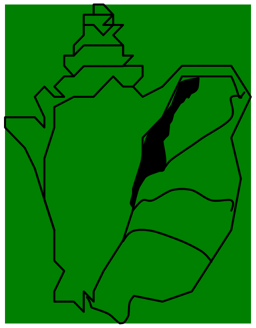
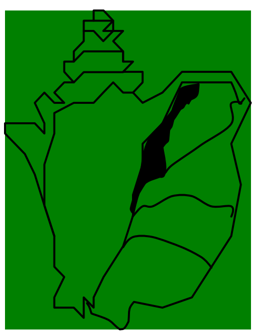


CONCH (*Strombus gigas*) STOCK ASSESSMENT MANUAL



Nelson M. Ehrhardt and Monica Valle-Esquivel

CARIBBEAN FISHERY MANAGEMENT COUNCIL
2008

1. CITES CONTROLS

The **C**onvention on **I**nternational **T**rade in **E**ndangered **S**pecies of Wild Fauna and Flora -- **CITES** –

- International agreement between "**voluntary participating**" States organized under the UN.
- An organization "**without enforcement capabilities"** that "**checks compliance of international trade documents with declared export quotas**".

Enforcement is in the power of exporting-importing countries, this is if they have the political will to protect endangered species.

CITES voluntary State declared export quota system

There is "**no specific requirement**" in the text of the Convention to establish quotas to limit the trade in CITES-listed species.

Export quotas are established by each voluntary member State "**unilaterally**".

Before any State may issue an export quota, **its Scientific Authority must advise that the proposed export will not be detrimental to the survival of the species (INTEREST IS ON THE SPECIES AND NOT ON THE FISHERY)**

CITES **does not promulgate, advocate or suggest ways, methods or algorithms** that should be used when estimating Queen Conch export quotas.

CITES **assumes that Countries have the know-how and the resources** (financially and scientifically) to define annual non detrimental export quotas for Queen Conch.

CITES **assumes** also that Governments and fishing industry **are fair players.**

Reasons to include Conch in Appendix II of the CITES

Internal fertilization imposes biological demands on minimum population density levels such that **individuals can find mates** or be properly **stimulated to mate** .

CITES Queen Conch biological and trade criteria for inclusion in Appendix II are:

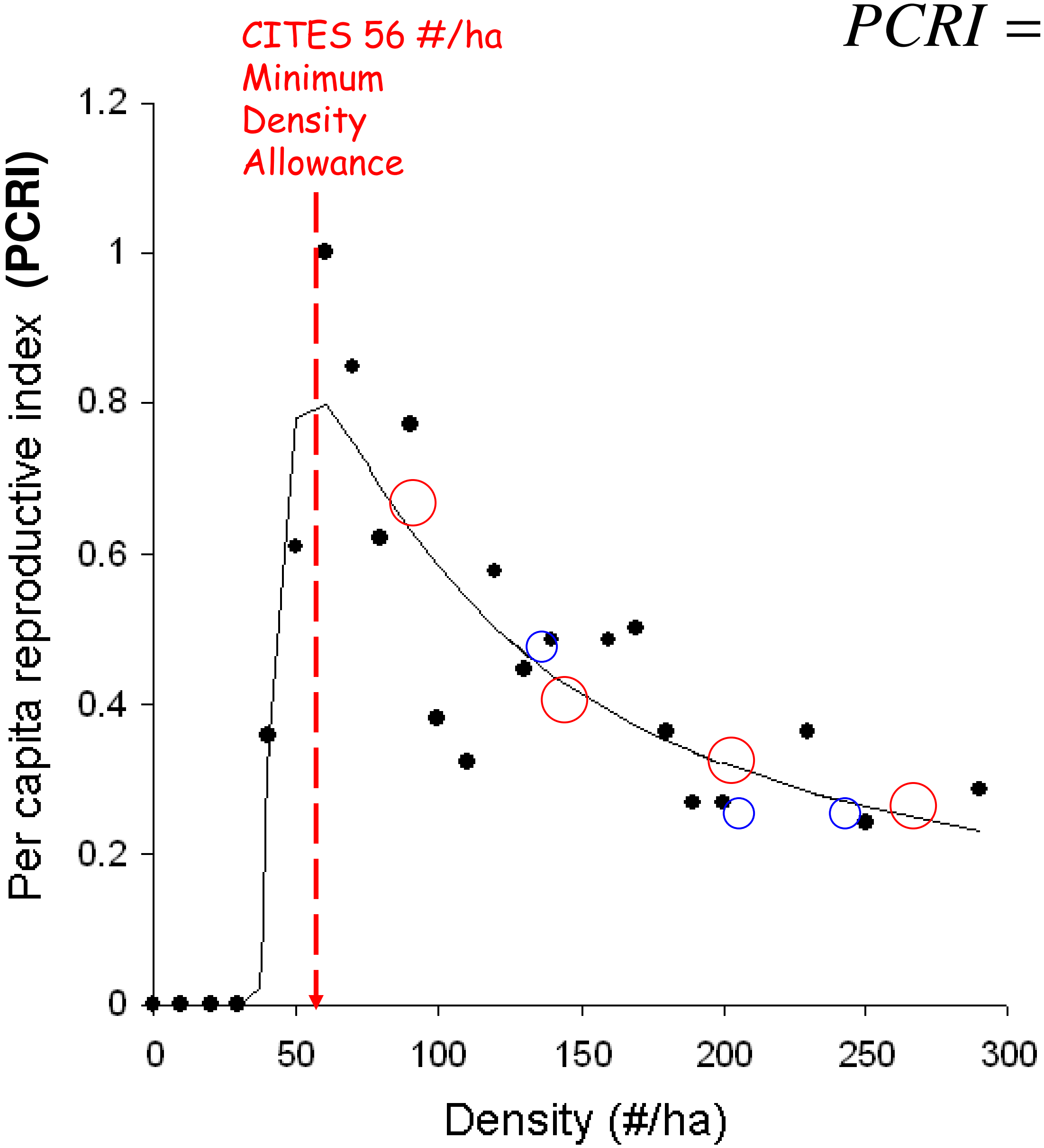
1) Exported annual quotas should not be detrimental to reproductive (mating) success.

2) The minimum population density threshold for successful mating is defined as **56 individuals/ha**.

Mating success modeling

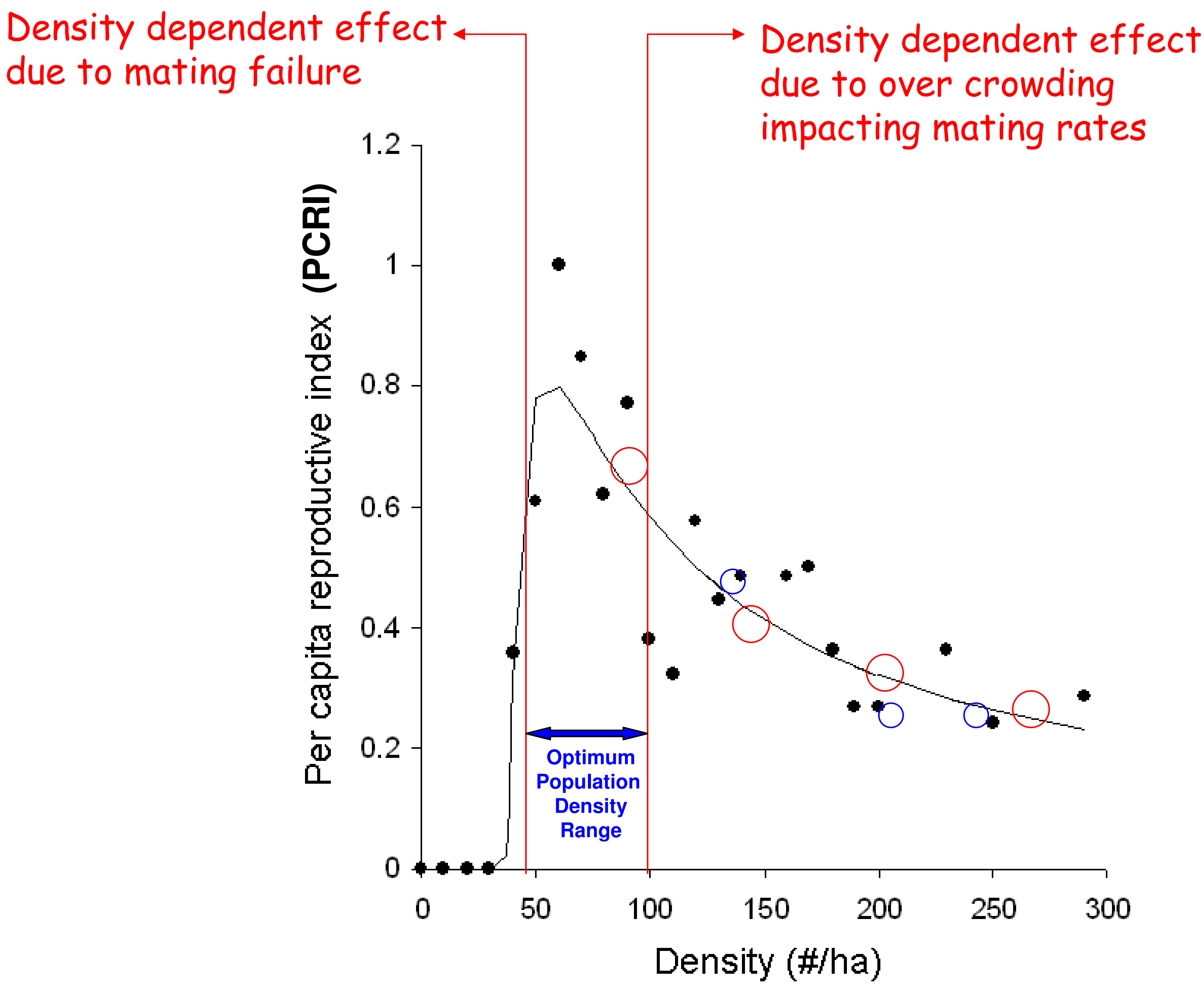
$$PCRI = \alpha(D-\beta)(1-\gamma\lambda(D-\beta))^{\frac{1}{\lambda}}$$

λ	-0.52741
γ	0.11413
β	37.3754
α	0.17992



The Bahamas
Honduras

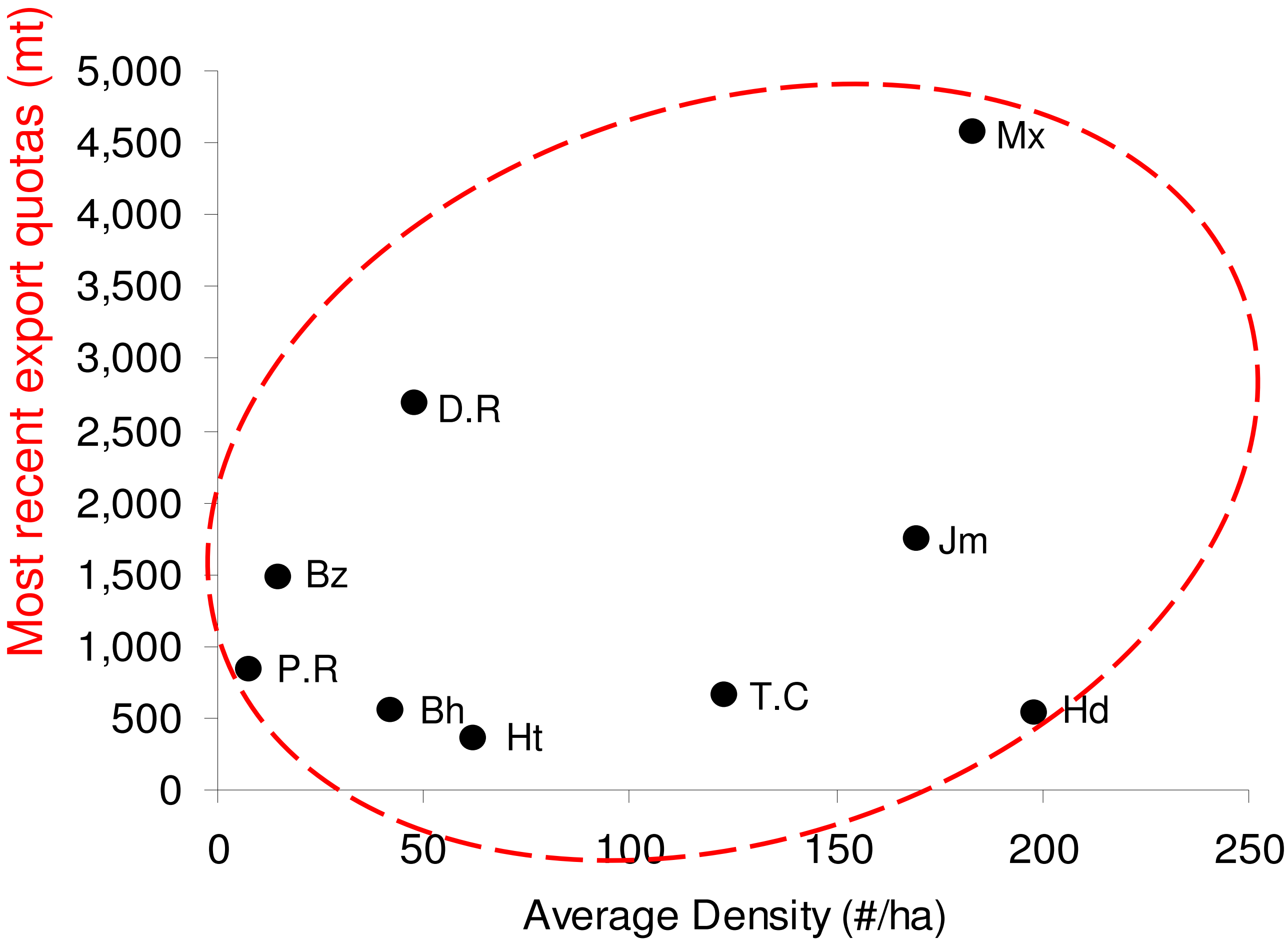
Bahamas data from: Stoner and Ray-Clup 2000



