An introduction to effective science communication

September 15, 2015
National Water Quality Monitoring Council
Webinar

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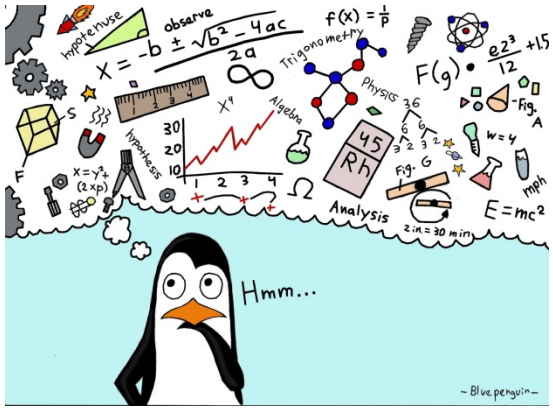
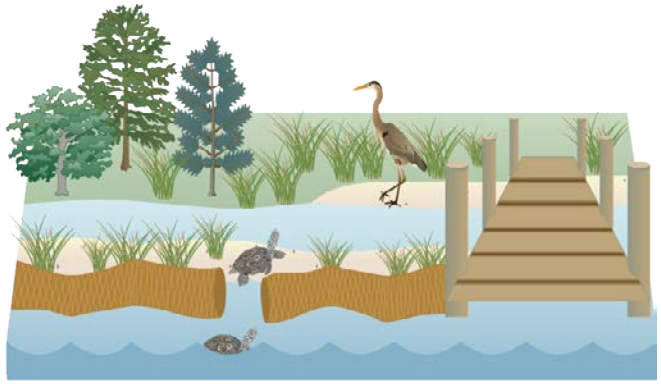
Innovation for a better future
University of Maryland
Center for Environmental Science

Overview of presentation

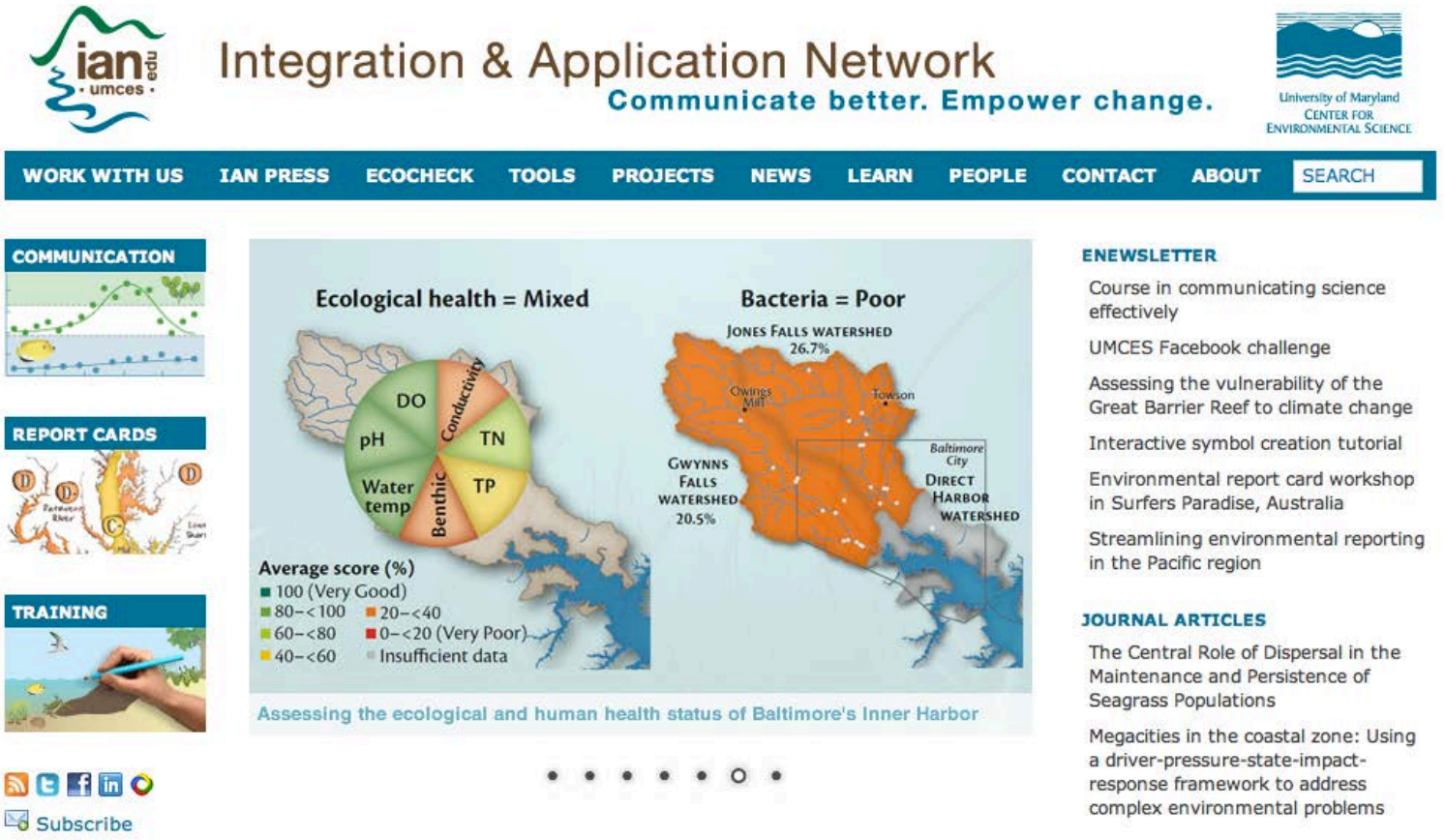
- What is the Integration and Application Network?
- Science Communication
  - Bit of theory
  - Applications
- Conceptual diagrams





What is the Integration and Application Network?

IAN's aim is to enable better communication to empower change.



Solving, not just studying environmental problems

STUDY

- Dispassionate
- Embrace complexity
- Publish & funding via peer review
- Getting it right

SOLVE

- Passionate
- Simplify
- Publish & funding via stakeholders
- Getting it done

IAN is making a global impact

IAN's is creating a global symbol language

130,561,717

images downloaded

Objectives of this talk

- *Revisit* the long history of effective science communication

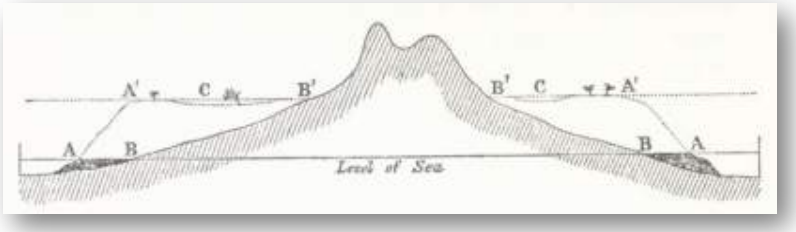
- *Provide* some overarching science communication principles

- *Establish* an underlying philosophy for science communication

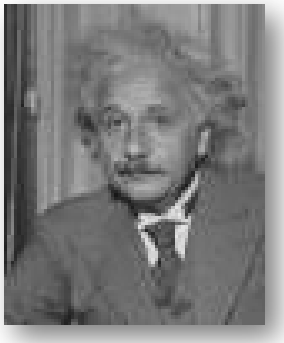
The great scientists are/were also great communicators

Charles Darwin:
119 published books & papers

"Finally when … barrier-reefs … atolls… and fringing-reefs … are laid down on a map, they offer a grand and harmonious picture of the movements which the crust of the earth has undergone within a late period. We there see vast areas rising, with volcanic outbursts; and we may feel sure that the movement has been so slow as to have allowed the corals to grow up to the surface…"



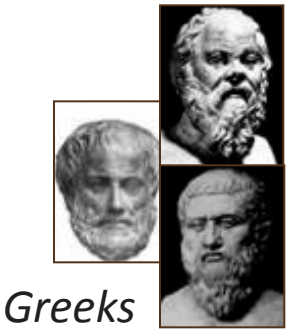
The Structure and Distribution of Coral Reefs
Charles Darwin, 1874 2nd Edition,
revised 1842 1st Edition



Albert Einstein:
248 published books & papers

"Make everything as simple as possible, but not simpler." A. Einstein

Paradigm shifts occur when scientific discovery is effectively communicated to society

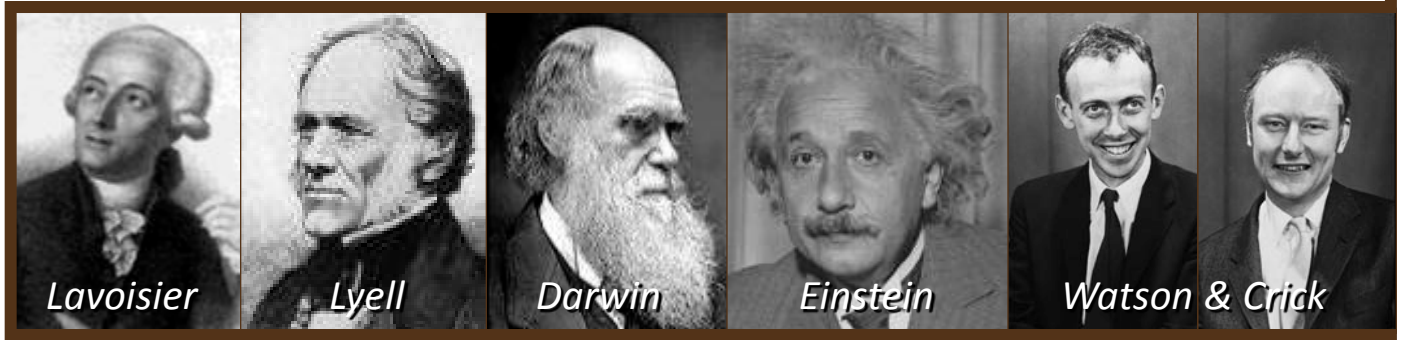


Greeks

1500-1550 | 1550-1600 | 1600-1650 | 1650-1700 | 1700-1750

Astronomy | Physics | Astronomy | Physics | Biology

1750-1800 | 1800-1850 | 1850-1900 | 1900-1950 | 1950-2000



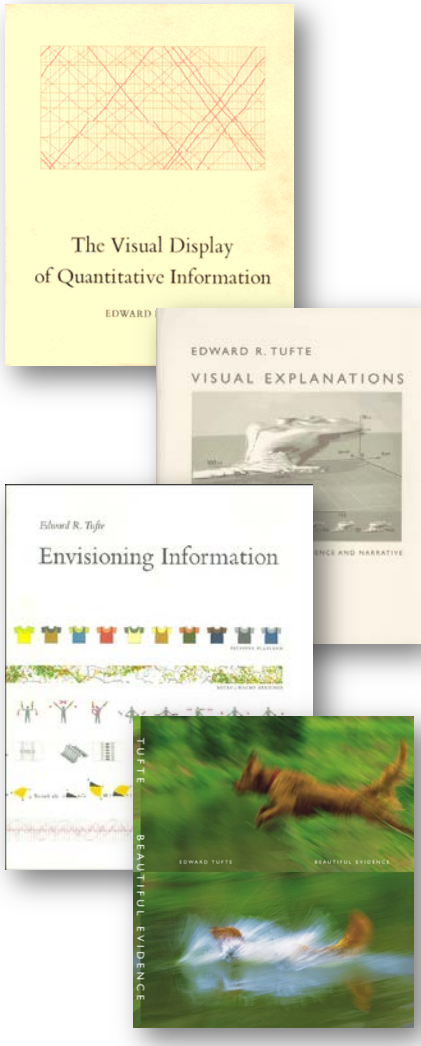
Chemistry | Geology | Evolution | Physics | Biology

2000-2050

Sustainability

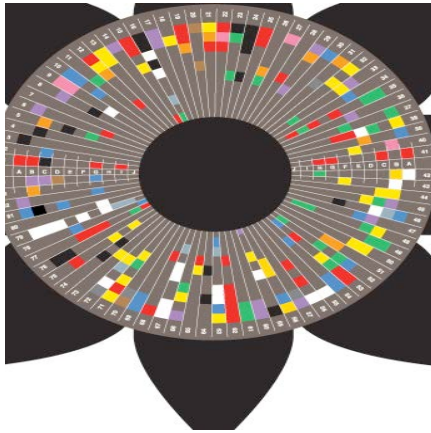
Principles of Analytical Design: Edward Tufte

