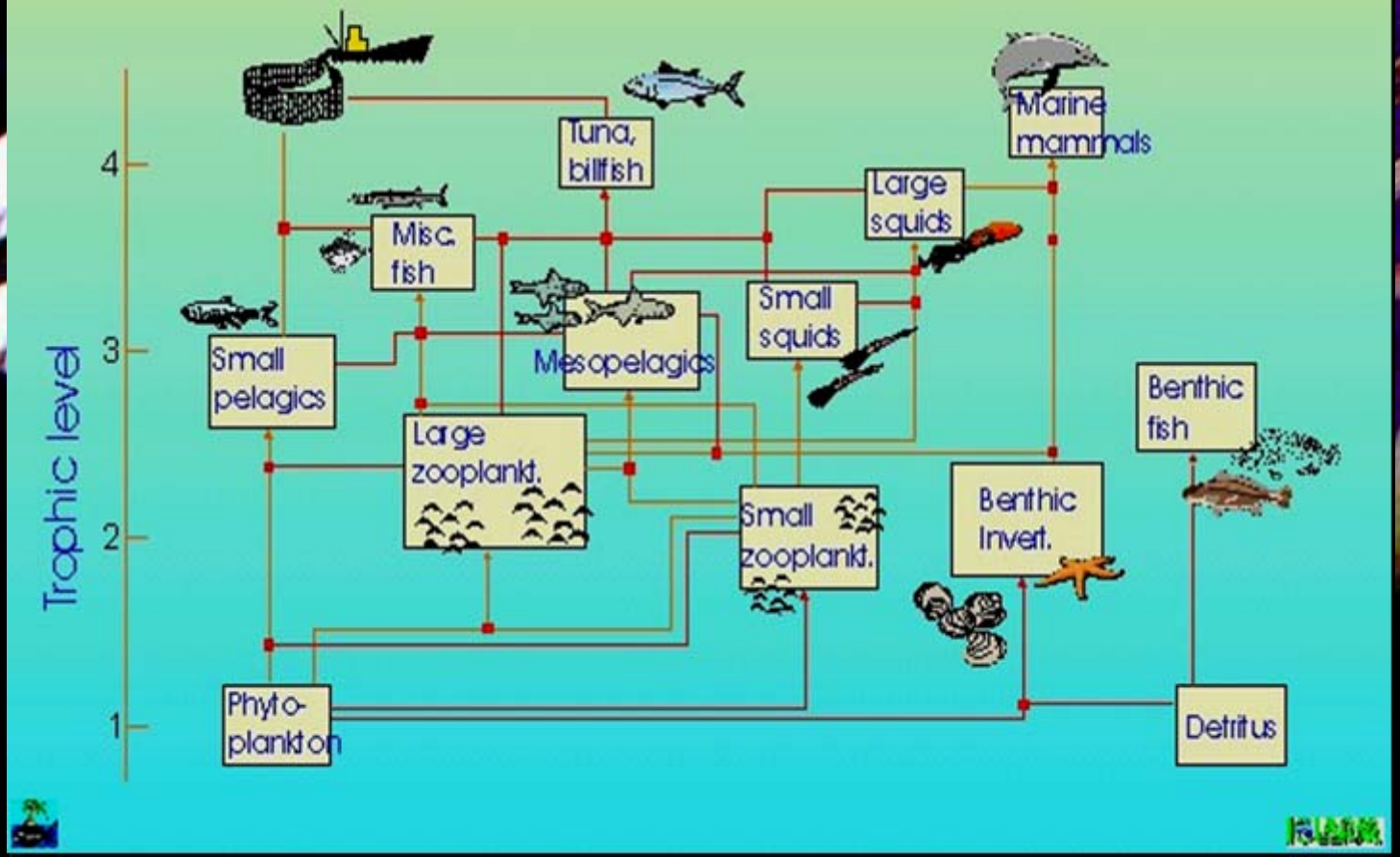

WHAT ARE THE
ECOPATH & ECOSIM


•Model for ecosystem based fishery management
•Free of charge
•User friendly

# Ecology of fisheries




Fisheries form part of complex eco-systems

# Ecopath with Ecosim

- The Ecopath software package which includes time-dynamic (Ecosim) and spatial simulation (Ecospace) sub-models can be used to study fisheries resources in an ecosystem context, for overall ecosystem analysis, and for exploring management policy options.

