Living with uncertainties in fisheries and environmental research

Australasian Applied Statistics Conference (GenStat & ASReml)

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You-Gan Wang
The University of Queensland
The frontier race

Space
Maximum Economic Yield (MEY)

The Australian federal government is in the process of introducing MEY-based management for 26 fish species (2008)

- scampi, squid, scallops and bugs
- 9 species of prawns
Map of the Northern Prawn Fishery
(source: AFMA Report)

Area of the Northern Prawn Fishery 771 000 square km
Historic Data

a) 

Number of vessels


0 50 100 150 200 250 300 350

# of Vessels

b) 

Catch


0 1000 2000 3000 4000

Catch (tonnes)

- P. esculentus
- P. semisulcatus

CPUE


0 0.01 0.02 0.03 0.04 0.05 0.06

CPUE (tonnes/day)

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NPF: Health?

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NPF: MSY/MEY

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Sustainable Yield

P. semisulcatus

Equilibrium yield (tonnes)
0 500 1000 1500 2000 2500
0 5000 10000 15000 20000
Fishing effort

S1
S2
S3

P. esculentus

Equilibrium yield (tonnes)
0 500 1000 1500 2000
0 5000 10000 15000 20000
Fishing effort

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MSY in Enlarged Inference Domain vs traditional MSY

$\gamma_1 = 1.2$

$\gamma_2 = 2$

$\max G_s$

$\text{MEY}_{f}$

$\text{MEY}_s$

$\text{MSY}$

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The space-time race

\[ \Delta T = \sqrt{\Delta t^2 - \Delta r^2 / c^2} \]

Space heterogeneity and movement models

Mathematics is always indispensible!
Spatial distributions

Grid-based with fixed/random effects

Improvement will lead to more accurate stock assessment
The frontier race

Space
The frontier race

Space
Random fields

Stationary models for the covariance function for the random field $Z$

$$\text{Cov}\{Z(\tilde{x},s), Z(\tilde{y},t)\} = K(\tilde{x} - \tilde{y}, s - t)$$

at any locations $x$ and $y$ and observations times $s$ and $t$. 
Spatio-temporal model with nugget effects

\[
\text{Cov}(\tilde{y}) = \\
\sigma^2 \left[ \nu_1 I_{ST} + \{(1 - \nu_1)(\nu_2 I_T + (1 - \nu_2)I)\} \right] \\
\otimes \{ \nu_3 \mathcal{I}_S + (1 - \nu_3)\Delta \}
\]

\(\nu_1\): prop meas error

\(\nu_2\): nugget prop in time

\(\nu_3\): nugget prop in space
Surface Chlorophyll-a water quality data analysis

Gaussian spatio/temporal decay

\[ \sigma^2 = 0.246, \nu_1 = 0.16, \nu_2 = 0.45, \nu_3 = 0.43 \]

decay rate in time: \( \gamma = 96.4 \text{ days} \),
decay rate in space: \( \delta = 0.08 \text{ km} \)
Statistics & bikinis

• “Statistics are like bikinis. What they reveal is suggestive, but what they conceal is vital”

• Even the owners and operators may not fully aware of the true.

• Your educated common sense should lead you to your knowledgable recommendations/decisions
Effort Allocation for Multi-species Moreton Bay Prawn Fishery:

Catches consist of bay prawn (greasyback) (37%), brown tiger (28%), eastern king (17%) and other prawn species (18%).
Tiger, greasyback, Eastern Kings,

Kindly provided by Tony Courtney, DEEDI
Tagged king prawn

Kindly provided by Tony Courtney, DEEDI
How do we catch them?
You-Gan Wang, DPhil (Oxon)
Phone: 07 33652311
Email: you-gan.wang@uq.edu.au

Centre of Applications in Natural Resource Mathematics (CARM)
The University of Queensland, Australia

Thank you