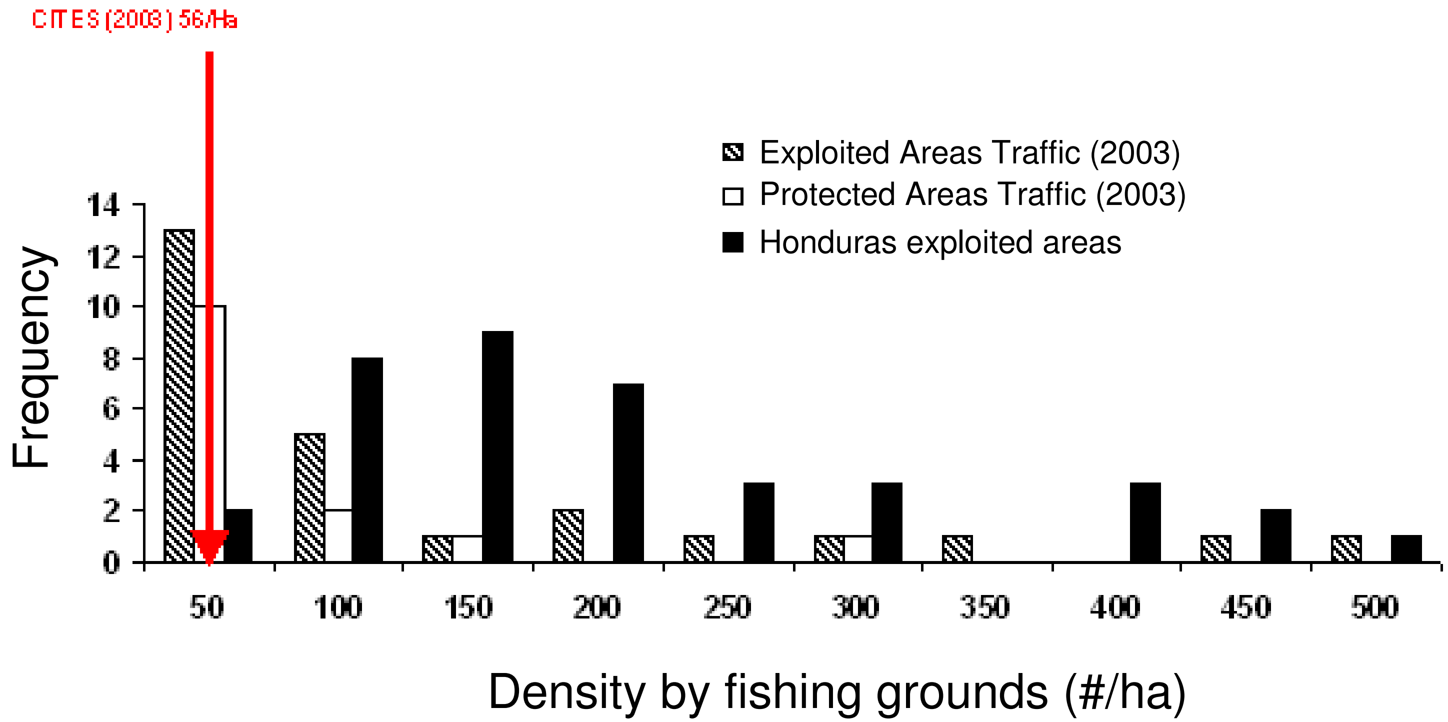
Density dependent effect due to mating failure
Density dependent effect due to over crowding impacting mating rates
Per capita reproductive index (PCRI)
Density (#/ha)
Optimum Population Density Range
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300

RESULTS OF USING NON STANDARDIZED PROCEDURES TO DEFINE QUEEN CONCH EXPORT QUOTAS UNDER A FAIR PLAY CONCEPT

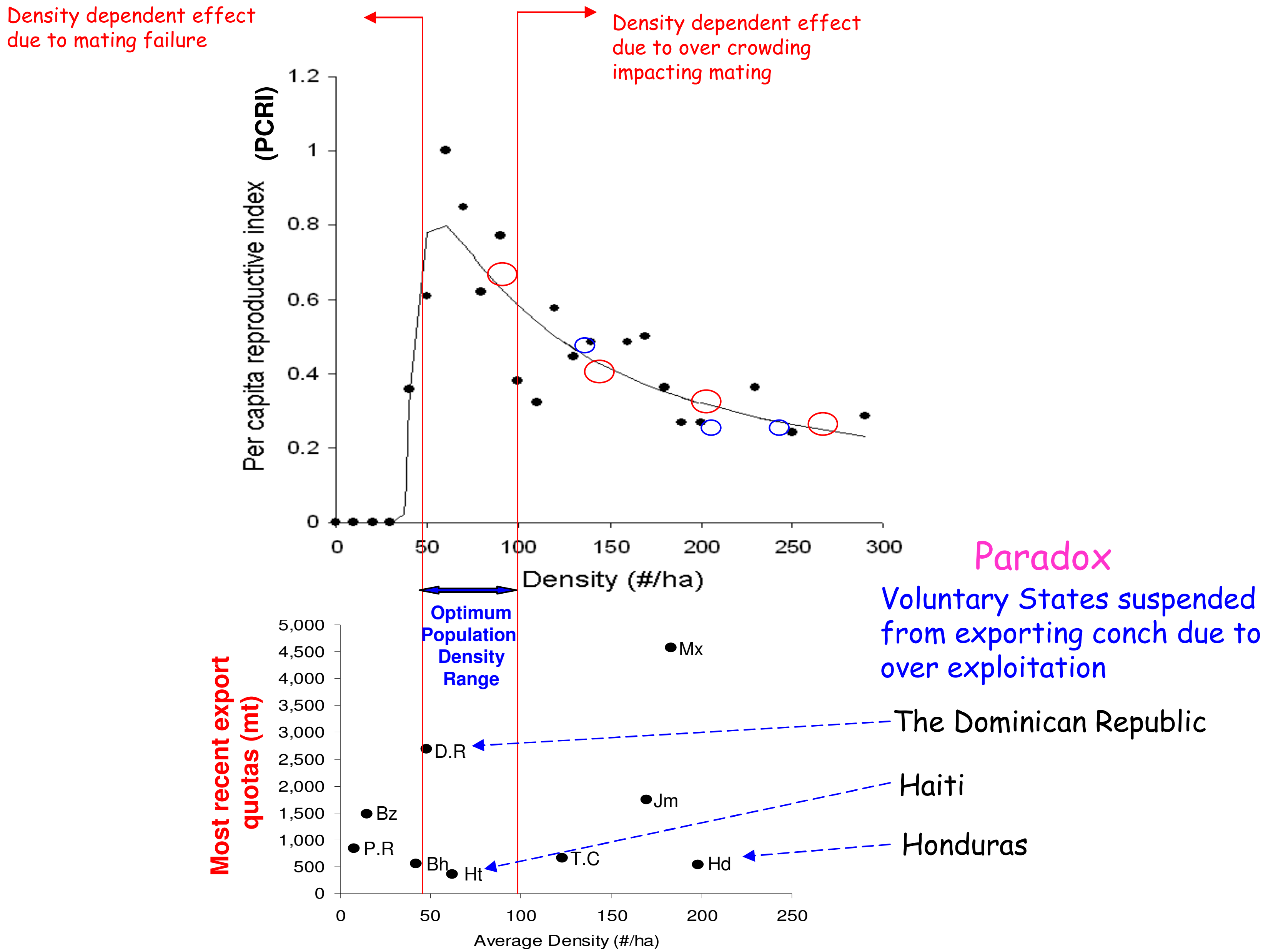
There is no correlation between the non-detrimental export quotas and the sustainability criteria established for the species (population density)



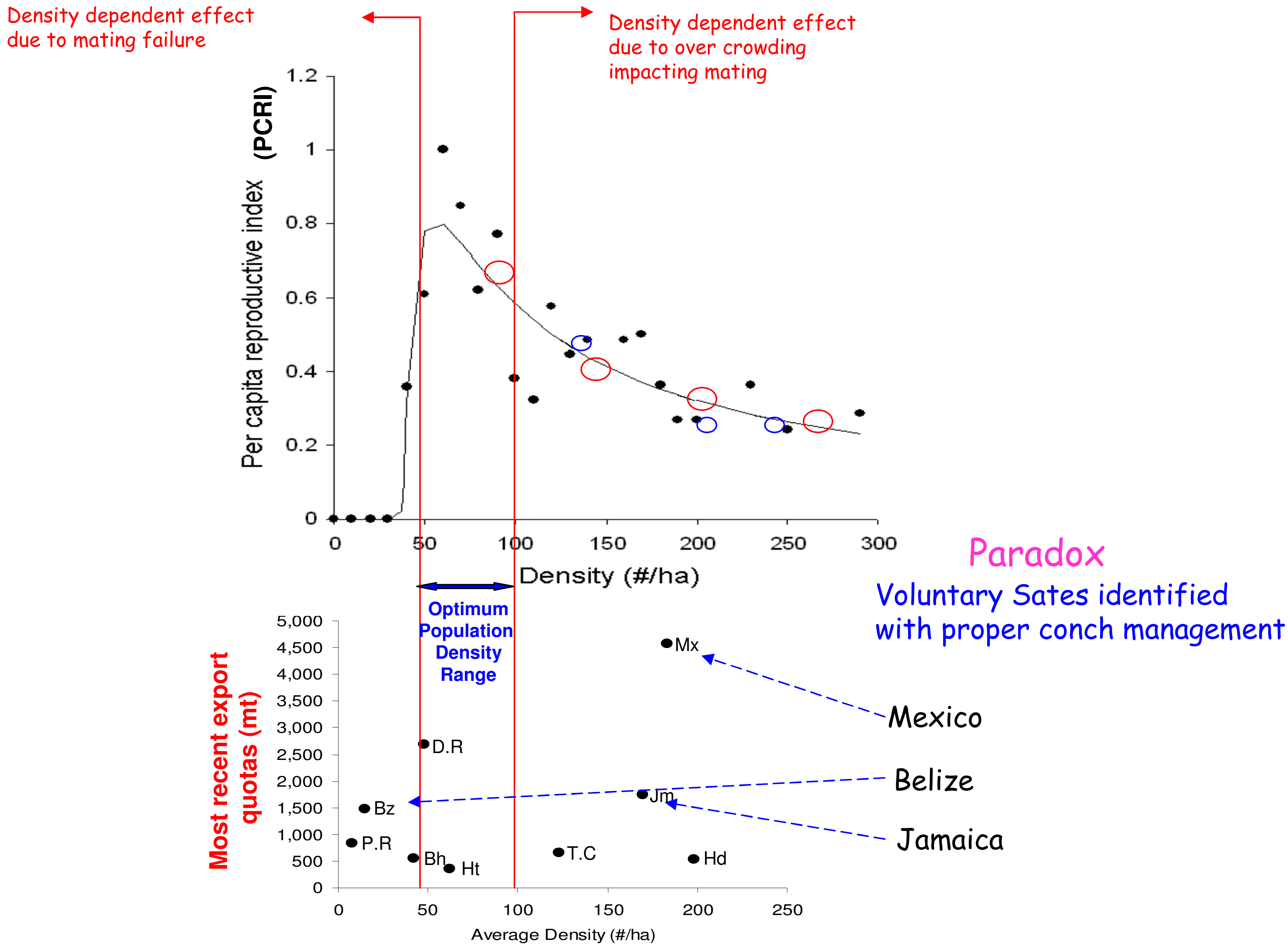
Regional Queen Conch Population Densities



1. Densities are higher in the exploited areas than in protected areas.
2. Issue: How do we estimate quotas based on population density only?



Density dependent effect due to mating failure
Density dependent effect due to over crowding impacting mating
(PCRI)
Per capita reproductive index
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
Density (#/ha)
Optimum Population Density Range
Most recent export quotas (mt)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Mx
D.R
Jm
Bz
P.R
Bh
Ht
T.C
Hd
0
50
100
150
200
250
Average Density (#/ha)
Paradox
Voluntary States suspended from exporting conch due to over exploitation
The Dominican Republic
Haiti
Honduras


Density dependent effect
due to mating failure
Density dependent effect
due to over crowding
impacting mating
Per capita reproductive index (PCRI)
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
Density (#/ha)
Optimum
Population
Density
Range
Most recent export
quotas (mt)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Mx
D.R
Jm
Bz
P.R
Bh
Ht
T.C
Hd
0
50
100
150
200
250
Average Density (#/ha)
Paradox
Voluntary Sates identified
with proper conch management
Mexico
Belize
Jamaica

Technical Issues with CITES export quotas

Condition 1

Voluntary Countries unilaterally report the non detrimental export quotas.

Issues with Condition 1:

1) CITES does not perform a scientific review of the non detrimental quota "declared" by the countries. Reason: CITES does not have specialized personnel or handling power to carry out such reviews.

2) There are no Queen Conch stock assessment protocols adopted by the CITES; therefore, countries "declare" annual non detrimental quotas under different data and methods, usually following historic "intuitive" reasoning.

Condition 2.

The Government CITES Office (Management Authority) requests the Government Scientific Authority to review the status of the quota each time a CITES export certificate is requested. Scientific Authority checks if the exports are legally obtained, and certify that exports under CITES Certificates will not be detrimental to the survival of the species.

Issuess with Condition 2.

1) Traceability of the products is impossible due to integration of several landings in the exported products. Most of the illegally caught Queen Conch cannot be retained once it is processed and packed.

2) There is no check on the non detrimental character of each export because it is implicit that if a quota is still open, such quota was already "declared non detrimental" to the survival of the species by the Management Authority to the CITES.

3) Countries do not have enforcement capabilities to prevent high seas product transfer.

