

# Traditions and cultural heritage in grey mullet culture

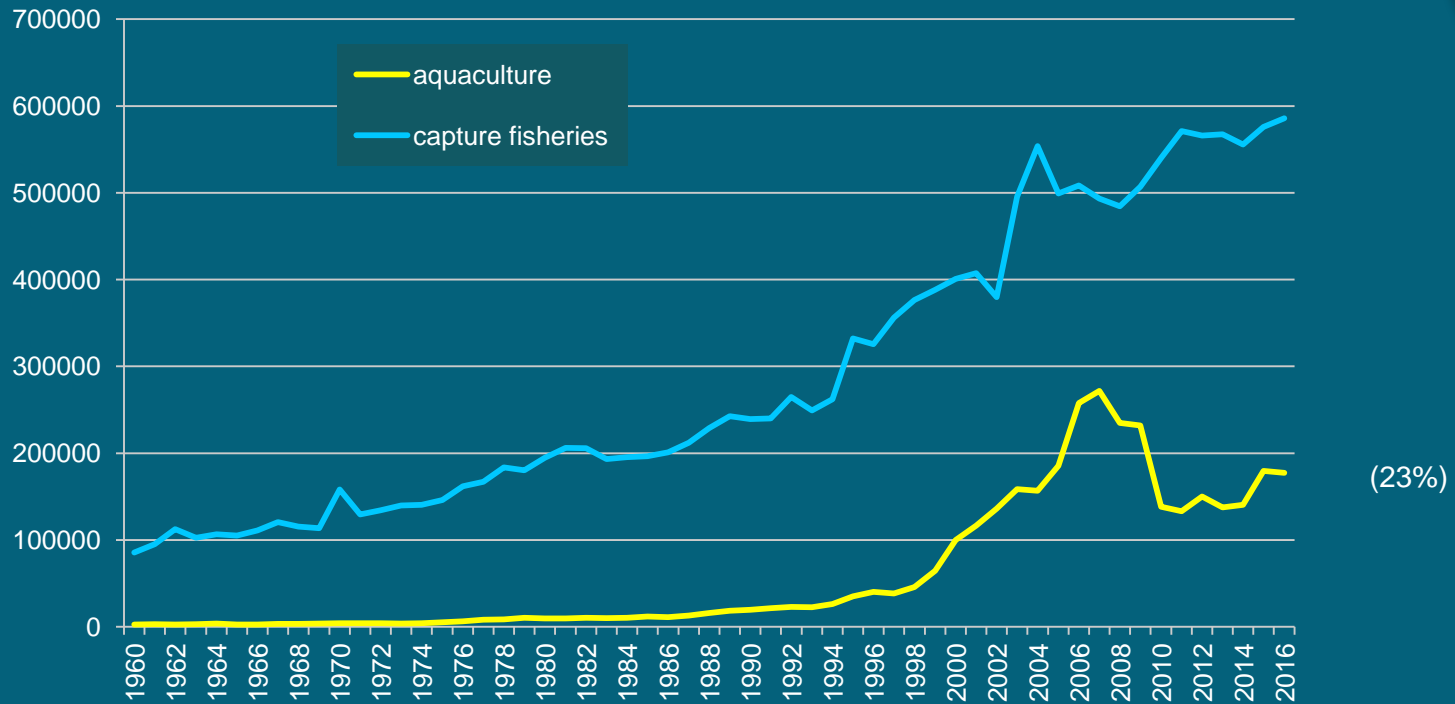
Donatella Crosetti

ISPRA VAL-AMC, Roma (Italy)



2016 world mullet production : 763,281 tonnes (585,959 + 177,332)