# Key routines in Ecopath with Ecosim

- **Ecopath** routines for entry of key data on the biology and exploitation of ecosystem groups, and for establishing mass-balance;
- **Econet**: network analysis for study of ecosystem form and functioning;
- **Ecotrace** routine for tracing persistent pollutant accumulation in food webs.

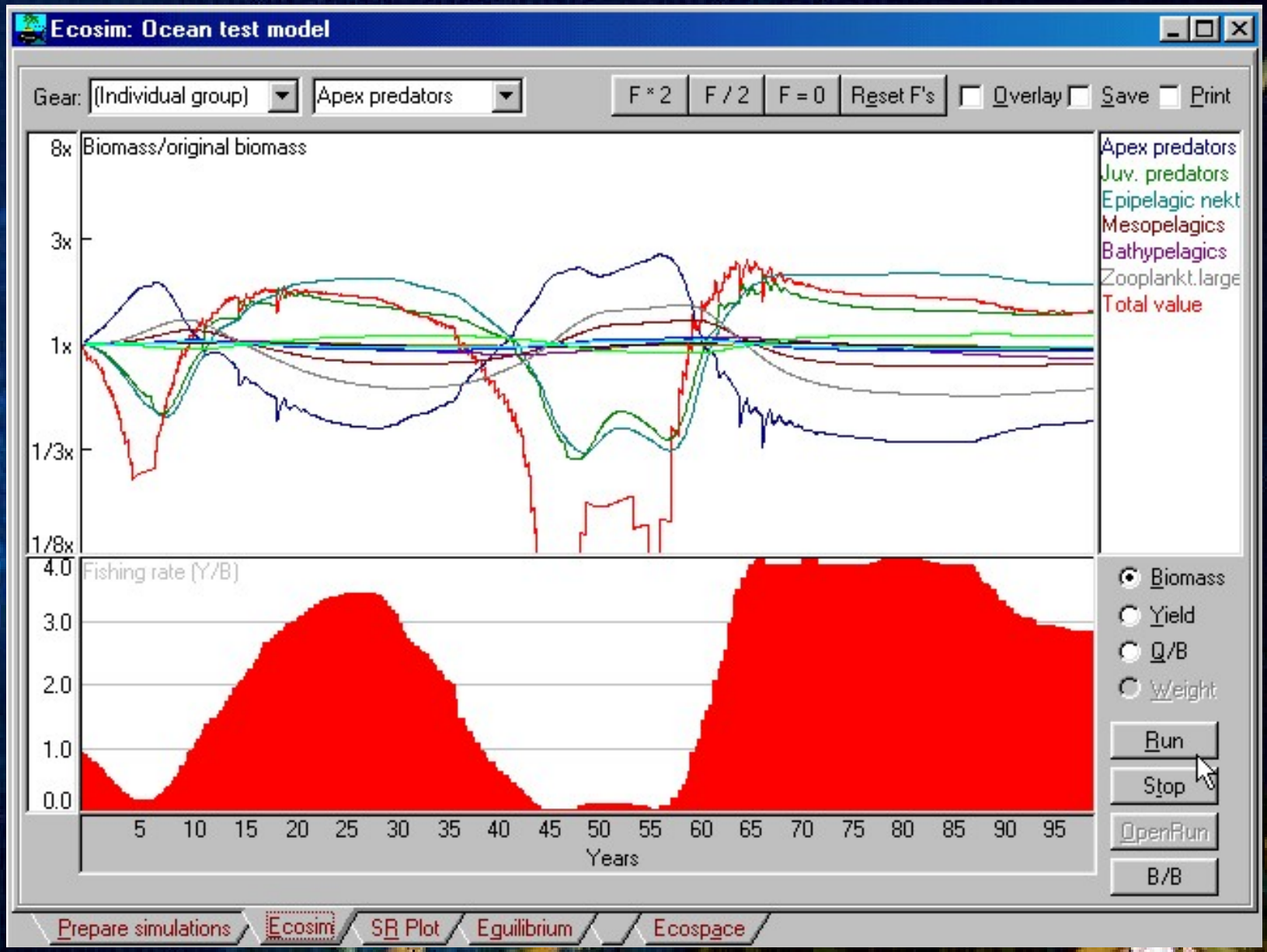
# Key routines in Ecopath with Ecosim
# Addressing uncertainty

- **Pedigree** for input data and overall index of model quality;
- **Ecoranger** routine for explicit consideration, in a Bayesian context, of the uncertainty inherent in all input;
- **Sensitivity analysis** for documenting the effect of inputs on estimated parameters.

