The Role of Game Theory in Fisheries Economics: From Non-existent to Indispensible

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Introduction

- This paper is designed to set the stage for our Special Session on Game Theory and Fisheries Management.
- Its purpose is to review the history of the role of game theory in fisheries economics, and to look forward to future avenues of research.
  - it argues that: 40+ years ago, game theory was irrelevant to fisheries economics; by 2018 it has become indispensible to this branch of economics.
- The paper draws heavily upon the forthcoming book: *Game Theory and Fisheries Management: Theory and Applications.*

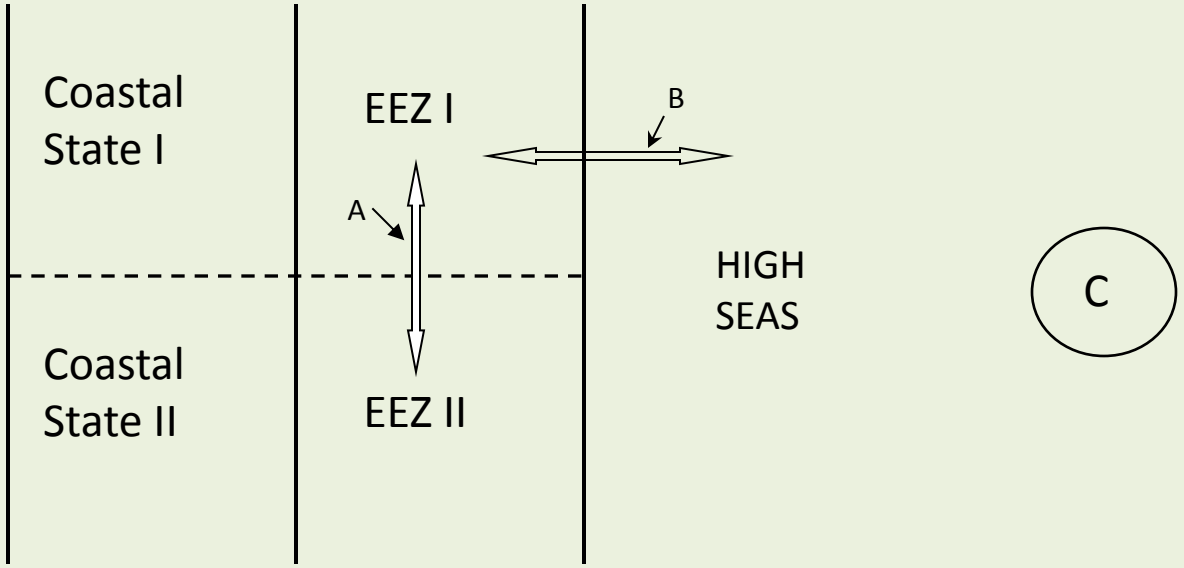
Era of Irrelevance

- A game theoretic situation, as all are aware, is deemed to arise when there is a strategic interaction between/among two or more decision makers.
- Up until the end of the 1960s, virtually no strategic interaction in fisheries was recognized by economists.
- Basic fisheries economics, starting with Gordon's seminal 1954 article, assumed that the fishing industry was perfectly competitive – open access, or that fishery controlled by "sole owner".
  - strategic interaction among states engaged in international management of the resources simply ignored by economists
  - first edition of Colin Clark's *Mathematical Bioeconomics*, 1976 – total number of references to game theory - **zero**

Relevance Achieved: Stage I

- The big event of the 1970s- ’80s – UN Convention on the Law of the Sea and the EEZ regime.
  - (1)massively increased the importance of national/regional fisheries management;
  - (2) brought the issue of internationally shared fish stocks to the fore
    - which in turn forced fisheries economists to bring in game theory .
- Coastal states forced to recognize that some of their EEZ fish stocks would cross into neighboring EEZs (transboundary stocks), or into adjacent high seas (straddling stocks).
- Economists had to recognize the issue, as well, and to recognize that strategic interaction between/among states sharing the fish stocks central to the economic management of the stocks – compelled to bring to bear theory of strategic interaction- game theory.
  - first game theoretic analyses of economic management of the stocks appeared in1979 –’80