STOCK ASSESSMENT MANUAL

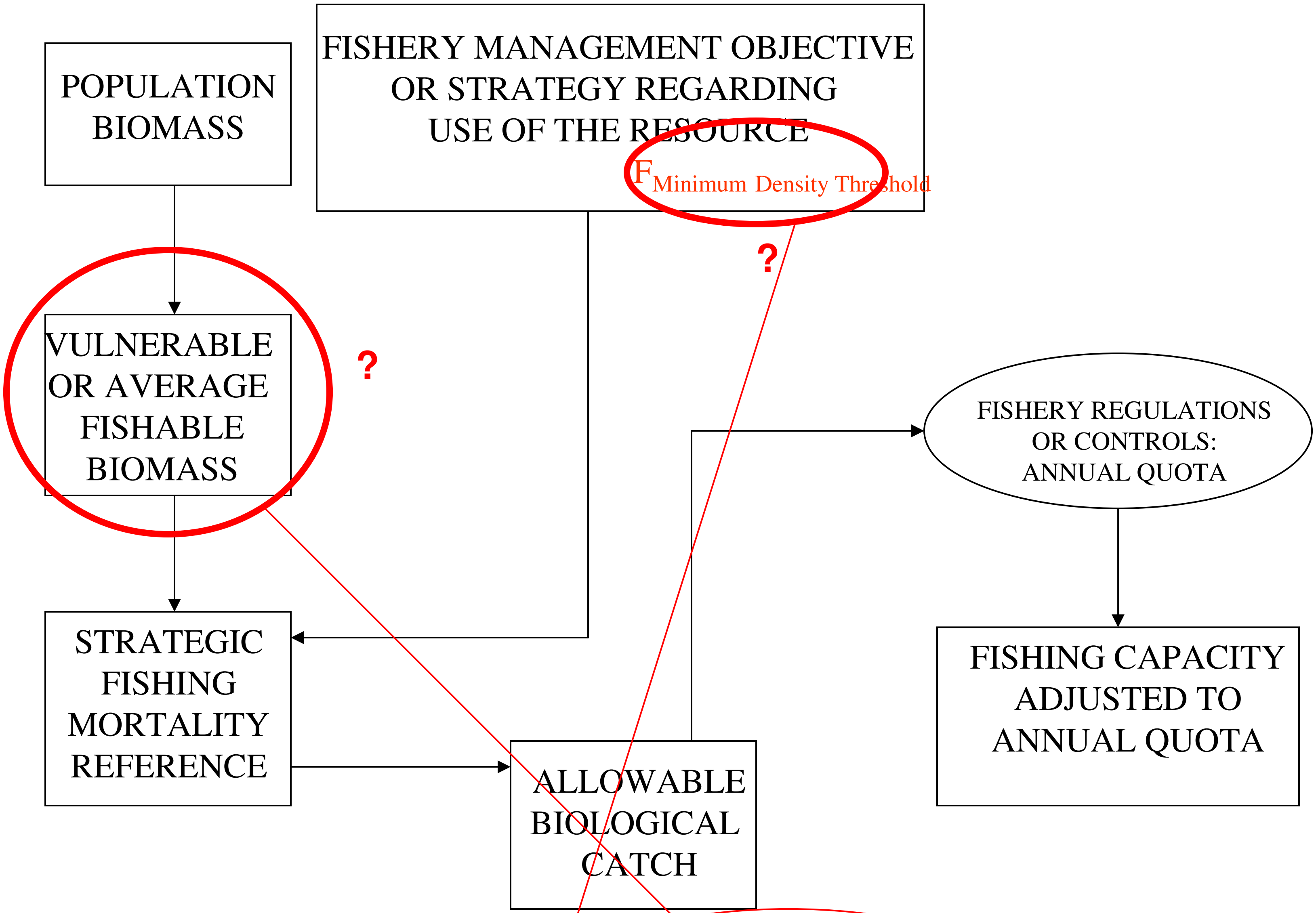
Queen conch annual quota estimation

$$\text{Quota} = F_{ref} * \text{Population Biomass}$$

Population Biomass = Average Density * Habitat Range * Average individual weight

F_{ref} = need population parameters (growth, natural mortality, fecundity, mating success as function of population density)

A SIMPLIFIED ANNUAL CONCH QUOTA DEFINITION



$ABC = F_{MDT}$ *Average Biomass

VULNERABLE
OR AVERAGE
FISHABLE
BIOMASS

FISHABLE BIOMASS CAN BE ESTIMATED FROM:

1) POPULATION DENSITY (DIVING SURVEYS) EXPANDED TO EXPLOITED POPULATION HABITAT.

2) EXPLOITATION PATTERNS GENERATED BY STOCK ASSESSMENTS USING FISHERY DATA.

FISHING MORTALITY REFERENCE POINTS FRAME FISHERY MANAGEMENT PROCESSES

FISHERY MANAGEMENT STRATEGY REGARDING THE RESOURCE

$F_{\text{Density Threshold}}$

$F_{\text{Density Threshold}}$ NEW CONCEPT BASED ON POPULATION DENSITY ESTIMATES AND THE FISHERY-BASED ESTIMATES OF FISHING MORTALITY THAT GENERATED SUCH DENSITIES

Paradox

Population density as biological criteria **and quotas** as **trade** criteria for CONTROL do not match.

Population density needs to be estimated for the habitat range of the species, including all fishing grounds; independently assessed due to habitat fidelity of conch.

Population density needs to be estimated "**every year**" under the requirement of annual export quotas.

Effective fishing grounds usually are a small fraction of the habitat range (where commercial densities are found).

"**Unilaterally declared**" quotas must be for an entire State with implicit spatial and temporal allocation.

Export quotas "**declared**" by States to the CITES cannot be estimated from existing data unless countries perform elaborated annual surveys to estimate population abundance. There is a time constraint to do this.

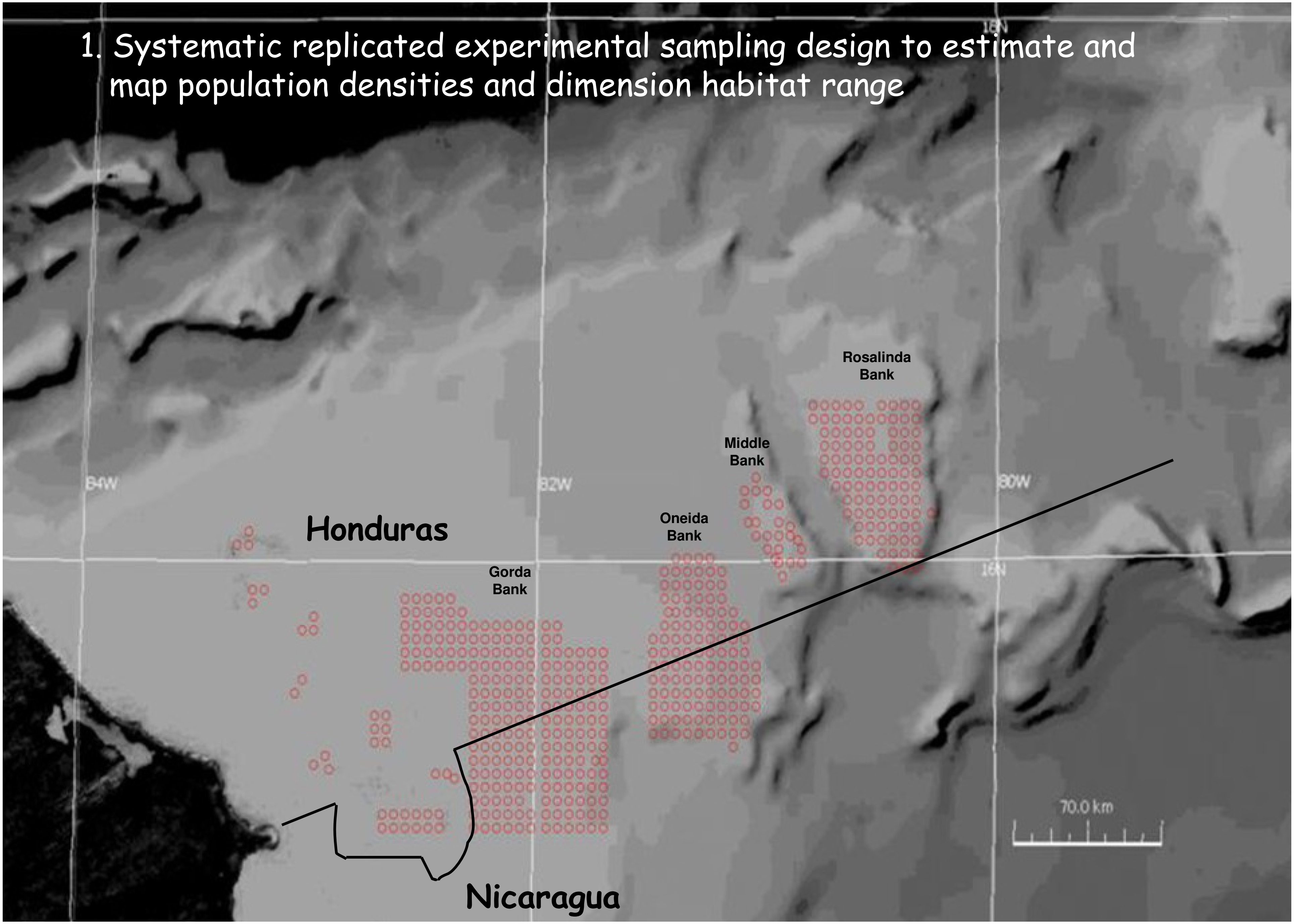
Models expressing the functional relationship between density, habitat range, and mating success at different density levels and quotas are still to be developed.

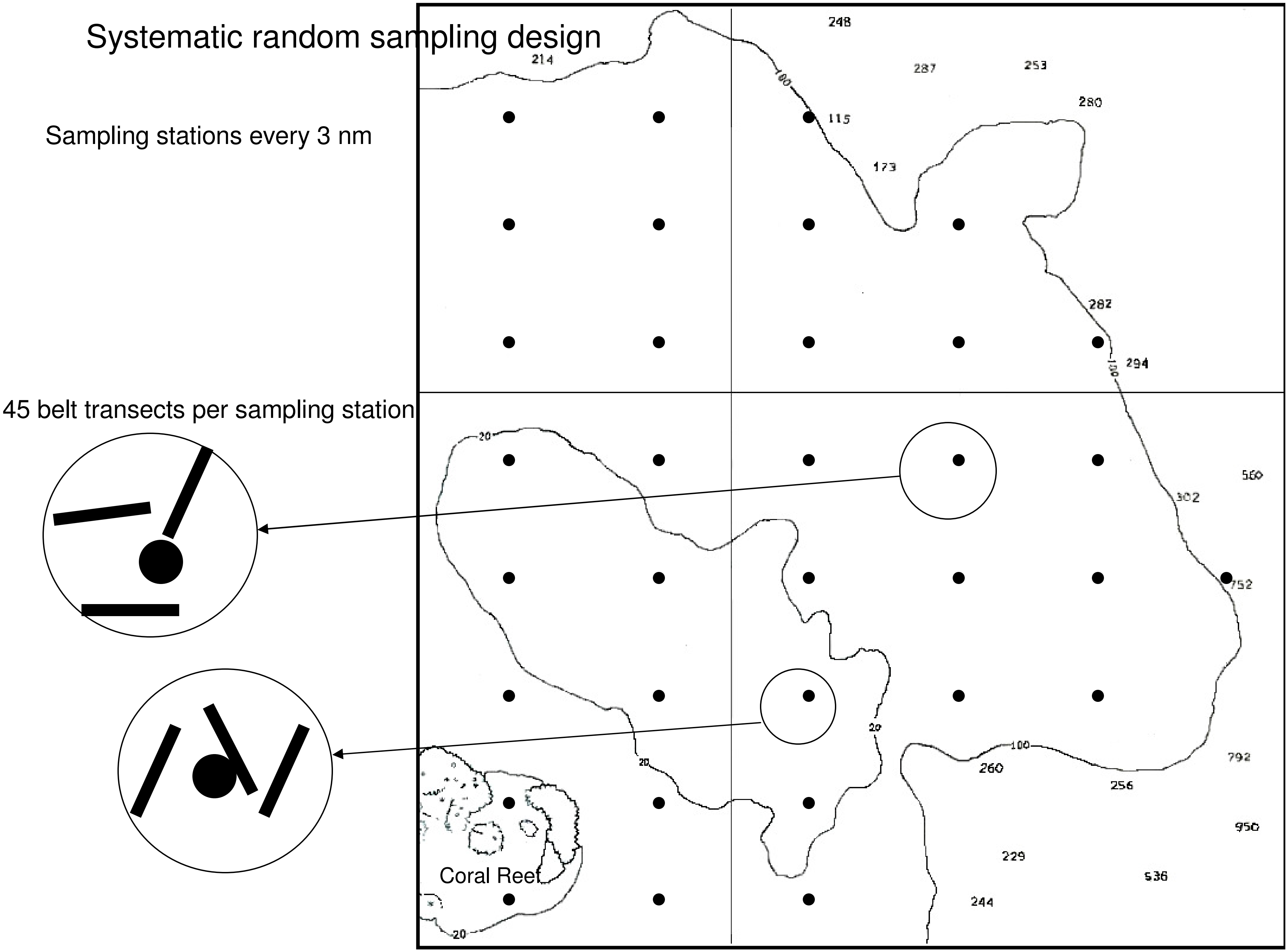
Survey approach to assess the resource and control fishing

1. Systematic replicated experimental sampling design to estimate:
   a. Population habitat range and fishing ground mapping
   b. Population density and size-sex structures
   c. Site fidelity regarding growth, mating success and spawning
   d. Overall population mortality rate and population abundance

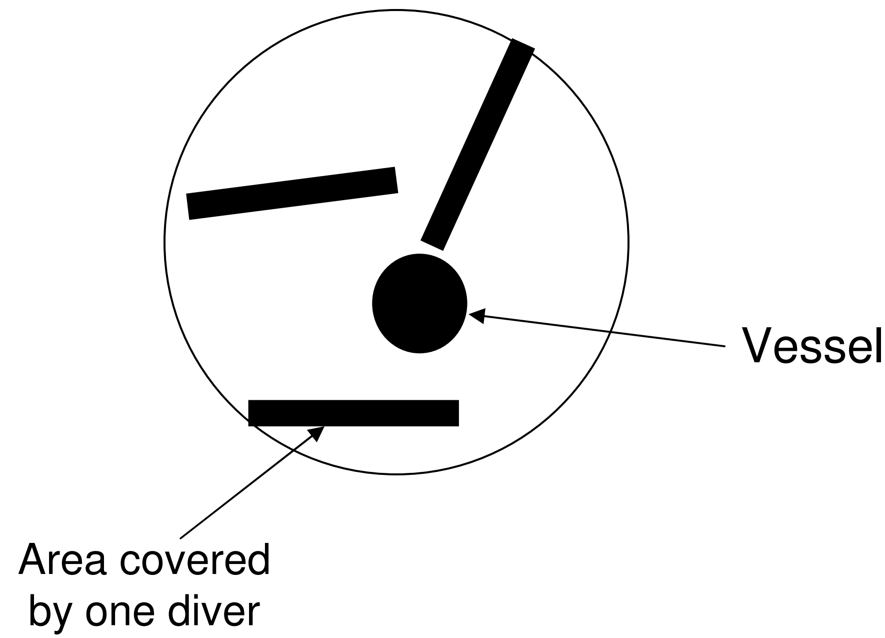
2. Commercial population density surveys and monitoring to estimate:
   a. Fraction of habitat range used
   b. Population density on fishing grounds
   c. Exploited population mortality rate and abundance

1. Systematic replicated experimental sampling design to estimate and map population densities and dimension habitat range




Systematic random sampling design
Sampling stations every 3 nm
45 belt transects per sampling station
Coral Reef
214
248
287
253
280
100
115
173
282
294
100
20
560
302
752
20
20
100
792
260
256
950
229
536
244
20