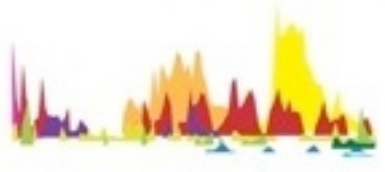
- Integrate word, image, numbers
- Content-driven
- Presentation enables thinking
- Use small multiples (maximize content variation; minimize style variation)
- Know your content and audience
- Use humor and hyperbole



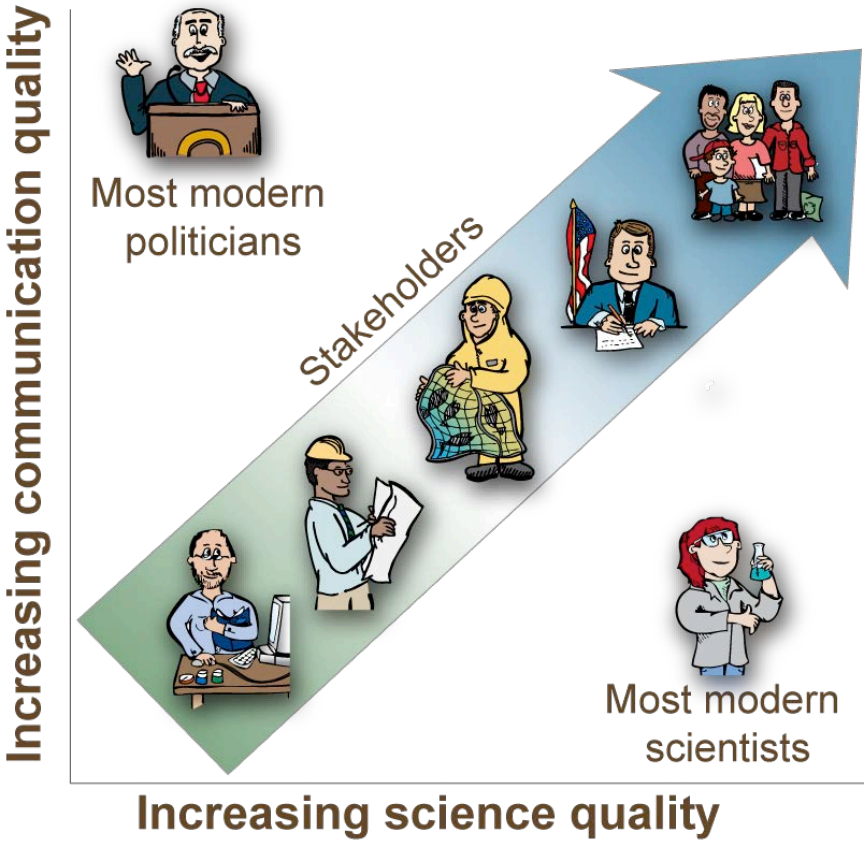
Information Is Beautiful: David McCandless

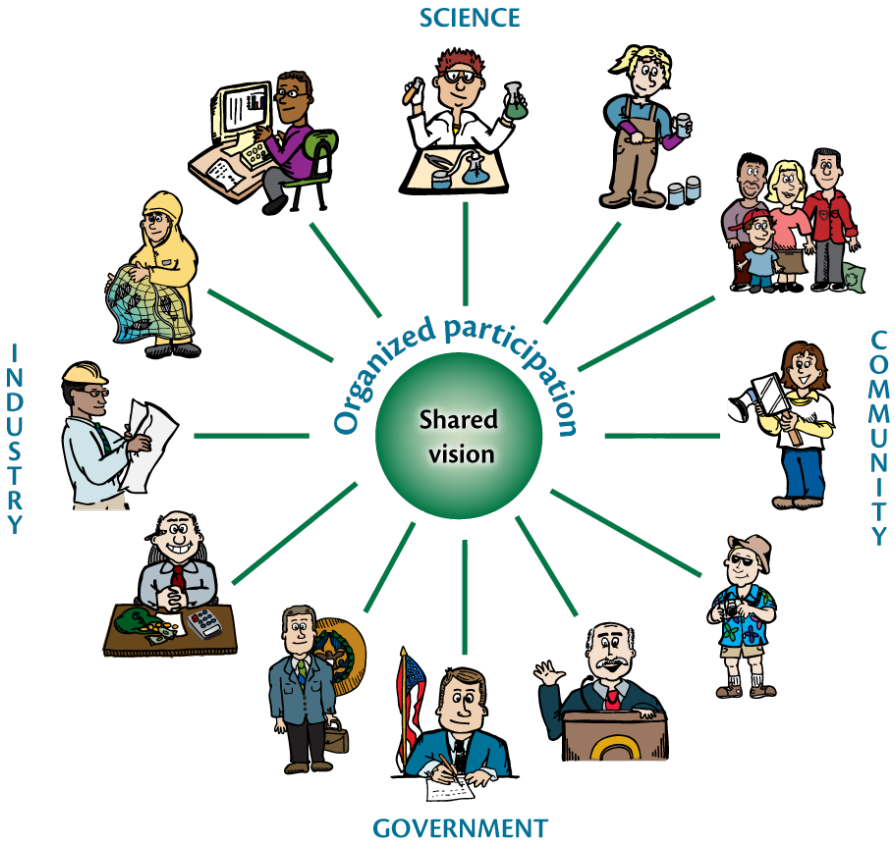
1. Have fun! Remember to play.
2. Influence yourself.
3. A hierarchy of information.
4. **Remember visual language. Try to add a visual element wherever possible.**
5. **Less is more. What can you take out?**
6. Grids are good. Use a mathematical grid to harmonize your layout.
7. **Color, color, color. Draw a color palette from your subject matter.**
8. Re-skin the wheel. Don't throw out pie, line, and bar charts. Just design them better.
9. **Make text work harder. Text is a graphical element of your visual too.**
10. Fonts speak. What does your chosen font say?





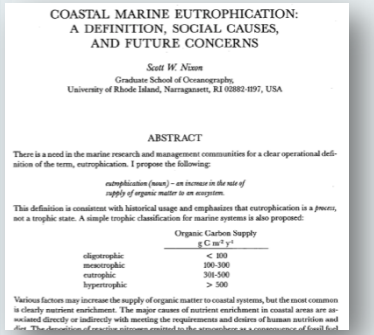
Science communication is a balance of quality science and communication





Employing different communication techniques

Scientific writing



COASTAL MARINE EUTROPHICATION:
A DEFINITION, SOCIAL CAUSES,
AND FUTURE CONCERNS

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University of Rhode Island, Narragansett, RI 02882-1197, USA

ABSTRACT

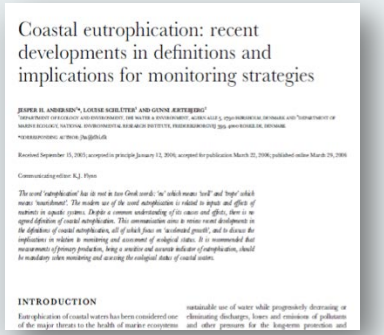
There is a need in the marine research and management communities for a clear operational definition of the term, eutrophication. I propose the following:

eutrophication (noun) – an increase in the rate of supply of organic matter to an ecosystem.

This definition is consistent with historical usage and emphasizes that eutrophication is a *process*, not a trophic state. A simple trophic classification for marine systems is also proposed:

	Organic Carbon Supply g C m^{-2} y^{-1}
oligotrophic	< 100
mesotrophic	100-300
eutrophic	301-500
hypertrophic	> 500

Various factors may increase the supply of organic matter to coastal systems, but the most common is clearly nutrient enrichment. The major causes of nutrient enrichment in coastal areas are associated directly or indirectly with meeting the requirements and desires of human nutrition and



Coastal eutrophication: recent developments in definitions and implications for monitoring strategies

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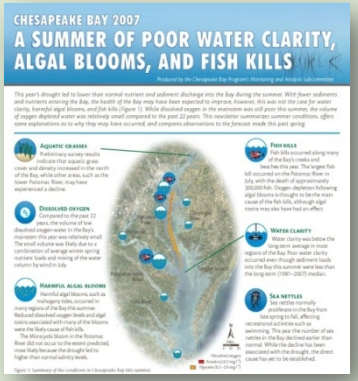
The word 'eutrophication' has its root in two Greek words: 'eu' which means 'well' and 'trophe' which means 'nourishment'. The modern use of the word eutrophication is related to inputs and effects of nutrients in aquatic systems. Despite a common understanding of its causes and effects, there is no agreed definition of coastal eutrophication. This communication aims to review recent developments in the definitions of coastal eutrophication, all of which focus on 'accelerated growth', and to discuss the implications in relation to monitoring and assessment of ecological status. It is recommended that measurements of primary production, being a sensitive and accurate indicator of eutrophication, should be mandatory when monitoring and assessing the ecological status of coastal waters.

INTRODUCTION

Eutrophication of coastal waters has been considered one of the major threats to the health of marine ecosystems sustainable use of water while progressively decreasing or eliminating discharges, losses and emissions of pollutants and other pressure for the long-term protection and

- Providing scientific context (references)
- Text > graphics
- Authorship exclusive
- Focus on results & interpretation

Science communication



CHESAPEAKE BAY 2007
A SUMMER OF POOR WATER CLARITY, ALGAL BLOOMS, AND FISH KILLS

Produced by the Chesapeake Bay Program's Monitoring and Analysis Subcommittee

This year's drought led to lower than normal nutrient and sediment discharge into the Bay during the summer. With fewer sediments and nutrients entering the Bay, the health of the Bay may have been expected to improve, however, this was not the case for water clarity, harmful algal blooms, and fish kills (Figure 1). While dissolved oxygen in the mainstem was still poor this summer, the volume of oxygen depleted water was relatively small compared to the past 22 years. This newsletter summarizes summer conditions, offers some explanations as to why they may have occurred, and compares observations to the forecast made this past spring.

AQUATIC GRASSES
Preliminary survey results indicate that aquatic grass cover and density increased in the north of the Bay, while other areas, such as the lower Potomac River, may have experienced a decline.

DISSOLVED OXYGEN
Compared to the past 22 years, the volume of low dissolved oxygen water in the Bay's mainstem this year was relatively small. The small volume was likely due to a combination of average winter-spring nutrient loads and mixing of the water column by wind in July.

HARMFUL ALGAL BLOOMS
Harmful algal blooms, such as mahogany tides, occurred in many regions of the Bay this summer. Reduced dissolved oxygen levels and algal toxins associated with many of the blooms were the likely cause of fish kills.
The Microcystis bloom in the Potomac River did not occur to the extent predicted, most likely because the drought led to higher than normal salinity levels.

FISH KILLS
Fish kills occurred along many of the Bay's creeks and beaches this year. The largest fish kill occurred on the Potomac River in July, with the death of approximately 100,000 fish. Oxygen depletion following algal blooms is thought to be the main cause of the fish kills, although algal toxins may also have had an effect.

WATER CLARITY
Water clarity was below the long-term average in most regions of the Bay. Poor water clarity occurred even though sediment loads into the Bay this summer were less than the long-term (1991–2007) median.

SEA NETTLES
Sea nettles normally proliferate in the Bay from late spring to fall, affecting recreational activities such as swimming. This year the number of sea nettles in the Bay declined earlier than normal. While the decline has been associated with the drought, the direct cause has yet to be established.

Figure 1: Summary of the conditions in Chesapeake Bay this summer.

HURRICANE ISABEL AND SEA LEVEL RISE

On Thursday September 18, 2003, Hurricane Isabel made landfall between Cape Lookout and Cape Hatteras on North Carolina's Outer Banks. A massive Category 2 hurricane, Isabel's strong winds and tidal surge resulted in widespread flooding, damage and power outages from North Carolina to New York.

Sea level in the Chesapeake Bay has risen by approximately 30 cm or 1 ft in the last 100 years. This is due to a combination of worldwide trends, such as global warming, and local factors like land subsidence and groundwater extraction.

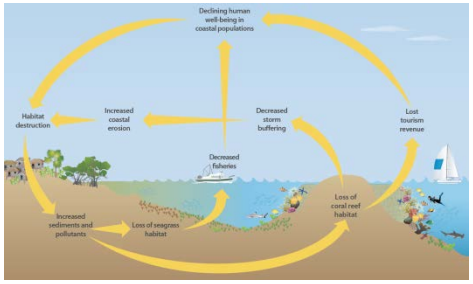
Hurricane Isabel caused more flooding and damage than would normally be expected of a Category 2 hurricane and this may be partly attributable to local sea level rise. Chesapeake Bay sea level is continuing to rise at nearly double the global average which suggests that the effects of tropical storms and hurricanes like Isabel may increase in severity in the future.