*World mullet production from capture fisheries and aquaculture (1960-2016)*



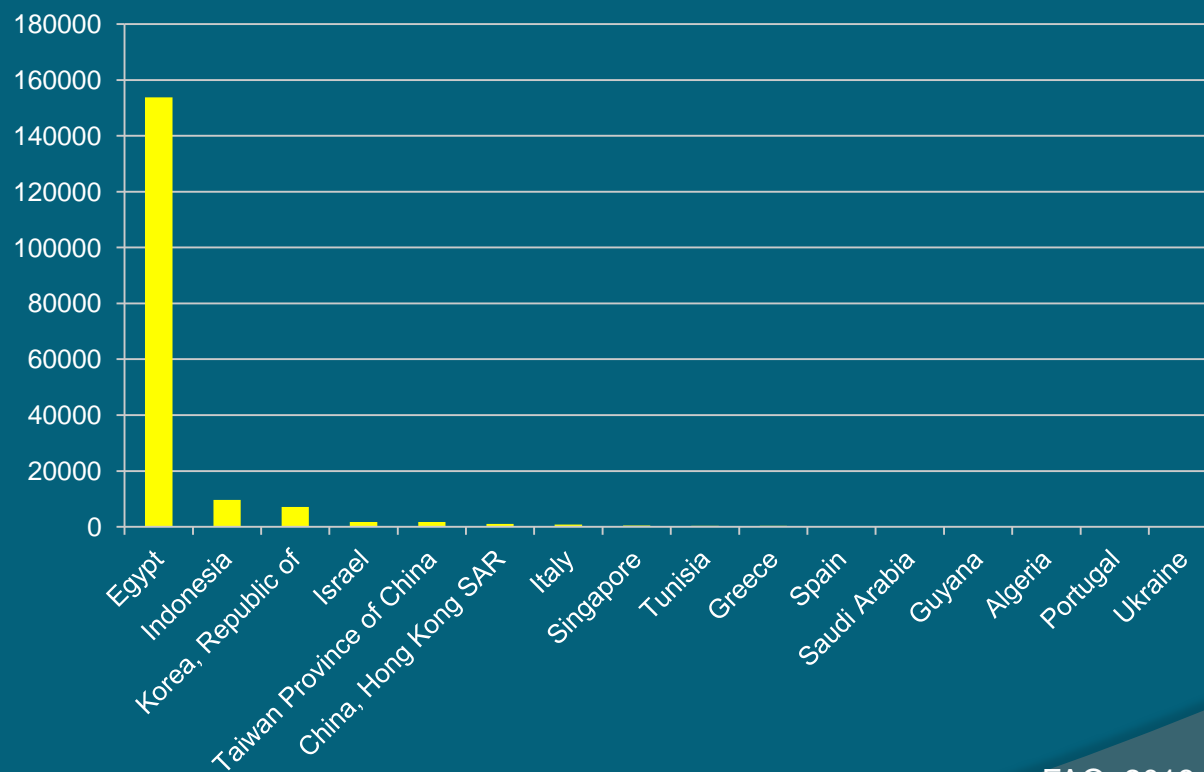
FAO, 2018

Egypt: 252,000 t in 2007

116,000 t in 2009

2016 world mullet production from aquaculture : 177,332 t

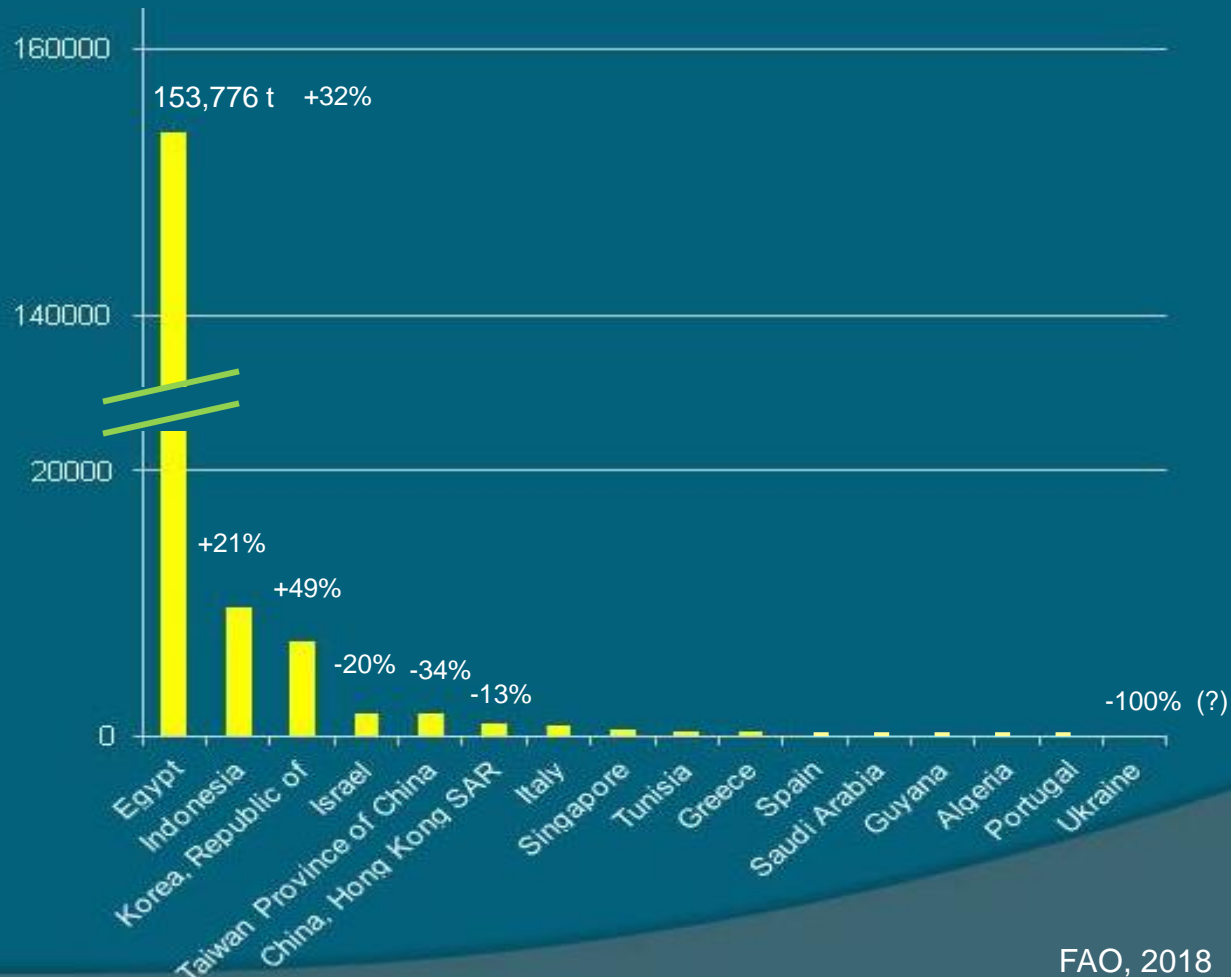
*Mullet production from aquaculture in the main producing countries in 2016 (tonnes)  
(2 spp+ mullet nei)*



FAO, 2018

World mullet production from aquaculture 2016: 177,332 t (+28.3% 2013-2016)

Mullet production from aquaculture in the main producing countries in 2016 (tonnes)  
+ differences 2013-2016



## Why grey mullets?

peculiar biological features:

- euryhaline spp => seawater, BW, FW
- consumers of the lower trophic levels  
=> efficiently convert into flesh what they eat
- many species (77 - ?)
- high quality flesh and products



*“the Mugilidae have the brightest future of all the marine and brackish water finfish in the developing technology of aquaculture” ( Nash and Shehadeh, 1980 )*

# Ancient Egypt

4 300 years ago

Capture or culture ponds?

*Vivariae piscinae* near temples and palaces: fish, amphibians, reptiles



Kagemni Tomb

Saqqara, Egypt (2340 B.C.)

