

The Human-Marine Interface:

How can genetic methods promote fisheries conservation and fair trade in SA?



Donna Cawthorn

PhD in Food Science (Stellenbosch University)



Introduction



We are all consumers...



“Consumers (buying fish) are definitely being ripped off”

- Robert Hanner, University of Guelph's Biodiversity Institute, 2009

“Children and pregnant woman should avoid fish high in mercury”

- FDA, 2004

“Skate may be fished to extinction”

- BBC News, 20090

On the menu...

1. Background

Fish species



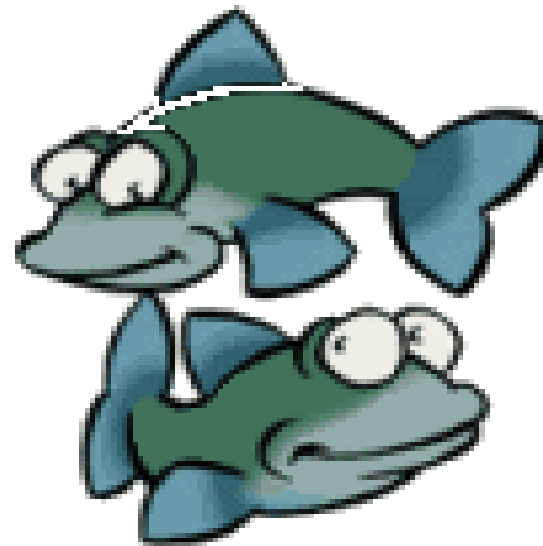
identification

2. Methods

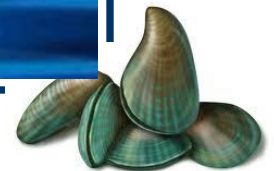
4. Conclusions

3. Results

Background



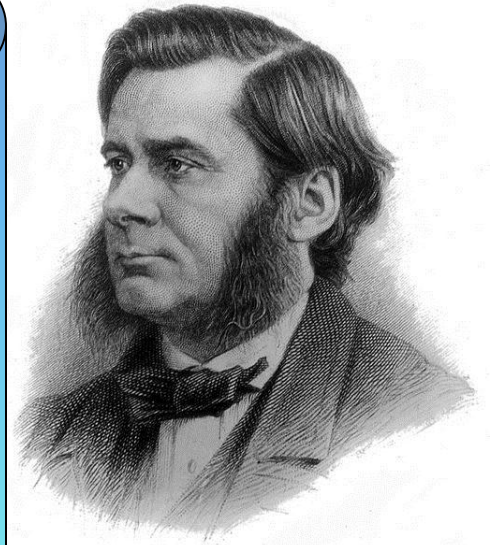
Background



Background

**‘Probably all the great sea fisheries
are inexhaustible;
that is to say that nothing we do
seriously affects the number of fish’**

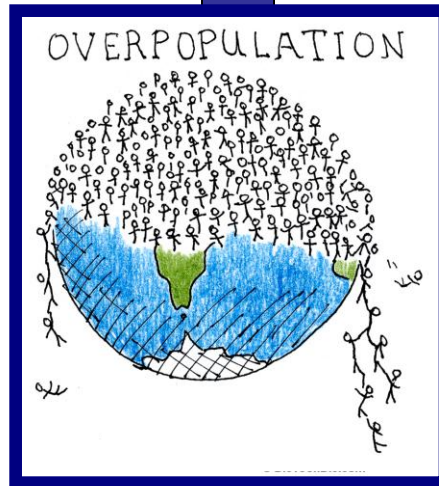
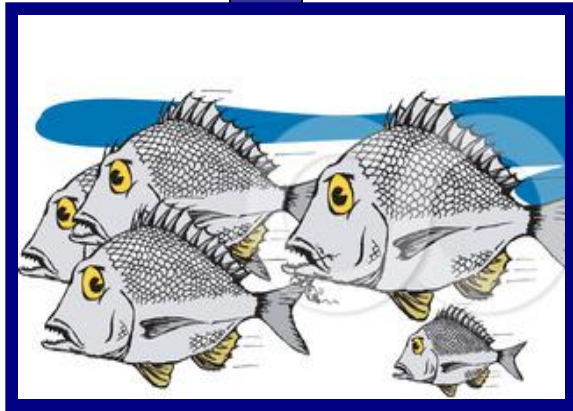
*- Thomas Huxley, 1883
International Fisheries Exhibition London*



(Jennings *et al.*, 2001)

Background

Just a few decades later...



