT WE WERE DOING IF THE STOCK IS INCREASING OR MAINTAINING ITSELF. IT COULD ALSO MEAN CHANGING OUR FISHING HABITS IF THE STOCK IS DECLINING.

WE ARE ALL INTERESTED IN MAINTAINING THE AVAILABILITY OF OUR FISHERY RESOURCES FOR FUTURE GENERATIONS, THEREFORE KNOWING STOCK SIZE IS ESSENTIAL IF WE ARE TO ACHIEVE THIS GOAL.





Ways of Estimating Stock Size.

Before we get to the actual methods we need to be aware of the kind of data we'll get. Most methods give us a measure of stock size that is relative only to the specific method used so we call this **Relative Abundance**. An example that illustrates relative abundance would be if a certain gear type, say a gill net, were used to gather stock size data then the stock estimate could only be compared to other estimates using the same data gathering method. As it turns out, most methods which estimate stock abundance actually provide relative abundance estimates.

If the abundance estimate is somehow standardized then we could say we have measured the **Absolute Abundance** of a stock. Absolute abundance estimates are usually derived from relative estimates by adjusting the data in terms of number (or weight) per square meter (or acre, or hectare, or square mile, or square foot or even cubic foot or gallon, etc.).

OK? SO NOW A BRIEF SUMMARY OF THE WAYS TO ESTIMATE STOCK ABUNDANCE:

(A) FISHING SURVEYS:

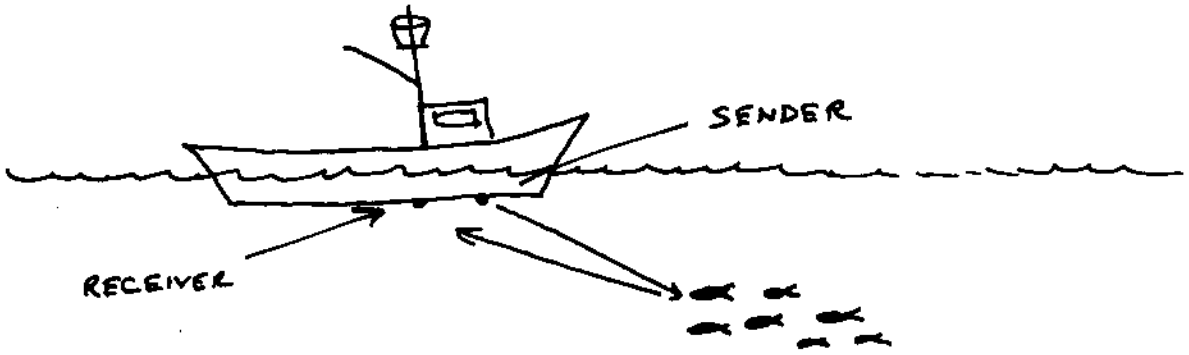
THIS METHOD IS USED A LOT WITH TRAWL (AND OTHER TYPES OF NET) FISHERIES. BASICALLY, YOU CAN GET AN ESTIMATE OF RELATIVE ABUNDANCE BY RECORDING THE CATCH, AREA OF CAPTURE AND AMOUNT OF TIME SPENT CATCHING.

(B) VISUAL SURVEYS:

SOMETIMES WE CAN GET AN ESTIMATE OF STOCK ABUNDANCE BY COUNTING EITHER FROM AN AIRPLANE (IN THE CASE OF WHALES, TURTLES, OR SURFACE SCHOOLING FISH) OR UNDERWATER FROM A SCUBA DIVER, CAMERA, OR SUBMARINE. WHEN SOME FISH ARE EXTREMLY NUMEROUS, AN ESTIMATE IS MADE OF PART OF THE STOCK AND THEN EXPANDED TO REPRESENT THE ENTIRE STOCK.

© Acoustic Surveys:

This is a relatively new method to determine stock size and it basically makes use of the reflection of underwater sound (something like sonar). Essentially what happens is a sound wave is produced and the "echo" it makes when it strikes a school of fish (or occasionally a large individual) allows us to get a sound "picture" of the number of fish. Of course you have to calibrate the apparatus to check out (usually with a good old fashion net!) just what kind (and approximate size) the fish in the school really are.



It's really quite a good method but it works best when the school is a few meters off the bottom or at some distance below the surface and the school consists mainly of only one species that are the same size.

(D) EGG AND LARVAL SURVEY:

BY SURVEYING THE NUMBER OF EGGS AND LARVAE IN THE WATER IT'S POSSIBLE TO GET SOME IDEA OF THE STOCK SIZE. THE LOGIC BEHIND THIS TECHNIQUE IS THAT: THE MORE EGGS AND LARVAE OUT THERE THEN ... ... THE MORE ADULTS IN THE STOCK TO PRODUCE THEM; OR THE OPPOSITE — THE FEWER THE EGGS AND LARVAE, THE SMALLER THE STOCK (THIS METHOD ALSO GATHERS DATA WHICH CAN BE USEFUL IN PREDICTING THE SIZE OF FUTURE STOCKS AS WELL!).