- Providing societal context (examples)
- Text ≈ graphics
- Authorship inclusive
- Focus on conclusions & recommendations

Good science communication can make you a better scientist

Completeness

Envisioning the ‘story’ can lead to comprehensive research program



Context

Identifying the linkages and developing comparisons can provide important insights

Visualizations

Combining visual elements can lead to new insights

Synthesis

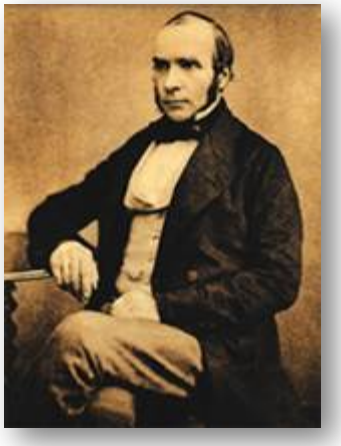
Combining and comparing different data sets or approaches can lead to insights

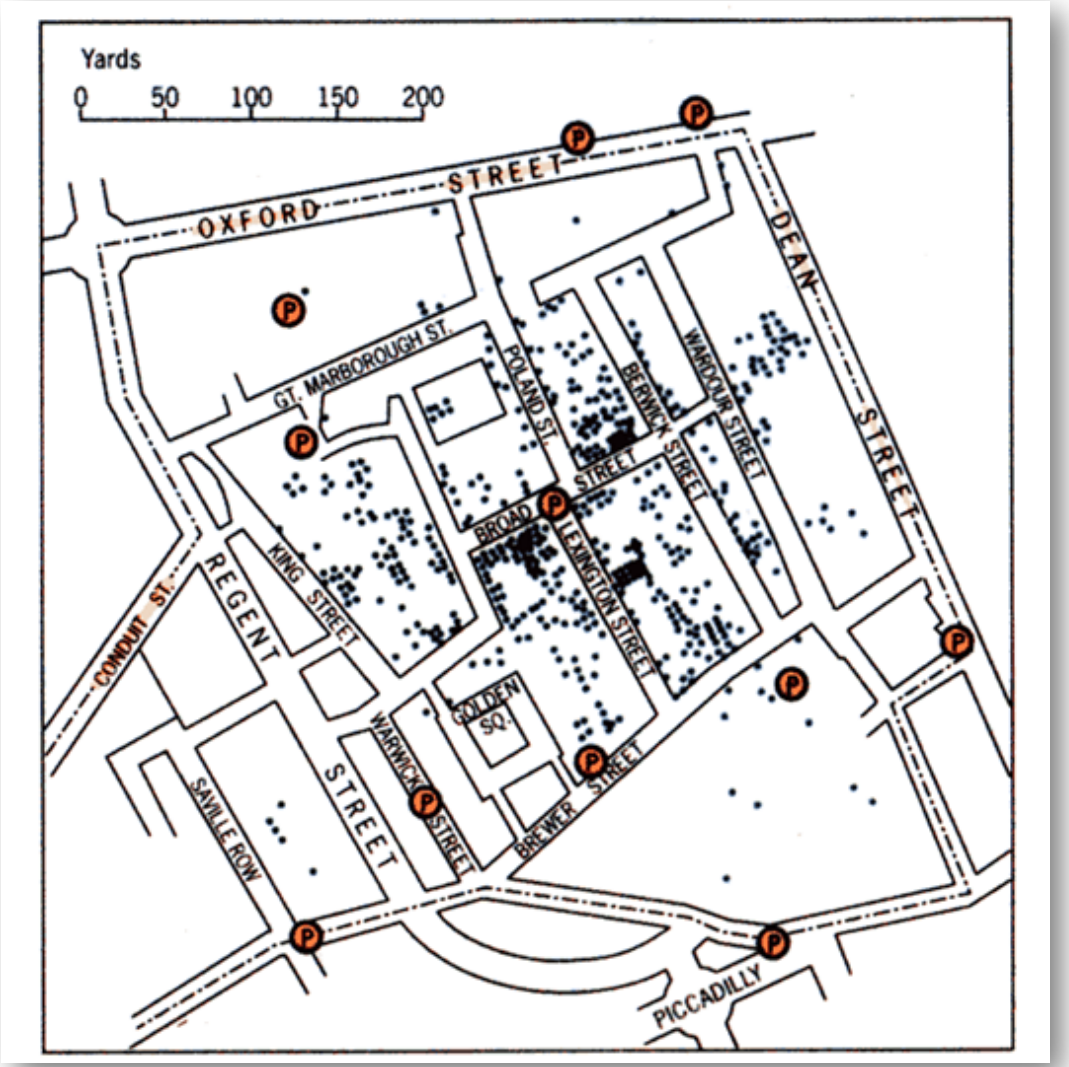
GOOD REEF HEALTH → POOR REEF HEALTH

Index	Cape York	Burnett–Mary	Wet Tropics	Fitzroy	Mackay–Whitsunday	Burdekin
Water Quality Index	0.78	0.70	0.63	0.62	0.47	0.42
Seagrass Index	0.80	0.67	0.67	0.69	0.62	0.50
Coral Index	0.79	0.68	0.65	0.64	0.64	0.46
REEF HEALTH INDEX	**0.79**	**0.68**	**0.65**	**0.65**	**0.58**	**0.46**

John Snow's 1854 cholera map

- Cholera outbreak in London
- John Snow mapped cholera cases
- Linked cholera cases to pump locations
- Pump handle removed; cholera subsided

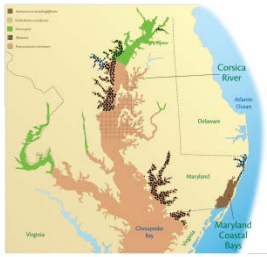




The art of science communication

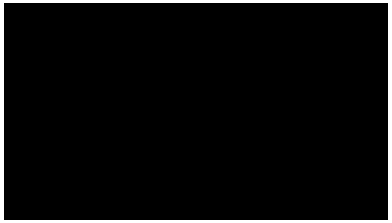
- Conceptual diagrams: context and synthesis

- Maps: geographic context and information-rich

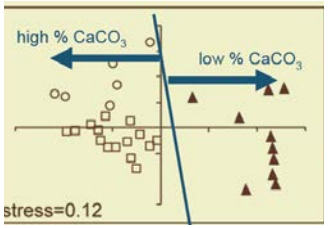


- Photos: describe methods, study site description, processes and relevance

- Video clips: capture system dynamics



- Tables and figures: scientific data



Conceptual diagrams

- What are conceptual diagrams?
- Why are conceptual diagrams effective?
- How can conceptual diagrams be used?

What are conceptual diagrams?

con·cept /ˈkänsept/

Noun: Something conceived in the mind

(Webster's 3rd Dictionary, 1986)

di·a·gram /ˈdīəˌgram/

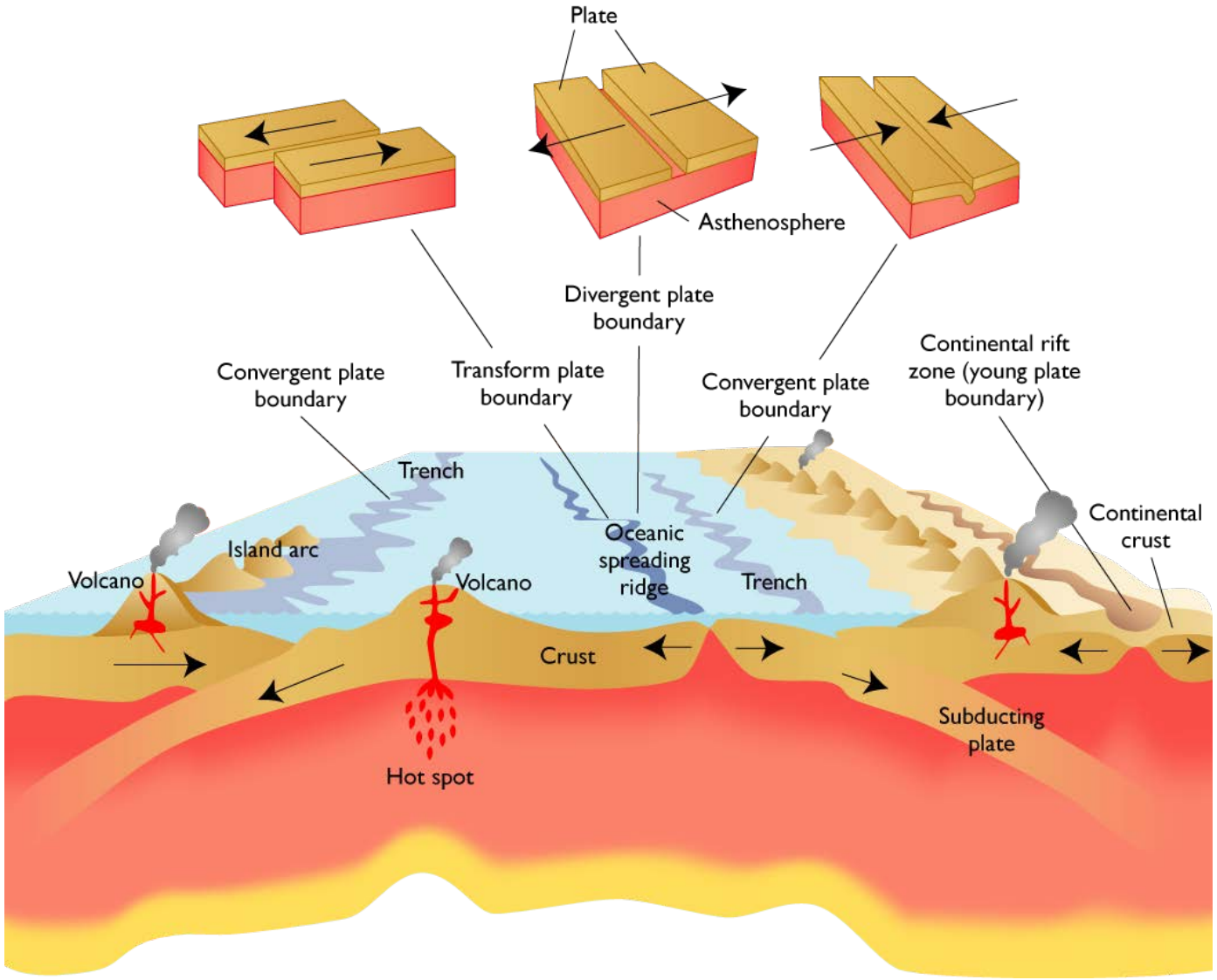
Noun: A drawing that shows relations

(Webster's 3rd Dictionary, 1986)

conceptual diagram

A diagram using symbols that depicts the essential attributes of a system

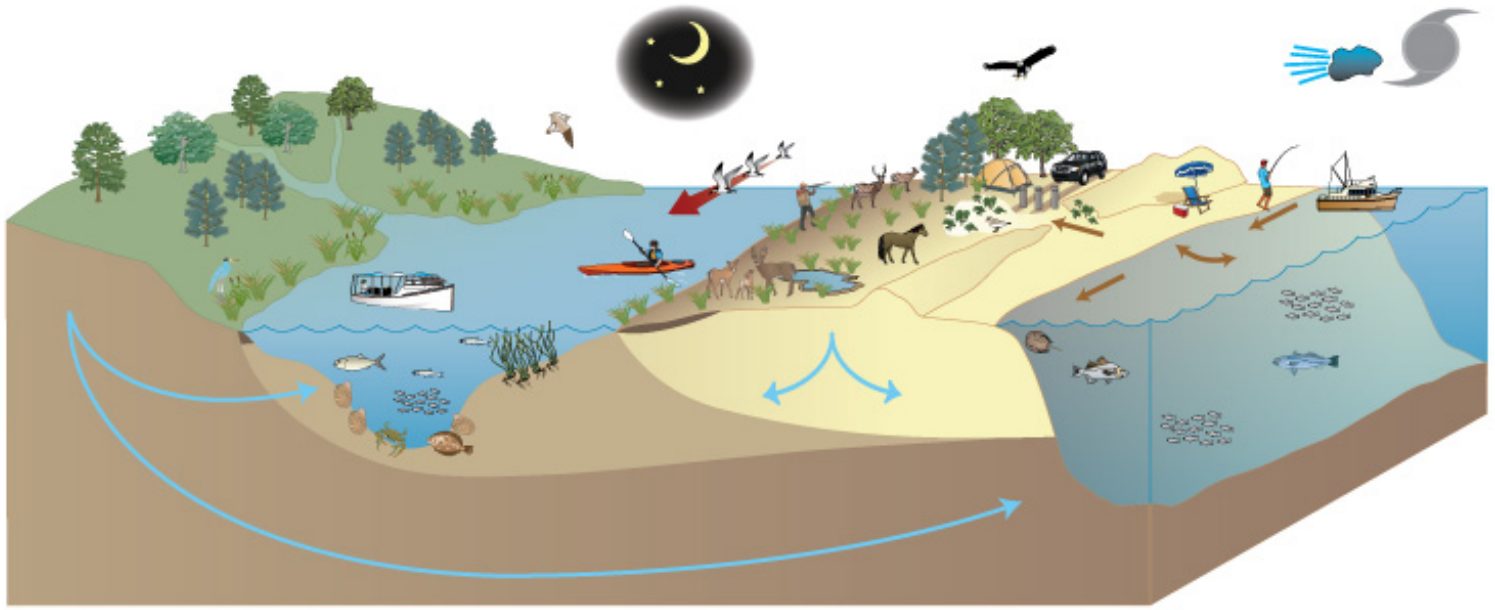
Conceptual diagrams provide synthesis, visualization, and context



What makes conceptual diagrams so effective?