# Key routines in Ecopath with Ecosim

- **Ecosim** for dynamic simulation of effect changes in fishing and/or environmental regimes may have on fisheries catches (volume and value) and the abundance of various groups in the ecosystem.

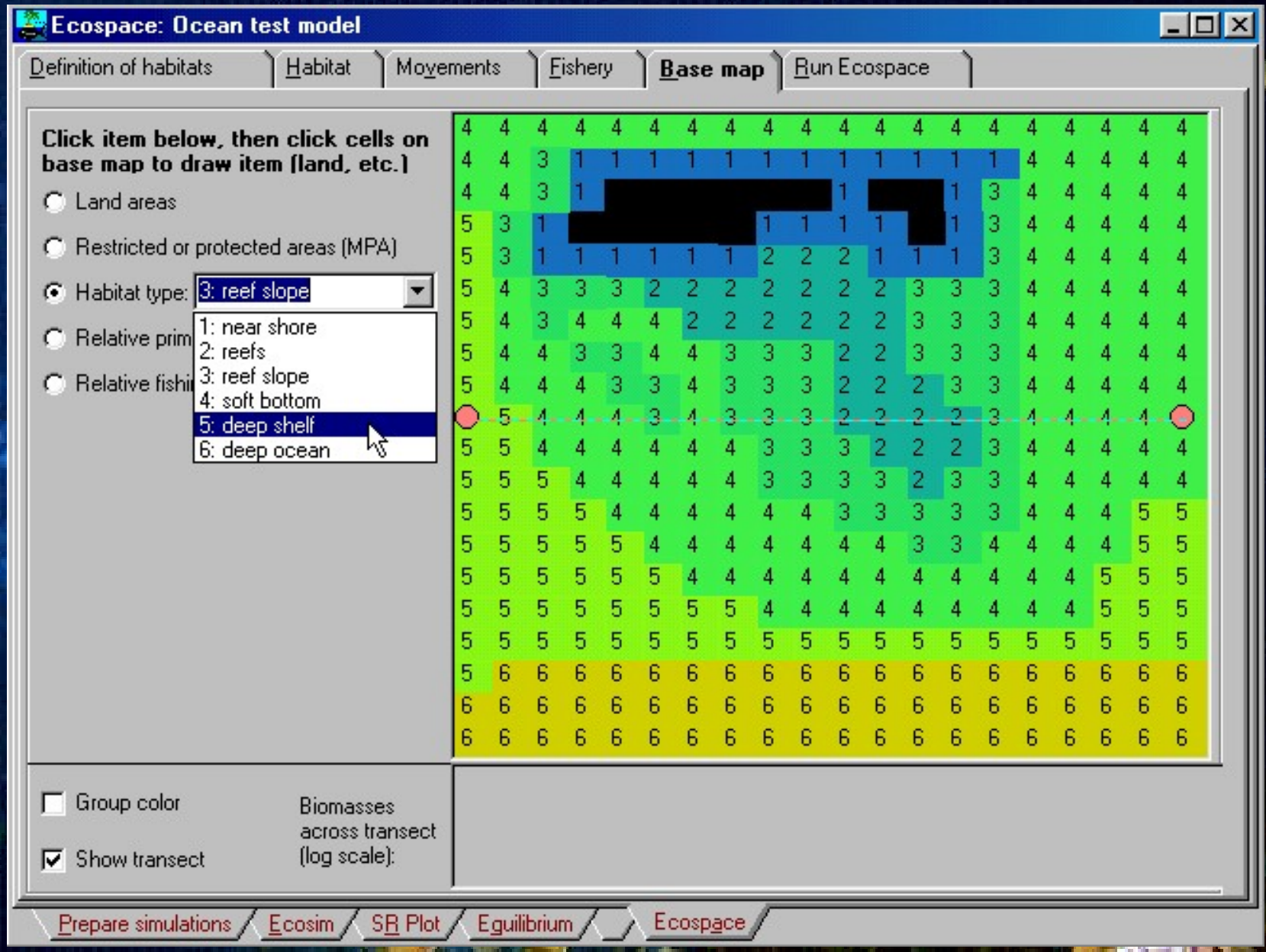
# Ecosim: ecosystem effects of fishing



# Key routines in Ecopath with Ecosim

- **Ecospace** for spatial analysis of Ecopath models given user-provided habitat preferences for the functional groups in the system, and a fishing regime that may include protected areas.