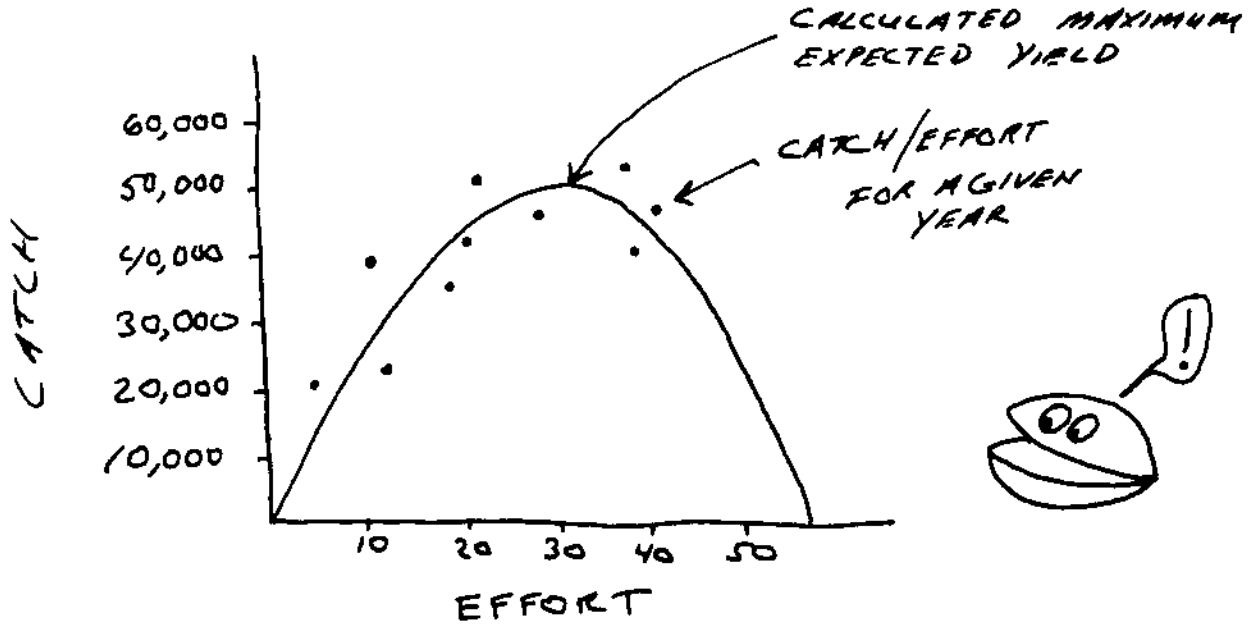
(E) TAGGING STUDIES:

BY PLACING A MARK OR TAG ON A GROUP OF FISH WHEN THEY WERE FIRST CAPTURED, RELEASING THEM, RESAMPLING THE STOCK, NOTING HOW MANY OF THE FIRST GROUP (TAGGED FISH) WERE AMONG THOSE IN THE SECOND GROUP AND DOING A FEW CALCULATIONS WE CAN EASILY (?) DETERMINE THE SIZE OF A STOCK. THIS METHOD WORKS WELL IN LAKES AND PONDS AND IN ESTUARIES WHERE THERE IS NOT A LOT OF CHANGE IN THE STOCK SIZE DUE TO MIGRATION OR DEATH.

THESE ARE THE MAJOR WAYS WHICH FISHERY BIOLOGISTS USE TO DETERMINE STOCK SIZE. AS YOU MIGHT IMAGINE, THERE ARE MANY MORE BESIDES THESE. THE METHOD SOMETIMES CHOSEN IS OFTEN DETERMINED BY A NUMBER OF FACTORS WHICH USUALLY WE HAVE NO CONTROL OVER, LIKE: SPECIES TYPE, BEHAVIOR OF SPECIES, AMOUNT OF FUNDS AVAILABLE AND NUMBER OF PEOPLE AROUND TO HELP YOU.

ANOTHER, BUT SLIGHTLY MORE SOPHISTICATED, WAY OF ASSESSING THE RELATIVE SIZE OF A STOCK IS BY LOOKING AT THE RELATIONSHIP BETWEEN THE SIZE OF THE CATCH (OR YIELD) FROM A FISHERY AND THE AMOUNT OF EFFORT USED TO OBTAIN THE CATCH. IT STANDS TO REASON THAT WHEN THE FISHING LEVEL IS VERY LOW (SAY ALMOST ZERO) THEN THERE WILL BE ALMOST NO CATCH. ALSO WHEN THE FISHING EFFORT IS EXTREMLY HIGH THERE WILL BE A LOW CATCH BECAUSE OVERFISHING (HIGH EFFORT) LEADS TO DEPLETED STOCKS. HOWEVER, AT SOME LEVEL THERE SHOULD BE JUST ENOUGH EFFORT TO GET THE MAXIMUM YIELD FROM A FISHERY. PLOTTING CATCH VERSUS EFFORT IS CALLED A SCHAEFER MODEL

AND IT LOOKS LIKE THIS . . .