## Aboriginal Australians

X-ray art  
Kakadu National Park, Australia

1 500 years ago

GM rock drawings indicate the importance of mullet to the Aborigine Australians

fish used to barter for goods and services



Records of commercial GM harvest date back to the 18th cent

GM fisheries economically and socially important for coastal communities, common occupation in coastal towns

At present, 20 spp of mullets, 95% catch on the east coast - 4,000-8,000 t/year

# Mauritania

500 years ago

*Imraguen* people, confined between sea and desert

traditional community fisheries, based on mullet spawning migration

- spatial distribution of villages along the coast
- fishing calendar based on tides (moon)
- during the fishing season
  - no fires
  - no night lights
  - no perfumes
  - no fish blood/guts in water



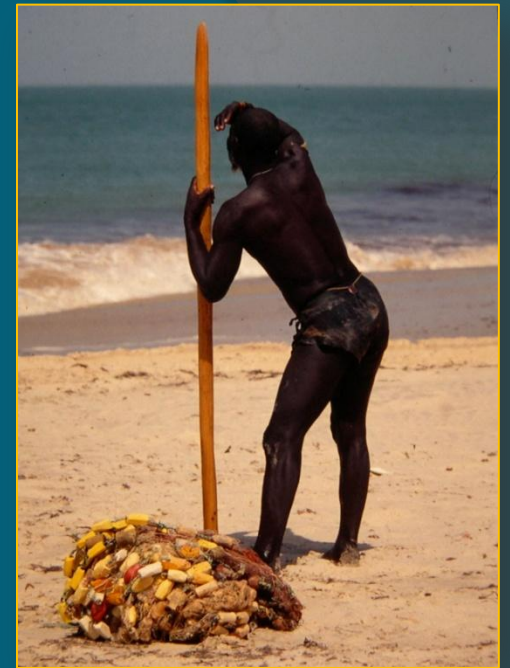
shoulder net: *cheba atik*

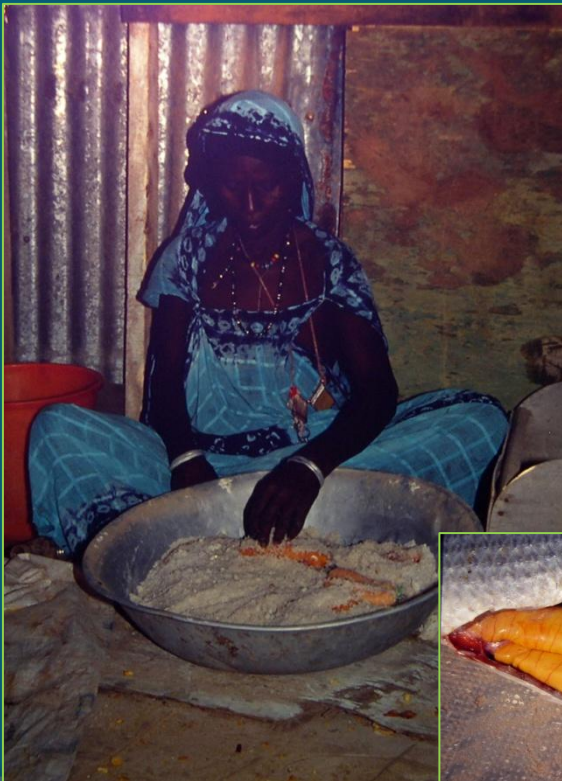
15-30m long  
1,5 m high  
110-120mm mesh

very selective  
fishing gear  
82% *M.c.*  
89% Mugilidae



Nov–Dec: mullet southward spawning migration





+ head





Modernisation....