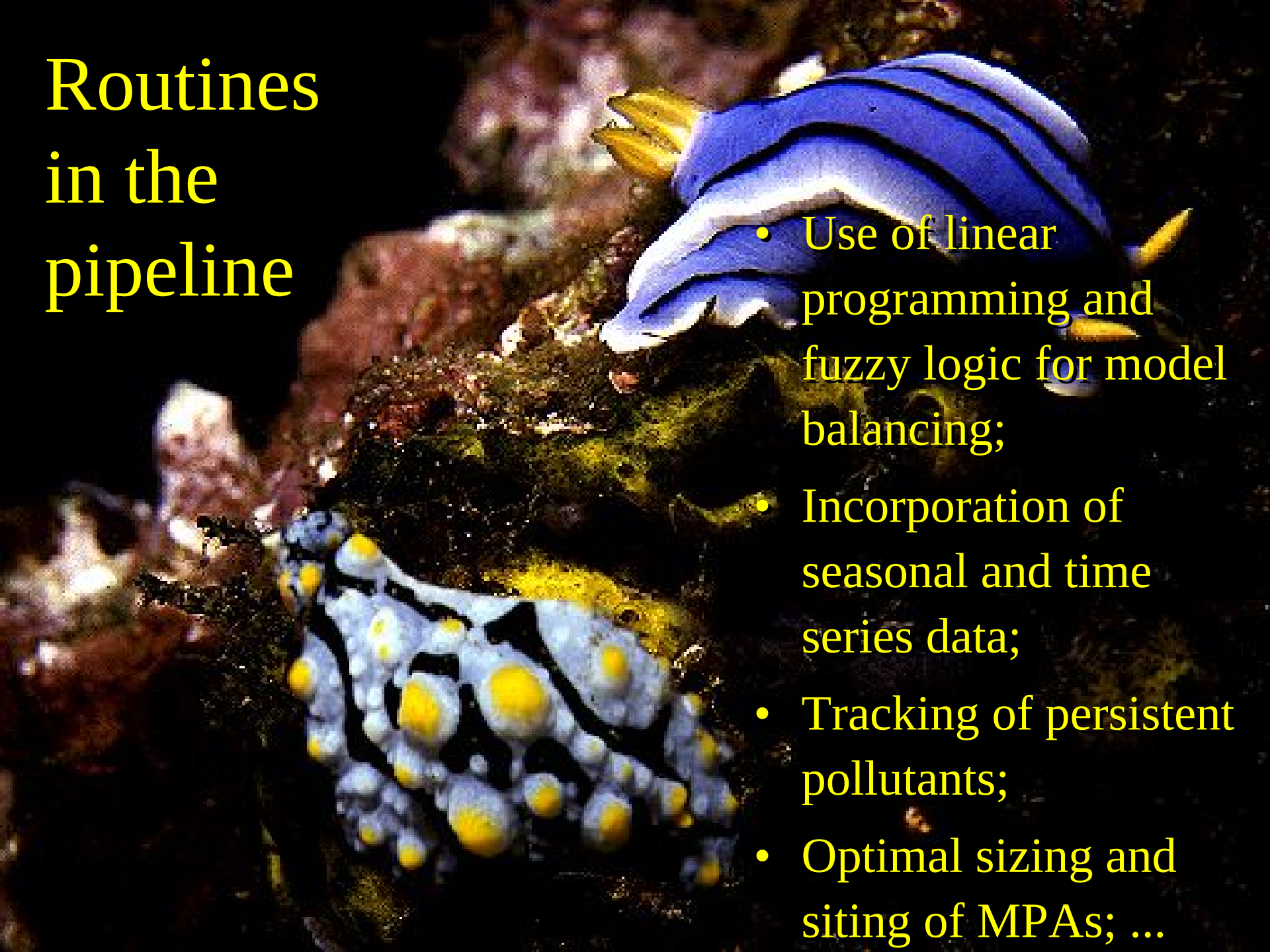
# Ecospace: spatial simulation



# Ecopath with Ecosim

- **Jointly, the elements of the package allow biological and policy analysis so far available only for areas where detailed, data-hungry multispecies models had been constructed over years by teams of experts;**
- **The integrated Ecopath approach continues to rely, however, on relatively few inputs, such as can be assembled within a one-week workshop by a multidisciplinary group of scientists knowledgeable about a specific ecosystem.**