- Help to clarify thinking
- Aid communication
- Can identify data gaps, management priorities, or key features and threats

Diagrams are an interface between scientists, government, and the community



Physical features

Storms result in inlet formation, closure, and island overwash.

Dynamic geomorphology includes longshore sand transport, island "rollover," and net westerly migration.

Mainland groundwater discharges to the coastal bays and the ocean. Assateague groundwater is isolated.

Removal of artificial structures is restoring natural processes such as dune building and overwash.

Ecosystem features

Rare overwash habitat supports specialized and rare species such as piping plover and seabeach amaranth.

Birds use the island for overwintering and a stop along a major Atlantic migration corridor.

The absence of ambient noise allows for sensitive species to be unimpacted by human activity.

Native white-tail deer and historically introduced horses and sika deer.

Human use features

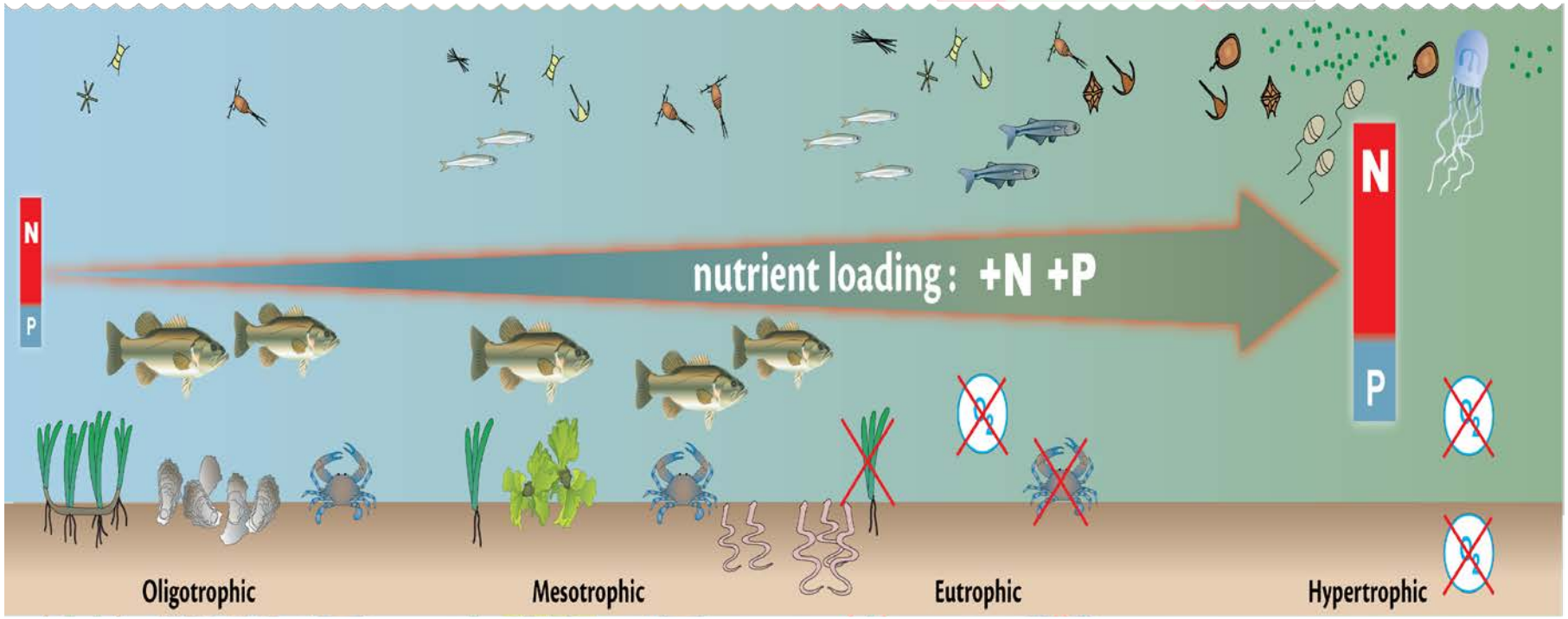
The bays and ocean provide important habitat for commercial and recreational fisheries.

Aesthetic appeal and observation of unique fauna attracts millions of visitors every year.

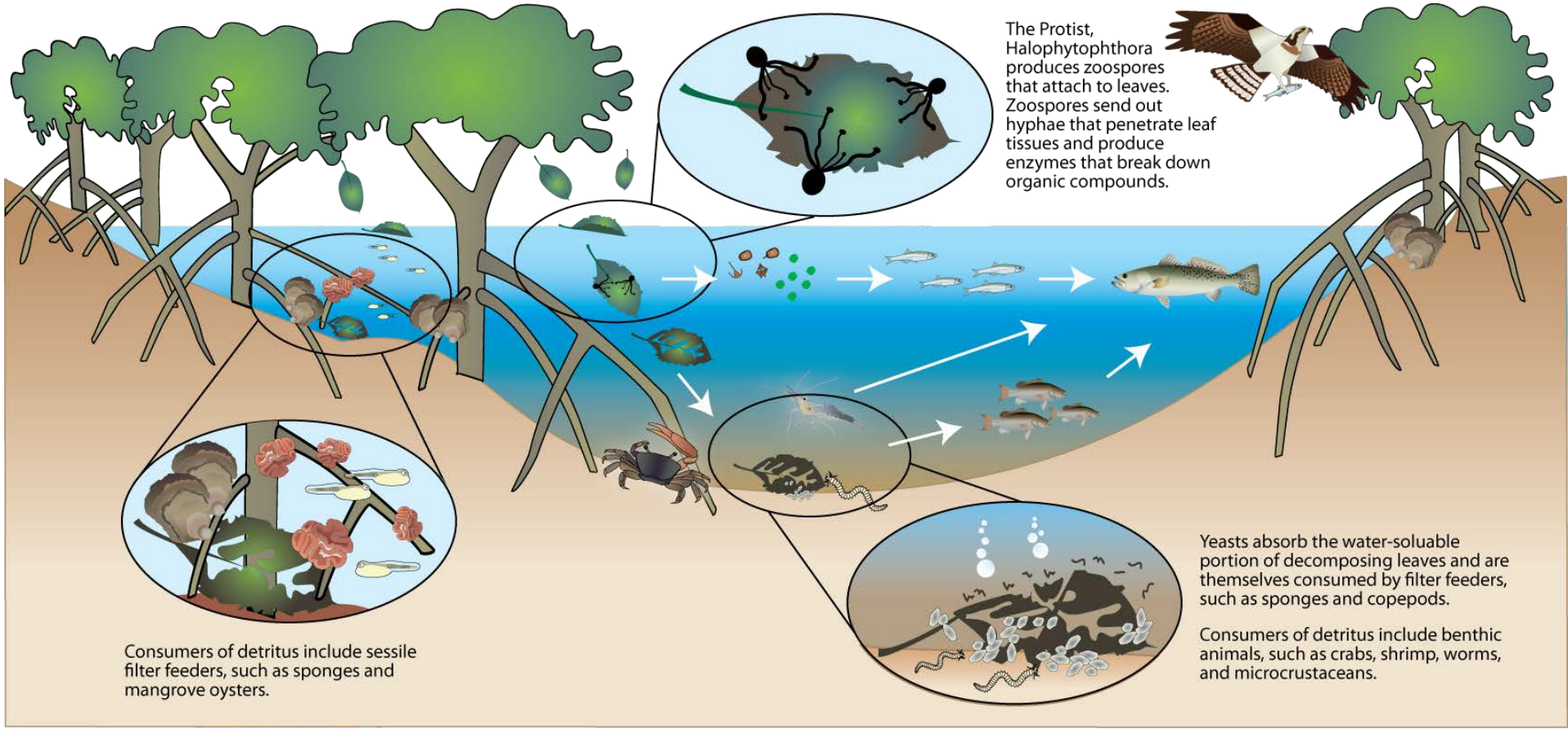
Increasingly rare on the US Atlantic coast, night darkness characterizes the sky.

Hunting of native white-tail deer and introduced sika deer help control population size.

Conceptual diagrams can illustrate complex processes



Conceptual diagrams can describe processes at different scales

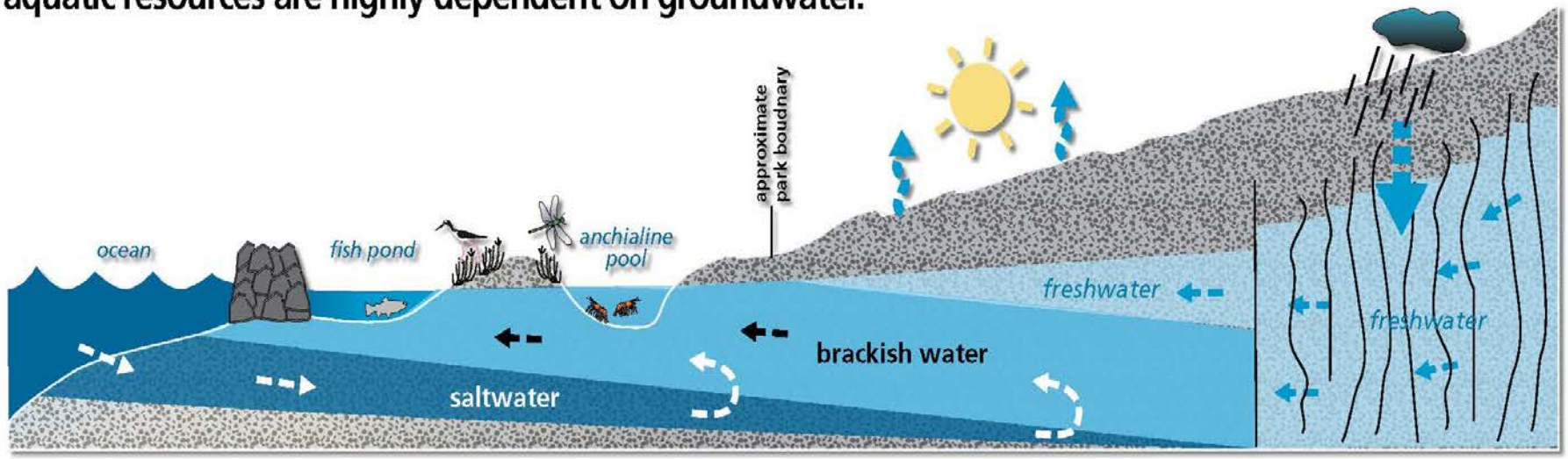


meters ⟶ centimeters

Conceptual diagrams can communicate ecosystem relationships

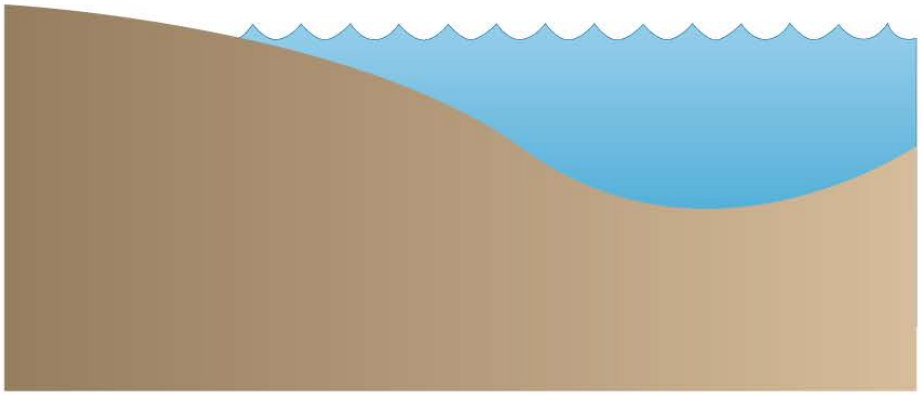
How does the groundwater system work in north Kona?