- Exceeded ocean's ecological limits
- Exhausted the "inexhaustible"

(Delgado *et al.*, 2003; Anyanova, 2008)

Background

- ⌘ The world today is facing a fisheries crisis...
- ⌘ Modern fisheries = grossly overcapitalised, unsustainable



“Too many boats chasing too few fish”

“The fish don’t stand a chance”

(Clark, 2006)

Background

Global fishing fleet capacity....

☞ 2.5 X what ocean can sustainably support



(Porter, 1998)

Background

Line around world
550 x

Longline fishing....

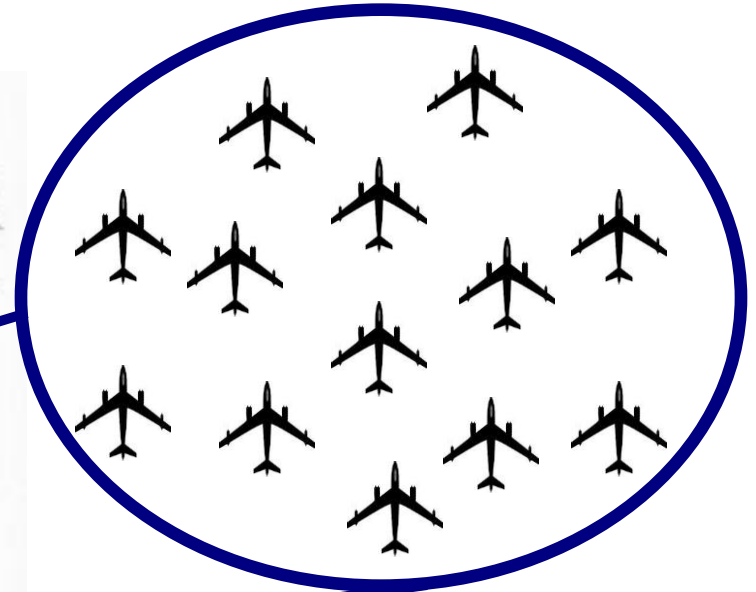
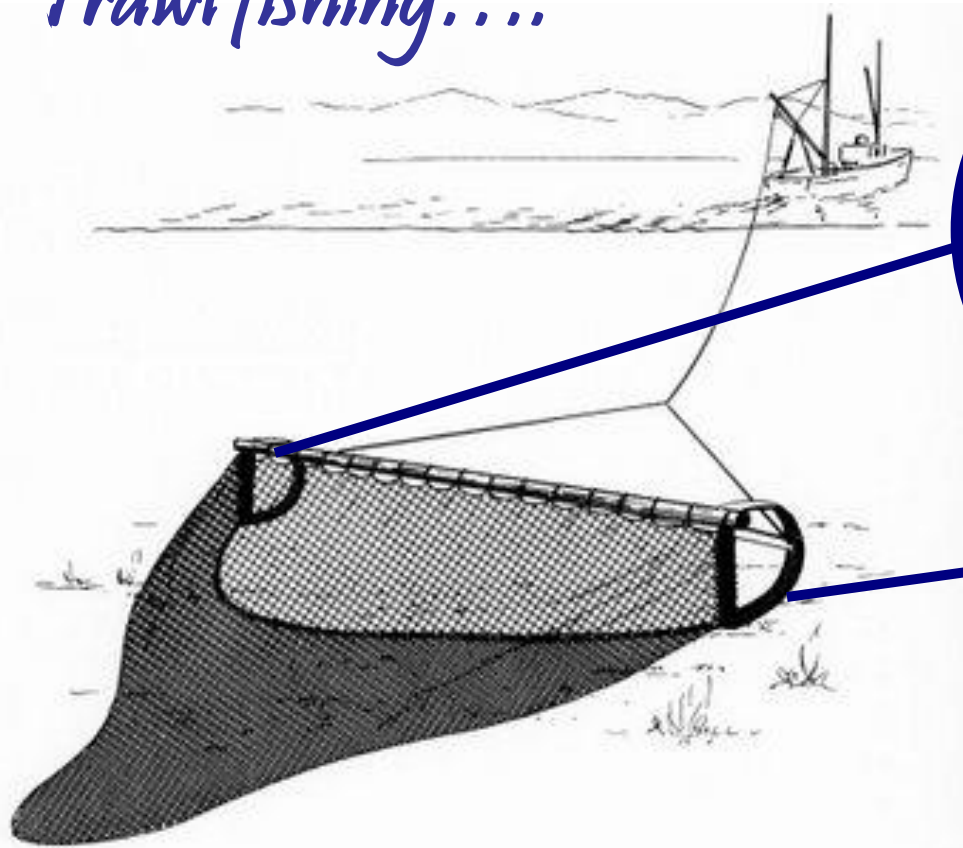


1.4 billion hooks / annum



Background

Trawl fishing....