I KNOW THIS IS A BIT CONFUSING BUT IF YOU THINK ABOUT IT, IT ISN'T. MOST DATA ON CATCH VERSUS EFFORT (THE DOTS ON THE GRAPH) FORM A PATTERN SIMILAR TO THE ONE ABOVE. BY DOING A LITTLE CALCULATING IT'S POSSIBLE TO FIGURE OUT EITHER 1) WHAT'S THE MAXIMUM YIELD WE CAN EXPECT FROM THIS FISHERY OR 2) WHAT'S THE EFFORT NEEDED TO MAINTAIN THE HIGHEST YIELD FROM THE FISHERY OR BOTH 1) + 2). THIS TYPE OF ANALYSIS CAN ALSO BE USED TO TELL US IF A FISHERY IS BEING OVERFISHED OR UNDER-FISHED. IT'S A PRETTY GOOD METHOD BUT ITS ACCURACY DEPENDS ON BEING ABLE TO

OBTAIN RELIABLE INFORMATION ON CATCH AND EFFORT FROM THE PARTICIPANTS IN THE FISHERY - MAINLY YOU AND ME.

BY THE WAY EFFORT IS MEASURED IN DIFFERENT WAYS IN EACH FISHERY. SOMETIMES IT'S THE NUMBER OF HOOKS USED OR THE NUMBER OF BOATS OR THE WEIGHT OF BOATS OR THE NUMBER OF FISHERMEN ETC. IT REALLY DOESN'T MATTER AS LONG AS THE NUMBERS ARE ACCURATE AND CONSISTENT.

THERE ARE, OF COURSE, MANY OTHER WAYS TO DETERMINE STOCK SIZE (AND EVENTUALLY, YIELD) BUT LET'S LOOK AT ONE OF THE METHODS THAT IS USED IN FISHERIES FOR WHICH WE HAVE BEEN ABLE TO OBTAIN A LOT OF BIOLOGICAL DATA, NAMELY - **THE DYNAMIC POOL MODEL.**

REMEMBER THE DIAGRAM IN FIGURE 14. (PAUSE HERE FOR A MOMENT TO GO BACK AND LOOK AT IT)? THE DYNAMIC POOL METHOD MAKES USE OF THE RELATIONSHIP OF EACH OF THE FACTORS RESPONSIBLE FOR AFFECTING STOCK ABUNDANCE. WHAT A FISHERY BIOLOGIST DOES IS BREAK DOWN EACH OF THE COMPONENTS INTO SMALLER COMPONENTS, DESCRIBE THEIR RELATIONSHIP MATHEMATICALLY, SUBSTITUTE REAL DATA INTO THE EQUATION AND THEN SOLVE IT.

WE COULD REWRITE FIGURE 14. AS A MATH EQUATION:

$$\text{STOCK ABUNDANCE} = \text{GROWTH} + \text{REPRODUCTION} + \text{IMMIGRATION} - \text{EMIGRATION} - \text{NATURAL MORTALITY} - \text{FISHING MORTALITY}.$$

ALL WE WOULD HAVE TO DO IS GATHER DATA ON EACH OF THE PARTS, PUT THE VALUES IN, AND SOLVE!

. . . OR WE COULD GET REAL FANCY AND CALCULATE THE YIELD WE COULD EXPECT FROM A FISHERY AS BEVERTON & HOLT DID:

$$Y_{IELD} = FR\exp\left(-M\left(t_c - t_r\right)\right) W_{\infty} \sum_{n=0}^{n=3}\left\{\left[\frac{U_N}{F+M+nK}\right]\right.$$

$$\left.\left[\exp\left(-\left(nK\left(t_c - t_0\right)\right)\right)\right]\left[1-\exp\left(-\left(F+M+nK\right)\left(t - t_c\right)\right)\right]\right\}$$

RELAX, ALL I WANTED TO DO WAS IMPRESS YOU! EACH OF THE LETTERS REPRESENTS SOME DATA ON THE LIFE HISTORY OF MEMBERS OF THE FISHERY. IT LOOKS VERY COMPLEX BUT IN REALITY IT'S NO MORE DIFFICULT TO UNDERSTAND (ONCE YOU KNOW WHAT ALL THE LITTLE LETTERS STAND FOR) THAN FIGURE 14.

USING THE DYNAMIC POOL METHOD REQUIRES LOTS OF DATA AND IT HAS TO CONSTANTLY BE UPDATED. ALTHOUGH IT MAY BE THE WAY TO CALCULATE YIELD OR STOCK SIZE IT IS NOT USED TOO OFTEN BECAUSE OF THE REQUIRED DATA.