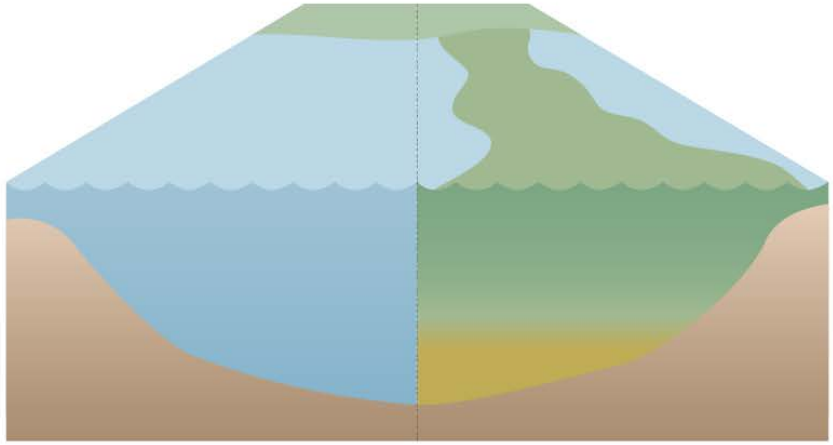
North Kona has low rainfall, dark porous soils, abundant sun, and high evaporation. As a result, aquatic resources are highly dependent on groundwater.

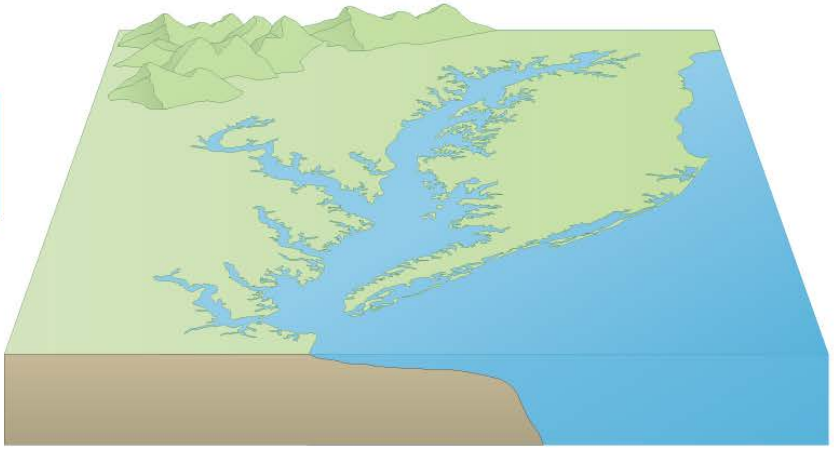


Rainfall that seeps into the soil forms a layer of fresh groundwater that floats on the layer of brackish groundwater. The brackish water emerges in low anchialine pools and seeps into the fishponds, wetlands, and nearshore marine waters.

The components of a conceptual diagram: BASE







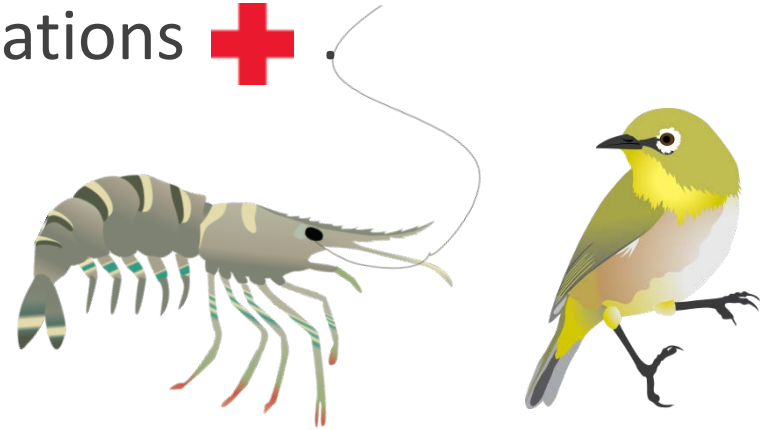
The components of a conceptual diagram: SYMBOLS

- Symbols are language independent and universal: mathematics  , weather  , music  , religion  , corporate branding  , signage  , and organizations  .

The components of a conceptual diagram: SYMBOLS

- Symbols are language independent and universal: mathematics π , weather ☀ , music 𝄞 , religion ⋊ , corporate branding ✓, signage 🚺 , and organizations ✚ .

- Symbols can represent something tangible



The components of a conceptual diagram: SYMBOLS

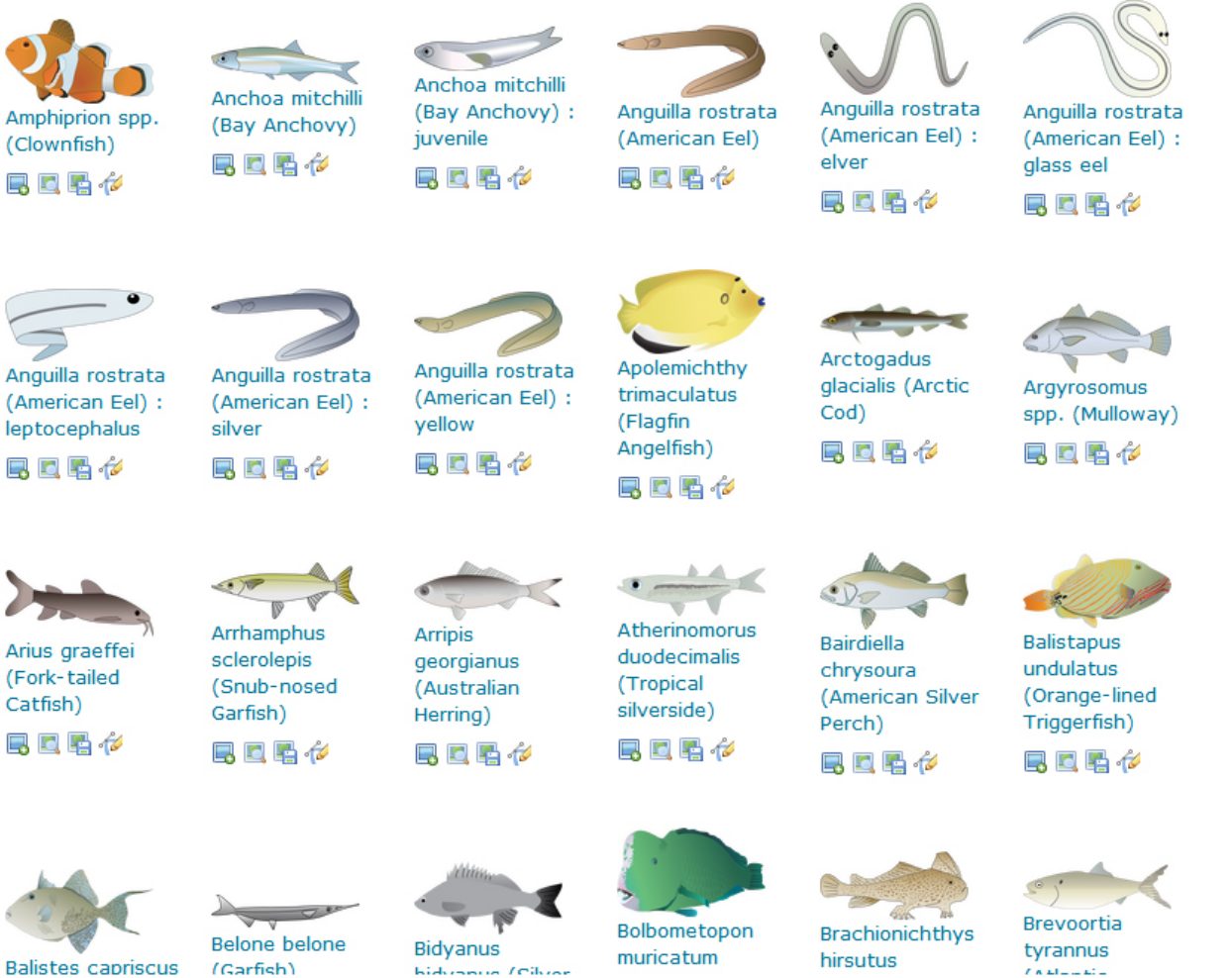
- Symbols are language independent and universal: mathematics π , weather ☀ , music 𝄞 , religion ⋊ , corporate branding ✓, signage 🚺 , and organizations ✚ .

- Symbols can represent something tangible

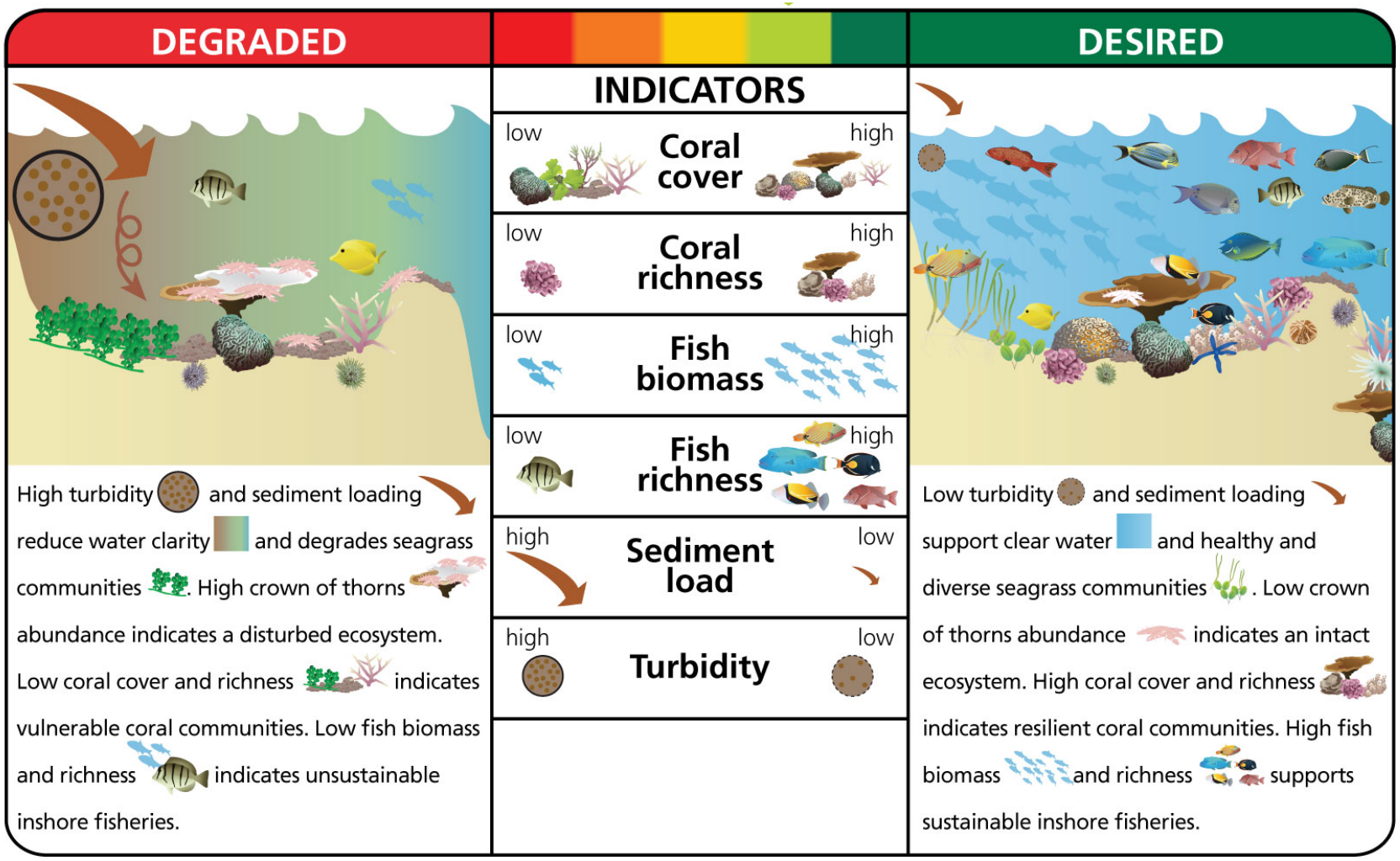
- Symbols can represent something invisible or intangible