1990-96 from 600 to 3000 pirogues 5x

Large seines: 800m long, 40m high, 100mm mesh  
Mobile camps to gut the mullets

1996: mullet carcasses abandoned (GM production 13.000 tonnes/year)

1997 : production halved

1998: project to Conservation of mullet fisheries and Imraguen cultural heritage

from 2003, back to traditions for sustainable fisheries

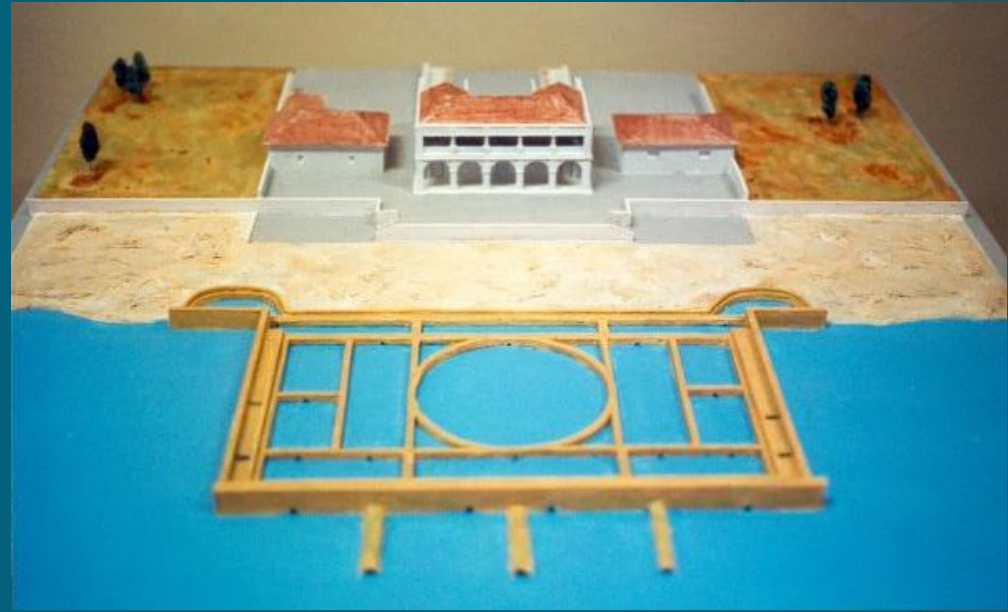
## Etruscans and ancient Romans

fish and shellfish: symbols of power

2 000 years ago

rich Patricians villas with marine pools  
(*piscinae salsae*) to stock live fish for  
banquets

(sometimes fish were fed)