- - - AND NOW THAT WE'VE HEARD THE REASONS WHY, THE HOW'S, AND THE WHAT'S ABOUT FISHERIES BIOLOGY IT'S TIME TO DIRECTLY ADDRESS **FISHERIES MANAGEMENT**.

BEFORE WE UNDERTAKE THE MANAGEMENT OF ANY FISHERY, INFORMATION ABOUT THE FISHERY, IT'S PARTICIPANTS, AND THE SPECIES MUST BE GATHERED. THIS INFORMATION (OR DATA) SHOULD INCLUDE MOST, IF NOT ALL (AND SOMETIMES A BIT MORE), OF THE TYPE OF DATA WE'VE ALREADY TALKED ABOUT. ALL OF THE INFORMATION THAT PERTAINS TO THE FISHERY (AND ITS ENVIRONMENT) SERVES AS A <u>DATA BASE</u> TO DETERMINE:

1. IF THE FISHERY NEEDS TO BE MANAGED,
2. IF THE FISHERY DOES'NT NEED TO BE MANAGED, <u>OR</u>
3. IF DATA ARE TOO LIMITED TO EVEN DECIDE WHETHER IT DOES OR NOT.

Let's assume that there are enough data and it looks like the fishery needs to be managed — now the question arises:

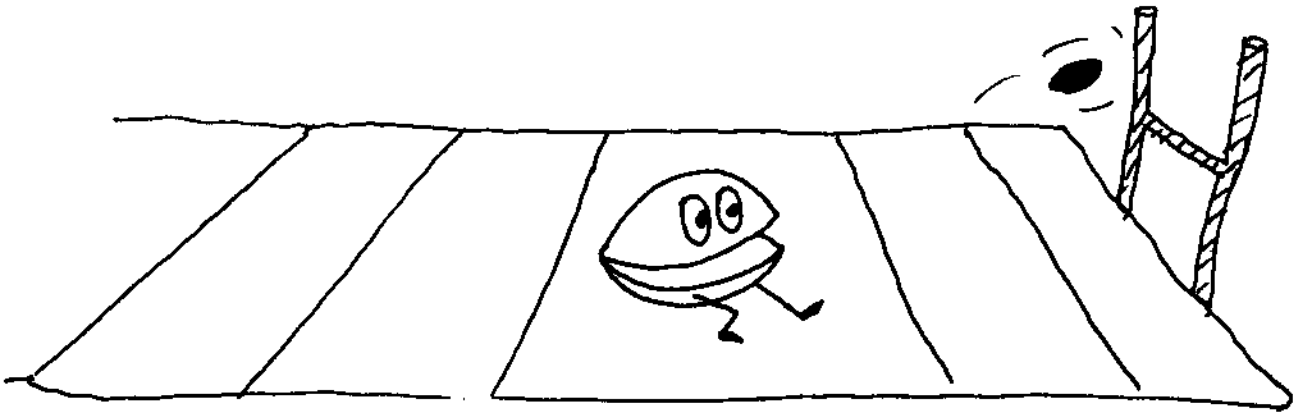
What management plan or strategy should be used?

— But in order to manage a fishery and choose a strategy, a <u>goal</u> (or goals) for each fishery (or stock within a fishery) should be established. Goals will vary according to the species, locations and conditions surrounding the fishery. Some examples of goals are:

(a) Increase the standing stock,

(b) maintain the stock at its current level in a certain area,

(c) Increase the stock of species "X" but decrease the stock size of species "Y" in a multispecies fishery.

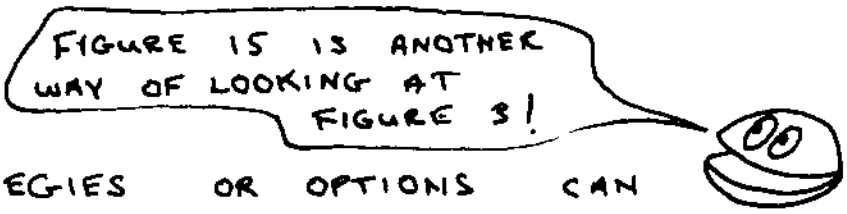


WAY BACK NEAR THE BEGINNING OF THIS BOOK, THE CONCEPT OF **OY** (= OPTIMUM YIELD) WAS PRESENTED. BASICALLY IT MEANS THAT THE GOALS OF FISHERIES MANAGEMENT SHOULD NOT ONLY BE DIRECTED TOWARD THE BIOLOGICAL ASPECTS OF A FISHERY BUT SHOULD INCLUDE MATTERS DEALING WITH ECONOMIC AND SOCIAL (EVEN POLITICAL) ASPECTS AS WELL. THEREFORE, GOALS CAN BE DESIGNED TO IMPROVE ECONOMIC AND SOCIAL ASPECTS OF A COMMUNITY.