# Routines in the pipeline



- Use of linear programming and fuzzy logic for model balancing;
- Incorporation of seasonal and time series data;
- Tracking of persistent pollutants;
- Optimal sizing and siting of MPAs; ...

# The basic assumptions

ECOPATH no longer assumes steady state but instead bases the parameterization on an assumption of mass balance over an arbitrary period, usually a year

# Ecopath Master Equation (I)

Production = predation

+ fishery

+ other mortality

+ biomass accumulation

+ net migration

# Ecopath Master Equation (II)

Consumption = Production

+ respiration

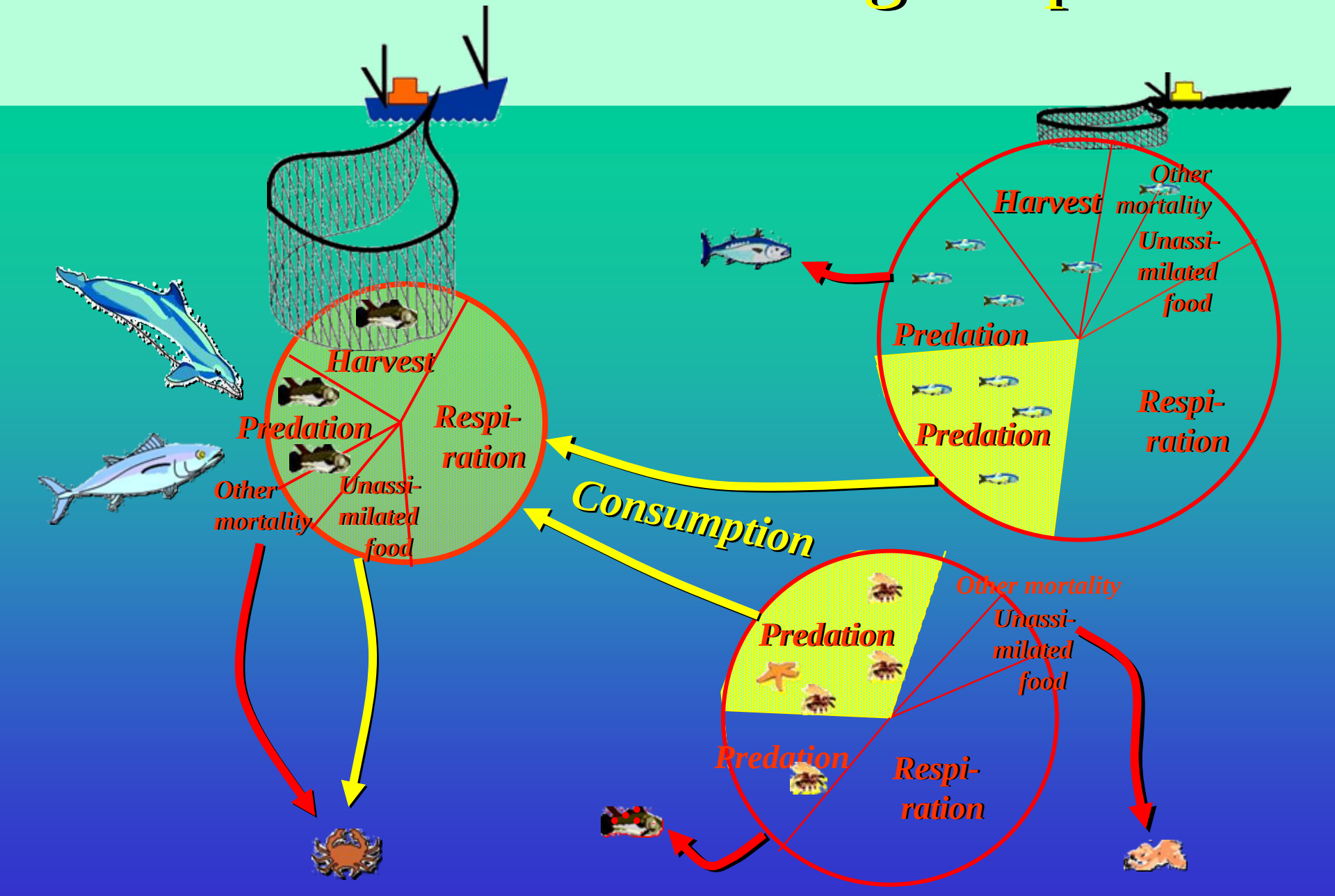
+ unassimilated food

Production = Consumption

- respiration

- unassimilated food

# Mass balance: cutting the pie



# ECOPATH Master Equation

$$P_i = Y_i + B_i M2_i + E_i + BA_i + P_i(1 - EE_i)$$

$P_i$ is the total production rate of (i),

$Y_i$ is the total fishery catch rate of (i),

$M2_i$ is the total predation rate for group (i),

$B_i$ the biomass of the group (i),

$E_i$ the net migration rate (emigration – immigration),

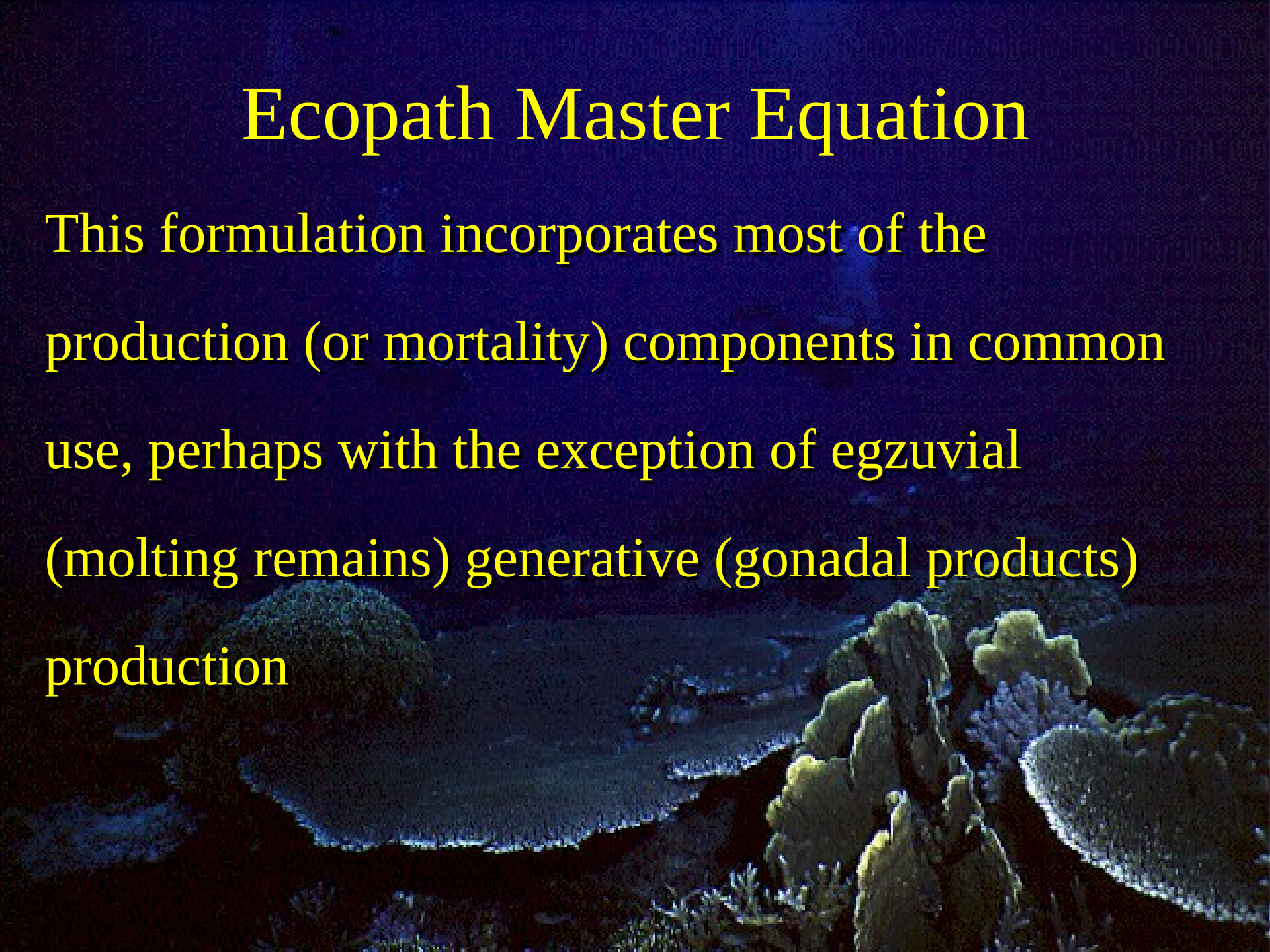
$BA_i$ is the biomass accumulation rate for (i), while