*Peschiera di Punta Vipera, S.Marinella, RM*

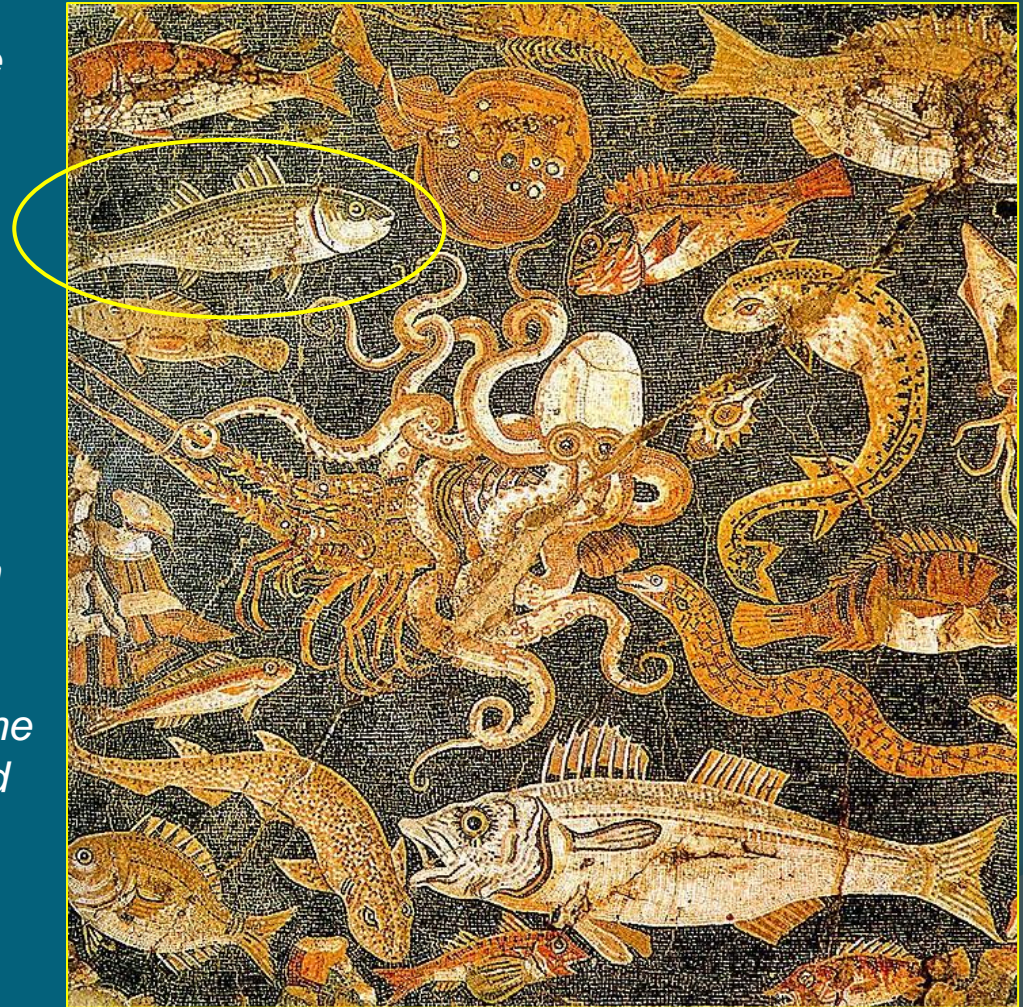


*Peschiera* in Nettuno, RM



Knowledge of mullet biology and behaviour applied to design the *piscinae salsae*:

“The **muggine** cannot be caught for stocking with a net, if its scales are touched it soon dies. The (Roman) Emperors insisted upon having **muggine** at all times, and therefore stocks had somehow to be found and kept.... It was done in this way: the **muggine** is a great glutton of freshwater; a strong jet of such water was shot from the tank through a hole below the sea level; it attracted the **muggine**, who immediately followed up the freshwater track into the tanks, and could not get out again”.



Common Romans ate fish from coastal lagoons and rivers, where fish (mullet, eels) migrated

4 storey house, Pompei, 1st cent. A.D.  
(Naples Archeological Museum)

## GM in extensive culture systems

traditional Hawaiian ponds	Hawaii, USA
North Adriatic <i>valli</i>	Italy
Indonesian <i>tambaks</i>	Indonesia
Egyptian <i>hosha</i>	Egypt
<b>bheris</b> of Gangetic estuaries	India
coastal “ <i>harbour culture</i> ”	North China
kava culture	Japan.....

# traditional Hawaiian ponds

# Hawaii, USA

loko i'a (traditional Hawaiian fishpond systems)

600-800 years old

*'ama 'ama* (M.c), believed to be a supernatural fish

highly priced fish during the Hawaiian Kingdom (1795-1893)

coastal fish ponds, in small bays at stream mouths or freshwater spring

ponds 0.4-212 ha, 60-120cm deep, walls up to 1km long

- fry and juvenile recruitment during rising tide through sluice gates, or through the pervious walls

- additional stocking with wild fry captured long the shore

Mullets for the Hawaiian royalty



**Hawaiian language terminology describing the different size classes (A) and migratory behavior (B) of the native striped mullet, *Mugil cephalus*, on O‘ahu.**