ANOTHER POINT WORTH CONSIDERING IS THAT GOALS (AND CONSEQUENTLY, STRATEGIES) SHOULD BE BOTH SHORT TERM (FOR THE IMMEDIATE FUTURE) AND LONG TERM (FOR THE NOT SO IMMEDIATE FUTURE). SO THEREFORE WHEN ESTABLISHING GOALS, IT'S IMPORTANT TO CONSIDER THE TIME FRAME AS THIS CAN HAVE A SIGNIFICANT INFLUENCE ON THE KIND OF STRATEGY CHOSEN.

FOOT NOTE: GOALS SHOULD BE SET BUT ALLOWANCES MUST BE MADE FOR THOSE UNFORSEEABLE YET INEVITABLE **CATASTROPHIES** THAT NATURE (OR ECONOMIC AND SOCIAL CIRCUMSTANCES) PROVIDE !

AFTER THE DECISION HAS BEEN MADE TO MANAGE A FISHERY AND A GOAL (OR GOALS) HAS BEEN SET, FISHERIES BIOLOGISTS THEN DECIDE ON A MANAGEMENT STRATEGY THAT WILL "BEST" ACHIEVE THE GOAL. (BY THE WAY, ALL OF THIS HAS BEEN DIAGRAMMED AND SUMMARIZED IN FIGURE 15.



STRATEGIES OR OPTIONS CAN VARY AND CERTAINLY THERE ARE AS MANY AS THERE ARE "FISH IN THE SEA" BUT BELOW I'VE TRIED TO SUMMARIZE AND ORGANIZE THEM.

ONE MAJOR WAY TO MANAGE OR CONTROL A FISHERY IS TO INFLUENCE **FISHING PRESSURE.** FISHERY PRESSURE IS USUALLY OF TWO GENERAL TYPES: ① DIRECT – WE CAN DIRECTLY INFLUENCE FISHING PRESSURE BY USING SEVERAL METHODS WHICH INCLUDE - CLOSED SEASON, CLOSED AREA, LIMITING ENTRY BY RESTRICTING THE NUMBER OF FISHERMEN OR BOATS, CONTROLLING GEAR OR ESTABLISHING CATCH QUOTAS. THE OVERALL EFFECT IS TO MANAGE BY DIRECTLY CONTROLLING OR INFLUENCING FISHING PRESSURE.

(2) INDIRECT — WE CAN INDIRECTLY CONTROL FISHING PRESSURE BY TAXING FISHERMEN OR BOATS OR GEAR, ARTIFICIALLY INCREASING OR DECREASING COSTS TO FISH, REDUCING DEMAND FOR FISH PRODUCTS OR OFFERING (OR DISCOURAGING) ALTERNATIVE SOURCES OF INCOME. USING THESE METHODS PUTS INDIRECT PRESSURE ON FISHERMEN AND, IN TURN, AFFECTS FISHING PRESSURE.

A SECOND MAJOR WAY TO MANAGE A FISHERY IS THROUGH THE USE OF **ENVIRONMENTAL CONTROLS AND CONSERVATION.** MANAGEMENT OPTIONS HERE INCLUDE: HABITAT IMPROVEMENT (FOR EXAMPLE - BUILDING ARTIFICIAL REEFS OR REDUCING POLLUTION), FISH FARMING (AQUACULTURE), STOCKING, OR BREEDING.