13 x Boeing 747's

Background

Effect of bottom trawling on seabed...

☞ Ploughing a field seven times a year



Untrawled



Trawled

Background

Advanced fishing technologies....

☞ Greater amounts of target catch

Bycatch....

☞ 40% of total



(Delgado *et al.*, 2003)

Background



More than 70 percent of the world's fisheries are 'fully exploited', 'over exploited' or significantly depleted.'

Background

- SA: Linefish target of overfishing
- 6 of 10 most commercial species

Kabeljou (silver & dusky kob)

Geelbek (Cape salmon)

Red stumpnose

Carpenter (silver)

Roman

(Siebert, 2009; SASSI, 2011)



Background



- 2004: Southern African Sustainable Seafood Initiative (SASSI)
- Provides list of commonly encountered seafood species in South Africa & “traffic light” system

| GREEN - BEST CHOICE | | ORANGE - CAUTION | RED - NO SALE |
|--------------------------------------|---|--|---|
| Anchovy | Mussels | Abejone - not farmed | Bardman (belman; tasselfish) |
| Angelfish (Atlantic pomfret) | Octopus | Bluefin tuna | Banded galjoen |
| Bluefish (bluenose) | Oysters | Carpenter (silverfish; silver) | Blacktail (dassie; kolstert) |
| Blueskin (trawl soldier) | Panga | Dagersaad | Brindle bass Ⓢ |
| Blue hottentot | Queen mackerel (Natal snoek) | Elf (shad) - no sale in KZN | Bronze bream |
| Butterfish | Sand soldier (red tjor-tjor) | Englishman | Cape stumpnose |
| Chub mackerel (makriel) | Santer (soldier) | Geelbek (Cape salmon) | East coast rock lobster |
| Dorado (dolphinfish; mahi-mahi) | Sardine (Pilchard) | King mackerel (couta;cuda) | Galjoen |
| Gumard | Snoek | King soldierbream | Garrick (leervis) |
| Hake (stockfish) | South coast rock lobster | Kingklip | John Brown (Janbruin) |
| Harder (mullet) - not from estuaries | Squid (calamari; tjakka) | Kob (kabeljou; dusky, silver, and squaretail kobs) | Kingfishes |
| Horse mackerel (maasbanker) | Steentjie | Langoustines - local trawled ✕ | Knife jaw, Cape and Natal (cuckoo bass; kraalbek) |
| Hottentot | Tuna - not bluefin; pole caught is better | Marlins Ⓢ | Large-spot pompano (moony; wave garrick) |
| Jacopever | West coast rock lobster (west coast crayfish) | Sharks - all except those on Red list Ⓢ | Natal stumpnose (yellow bream) |
| John Dory | White stumpnose | Skates and rays Ⓢ | Natal wrasse Ⓢ |
| Monkfish | Yellowtail | Slingers | Potato bass Ⓢ |
| | | Snappers - all except river snapper Ⓢ | |
| | | Sole - local ✕ | |
| | | Swordfish | |
| | | Poenskop (black musselcracker) | Ragged tooth shark |
| | | Prawns - local trawled ✕ | River bream (perch) |
| | | Red steenbras (copper steenbras) | River snapper (rock salmon) |
| | | Red stumpnose (Miss Lucy) | Sawfishes Ⓢ |
| | | Rockcods - all except potato and brindle bass Ⓢ | Seventy-four Ⓢ |
| | | Roman (red roman) | Southern pompano |
| | | Scotsman | Spotted grunter (tiger) |
| | | | Spotted gully shark |
| | | | Springer (ten pounder) |
| | | | Stonebream |
| | | | Striped cat shark (Pyjama shark) |
| | | | West coast steenbras |
| | | | White musselcracker (brusher; cracker) |
| | | | White steenbras (pignose grunter) |
| | | | Zebra (wildperd) |