Sampling station

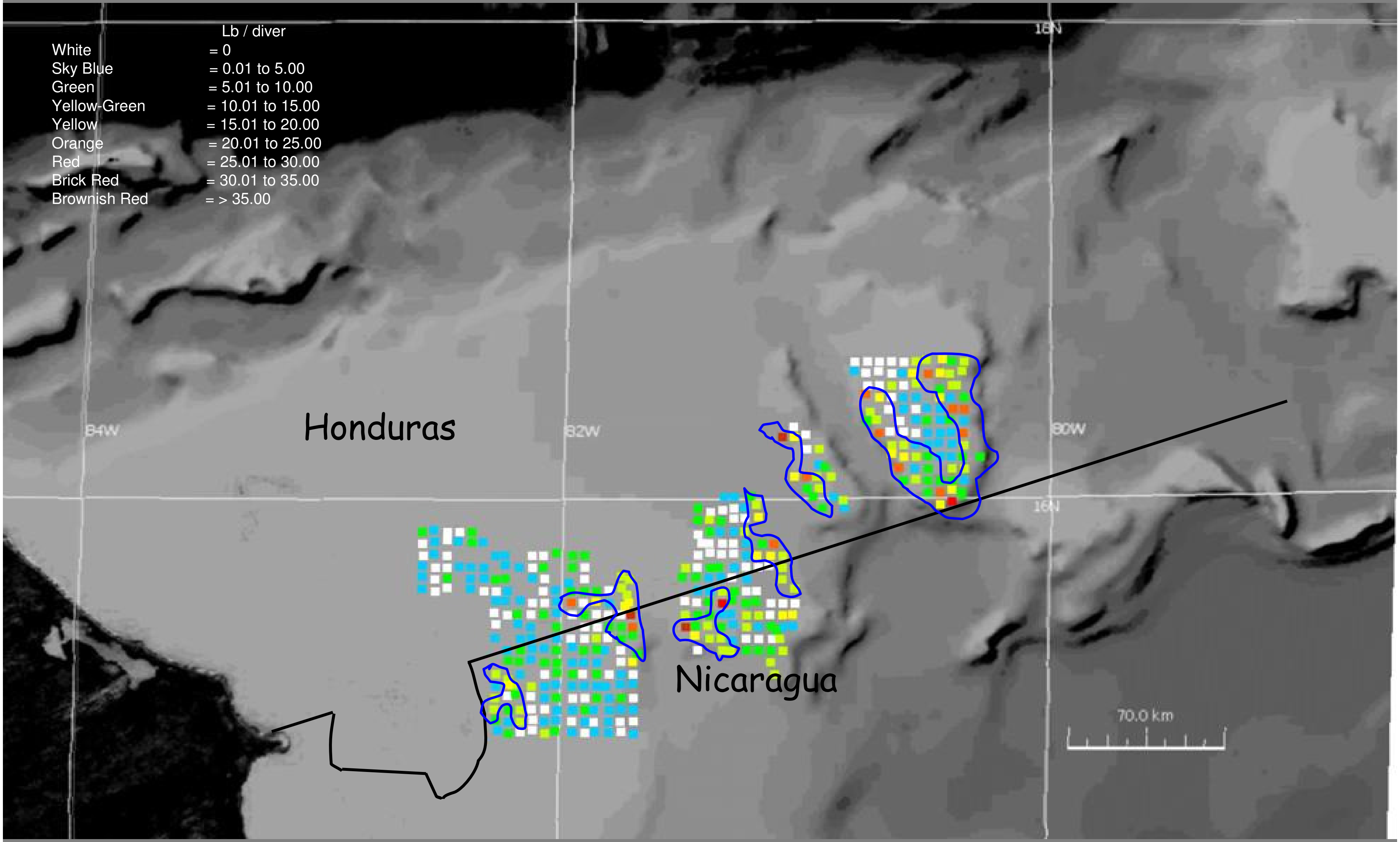


1) Conch density per belt transect

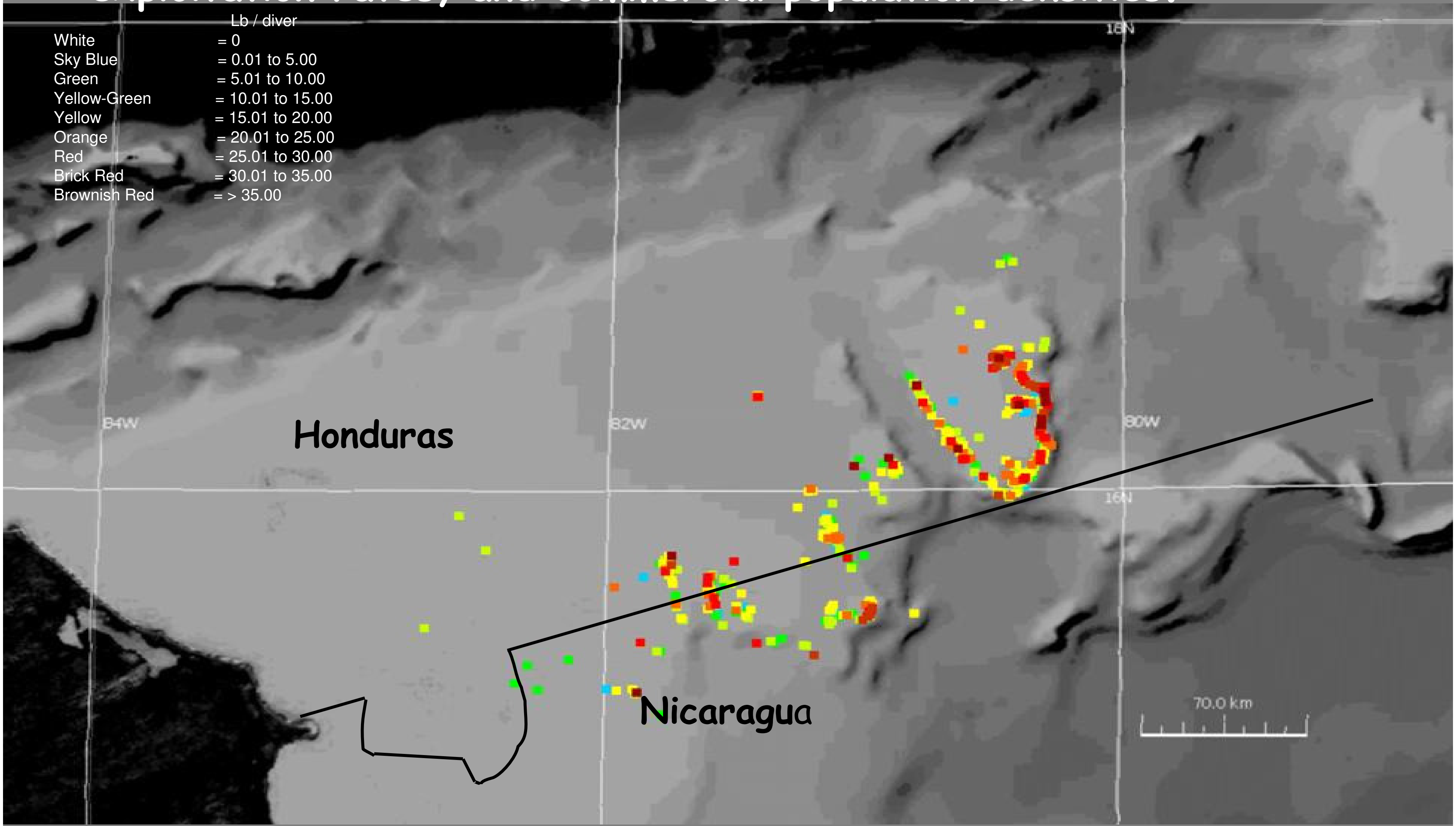
2) Average density and variance in sampling station

3) Statistics estimated per sampling station extrapolated to survey area.

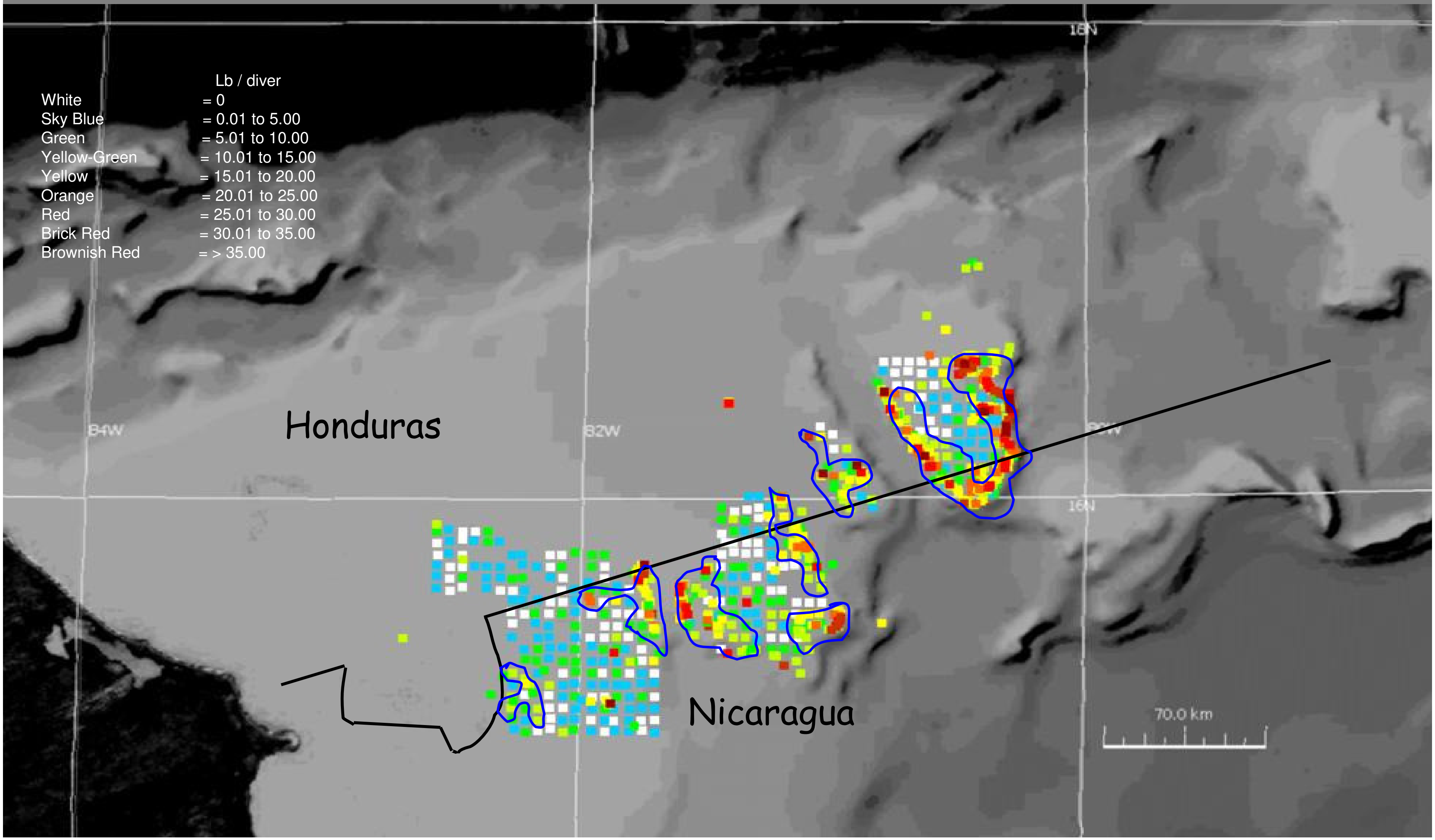
Experimental density sampling survey results



2. Monitored commercial operations to define fishing grounds, exploitation rates, and commercial population densities.

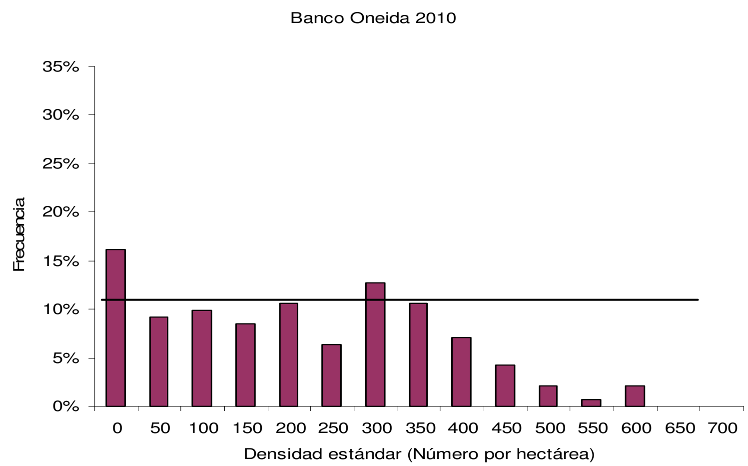


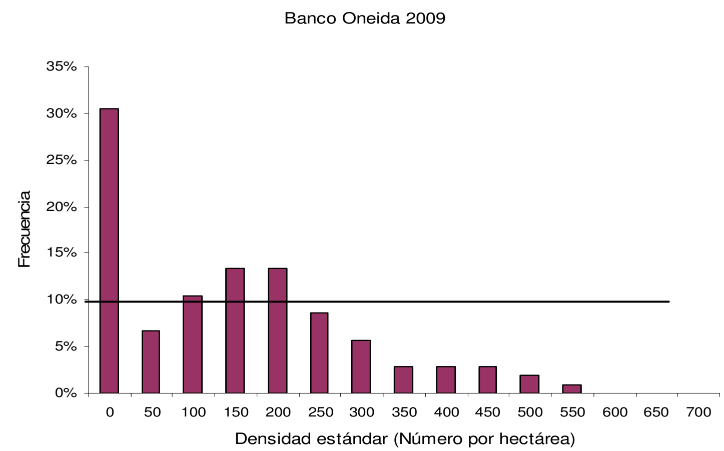
Combined experimental sampling surveys and monitored commercial operations to estimate resource characteristics and stock utilization

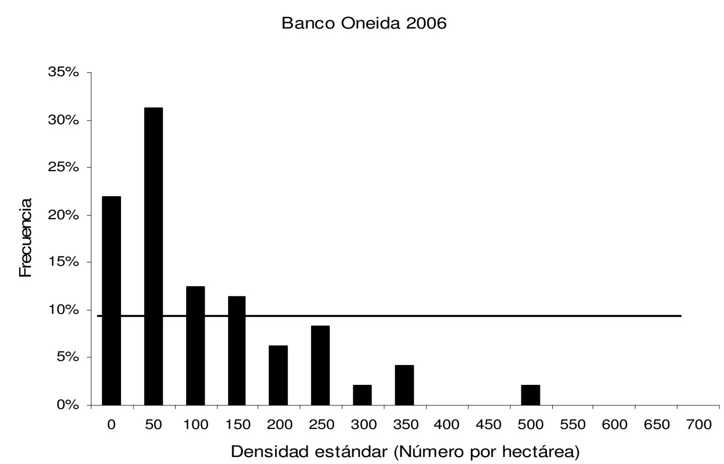


Oneida Bank
Average Density (#/ha)