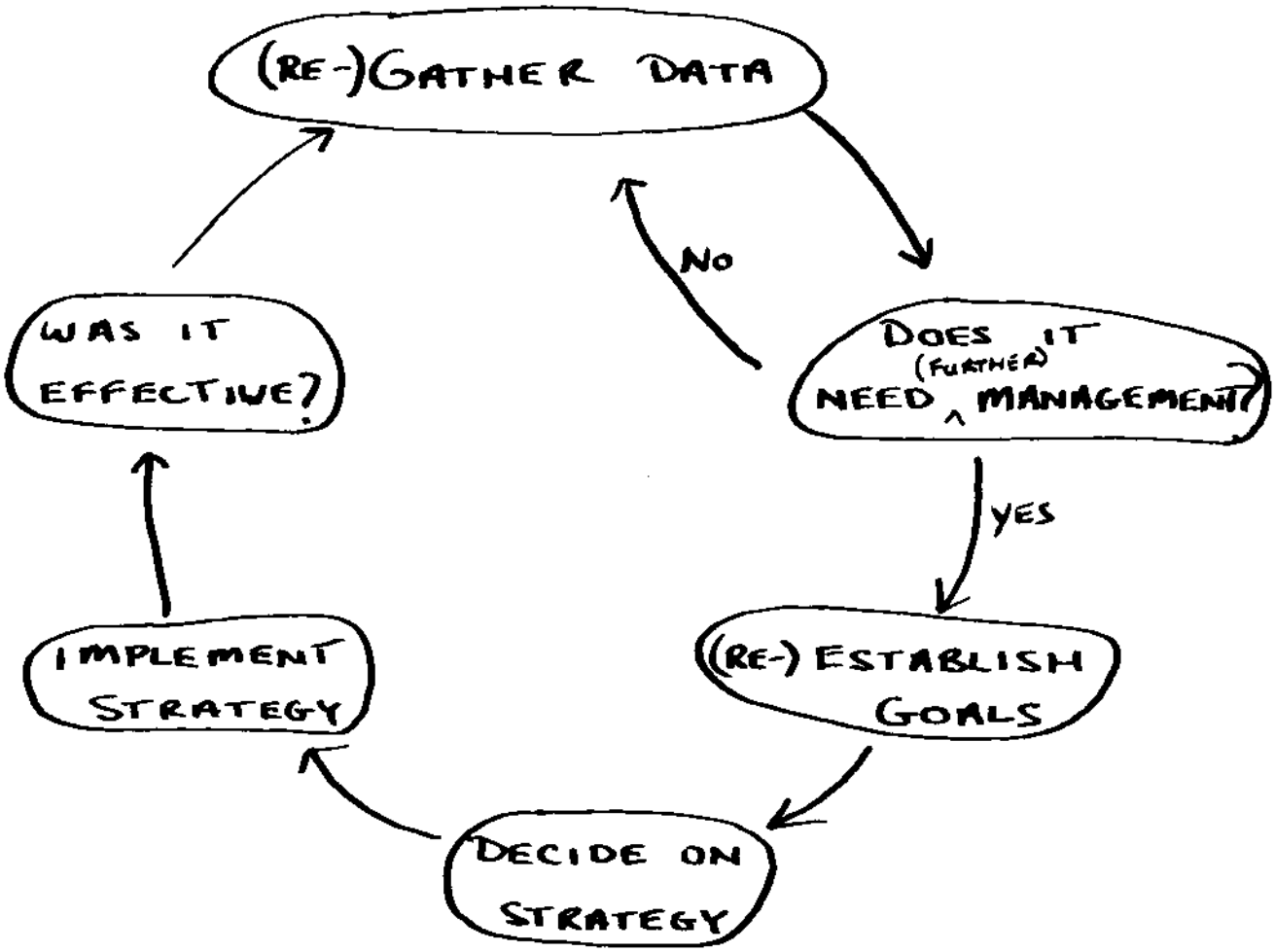
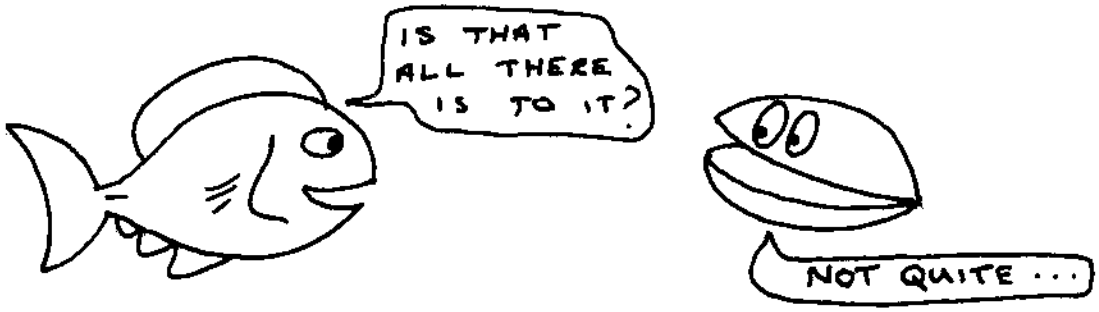


FIGURE 15 — A DIAGRAM INDICATING THE PATHWAY THAT DEVELOPMENT AND IMPLEMENTATION OF FISHERIES MANAGEMENT SHOULD FOLLOW.

EVEN BEFORE A STRATEGY IS ADOPTED AND PUT INTO EFFECT FISHERIES BIOLOGISTS CAREFULLY DEBATE, ARGUE, AND THEN TRY TO CALCULATE WHAT THE RESULTS OF IMPOSING A PARTICULAR STRATEGY WILL BE. EVERY STRATEGY CAN BE EXPECTED TO HAVE BOTH POSITIVE AND NEGATIVE ASPECTS TO IT. AFTER ALL THESE ASPECTS HAVE BEEN CONSIDERED, THE STRATEGY IS IMPLEMENTED.

YES, IT IS EASIER SAID THAN DONE. LET'S FACE IT — IF A POLICY IS ADOPTED AND NO ONE (OR ALMOST NO ONE) GOES ALONG WITH IT, THEN THE FISHERY SUFFERS. IT IS ALSO, THEN, THE JOB OF FISHERIES BIOLOGISTS TO WORK CLOSELY WITH THE PEOPLE IN THE COMMUNITY SO THAT <u>REASONABLE</u> AND <u>APPROPRIATE</u> MANAGEMENT POLICIES ARE ADOPTED.

