Our coastlines are becoming increasingly developed as more and more people live and recreate in coastal areas.

Seagrass abundance is declining globally. Physical disturbance and poor water quality threaten this valuable ecosystem.

Many fish and shellfish species have been declining for the last few decades. Careful management can sustain populations of important commercial and recreational fisheries.

In our estuaries and coastal waters increased nutrient and sediment loads are resulting in areas with little or no oxygen (dead zones) which cannot support life.
Outline

• What are conceptual diagrams?

• Why are conceptual diagrams effective?

• How can conceptual diagrams be used?
Integration and Application Network

• A collection of scientists interested in solving, not just studying environmental problems

• Part of the University of Maryland Center for Environmental Science

• Partner with other academic institutions, resource management agencies and non-governmental organizations
What is a conceptual diagram?

**Concept**  something conceived in the mind  *(Webster’s 3rd Dictionary, 1986)*

**Diagram**  a drawing that shows relations  *(Webster’s 3rd Dictionary, 1986)*

**Conceptual diagram**  = A diagram using symbols that depicts the essential attributes of a system
Good conceptual diagrams synthesize and present information.
Conceptual diagrams are not... cartoons
Conceptual diagrams are not...

... cartoons

... model relationships
Conceptual diagrams are not...

... cartoons

... model relationships

... colored box & arrow diagrams
Conceptual diagrams are not...

- cartoons
- model relationships
- colored box & arrow diagrams
- A REPLACEMENT FOR GOOD, WELL INTERPRETED DATA!
Why are conceptual diagrams effective?

- Helps to clarify thinking
  (words can be ambiguous; an image commits to the message being portrayed)
- Communication
  (one-way and two-way – idea presentation and idea development)
- Identify gaps / priorities / essential elements
- Develop syntheses (or present synthesis)
Conceptual diagrams provide an interface

**Science**
- Current understanding
- Credibility & support

**Community**
- Priorities & environmental values
- Commitment & resources

**Shared vision**

Healthy Chesapeake Waterways

INTEGRATION & APPLICATION NETWORK
Conceptual diagrams use symbols to depict unequivocal messages.
Symbols (icons) are a key element of conceptual diagrams

- Something that stands for or suggests something tangible
- A visible thing that stands for something invisible or intangible
- Symbols used in mathematics (e.g. $\pi$), chemistry (e.g. $^{210}\text{Pb}$), music (e.g. $\text{\guitar}$), weather (e.g. $\text{\sun}$), religion (e.g. $\text{\cross}$), corporations (e.g. $\text{\nike}$), and organizations (e.g. $\text{\plus}$)
- Symbols can be universal; language independent
- Symbols are scalable; size of symbol can represent relative importance (e.g. $\text{\bigarrow}$ vs. $\text{\arrow}$)
- Symbols can be information-rich: size, shape, color and position of symbols can convey information
Both shape and color of symbols can be important for recognition.
In conceptual diagrams, as in maps, symbols need to be explained in a legend.

**Map legend**

- Hiking trail
- Steep trail; arrows point uphill
- Overlook
- Horse trail
- Unpaved road
- **Poplar**

Legend symbols:
- Parking
- Ranger station
- Picnic area
- Wheelchair accessible
- Public campground
- Private campground

**Conceptual diagram legend**

- **7 exuviae**
- **8 Zostera seed bank**
- **9 Halophila seeds**
- **10 urchin grazing**
- **11 dugong grazing**
- **12 green sea turtle grazing**
- **13 epiphytic grazers abundant**
- **14 fisheries**
- **15 fin fisheries**
- **16 Parrotfish grazing**
- **17 seabird guano**
- **18 low seagrass production**
- **19 high seagrass production**
- **20 seagrass leaf recycling**
- **21 organic carbon release**
- **22 respiration**
- **23 nitrogen fixation**
- **24 ammonification**
- **25 stable seagrass**
- **26 seagrass detritus**
- **27 Avicennia**
- **28 Rhizophora**
- **29 branching coral**
- **30 boulder coral**
- **31 giant clam**
- **32 sea cucumber**
- **33 Angel fish**
- **34 duck**
- **35 wader**

**Physical environment**

- **36 seasonal turbidity runoff**
- **37 cyclone**
- **38 nutrient and sediment input**
- **39 environmental variability**
- **40 limestone**
- **41 carbonate sand**
- **42 terrigenous sand and mud**

**Threats**

- **43 canal development**
- **44 port development, marinas**
- **45 beef / dairy farming**
- **46 treated sewage outflow**
- **47 sugar cane**
- **48 boating**
Developing a global symbol language

>41,000 people from 230 countries ( ) registered

1500+ symbols
How can conceptual diagrams be used?

Research

Synthesis

Monitoring

Management
Conceptual diagrams can be incorporated into various publications:

Newsletters
Science Journals
Posters
Reports
Books
Conceptual diagrams can depict processes at different scales.