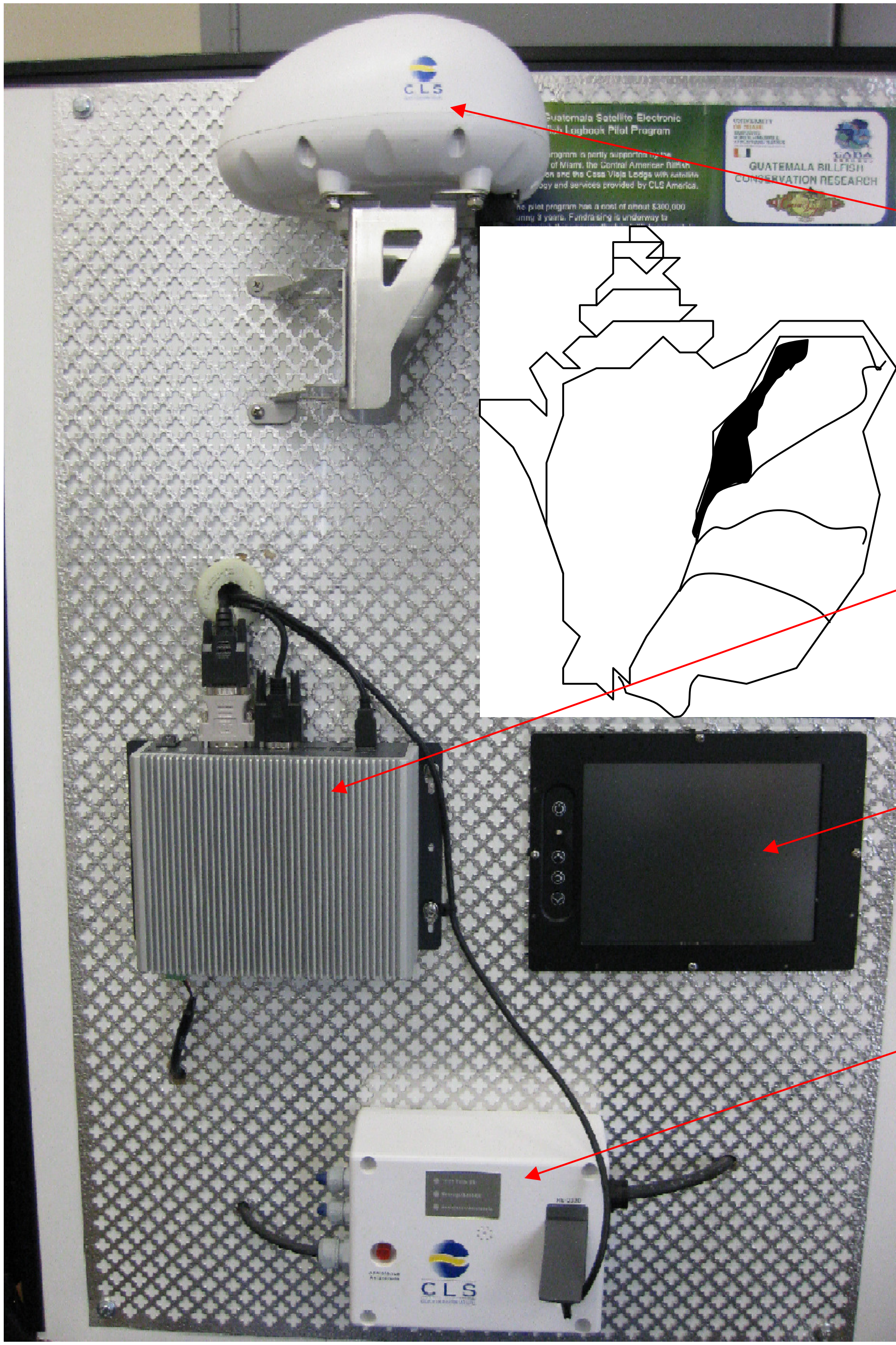
2006	2009	2010
86.0	129.7	193.00







Monitoring commercial fleets by Electronic Satellite Logbook System

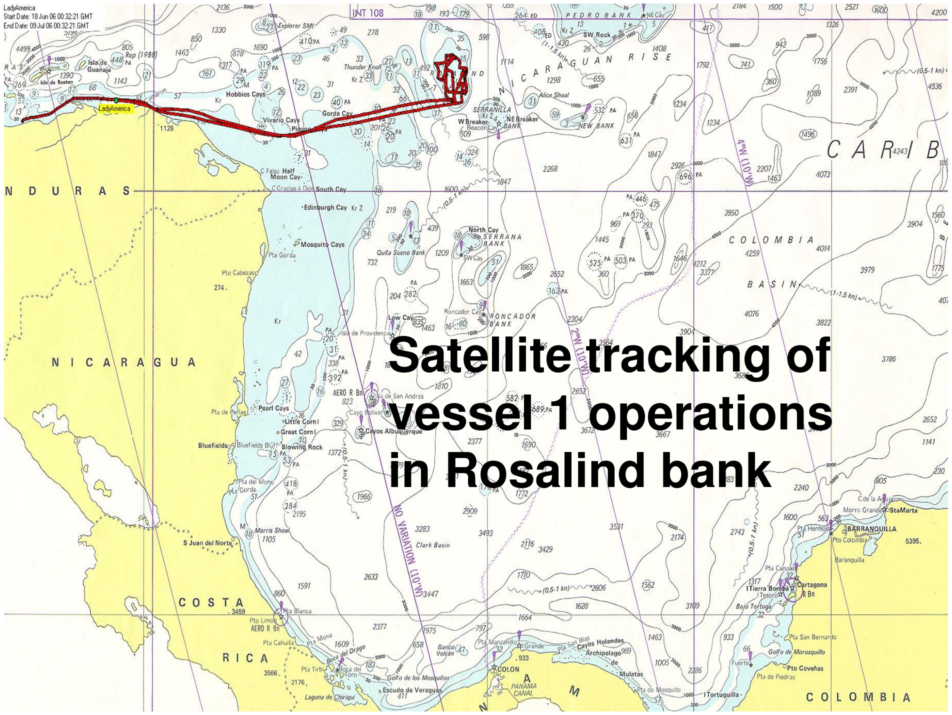


Satellite Antenna

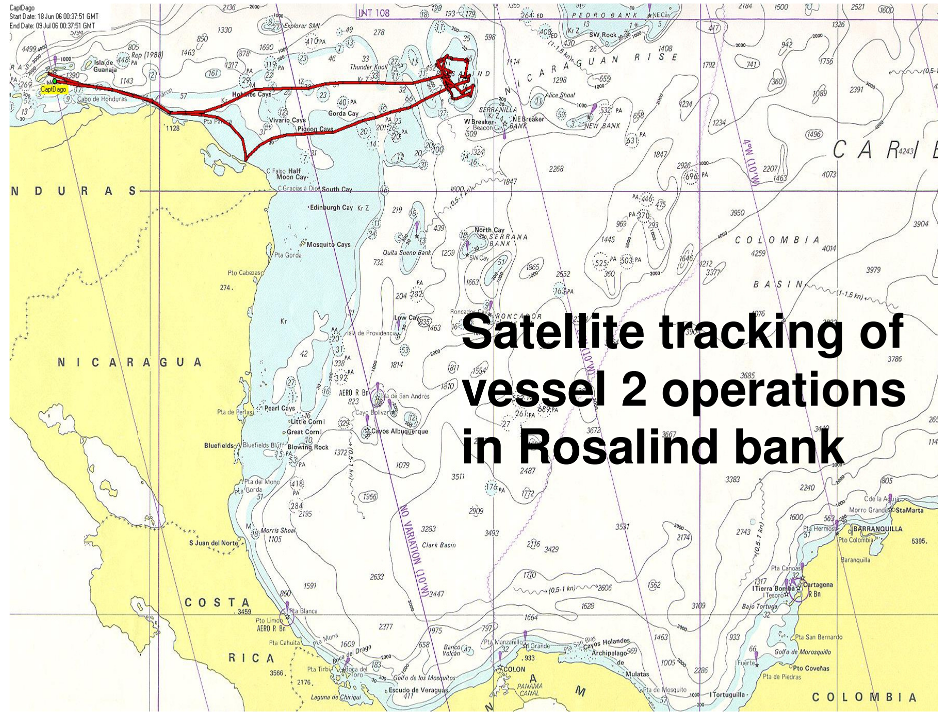
Marine Sealed Microcomputer

Marine Sealed Touch Screen for data entry

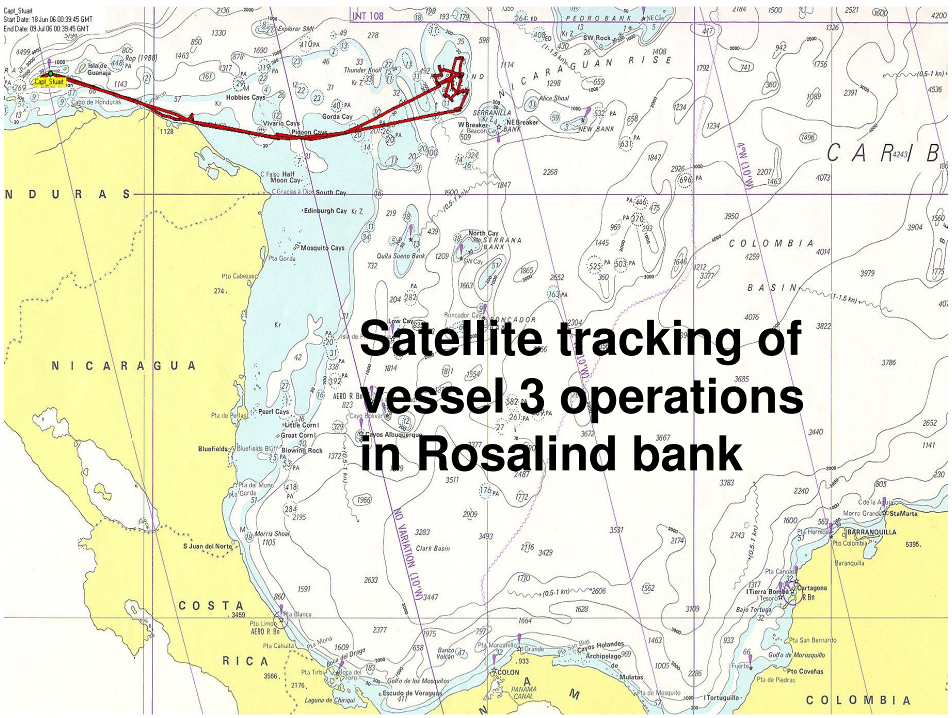
Switch Box



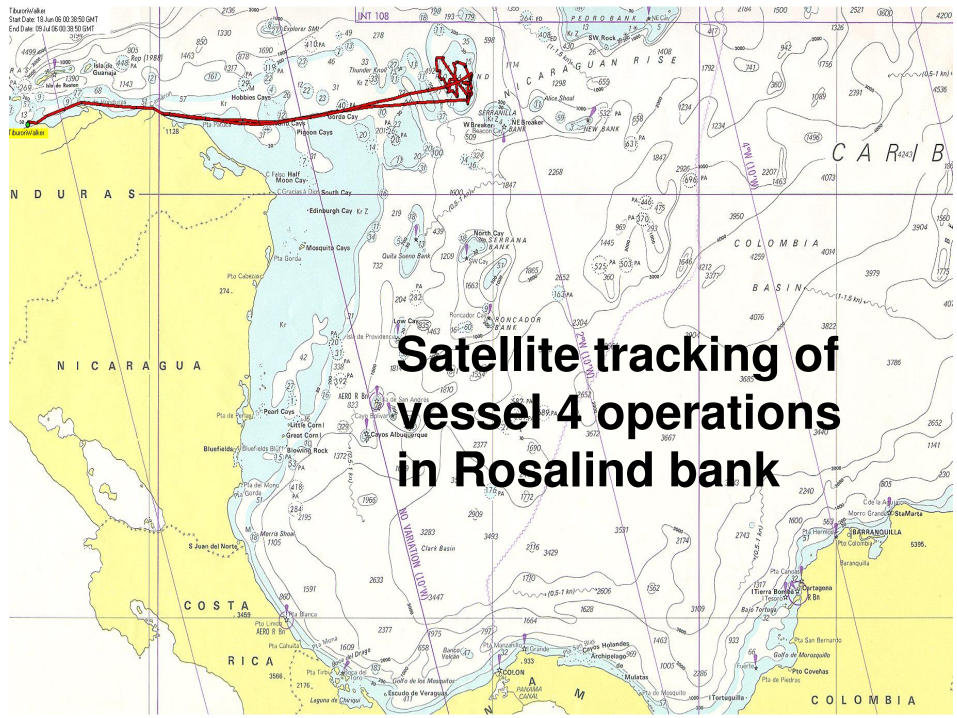
Satellite tracking of vessel 1 operations in Rosalind bank