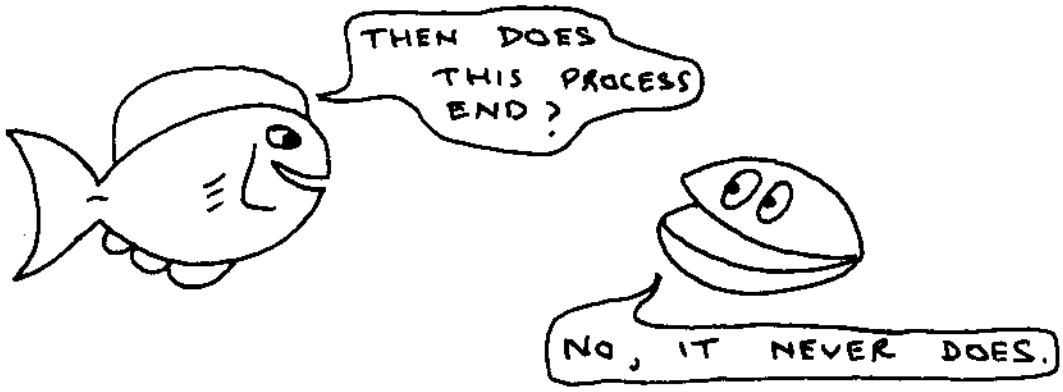


ONCE A STRATEGY IS ADOPTED AND IMPLEMENTED THEN A CAREFUL **MONITORING PROGRAM** IS ESTABLISHED. THIS MEANS THAT ADDITIONAL DATA WILL BE GATHERED TO:

1. RE-EVALUATE THE STATUS OF THE FISHERY,
2. DETERMINE IF THE STRATEGY WAS EFFECTIVE,

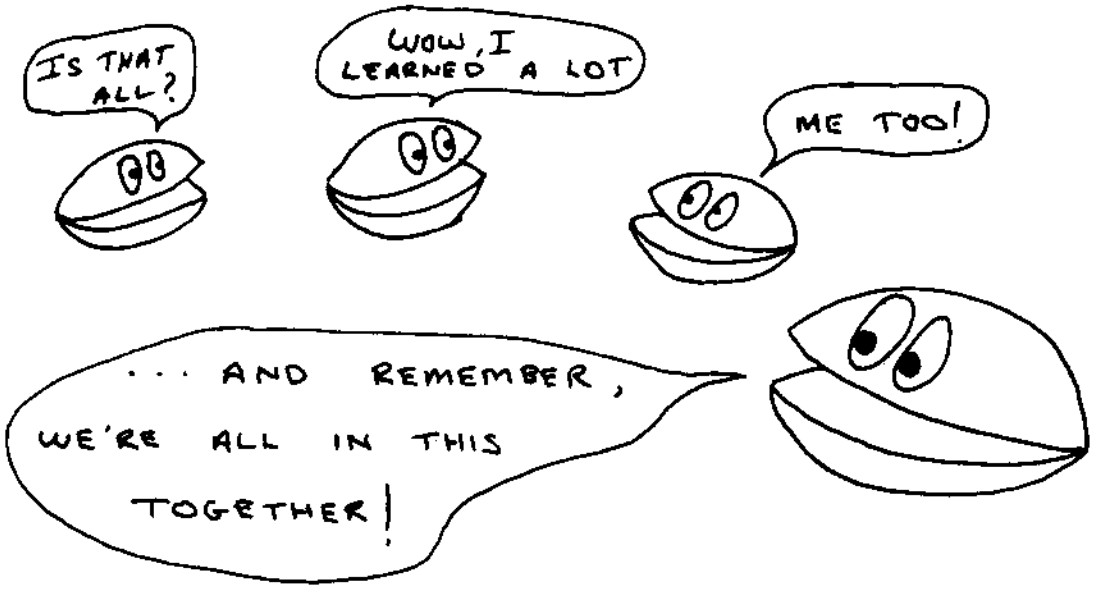
AND

3. SUGGEST CHANGES IN THE MANAGEMENT PLAN TO PERMIT THE GOALS TO BE ATTAINED.



OUR FISHERY RESOURCES WILL REQUIRE CONSTANT STUDY AND MANAGEMENT IF WE ARE ALL TO GET THE MAXIMUM BENEFIT FROM THEM. IT IS HOPED THAT A BETTER UNDERSTANDING OF THE FISHERMEN'S CONCERNS BY FISHERIES BIOLOGISTS AND BY FISHERMEN

LEARNING ABOUT FISHERIES BIOLOGY + MANAGEMENT WILL ENCOURAGE A COOPERATIVE EFFORT TOWARD SOLVING OUR PRESENT FISHERIES PROBLEMS AS WELL AS THE PROBLEMS SURE TO COME ALONG IN THE FUTURE.