Background



- Success of seafood awareness campaigns
- Reliant on provision of accurate information (labelling) to consumer
- “Wrong” choice may be made if fish mislabelled
- In spite of the good intentions of purchaser

(Jacquet & Pauly, 2007; Logan *et al.*, 2008)

Background

- ❧ Fish mislabelling - pervasive on a global scale
- ❧ Driving factors:

- Resource scarcity
- Potential for greater profits
- Poorly-enforced regulations



(Jacquet & Pauly, 2007; 2008)

- **Whether accidental or deliberate....**



**1. Economic
impacts**

**2. Health
impacts**

**3. Environmental
impacts**

Background

The problem...

- ☞ >30 000 fish species
- ☞ Identification of fish at species level a challenge:
 - Industry
 - Consumers
 - Regulators



WHY?

What fish species is this?

- ☞ Processing & globalisation of trade

Background

The solution...

- ⌘ Molecular methods (PCR & sequencing)
 - DNA is present in all tissue types
 - Stable at high temperatures
 - Diversity afforded by genetic code allows differentiation of closely-related species

(Mackie, 1996; Woolfe & Primrose, 2004)



Background

South African fish species



⌘ In spite of utility of DNA-based methods...



⌘ Lack (or even complete absence) of reference genetic sequence data



⌘ Many fish species commercially available in South Africa, including conservation concerns

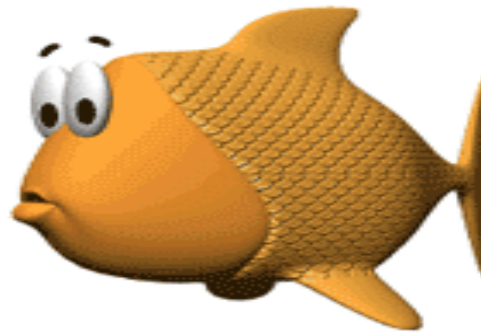
⌘ Precludes accurate species identification!

Aims...

1. Market
evaluatio

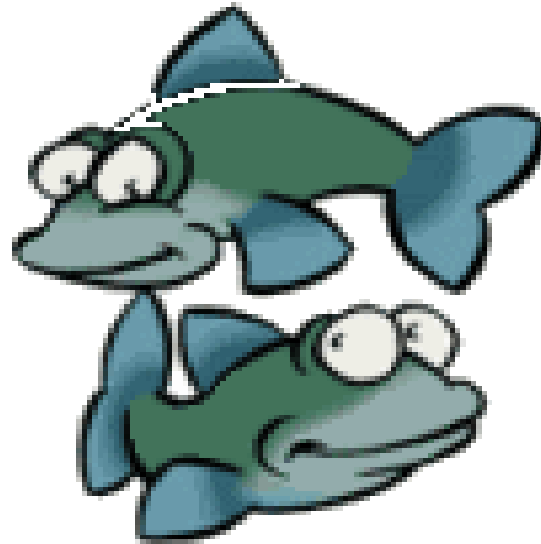
2. Gen
abase

3. Mislabeling
in SA



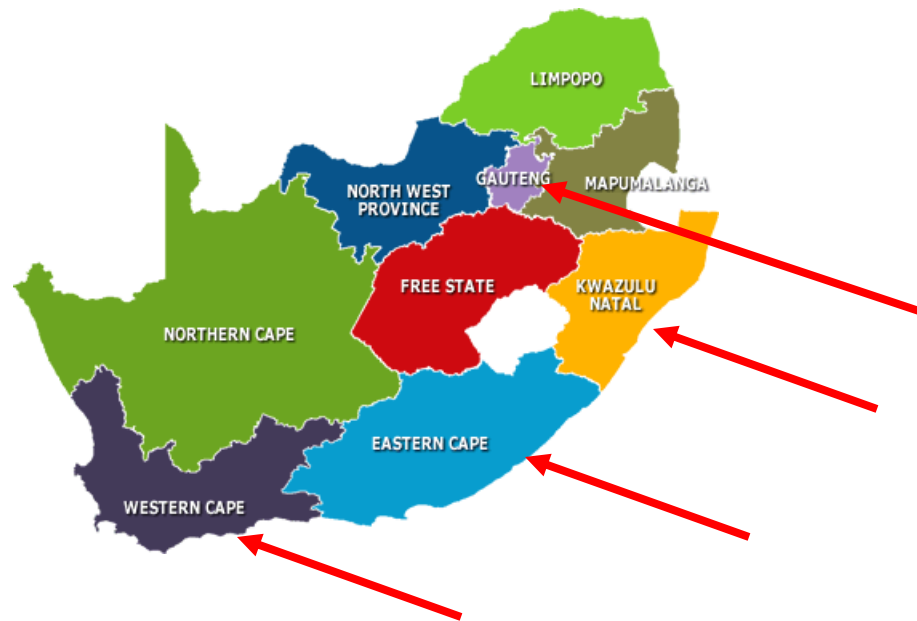
Research aim 1:

Market surveys



The state of the fisheries market in SA

- Surveys in 215 restaurants and 200 retail outlets
- Retail outlets = 100 supermarkets, 100 fish markets
- Four provinces of SA (WC, EC, KZN, GP)



The state of the fisheries market in SA

Parameters assessed:

- ❧ **Which species most commercially available**
- ❧ **Form in which marketed (fresh, frozen, whole, fillets)**
- ❧ **Information available to identify fish (common name that can be linked to species)**
 - ❧ Product labels
 - ❧ Vendor interviews

Results: fish species availability

Table 1 Fish availability by frequency of species appearance in restaurants and retail outlets in four provinces of South Africa

| <i>Restaurants (N=215)</i> | | | <i>Retail outlets (N=200)</i> | | |
|----------------------------|------------------|-------------------|-------------------------------|------------------|-------------------|
| Fish marketed | Frequency | SASSI list | Fish marketed | Frequency | SASSI list |
| Kingklip | 88% | Orange | Hake | 92% | Green |
| Salmon | 59% | White | Kingklip | 75% | Orange |
| Hake | 58% | Green | Snoek | 67% | Green |
| East coast sole | 50% | Orange | Salmon | 61% | White |
| Yellowfin tuna | 42% | Green | Yellowfin tuna | 45% | Green |
| Dorado | 36% | Green | East coast sole | 44% | Orange |
| Kabeljou | 24% | Orange | Kippers/herring | 38% | White |
| West coast sole | 23% | Orange | Yellowtail | 31% | Green |
| Yellowtail | 18% | Green | Mackerel | 31% | Green |
| Butterfish | 18% | Green | Kabeljou | 25% | Orange |
| Geelbek | 16% | Orange | Dorado | 23% | Green |
| Angelfish | 11% | Green | Butterfish | 23% | Green |

Results: fisheries market in SA

Fish availability and sustainability

- ☞ Of species in >15% of outlets: ~50% SASSI **orange** list
- ☞ Most popular kingklip, EC sole, WC sole, kabeljou, geelbek
- ☞ Kingklip in almost every outlet surveyed
- ☞ TAC for kingklip only ~ 3500 ton p.a



“Far more fish named ‘kingklip’ on menus is eaten than is ever caught”

- Smith & Smith, 1966

- ☞ Closely related “ling” from Aus/NZ – expected substitute

Results: fisheries market in SA

Red-list species marketed in SA

⌘ **Red** species = recreational/protected – **illegal to sell**

⌘ White steenbras (*Lithoganus lithognathus*)

⌘ WC & KZN restaurants

⌘ White musselcracker (*Sparadon durbanensis*)

⌘ Natal stumpnose (*Rhabdosargus sarba*)

⌘ White steenbras (*Lithoganus lithognathus*)

⌘ Flouted in retail markets, mainly in KZN



Results: fisheries market in SA

State in which fish sold

☞ Fish observed in retail outlets

☞ 67% filleted

☞ 58% frozen



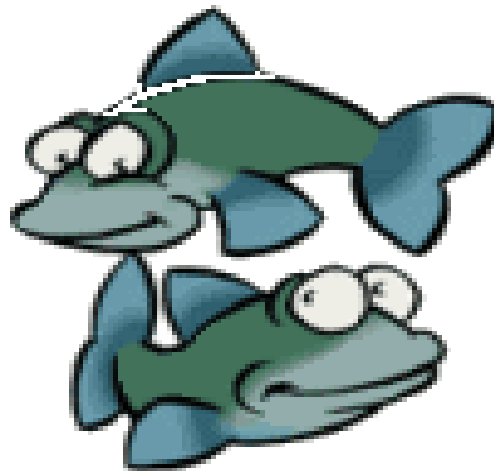
☞ Difficult to assess if fish actually what vendors indicated