Satellite tracking of vessel 2 operations in Rosalind bank

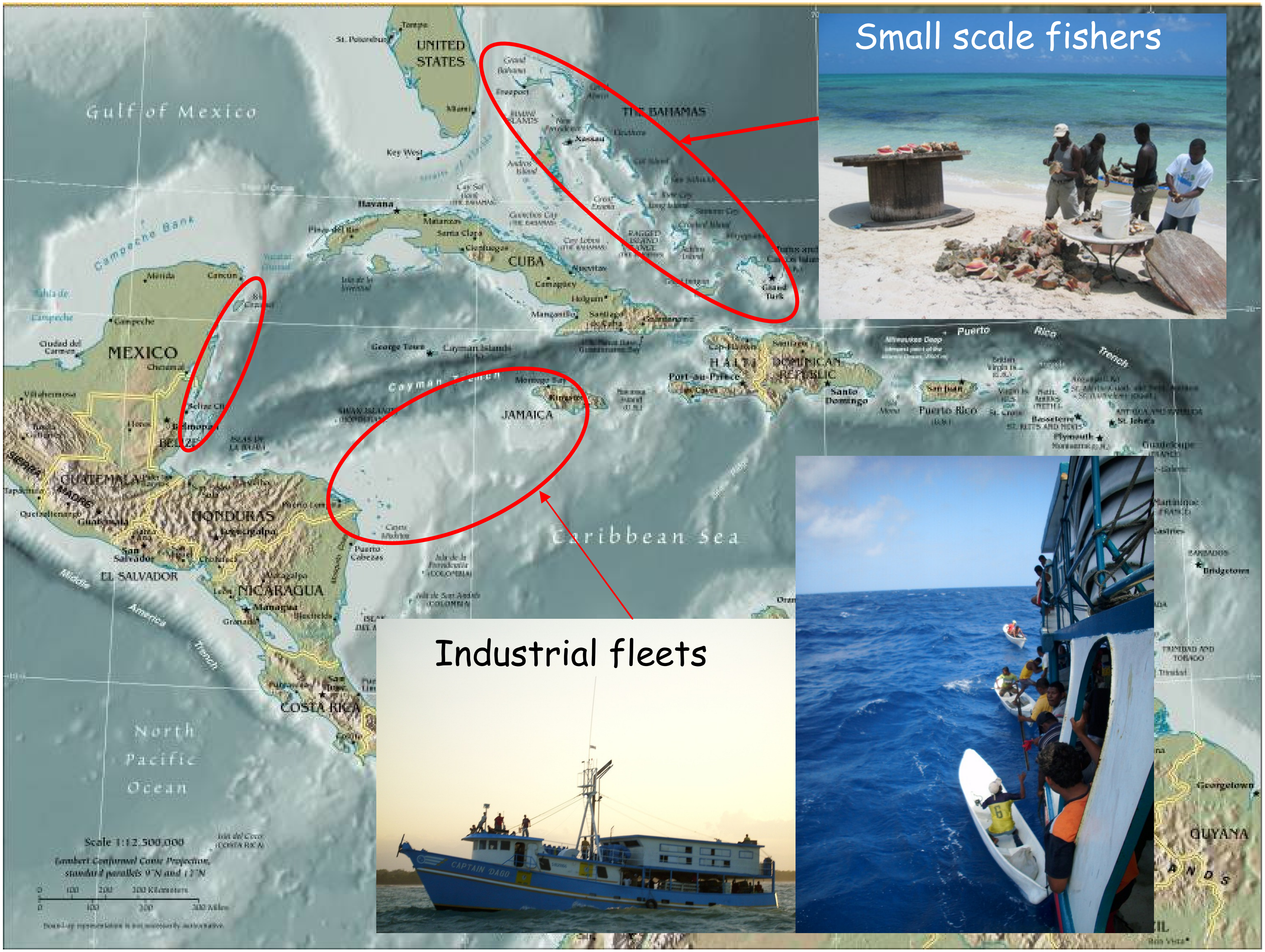


Satellite tracking of vessel 3 operations in Rosalind bank

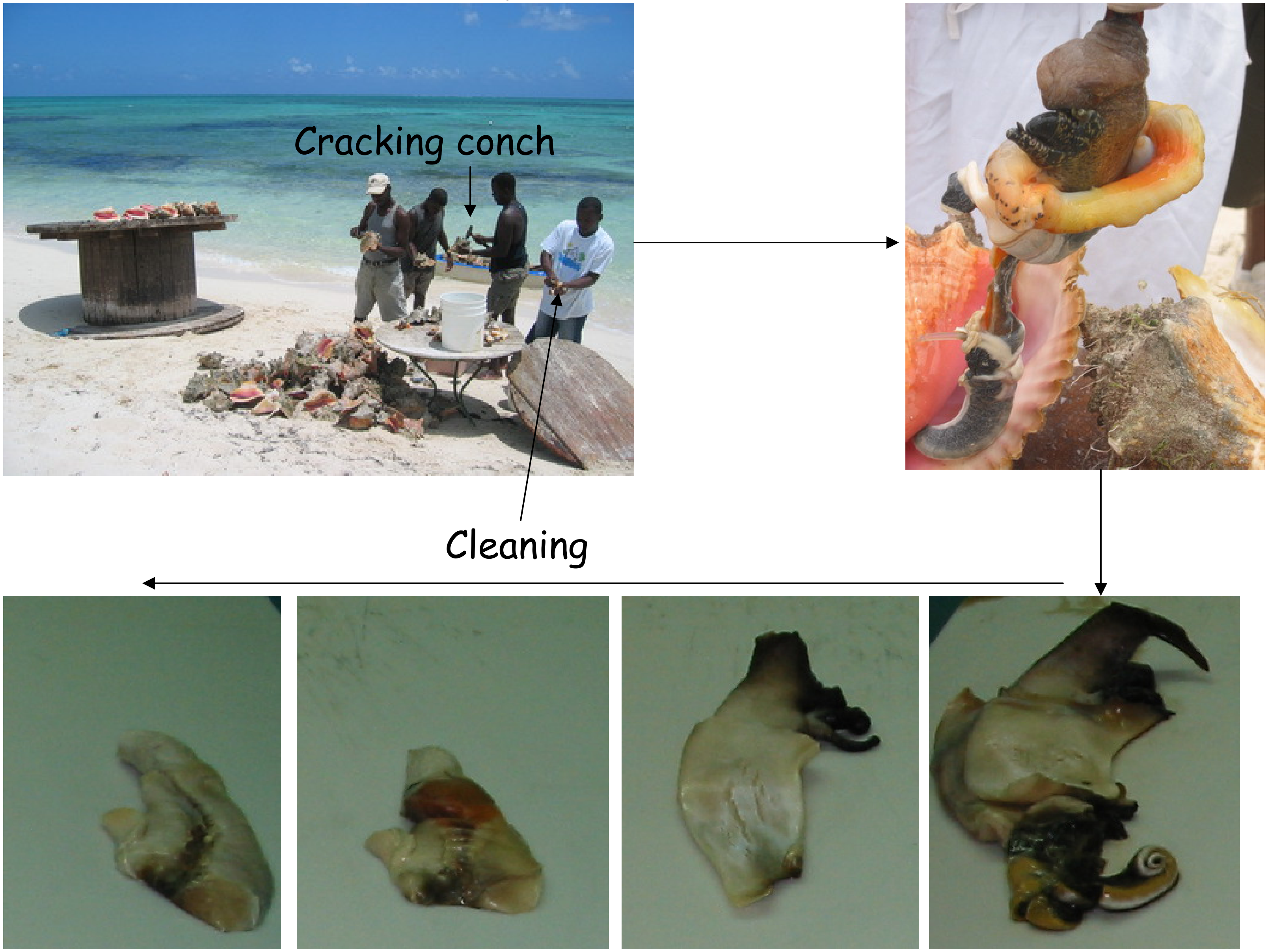


Satellite tracking of vessel 4 operations in Rosalind bank

Characteristics of the fisheries define options for data gathering



Small scale fishers land whole queen conch



100% Clean | 85% Clean | 65% Clean | Whole

PROBLEM:Whole animals are not available to measure size frequencies,sex or maturity.

Operational Fishing Characteristics that Affect Conch Stock Assessments

Fishing operations take place in areas with the highest densities; therefore, CPUE does not represent average stock abundance.

Each fishing ground portrays distinct conch biological properties associated with geographic identities. However, landings are a mix of catches from many different fishing grounds; therefore:

Surplus production may not capture these distinct geographic identities.

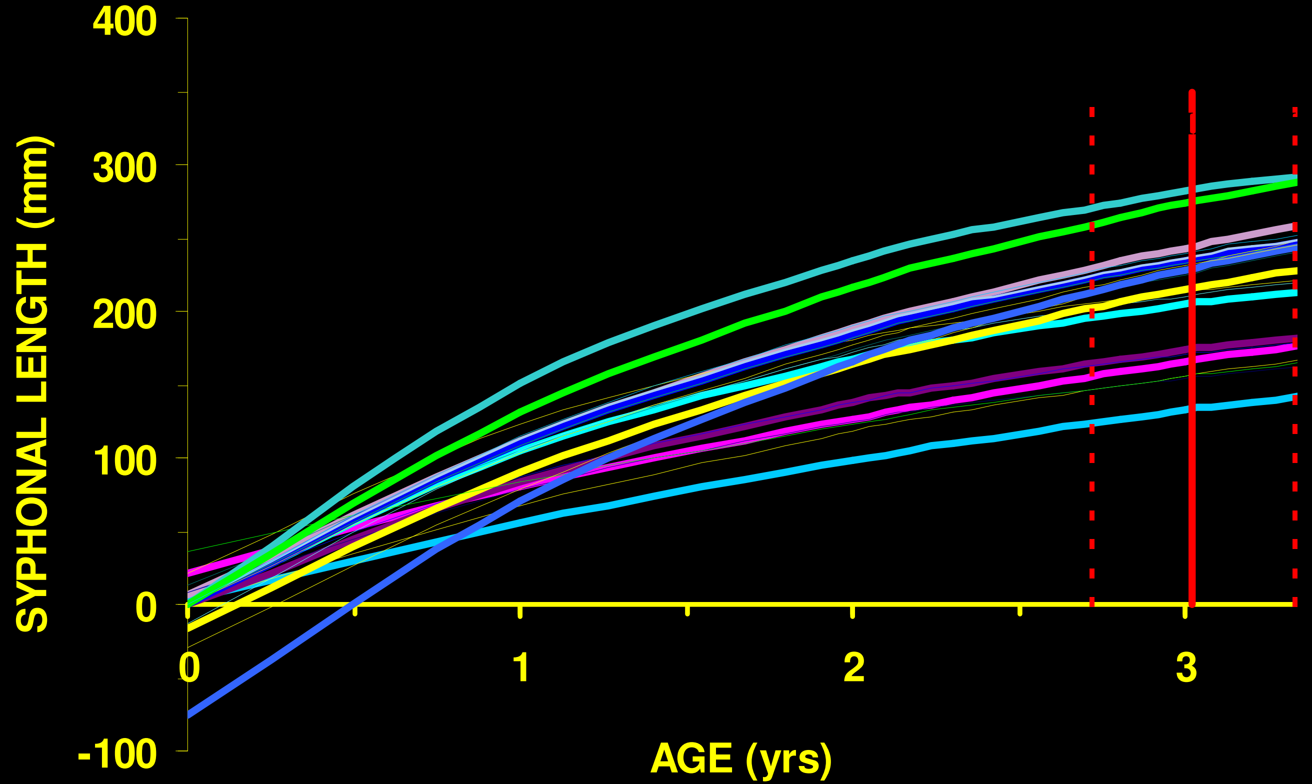
In most fisheries only clean meat is landed. This mars the process of identifying maturity and size of the individuals landed.

Fishing intensity among the fishing grounds differs and it is difficult to assess. Such differences are significant to the CPUE standardization.

Stock assessment methods based on size structures of individuals in the landings

1) Growth as a function of clean meet size at age.
2) Empirical natural mortality rate formulation based on growth function.
3) Weight converted catch curves to estimate fishing mortality rates.

Regional Juvenile Conch Growth Functions



AVERAGE GROWTH PARAMETERS

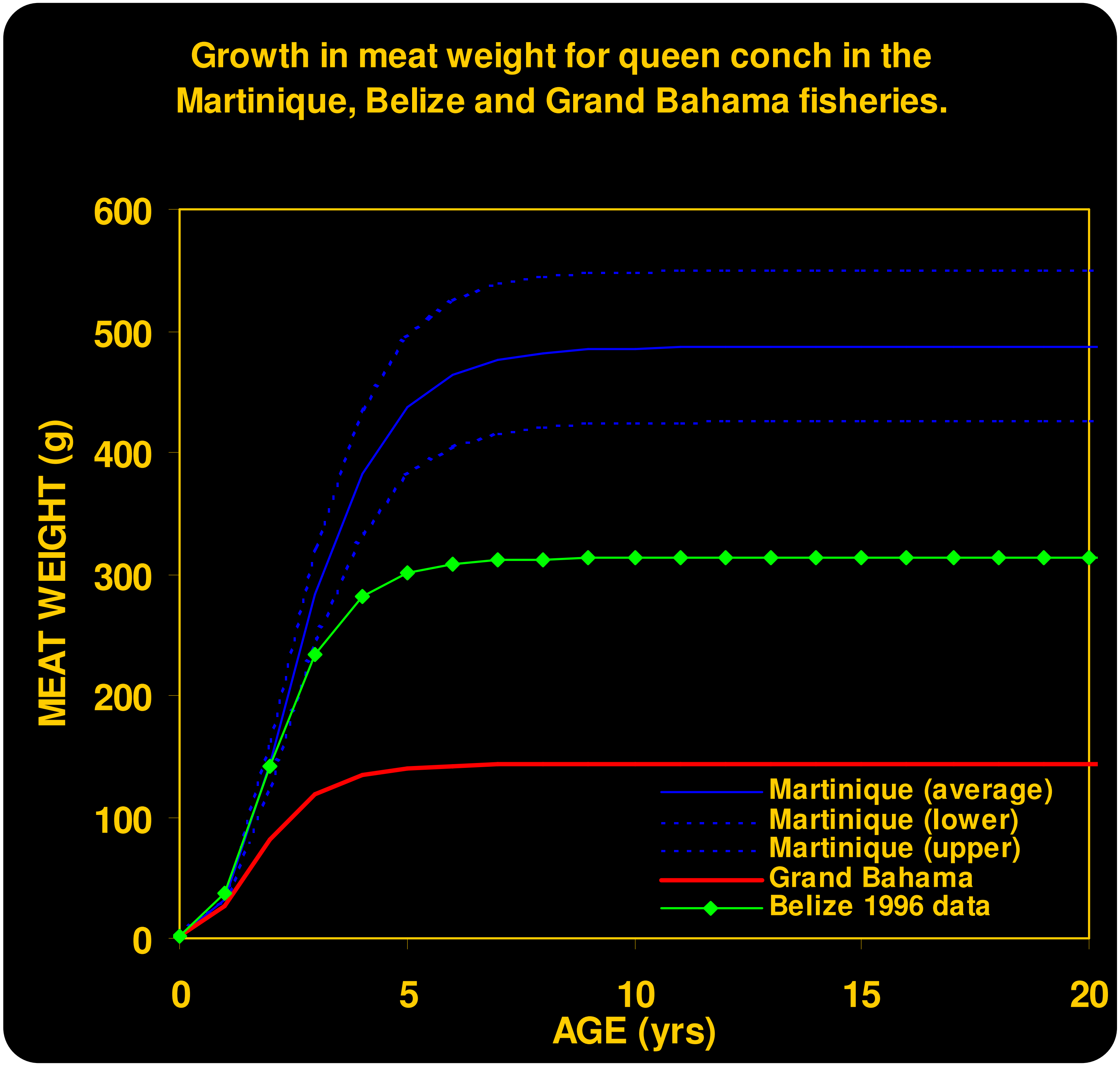
PARAMETER	Loo	K	to
MEAN	316.42 mm	0.385	-0.051
SD	61.25	0.113	0.28

CONCH GROWTH MODEL (based on clean foot meat weight)

$$W_t = \frac{W_\infty}{W_\infty^{\mathrm{EXP}(-A3*t)}}$$

Relative Age is expressed as

$$t = \frac{-\ln\left[\dfrac{\ln\left(W_\infty / W_t\right)}{\ln\left(W_\infty\right)}\right]}{A3}$$