IAN's symbol libraries are a key tool for scientists and managers

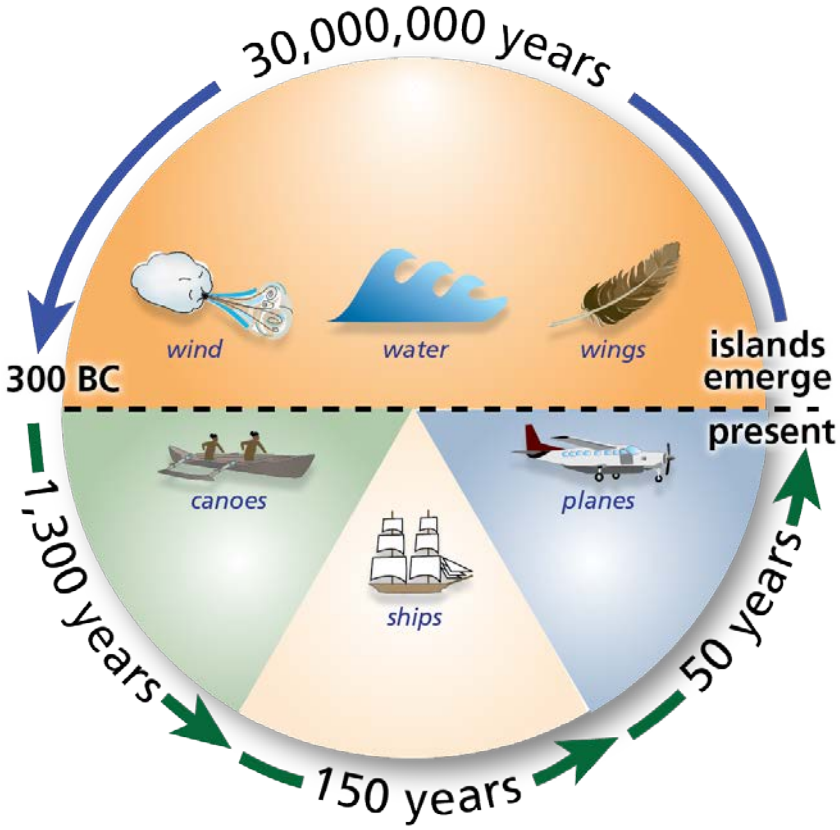
Fauna: Fish - use arrow or PgUp/PgDn keys to browse to other albums

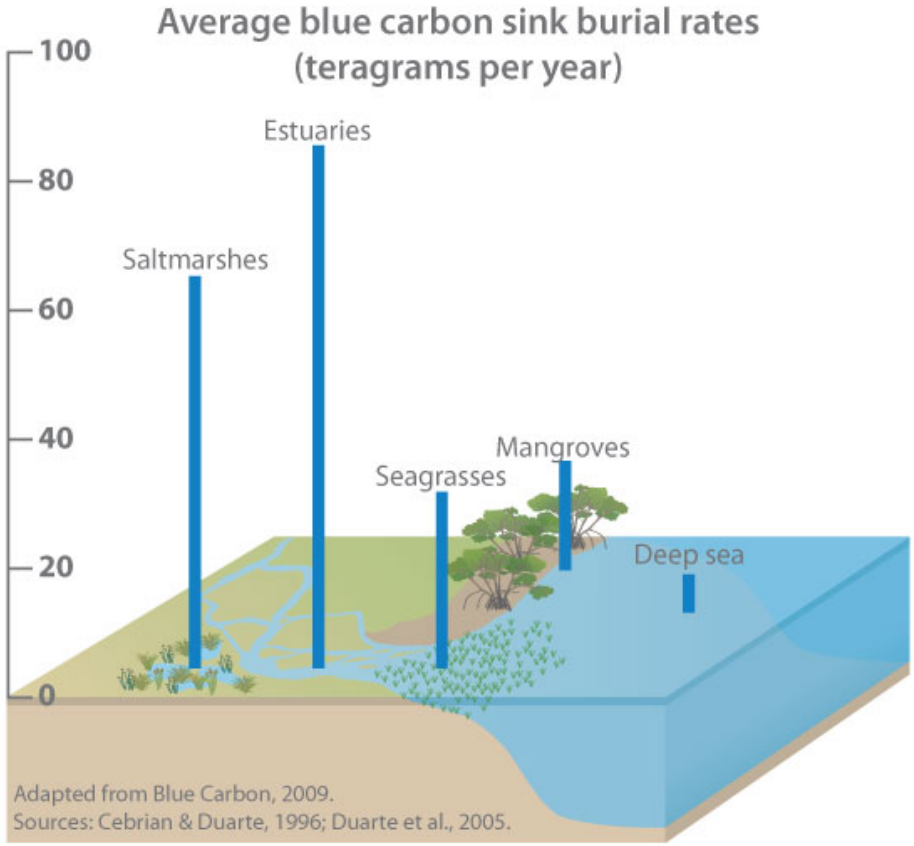


Use the size and color of symbols to convey information



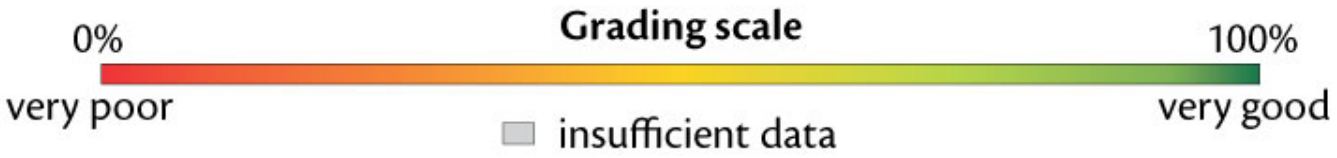
Symbols can be used in graphs



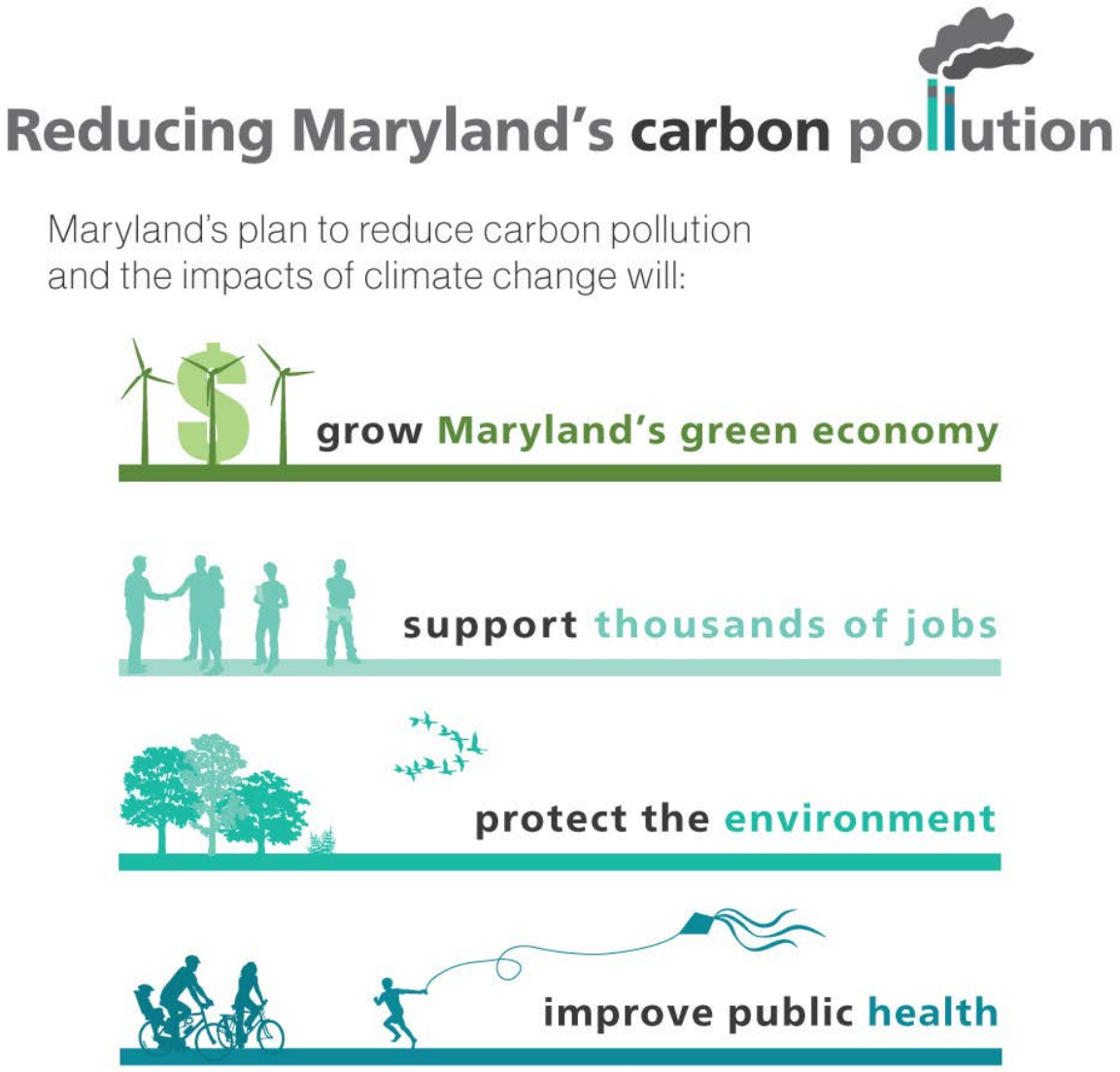


Symbols can be used in tables

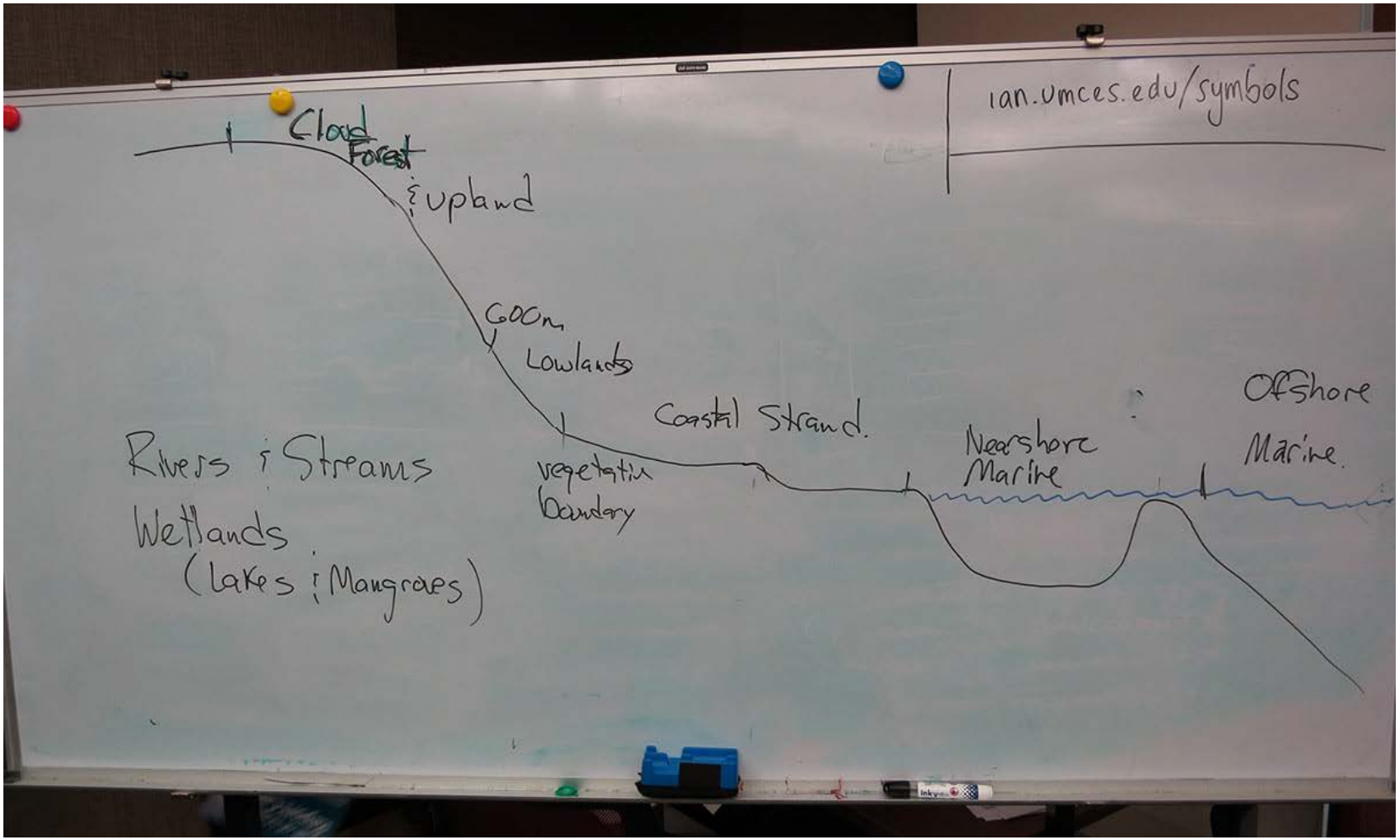
Water quality & habitat indicators	McHenry	Mid-lake	Southern lake	Overall
DO Dissolved oxygen	93	79	93	87
TP Total phosphorus	100	95	81	88
Water clarity	67	83	69	74
Chlorophyll *a*	64	73	65	68
pH	100	100	99	100
Hg Mercury	n/a	n/a	n/a	n/a
Aquatic grasses	n/a	n/a	n/a	n/a