$M0_i = P_i \cdot (1\text{-}EE_i)$ is the 'other mortality' rate for (i).

$EE_i$ is the ecological efficiency of the group (i)

# Ecopath Master Equation

This formulation incorporates most of the production (or mortality) components in common use, perhaps with the exception of egzuvial (molting remains) generative (gonadal products) production



# Ecopath Master Equation (I): How it is actually implemented

$$B_i * P/B_i * EE_i = Catch_i + \Sigma_j B_j Q/B_j DC_{ji} + Net\ migration_i + Biomass\ accumulation_i$$

- Most common input: B, P/B, Q/B, Catch, Net migration (NM), biomass accumulation rate (BA), and diet compositions (DC).
- B, P/B, Q/B, EE, NM or BA is estimated by Ecopath.
- DC's are usually modified as required to ensure that EE's are ≤ 1.

# Key data requirements for Ecopath

- Biomass ($t \cdot km^{-2}$)
- Production / Biomass ($t \cdot km^{-2} \cdot year^{-1}$)
- Consumption / Biomass ($t \cdot km^{-2} \cdot year^{-1}$)
- Ecotrophic efficiency (proportion)
- Diets (proportion)
- Catches (by fleet) ($t \cdot km^{-2} \cdot year^{-1}$)
- Growth parameters for PSD & Ecosim

It is possible to use ranges for all parameters (see Ecoranger).

# Addressing uncertainty:

- Pedigree for input data and overall index of model quality;
- Sensitivity analysis for documenting the effect of inputs on estimated parameters;
- Ecoranger routine for explicit consideration, in a Bayesian context, of the uncertainty inherent in all input;
- Closed-loop policy simulations for evaluating the effect of uncertain inputs on the management process.

# Ecoranger

- Semi-Bayesian parameter estimation for Ecopath

*Input ranges*

***'Priors'***

*10,000 x*

*Acceptable inputs*

*Resampling*
*(Sampling Importance Resampling)*

***Selection of possible models***

***Mass balance & physiological constraints***

*Accepted inputs*

*Outputs*

***Selection of 'best' model***

***'Posteriors'***

# Dissemination

- 1600+ users in some 100 countries (half in the tropics);
- Present rate: 3 new users a day;
- 16+ workshops, of which 8 since Dec 97;
- 100+ published models;
- 50+ models known to be in preparation;
- 77 peer reviewed papers, incl. some high profile;
- 33 other publications;
- 13+ universities offering courses;
- 13 PhD's completed;
- 4 MSc's completed;
- 10000+ www.ecopath.org visitors in the first year.