Internationally Shared Fish Stocks



A – Transboundary stocks – EEZ to EEZ

B – Straddling stocks (broadly defined) – EEZ to high seas

C – Discrete high seas stocks

Relevance Achieved: Stage II

- Initially believed that, of internationally shared fish stocks, only the transboundary ones significant
  - result: economists could, to a considerable degree, get away with simple n = 2 game theoretic models – very important for cooperative game theory models
- The initial belief shattered by end of ‘80s –straddling stocks are, in fact, very significant. Result: UN Fish Stocks Agreement and the RFMO regime.
- Unlike transboundary stock cooperative management arrangements, number of players in typical RFMO is large, e.g. NAFO with 14 members, and property rights to RFMO fishery resources are ambiguous.

Game Theoretic Consequences

- The game theory models used to analyse transboundary stock management hopelessly inadequate for analysis of straddling stock management.
  - relevant game theory models; we now have n >>> 2. Forced into the realm of coalition games.
- Issues: (a) optimal ("fair") sharing of net economic benefits
  - characteristic function games

(b) stability of cooperative arrangement -chronic threat of free riding, unlike anything seen in transboundary stock management

  - most successful approach to date – partition function games.
- Much remains to be done, e.g. questions of uncertainty, as this session will make evident.

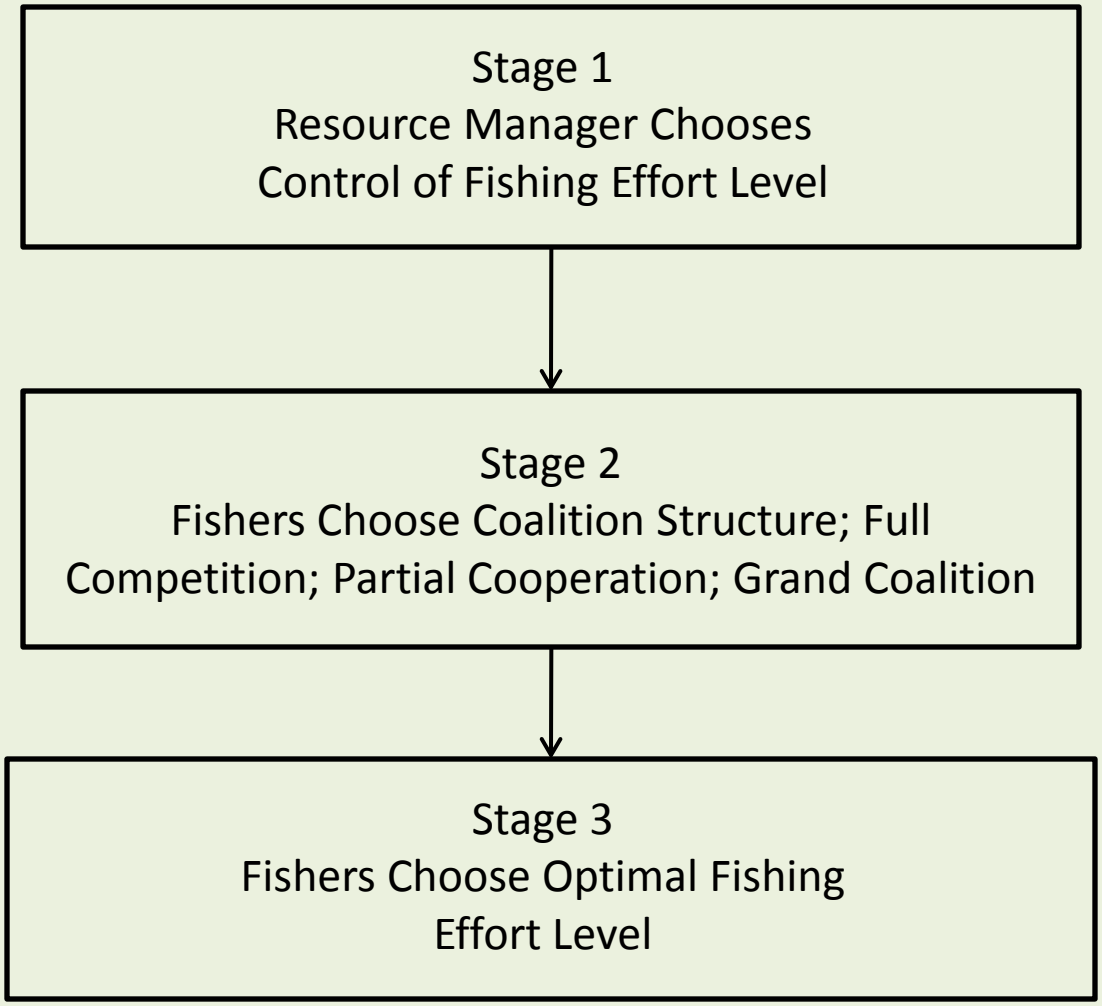
National/Regional Fisheries

- Is game theoretic analysis relevant to “domestic” fisheries? –Yes is the decisive answer, but application of that analysis lags far behind application at international level.
- Move towards harvesting rights based management - ITQs, fisher co-operatives (including TURFs) - makes need for application increasingly pressing.
  - to begin, both imply limiting number of vessels in a given fishery –assumption of perfectly competitive industry collapses –ample scope for strategic interaction.

Kronbak-Lindroos Model and ITQs

- The foundational 2006 Kronbak-Lindroos (K&L) model –stage game model- makes the fundamental point that it is not enough to focus on strategic interaction among fishers, must also focus on strategic interaction between fishers and resource manager – **multi-level games**.
- First with respect to ITQs, view that ITQ holders to be seen as playing as singletons, because scope for cooperation among them is so limited, now undermined by the often cited case of the British Columbia groundfish fishery.
  - furthermore, not recognized in K&L model, in that B.C. case, game between fishers and resource manager, hitherto competitive, has evolved into a cooperative one.

The K&L Three Stage Game



Source: Kronbak and Lindroos, 2006.