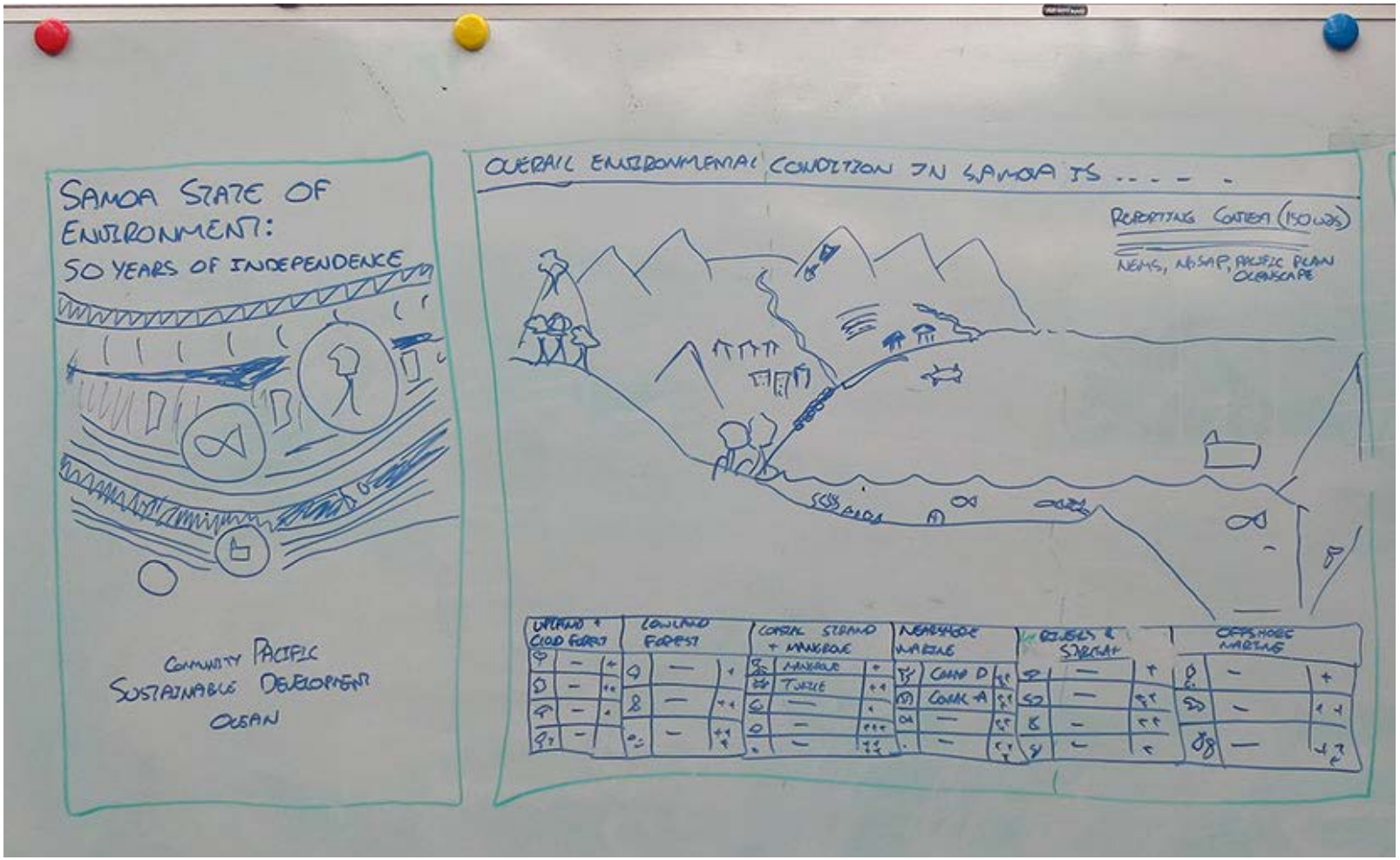
Symbols can be used in infographics



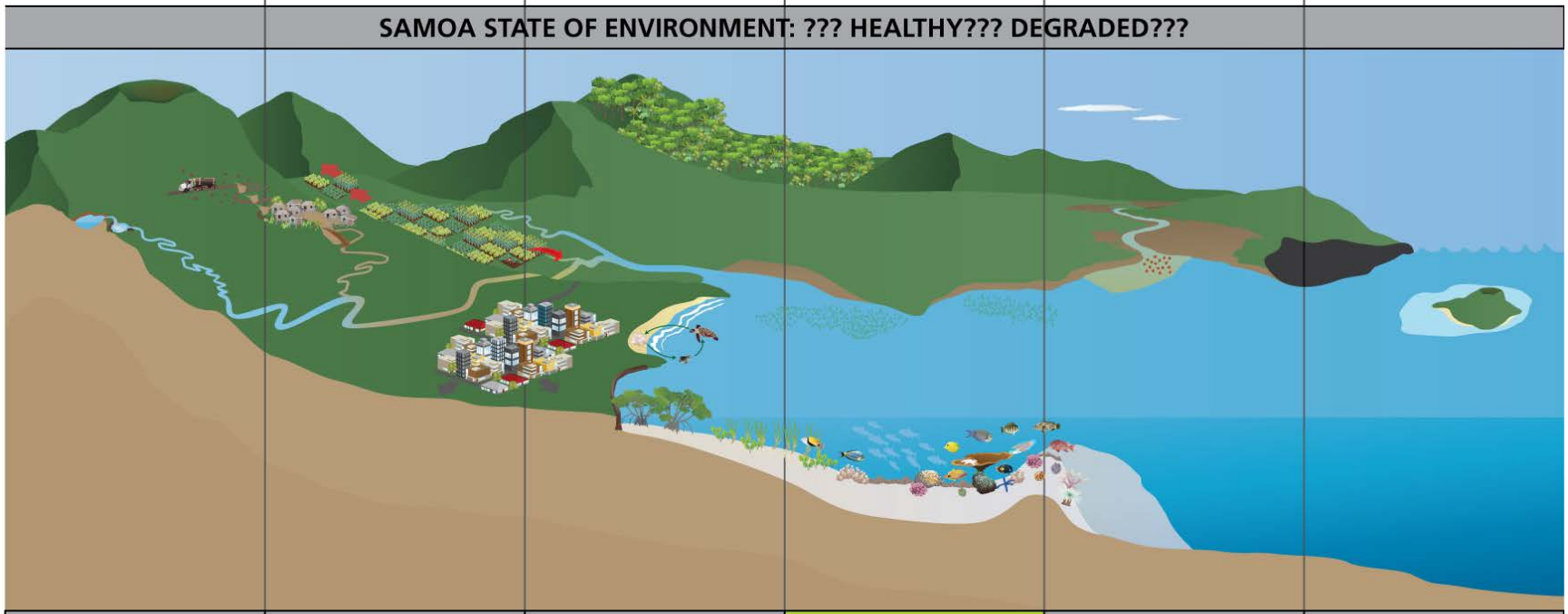
Diagrams can be produced in real time to create a shared vision



Diagrams can be produced in real time to synthesize key messages



Diagrams can be produced in real time to synthesize key messages



Conceptual diagrams can transform text…

Ecosystem Based Management

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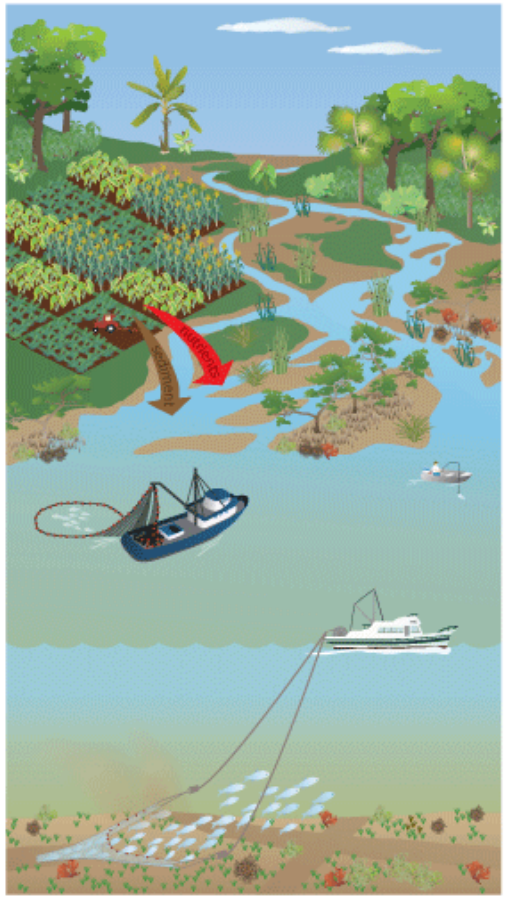
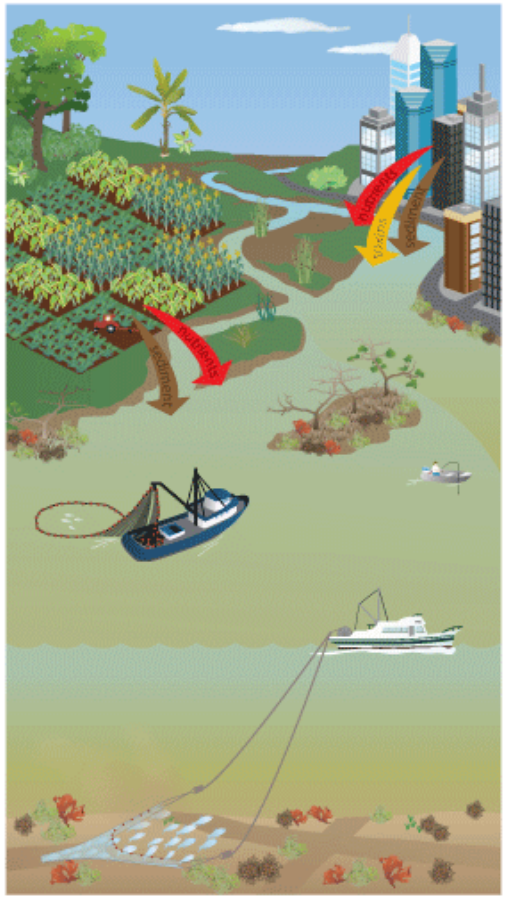
…into synthesized cumulative impact visualizations

Intensive Fishing

Intensive Fishing + Agriculture

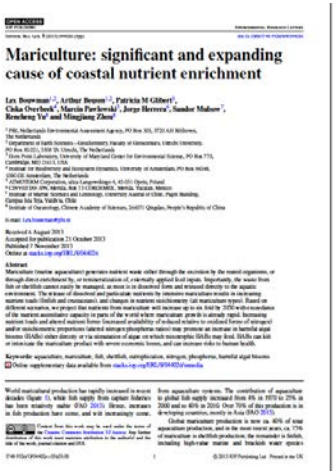


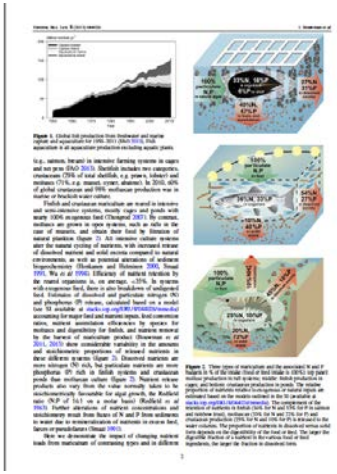
Intensive Fishing + Agriculture + Development