- **Kilometers**:的概念图可以显示不同尺度下的过程。这些图示通常用于科学和工程领域，帮助解释复杂的自然现象。

- **Meters**: 这些图示通常用于科学和工程领域，帮助解释复杂的自然现象。

- **Centimeters**: 这些图示通常用于科学和工程领域，帮助解释复杂的自然现象。
Conceptual diagrams can be nested

NORTH-EAST QUEENSLAND WATERS

COASTAL

Increasing variability: salinity, turbidity, exposure

LEGEND

Biological processes
- High biodiversity
- Fish, fisheries
- Seagrass loss and recovery
- Seagrass loss
- Ecosystem processes

Biological transformations
- CO2
- Low seagrass production
- CO2
- High seagrass production
- Seagrass leaf recycling
- Organic carbon release

COASTAL SUBTIDAL

Ungrazed

Grazed

Halodule un serrata
Halodule ovalis
Zostera capnoides
Halodule un serrata
Halodule ovalis
Halophila Halophila Halophila Halophila

Biota
- Stable seagrass
- Seagrass documents
- Algae
- Amphibians
- Birds

Physical environment
- Seasonal turbidity
- Cyclones
- Environmental variability
- Turbidity
- Tides

Physical processes
- Full light
- Reduced light quantity and quality
- Deposition and dissolving
- Sediment re-deposition

INTEGRATION & APPLICATION NETWORK
Literature citations can be added

References

1. Brodie, 1992
2. Heggie 1999
3. McKee et al, 2001
4. Risk et al, 1994
5. Coles 1987
6. Fabricius & Wolanski, 2000
7. Klumpp and Mckinnon, 1992
8. Revelante & Gilmartin, 1982
9. Perry & Dennison, 1999
10. Preen, 1995
11. Aragones & Marsh, 2000

Wet season river floods result in pulsed turbidity events influencing catchment to coral reef zones (1, 4).

Macro grazers (dugong and sea turtle) continually disturb river, estuarine, and coastal zones (9, 10, 11).

Extremely low nitrogen and phosphorus control the coral reef zone (2, 3).
Hybrid data–diagrams increase information density

Fig. 2. Growth response of the seagrasses to fertilisation with phosphorus (+P), nitrogen (+N) and nitrogen plus phosphorus (N+P). Height of the leaves represents the average leaf canopy height. Number of shoots represents the mean number of new shoots formed since the rhizomes were tagged (92–94 day) and the rhizome leaf scars are equal to the mean number of leaves produced.
Conceptual diagrams can be used in PowerPoint presentations

Overall summary

**Nutrient inputs to the west Yucatan Peninsula**

- Limestones
- Sand Ridge
- Lagoon
- Reef

Col Limpus & co-workers have observed turtles foraging in mangroves for the past 15 years. At high tide, turtles move into the mangroves feeding on propagules, cotyledons and canopy leaves. Observed in Shoalwater Bay, Moreton Bay, Western Australia & Galapagos Is.

Question statement

**Turtle diet and feeding behaviour**

- Green turtles mostly herbivorous
- Hatchlings to juveniles omnivorous
- Young adults and adults feed mostly on seagrasses
- But macroalgae, jellyfish, sponges, squid eggs, mollusc eggs, ascidians & other invertebrates have been recorded

Question resolution

**Feeding preference of turtles**

<table>
<thead>
<tr>
<th>Seagrass</th>
<th>Bite marks</th>
<th>No bite marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halodule</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Zostera</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Green turtles seem to prefer *Halodule*
- Less likely to eat *Zostera* if it is <1mm
Diagrams and figures can be produced in real time to synthesize main messages.

Result of two day meeting about eutrophication in estuaries around the country.
Diagrams and figures can be produced in real time to synthesize main messages.

Result of two day meeting about eutrophication in estuaries around the country.
Example of embedded legend
Example of comparison conceptual diagram

A healthy ecosystem includes thriving benthic communities.

A degraded ecosystem has lost its benthic communities.

As urban development increases, housing developments may encroach upon Bay installations. This may include the construction of transportation corridors that cut through Bay installations. Increased development surrounding installations leads to elevated nutrient inputs and increased pollution.

If smart growth is employed during housing developments, they do not encroach upon Bay installations. In addition, patches of forest, farmland, and urban centers are separated from installations. Smart growth also leads to smaller nutrient inputs than conventional urban development.

Symbols courtesy of the Integration and Application Network (www.iian.umces.edu/symbols), University of Maryland Center for Environmental Science.
Example of blowouts (with associated text)

Symbols courtesy of the Integration and Application Network (www.ian.umces.edu/symbols/), University of Maryland Center for Environmental Science.
Questions?

The Integration and Application Network (IAN) is a collection of scientists interested in solving, not just studying environmental problems. The intent of IAN and Ecosphere is to inspire, manage and produce timely syntheses and assessments on key environmental issues, with a special emphasis on Chesapeake Bay and its watershed. IAN is an initiative of the University of Maryland Center for Environmental Science, but links with other academic institutions, resource management agencies and non-governmental organizations.

IAN in the News
A call to act on streams, bay
The Baltimore Sun - May 02, 2008

NEW REPORT
Fine scale patterns of water quality in three regions of Maryland’s Coastal Bays: assessing nitrogen source in relation to land use

This report details the outcomes of a project which utilized stable isotope bioindicator techniques, along with traditional water quality analyses to determine fine scale patterns in the Maryland Coastal Bays.

IAN SYMBOL LIBRARIES
- Completely cost and royalty FREE
- Now over 1500 symbols in 32 libraries
- Lots of new landscape bases
- New EPS & SVG versions for non-illustrator users
- Interactive tutorial
- Updated searchable index PDF
- Still don’t have what you need? Don’t forget about our free Symbol Creation Service

www.ian.umces.edu
**Concept:** Acid rain kills forests

**Definition:** Acidification of rainfall by emissions kills trees

**Keywords:** Air pollution

Tree death

Each person is timed and has to draw the concept for others to guess – all keywords must be written down to finish
Wrap up and review

- You can quickly and effectively sketch complex scientific concepts
- No artistic talent is need – symbols do the work
- Draft and revise… and revise some more
- Obtain stakeholder input and feedback