☞ Same problem consumers face when purchase fish

☞ Opportunity for mislabeling and fraud

Research aim 2:

Establishment of genetic database





Materials & Methods

- Results from surveys & catch data
- 50 commercially available fish species
 - 46 domestic species and 4 were imported
- 3 specimens per species
- Morphologically identified (fish taxonomists)



Materials & Methods

DNA extraction

☞ DNA extracted - SureFood[®] PREP DNA kit

Polymerase chain reaction

☞ PCR with primers targeting 3 mitochondrial genes

Table 2 Mitochondrial gene sequences targeted in this study

| Target region | Size (bp) | Reference |
|----------------------|-----------|------------------------------|
| COX1 gene | 700 | Ivanova <i>et al.</i> , 2007 |
| 16S rRNA gene | 592 | Palumbi, 1996 |
| 12S rRNA gene | 543 | Infante <i>et al.</i> , 2006 |



Results

☞ >600 sequences generated & analysed in total

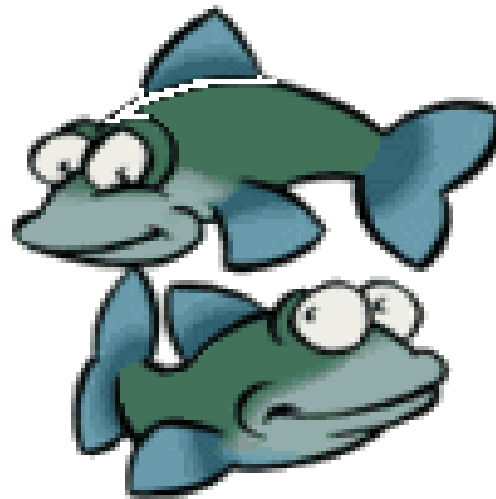
GenBank submissions

- ☞ First time - any sequence data (16% of species)
- Cox1 sequences (40% of species)
 - 12S rRNA sequences (54% of species)
 - 16S rRNA sequences (34% of species)



Research aim 3:

Fish mislabeling in South Africa



Methods

Collection of market samples

- 248 fish samples collected over 2-year period (2008 - 2010) from 4 provinces (EC, WC, KZN, GP)
 - 108 (42%) - fish distributors/wholesalers
 - 140 (58%) - retail (supermarkets & fish markets)
- PCR amplification & sequencing



Results

Distributor/wholesale samples:

- 10 of 108 (**9%**) mislabelled

Retail samples:

- 43 of 140 (**31%**) mislabelled

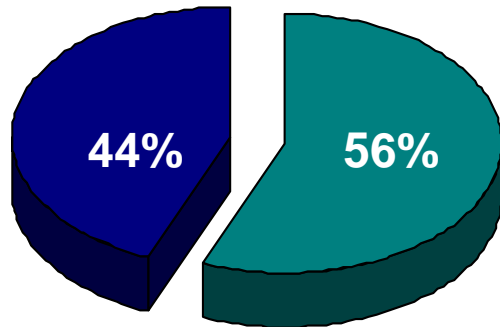
Overall:

- 53 of 248 (**21%**) mislabelled!

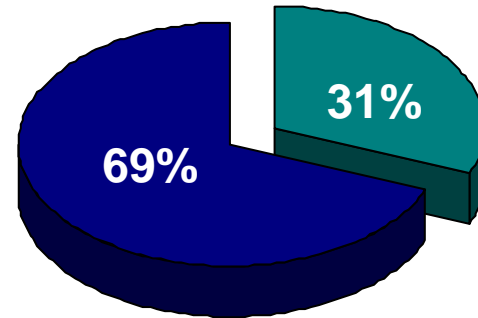


Results

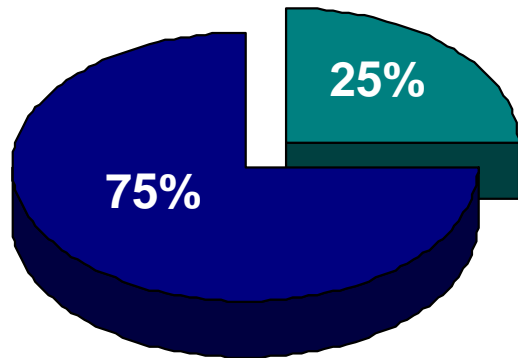
Mislabelling in retail outlets by province