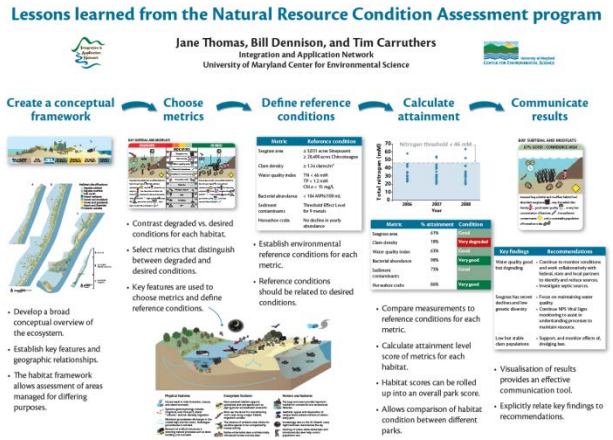
Conceptual diagrams can be incorporated into science publications

Science Journals

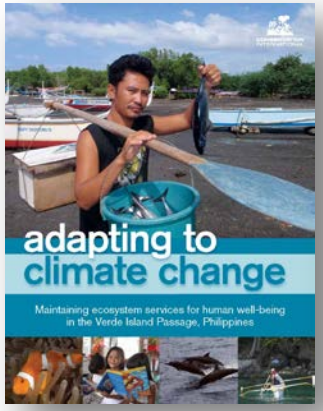

Mariculture: significant and expanding cause of coastal nutrient enrichment

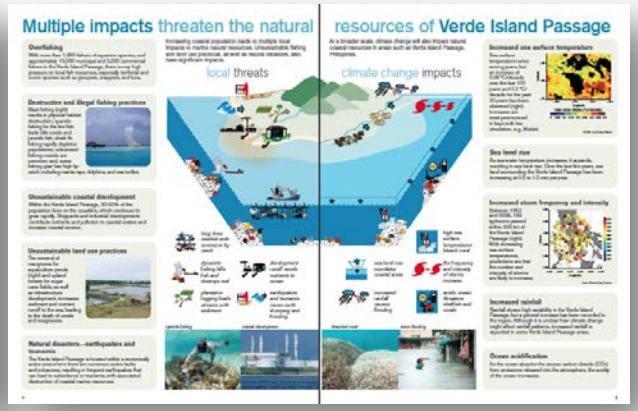


Posters



Reports



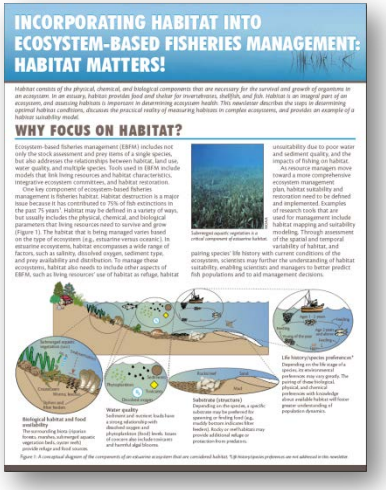


Online diagram creator

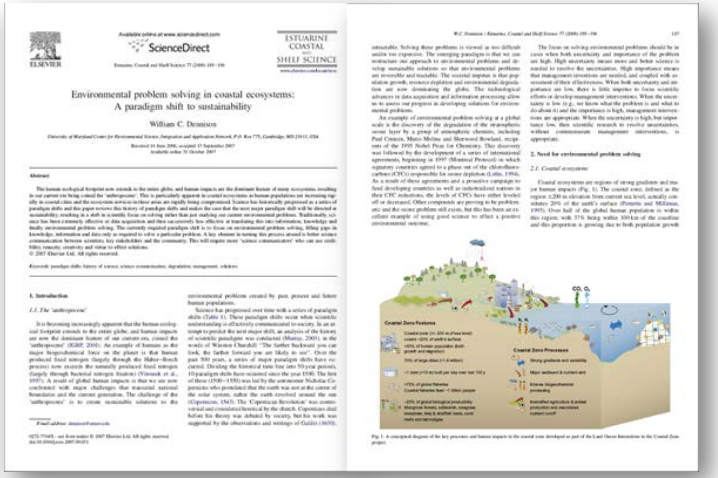
- http://ian.umces.edu/diagrammer/editor/svg-editor.php

Develop a variety of science communication products

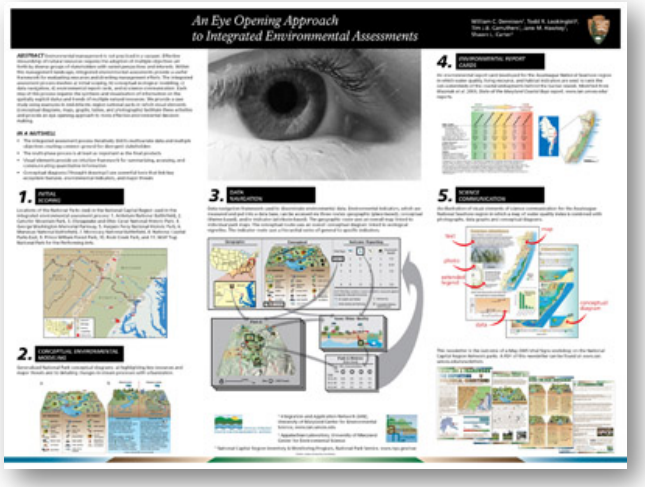
Newsletters



Science Journals



Posters



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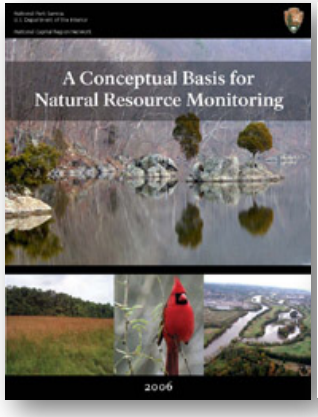
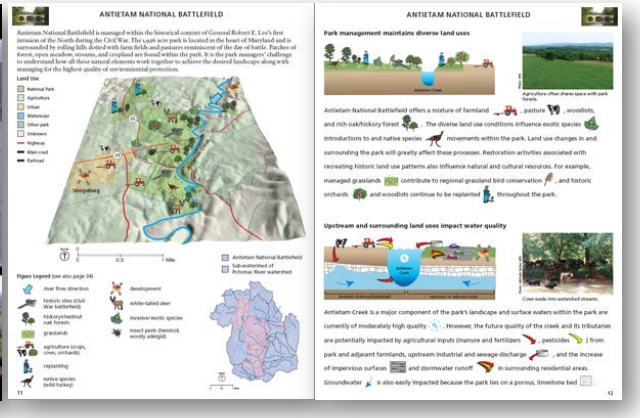
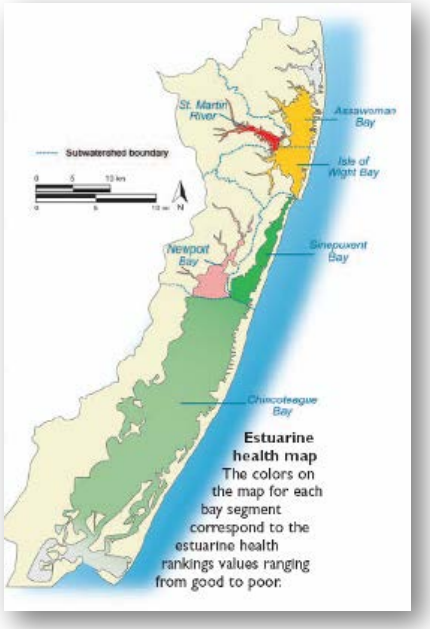




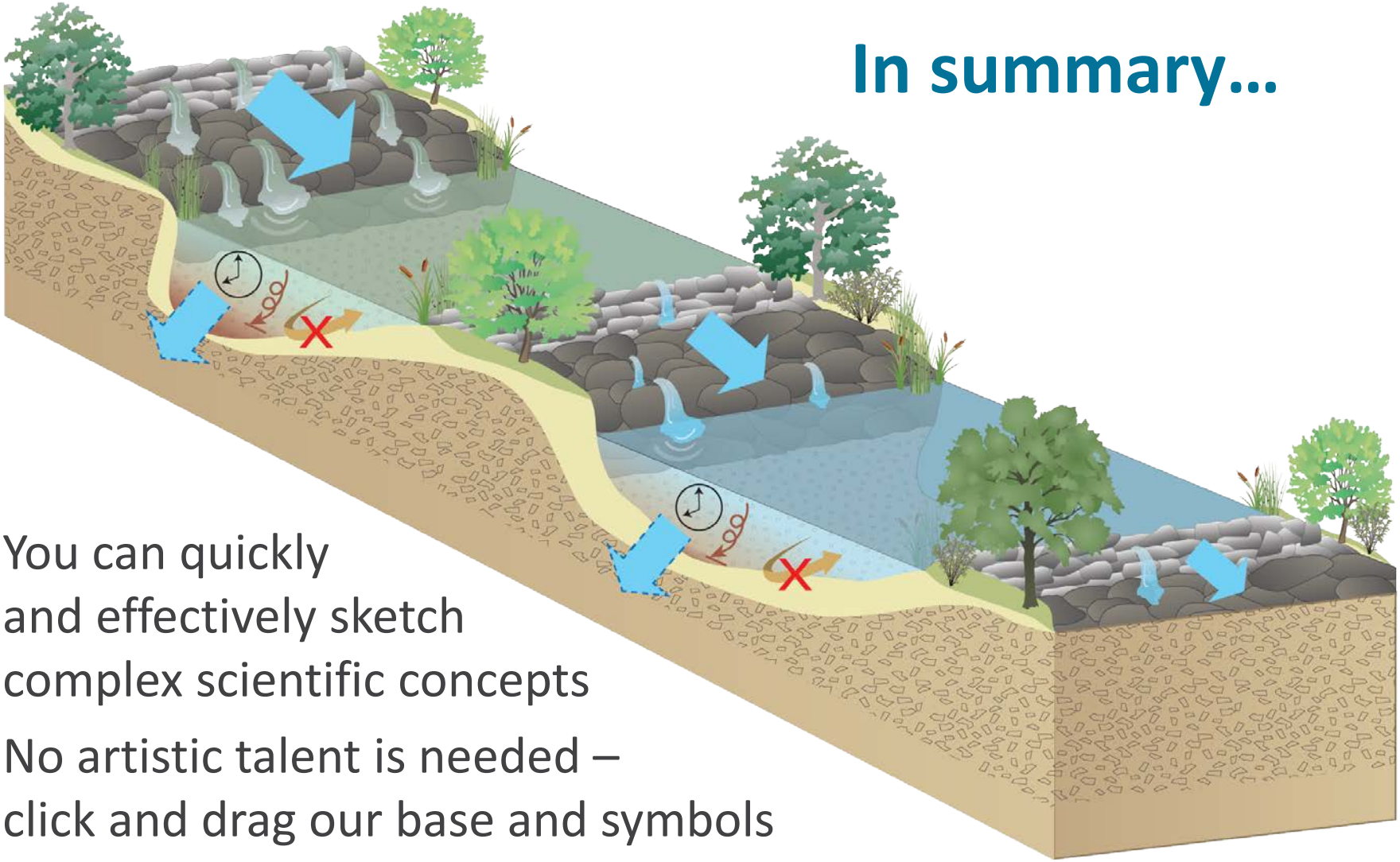
Websites and apps

Invest in science communication

- Building a library of high quality visual elements is an investment that will pay dividends over time
- High quality visual elements can be recycled for various media
- Good science communication …
  - Helps convey information
  - Helps make a good impression on your audience
  - Helps make a difference



In summary…



- You can quickly and effectively sketch complex scientific concepts
- No artistic talent is needed – click and drag our base and symbols
- Draft and revise
- Obtain stakeholder input and feedback

Thanks!

- Caroline Donovan
- cdonovan@umces.edu
- 410-330-3330
- Ian.umces.edu

http://www.nature.com/scitable/content/ne0000/ne0000/ne0000/ne0000/14239512/ECS_scientific-papers_ksm.jpg