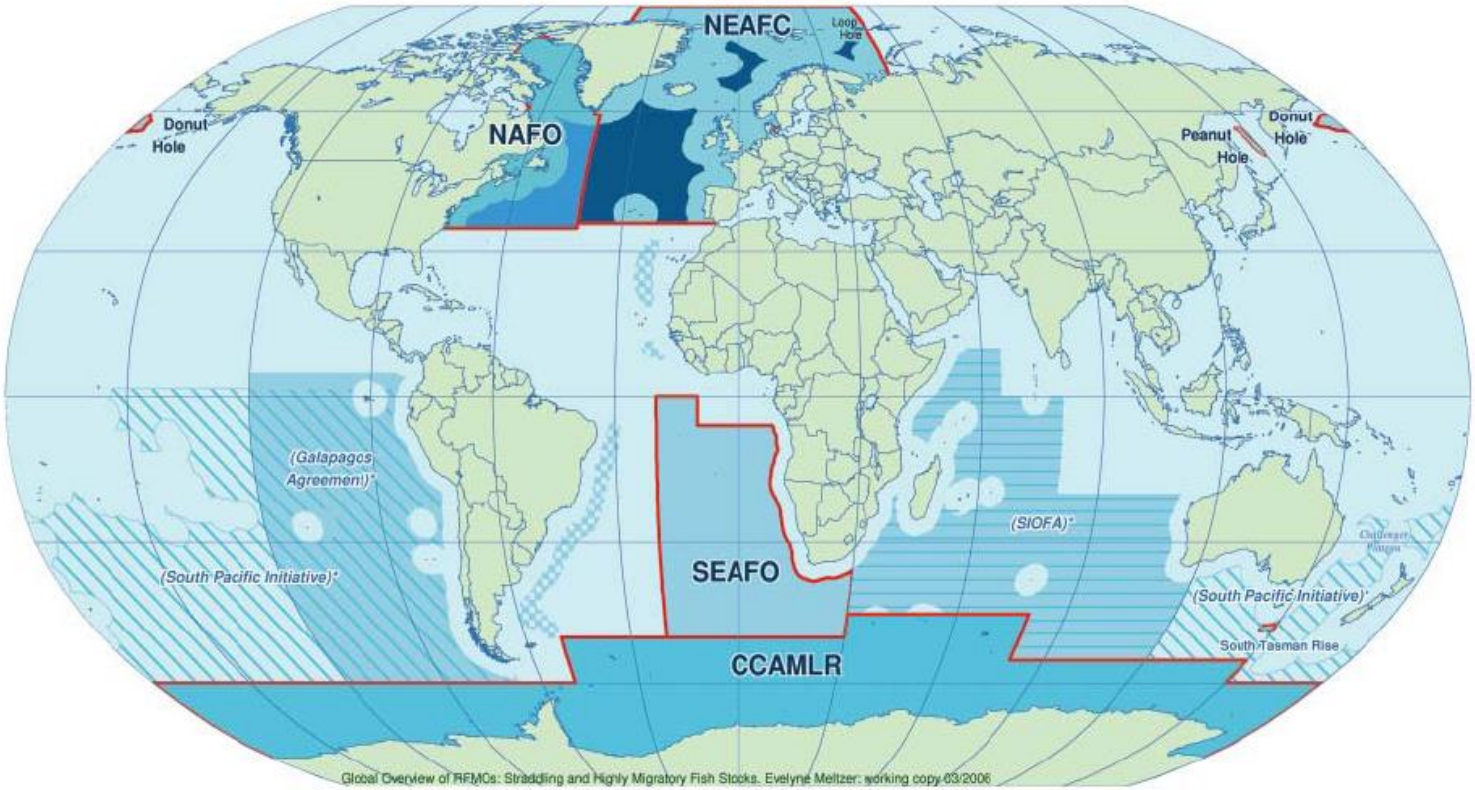
K&L Model and Fisher Co-operatives

- The multi level nature of the fishery games even more striking in the case of fisher co-operatives.
- We have:
  - game within co-op
  - game between co-op and neighboring co-op(s)
  - game between co-op or co-ops and resource manager
- While some game theoretic work done on achieving stable cooperative game within a co-op or ITQ scheme has been done, it is far from complete, as this session will reveal.
- As for analyzing multi-level games, this will require game theoretic tools yet to be found in fisheries economics – **the new frontier!**

A Few Conclusions

- For the first quarter of a century of modern fisheries economics, game theory an irrelevancy.
- The EEZ and RFMO revolutions forced economists to apply game theory to the analysis of international fisheries management.
- Now being realized that strategic interaction playing an increasing role in "domestic" fisheries management –***the new frontier***.
- Our conservative guess: fisheries in which there is significant strategic interaction among those involved account for not less than one-half of world capture fisheries harvests.
- In fisheries economics, game theory has gone from being irrelevant to the ***tool indispensible***.


Thank you for your attention



Global Overview of RFMOs:
Straddling Fish Stocks

RFMO Boundary

( )* RFMO area under negotiation, not yet adopted or not yet in force.

- SEAFO
- CCAMLR
- NEAFC Convention Area
- NEAFC Regulatory Area
- NAFO Convention Area
- NAFO Regulatory Area
- Donut Hole Arrangement
- *(SIOFA)* (Not yet adopted)*
- *(Galapagos Agreement)* (Not yet in force)*
- *(South Pacific Initiative)* (Under negotiation - preliminary boundary)*
- Other Unregulated High Seas Areas where Straddling Fish Stocks occur