P.S. – IF YOU WANT TO LEARN MORE ABOUT FISHERIES BIOLOGY, THE REFERENCES (BOOKS AND PAPERS) LISTED ON THE NEXT FEW PAGES SHOULD HELP YOU OUT. CHECK YOUR LOCAL LIBRARY! ALSO IF YOU HAVE ANY QUESTIONS OR NEED A BETTER EXPLANATION SEE YOUR LOCAL FISHERIES BIOLOGIST – THEY WANT TO HELP.

Sincerely
Steve Bortone

SOME PEOPLE WHO HELPED ME WRITE THIS BOOK AND WHO I WOULD LIKE TO THANK:

ARMAND ANNAN, GENE NAKAMURA, B.J. PUTNAM & BOB SHIPP FOR SHOWING ME THE NEED FOR SUCH A BOOK;

JIM BOHNSACK, JIM ZUBOY, TERRY LEARY, COLIN MOORE, KAREN STEIDINGER & WAYNE SWINGLE FOR SUGGESTIONS ON WHAT SHOULD BE INCLUDED OR EXCLUDED FROM THE CONTENTS;

PAUL CONNOLLY, PADDY GARGAN & THE STAFF AND FACULTY AT THE UNIVERSITY COLLEGE DUBLIN, IRELAND FOR THEIR ADVICE & FRIENDSHIP;

JIM CATO, BILL SEAMAN & THE OTHER FOLKS AT FLORIDA SEA GRANT COLLEGE FOR FINANCIAL SUPPORT;

BILLIE LOWRY & ESPECIALLY MIDGE BORTONE (HER REAL NAME IS MILDRED BUT SHE HATES ME TO CALL HER THAT — SO I WON'T) FOR EXPERT EDITORIAL ASSISTANCE;

AND ...

DOZENS OF COMMERCIAL & RECREATIONAL FISHERMEN FOR THEIR COMMENTS AND SPECIAL INSIGHT INTO OUR FISHERIES.

THE BOOKS + ARTICLES LISTED BELOW CAN BE FOUND IN YOUR LIBRARY AND SHOULD HELP PROVIDE MORE INFORMATION ☺

EVERHART, W.H., A.W. EIPPER + W.D. YOUNGS. 1975. PRINCIPLES OF FISHERY SCIENCE. CORNELL UNIVERSITY PRESS. ITHACA, N.Y.

GERKING, S.D. (ED.). 1978. ECOLOGY OF FRESHWATER FISH PRODUCTION. JOHN WILEY + SONS. N.Y.

GULLAND, J.A. 1974. THE MANAGEMENT OF MARINE FISHERIES. UNIVERSITY OF WASHINGTON PRESS. SEATTLE.

LACKEY, R.T. 1974. INTRODUCTION TO FISHERIES SCIENCE. VIRGINIA SEA GRANT. VIRGINIA POLYTECHNIQUE, BLACKSBURG.

LACKEY, R.T. AND L.A. NIELSEN. 1980. FISHERIES MANAGEMENT. HALSTED PRESS, N.Y.

MAIOLO, J.R. + M. K. ORBACK. 1982. MODERNIZATION + MARINE FISHERIES POLICY. ANN ARBOR SCIENCE, ANN ARBOR, MICHIGAN.

NIELSEN, L.A. + D.L. JOHNSON (EDS.). 1983. FISHERIES TECHNIQUES. AMERICAN FISHERIES SOCIETY, BETHESDA, MD.

PITCHER, T.J. + P.J.B. HART. 1982. FISHERIES ECOLOGY. AVI PUBLISHING CO. WESTPORT, CONN.

ROTHSCHILD, B.J. (ED). 1983. GLOBAL FISHERIES. SPRINGER-VERLAG, N.Y.

ROUNSEFELL, G.A. 1975. ECOLOGY, UTILIZATION, AND MANAGEMENT OF MARINE FISHERIES. C.V. MOSBY COMPANY, ST. LOUIS, MO.

WEATHERLEY, A.K. 1972. GROWTH + ECOLOGY OF FISH POPULATIONS. ACADEMIC PRESS, LONDON.

Copies available from:

Sea Grant Extension Program
G022 McCarty Hall
University of Florida
Gainesville, FL 32611

Florida Sea Grant College is supported by award of the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, grant number NA85AA-D-SG059, under provisions of the National Sea Grant College and Programs Act of 1966. This information is published by the Sea Grant Extension Program which functions as a component of the Florida Cooperative Extension Service, John T. Woeste, dean, in conducting Cooperative Extension work in Agriculture, Home Economics, and Marine Sciences, State of Florida, U.S. Department of Agriculture, U.S. Department of Commerce, and Boards of County Commissioners, cooperating. Printed and distributed in furtherance of the Acts of Congress of May 8 and June 14, 1914. The Florida Sea Grant College is an Equal Employment Opportunity-Affirmative Action employer authorized to provide research, educational information and other services only to individuals and institutions that function without regard to race, color, sex, or national origin.