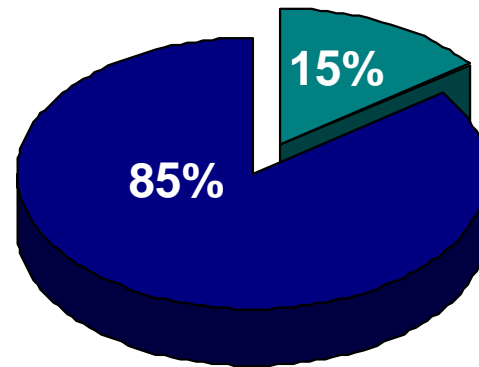
KZN



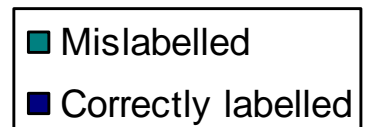
GP



WC



EC

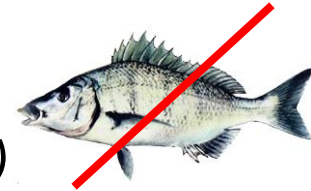


What DNA testing has shown:

☞ Fresh fish market in KZN: 10 of 15 samples mislabelled

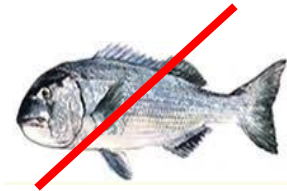
- Fillets marketed as “white steenbras”

- Big-scale pomfret (*Taractichthys longipinnis*)



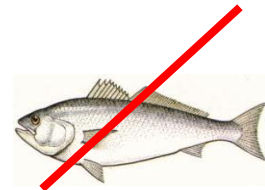
- Fillets marketed as “white musselcracker”

- Pelagic armorhead (*Pseudopentaceros richardsoni*)



- Fillets marketed as “Cape salmon”

- Actually shortbill spearfish (*Tetrapturus angustirostris*)



What DNA testing has shown:

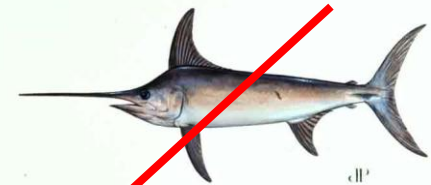
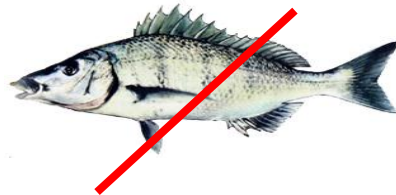
- 3 of 12 retail samples sold as “kingklip”



- NZ ling (*Genypterus blacodes*)



- Fillets marketed as “white steenbras” and “swordfish”



- Oilfish (butterfish) (*Ruvettus pretiosus*)



- Health implications

What DNA testing has shown:

☞ In GP, 18% of outlets sold fish as 'red snapper'



☞ DNA analysis showed on more than one occasion this was actually **river snapper** (*Lutjanus argentimaculatus*)



☞ A species which is illegal to sell in South Africa

What DNA testing has shown:

❧ Fish labelled as “barramundi”



❧ Actually common warehou (*Seriollevella brama*)



❧ Inferior and cheaper variety

❧ Was this an isolated incident?

❧ More than 10 samples drawn from outlets in SA

❧ Countrywide recall initiated – no longer on market

Conclusions



- ⌘ Endangered fish actively marketed in SA
- ⌘ Disparate naming, highly processed nature of fish, poor vendor awareness & low regulatory compliance
 - ⌘ Creates a market in SA conducive to fraud
- ⌘ Mislabeling shown to be reality in SA
 - ⌘ Not only been ripped off
 - ⌘ Denied right - informed choices (health & environment)
 - ⌘ Undermines efforts to conserve threatened species
- ⌘ Value of genetic database cannot be over-emphasised



What is needed...

- ⌘ Increased awareness & compliance by suppliers
- ⌘ Increased monitoring by authorities
- ⌘ Methods to detect fraud & mislabeling applied
- ⌘ More comprehensive labeling requirements
- ⌘ Uniformity in the naming of fish (seafood lists)
- ⌘ Co-operation of all - fishing industry, fish suppliers, government, academia & environmental org's



Can't wait to play my part!

Thank you!!