NORWAY
Tórshavn
Faroe Islands
(DENMARK)
Trondheim
SWEDEN
SHETLAND
ISLANDS
Gävle
Bergen
Oslo
ORKNEY
ISLANDS
Stockholm
Stavanger
Aberdeen
Göteborg
Glasgow
Edinburgh
North
Sea
UNITED
DENMARK
Belfast
Copenhagen
Malmö
Irish
Sea
Leeds
Manchester
Liverpool
Hamburg
KINGDOM
Birmingham
Amsterdam
NETH.
Bremen
Berlin
Cardiff
Rotterdam
London
Essen
Leipzig
Cologne
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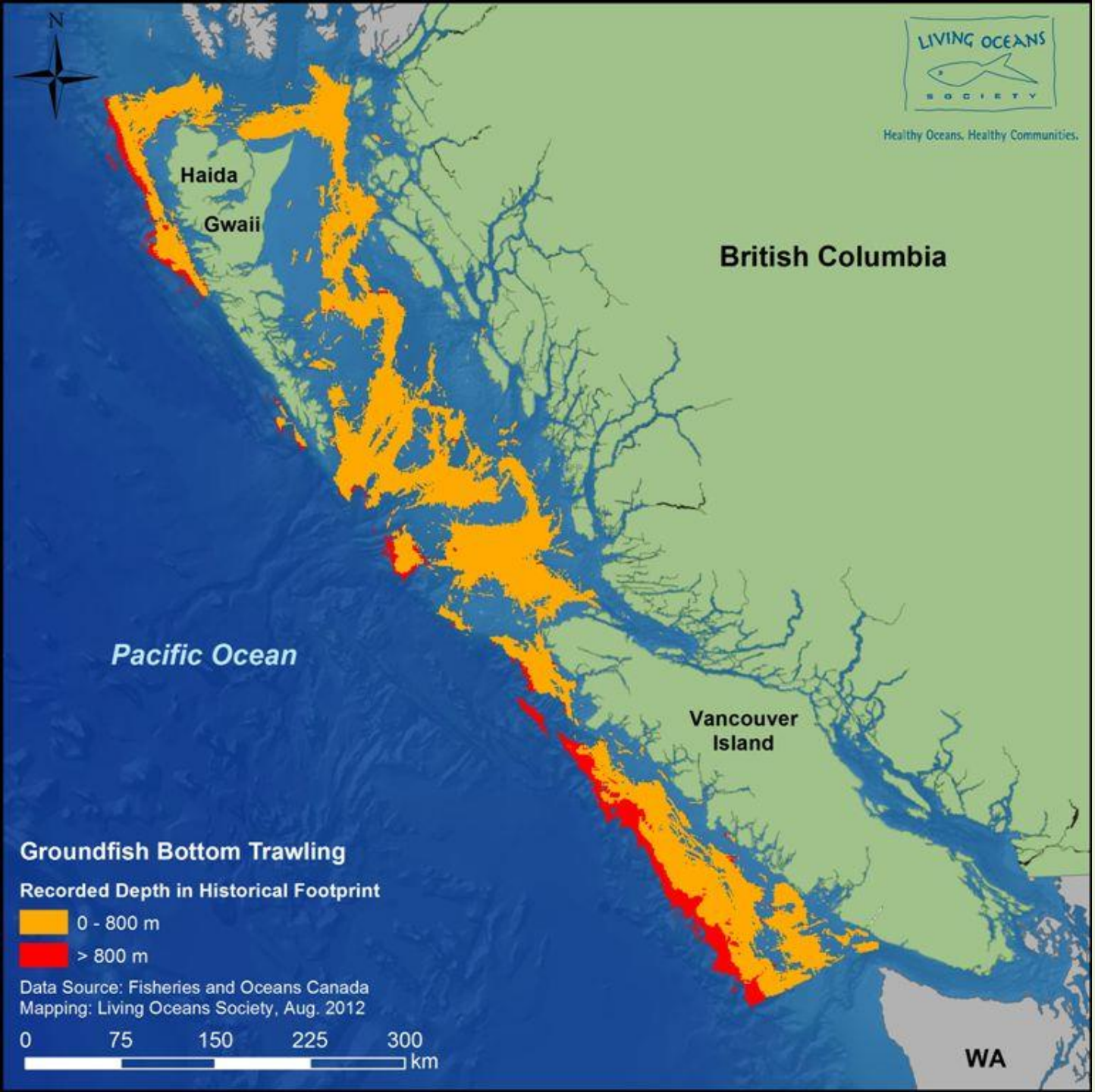
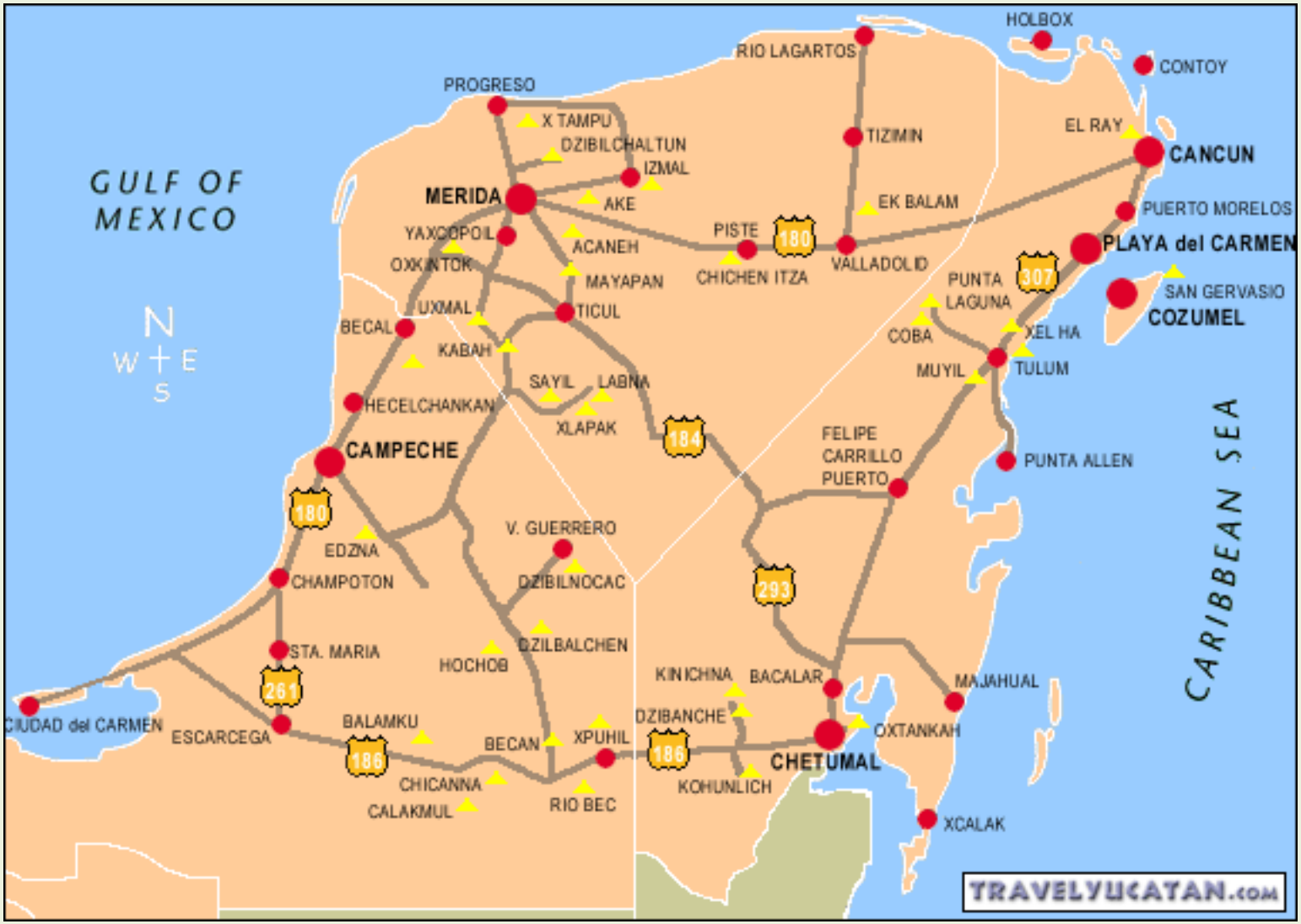


Bottom area trawled between 1997-2011

~41,000 km^2


GULF OF MEXICO
CARIBBEAN SEA
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PROGRESO
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IZMAL
TIZIMIN
EL RAY
CANCUN
MERIDA
AKE
EK BALAM
PUERTO MORELOS
YAXCOPOIL
PISTE
180
PLAYA del CARMEN
ACANEH
OXKUTZCAB
MAYAPAN
CHICHEN ITZA
VALLADOLID
307
PUNTA LAGUNA
SAN GERVASIO
COZUMEL
UXMAL
TICUL
BECAL
KABAH
COBA
XEL HA
MUYIL
TULUM
SAYIL
LABNA
HECELCHAKAN
XLAPAK
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FELIPE CARRILLO PUERTO
PUNTA ALLEN
CAMPECHE
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EDZNA
DZIBILNOCAC
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