Growth in meat weight for queen conch in the
Martinique, Belize and Grand Bahama fisheries.
MEAT WEIGHT (g)
600
500
400
300
200
100
0
0
5
10
15
20
AGE (yrs)
Martinique (average)
Martinique (lower)
Martinique (upper)
Grand Bahama
Belize 1996 data

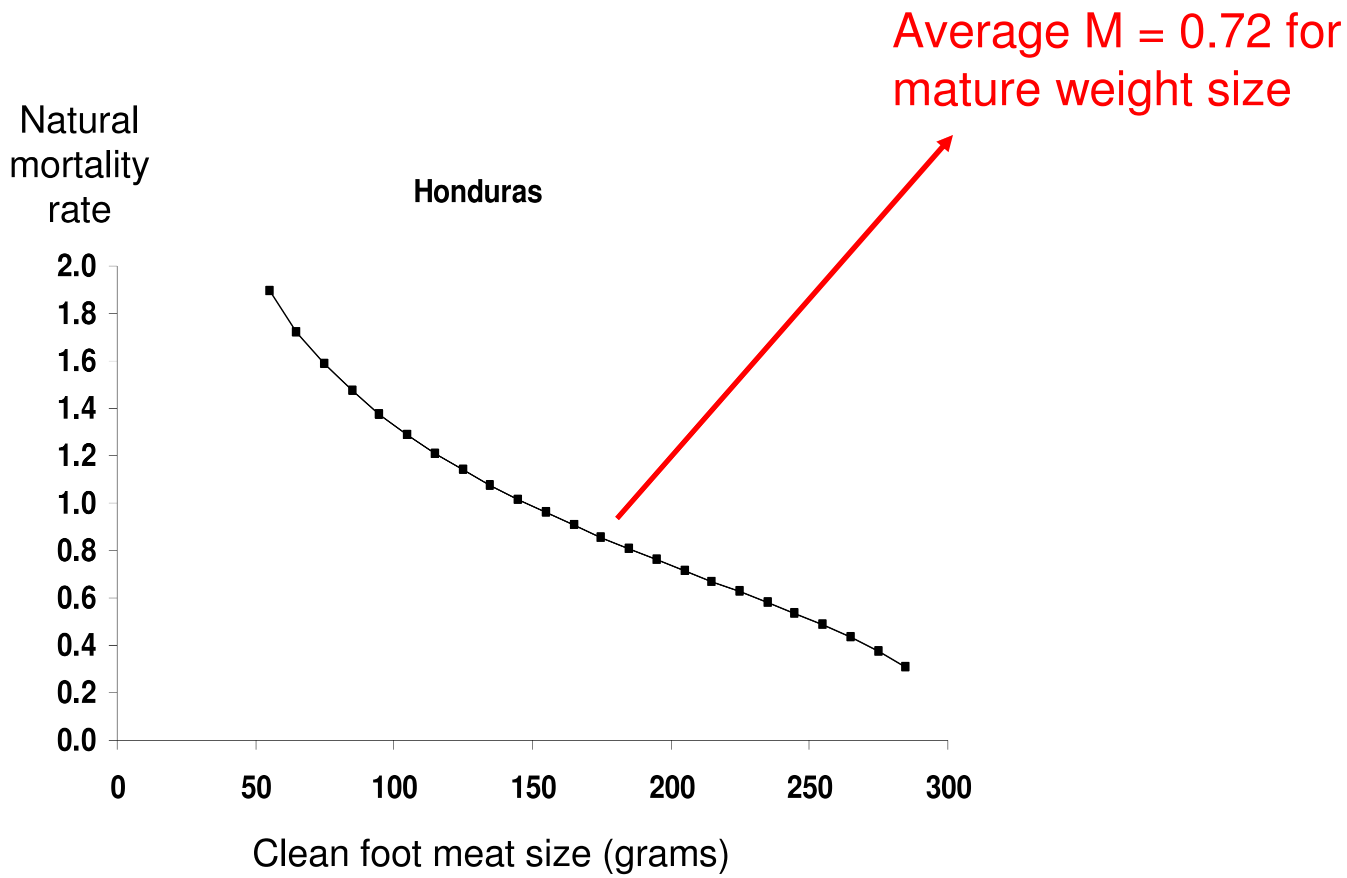
Natural mortality (M) estimation

M= -.0242 + 4.33/(Relative Age) (Appeldoorn 1988)

$$\mathrm{Re}\,lativeAge = \frac{-\ln\left[\dfrac{\ln\left(W_\infty / W_t\right)}{\ln\left(W_\infty\right)}\right]}{A3}$$

(From growth in Ehrhardt's weight at age equation)

$$M = -0.0242 + \frac{4.33 * A3}{-\ln\left[\dfrac{\ln\left(W_\infty / W_t\right)}{\ln\left(W_\infty\right)}\right]}$$



Natural mortality rate
Honduras
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
Clean foot meat size (grams)
Average M = 0.72 for mature weight size

Weight converted catch curve

$$\mathrm{Relative}Age = \frac{-\ln\left[\dfrac{\ln\left(W_\infty / W_t\right)}{\ln(W_\infty)}\right]}{A3}$$

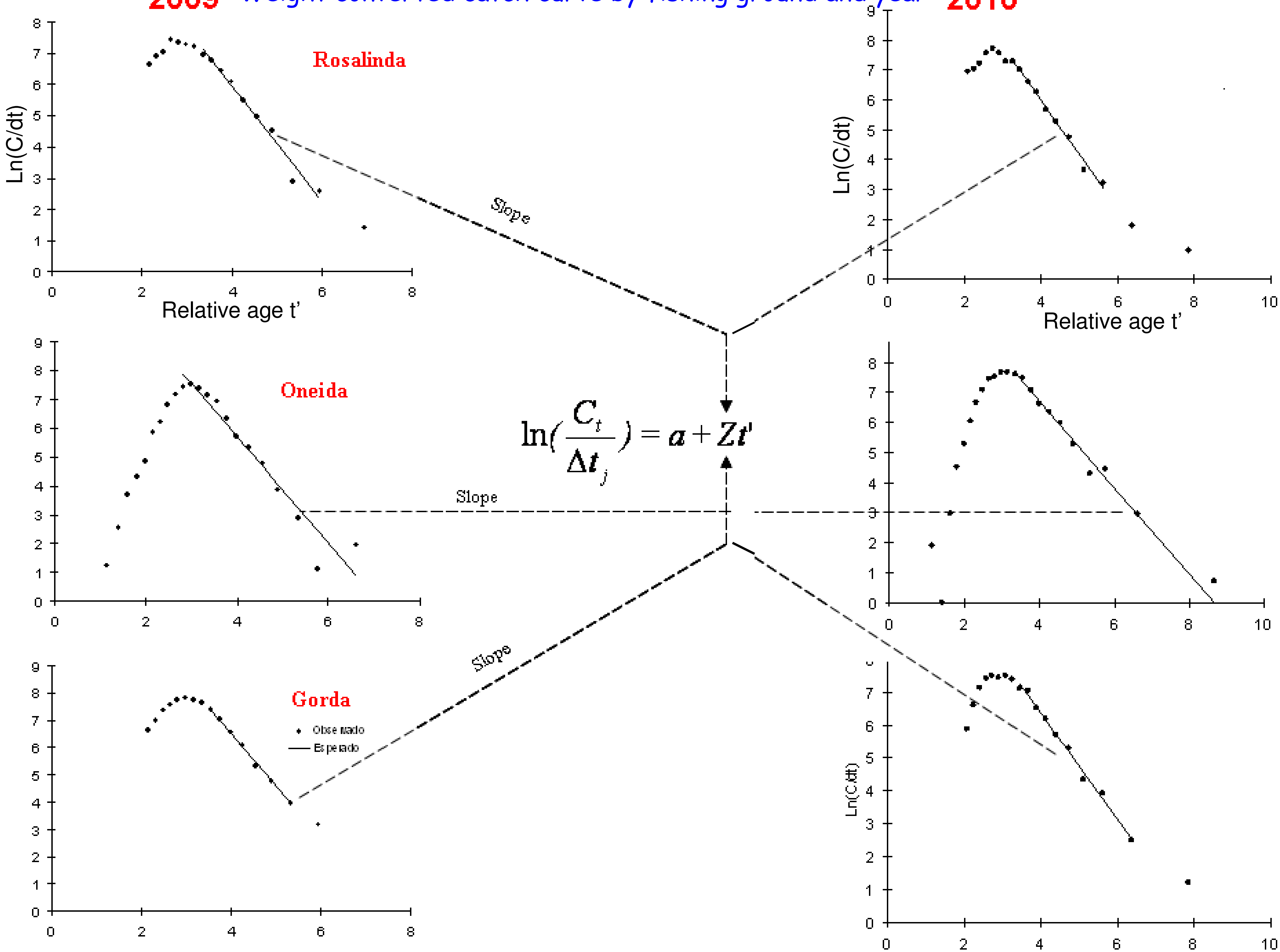
(From growth in weight of edible part at age)

Size increment $\Delta_{t_j} = t_{j+1} - t_j = \dfrac{1}{A3}\ln\left[\dfrac{\ln\left(W_\infty / W_j\right)}{\ln\left(W_\infty / W_{j+1}\right)}\right]$ (From growth in weight edible part)

Slope of line
total instantaneous
mortality rate

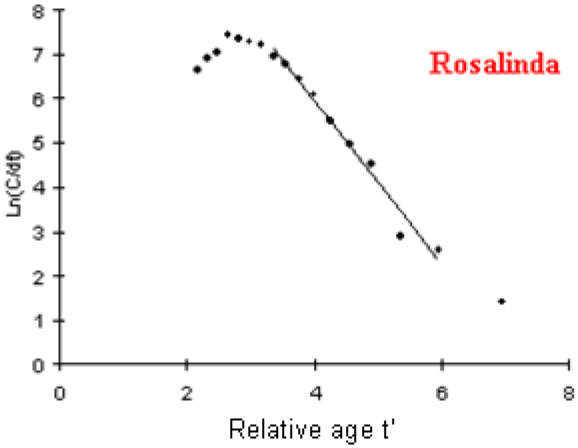
$$\ln\left(\frac{C_t}{\Delta t_j}\right) = a + Zt'$$