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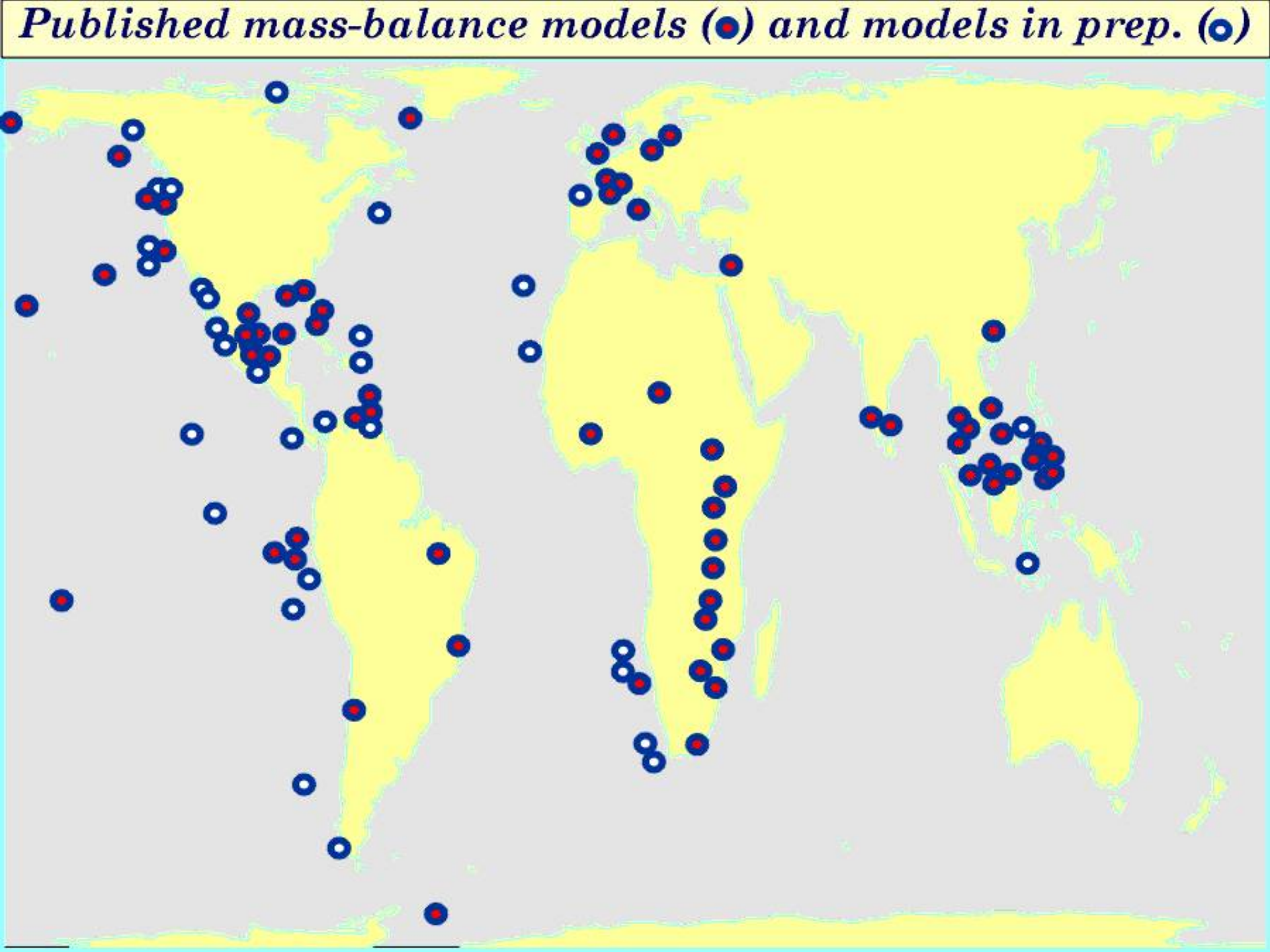
Published mass-balance models (●) and models in prep. (○)

# Ecopath models in S & SE Asia

## Marine

- Brunei Darussalam EEZ
- Hong Kong waters
- Indonesia, Java Sea
- Malaysia, Kuala Terengganu
- Philippines, Lingayen Gulf
- Thailand, Gulf of Thailand, 10-50 m
- Thailand, Gulf of Thailand, 1963
- Thailand, Gulf of Thailand, 1980
- Philippines, Bolinao reef flat
- Philippines, San Miguel Bay
- Vietnam/China Shelf
- South China Sea, deep shelf
- South China Sea, open ocean

## Freshwater

- India, Veli Lake
- Thailand, Uboltrana reservoir, 1968-1972, 1985-1988
- Philippines, Laguna Lake, 3 periods
- Philippines, 2 rice-fish models
- Philippines, farming system models
- China, mulberry dike-carp ponds

***Under construction:***

- Hong Kong, Pearl River estuary
- Taiwan, Chiku Lagoon
- ADB-RETA 5766