2009 Weight converted catch curve by fishing ground and year 2010



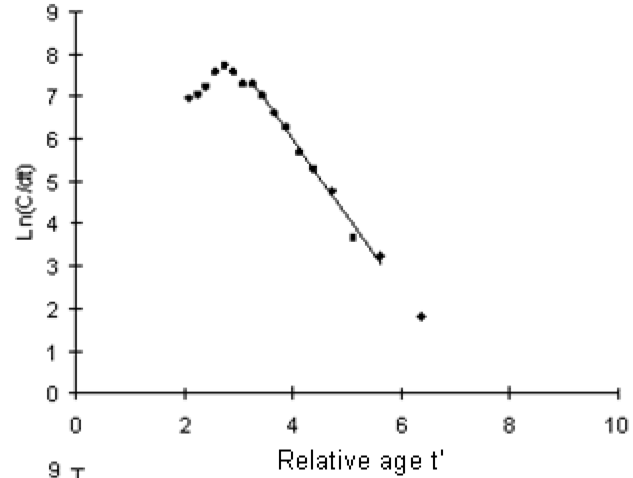
2009 **2010**

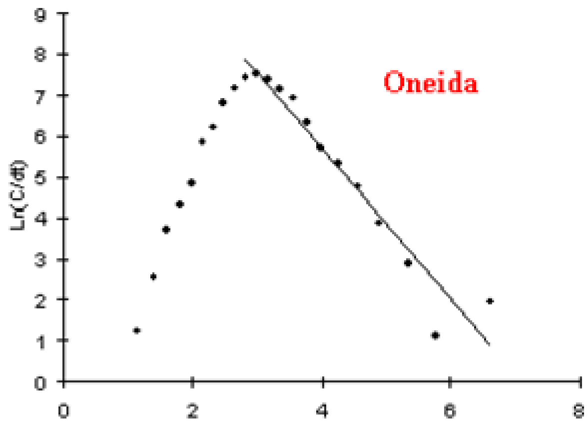
F = Z - M



F = 1.24

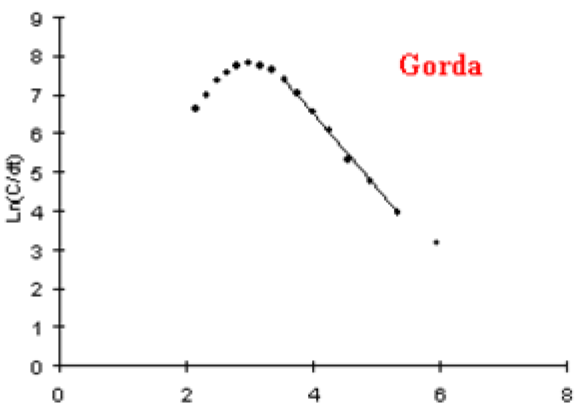
F = 1.16





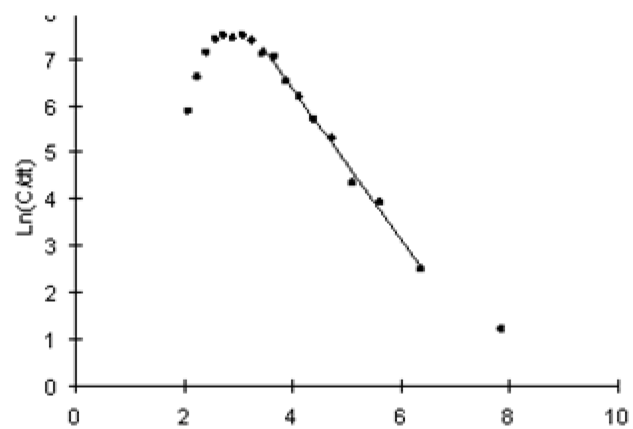
F = 1.27

F = 0.86



F = 1.33

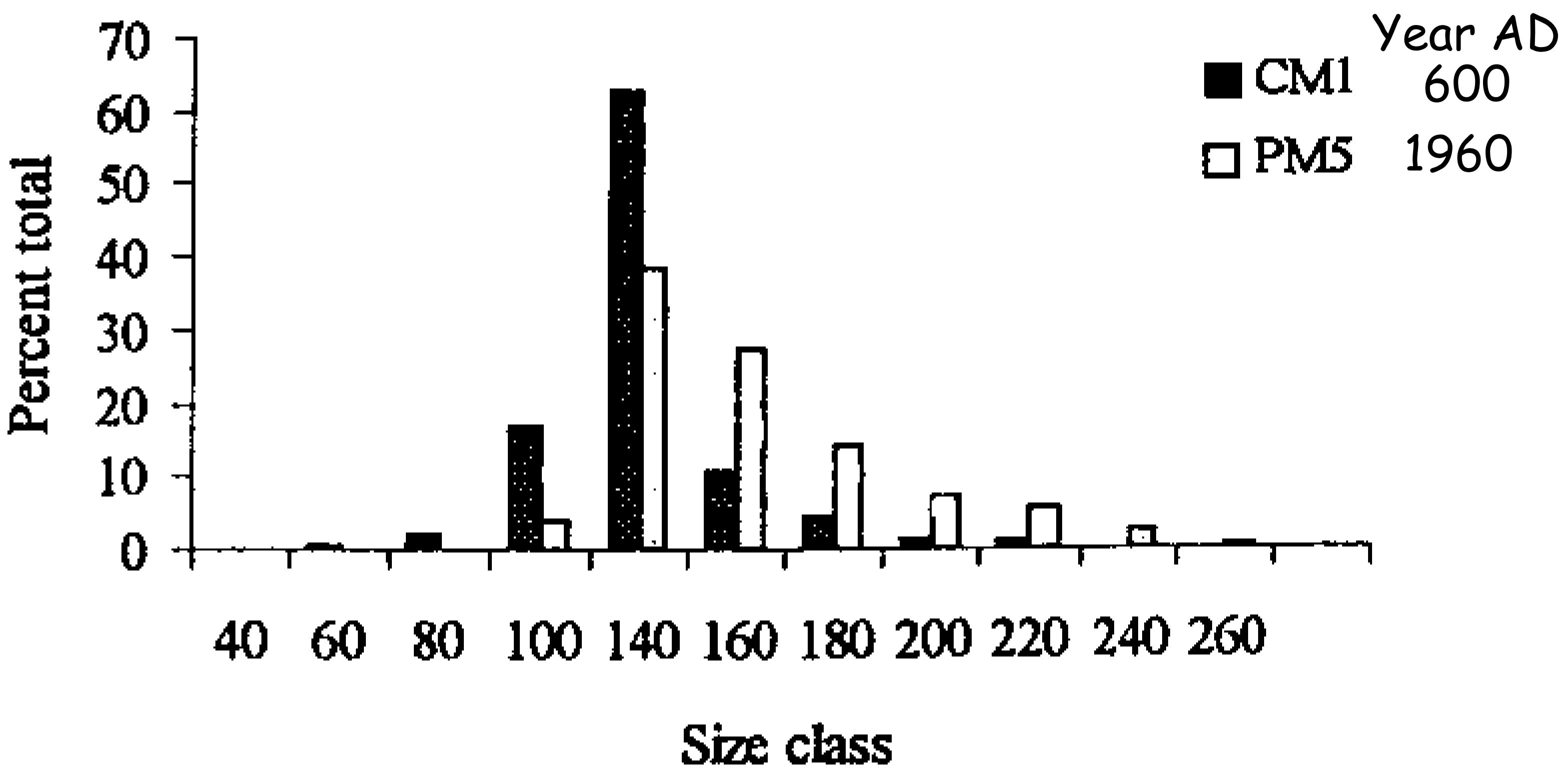
F = 1.01



Mortality estimation from historic shell discards

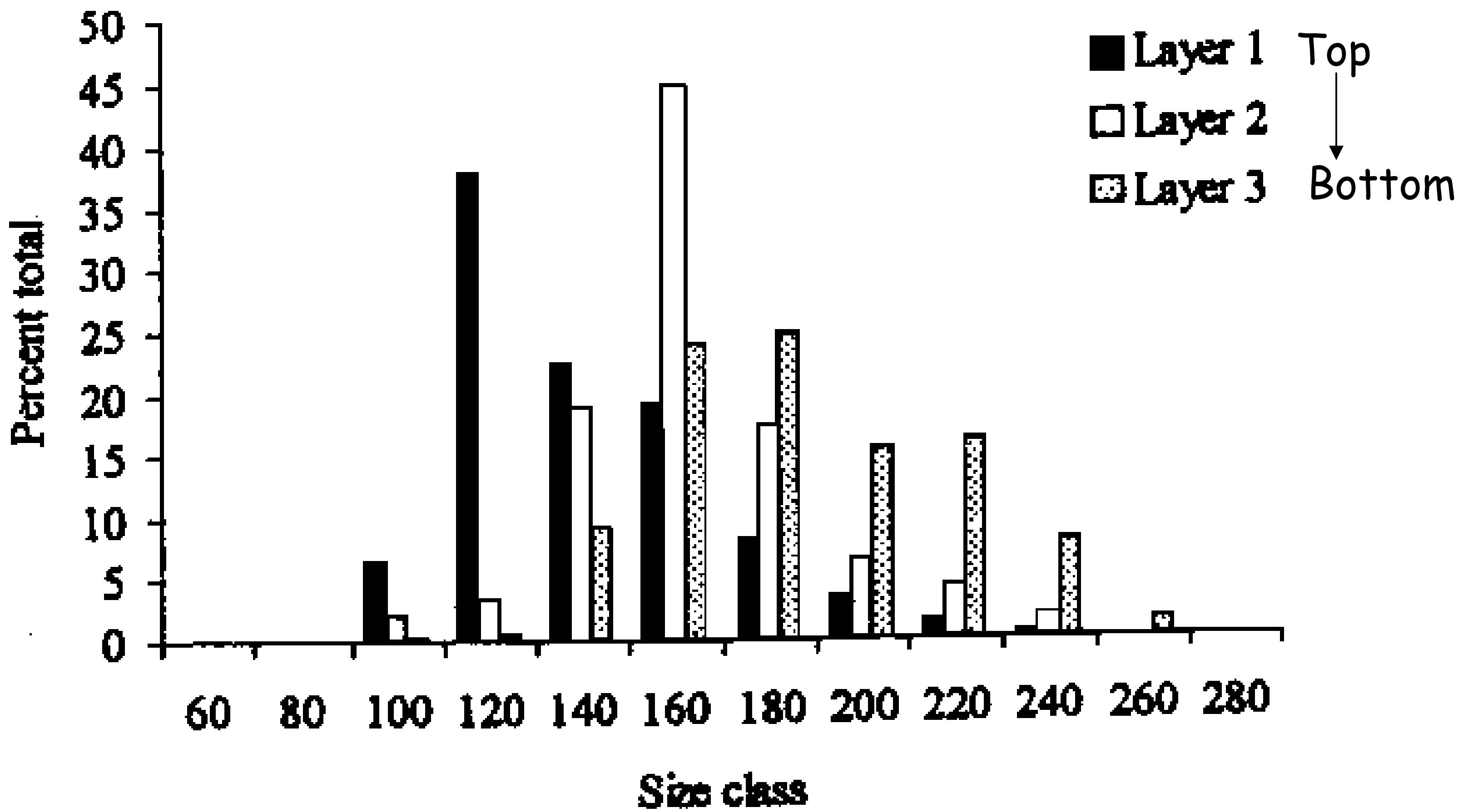
5.500.000 Pre-Hispanic (1160–1540 A.D.) queen conch shells.
Los Roques National Park, Venezuela.

600 AD and 1960 Discards. Dominican Republic



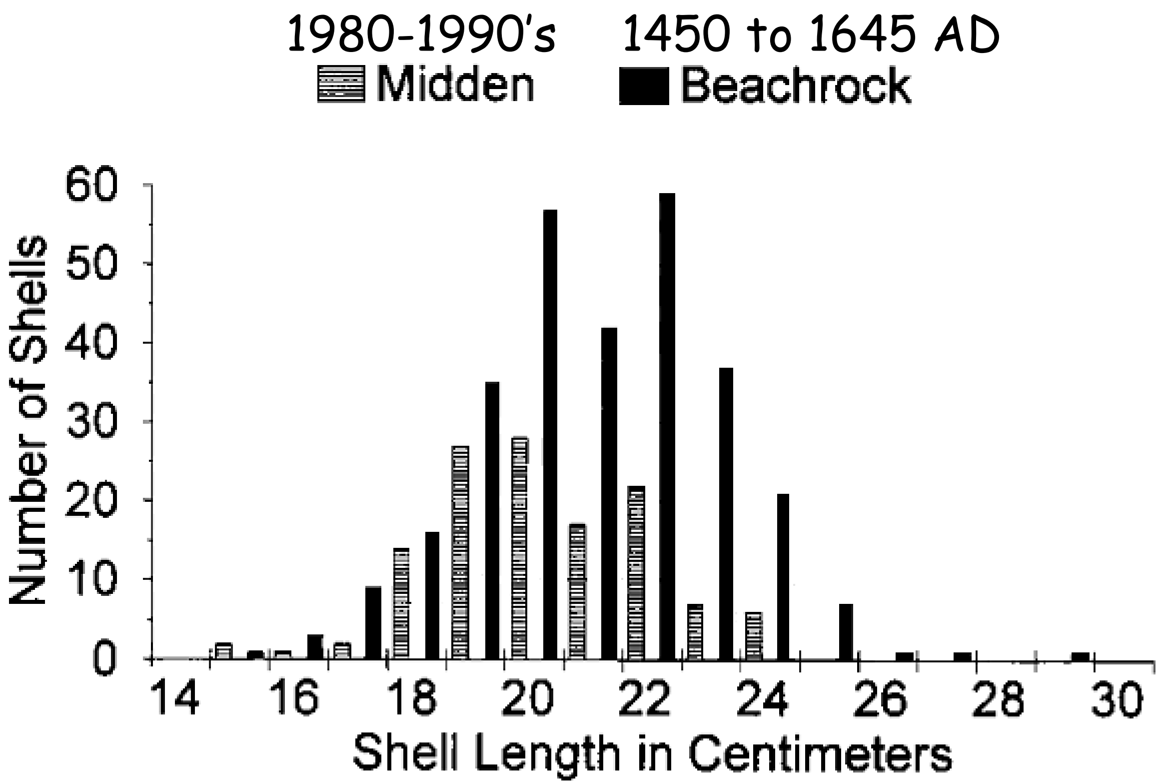
From Torres and Sullivan-Sealy (2002)

1960-Shell Discards Dominican Republic



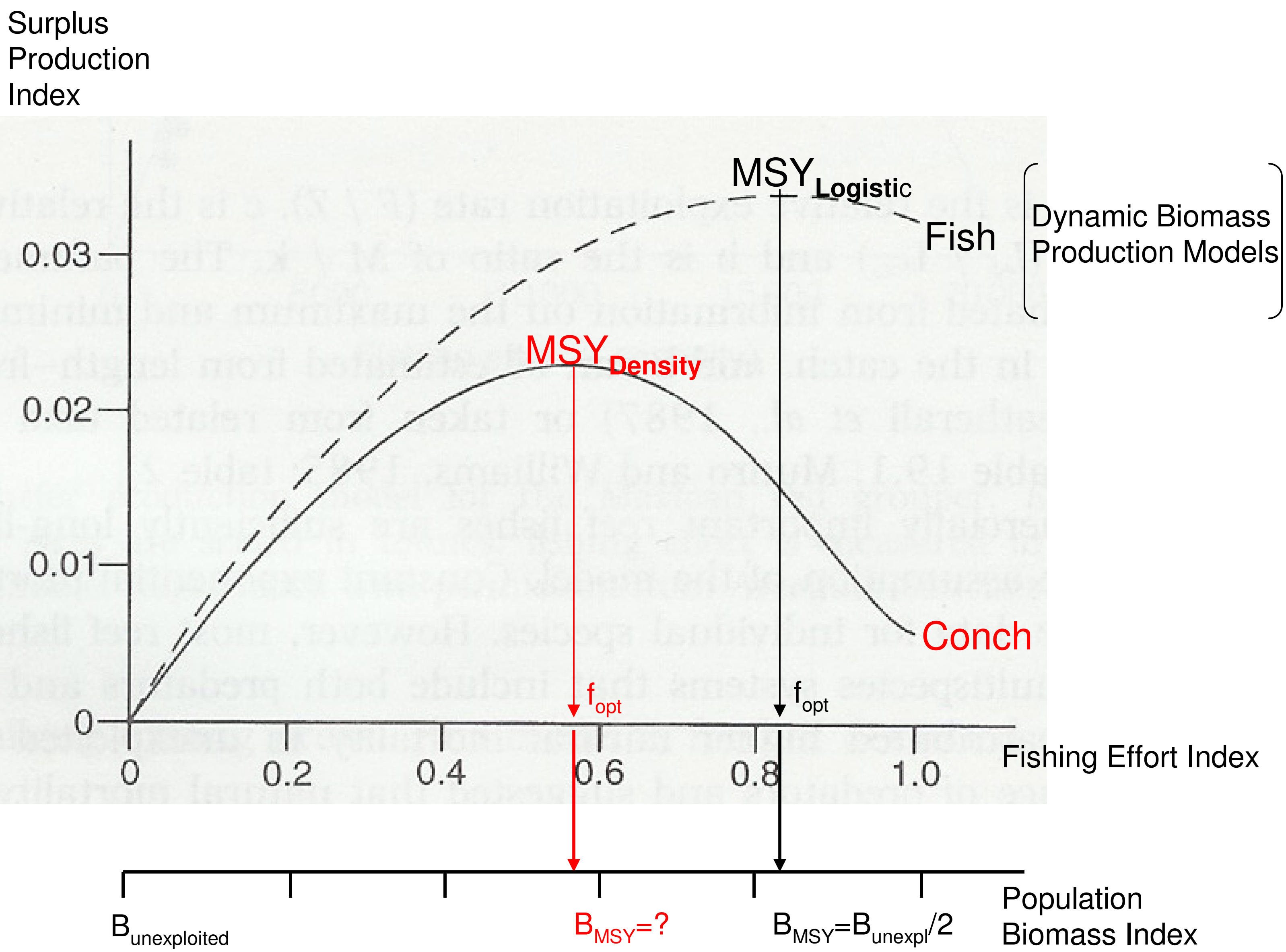
From Torres and Sullivan-Sealy (2002)

Turks and Caicos Islands



From Stager and Chen (1996)

PRODUCTION MODELING



Operational Impacts on Conch CPUE

$$U_t = q\overline{N}$$

Fundamental assumption: CPUE directly proportional
To average population abundance

$$U_t = q_0 e^{-b^* f_t} \overline{N_t}$$

CPUE affected by interactions among fishing units
(e.g. divers)

$$U_t = (qE_t^{\alpha} N_t^{\beta}) N_t$$

CPUE related to operational processes and conch
Behavior.

Production modeling issues

There is a need to understand the Queen conch population generation function which must be subjected to recruitment success as function of population density.

There is a need to understand catchability dynamics when fishing effort is fundamentally by diving.

There is a need to assess surplus production by fishing grounds due to site fidelity of the Queen conch.

There is a need to understand stock connectivity due to nature of larval drift in strong ocean current systems and the nature of the *up-stream* exploitation effects.

Colored drawing by Louis Charles Kiener (1799-1881)

Thank you