**A**

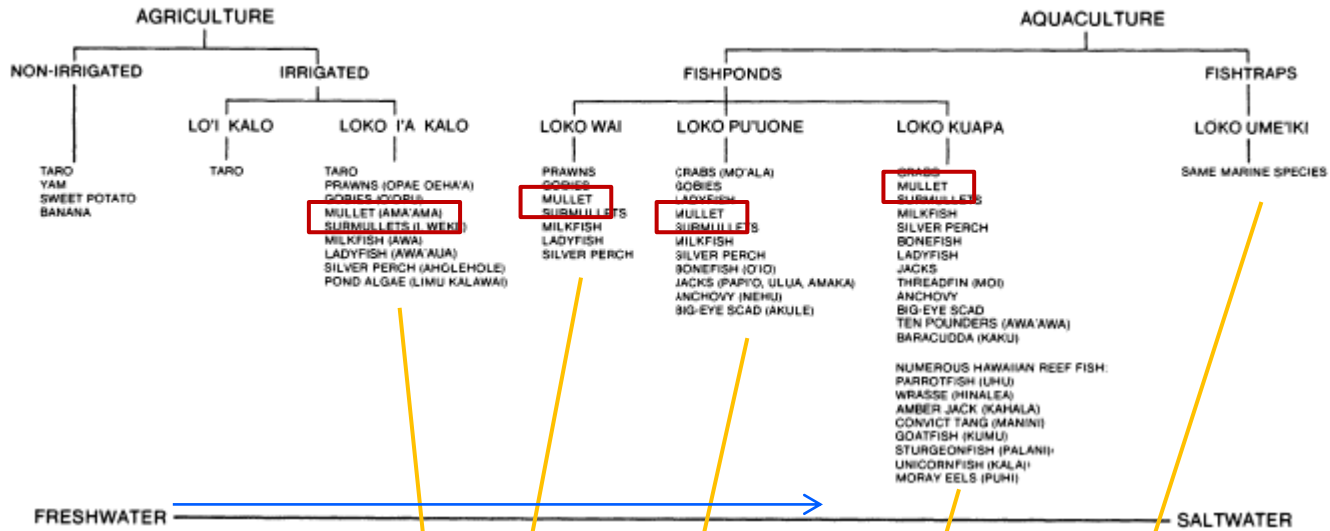
<b>Hawaiian Name</b>	<b>Size Class</b>
<i>Pua ‘ama, Pua po‘ola</i>	Finger size, new recruits
<i>Kahaha, Pahaha</i>	Hand length, juvenile stage
<i>‘Ama‘ama</i>	20 cm, estuary resident
<i>‘Anae</i>	30+ cm, reproductive adult

**B**

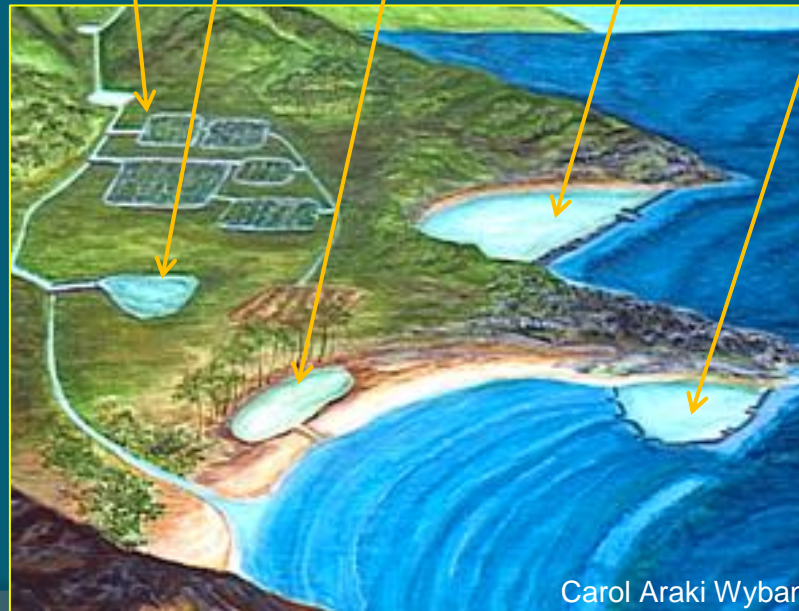
<b>Behavioral Group</b>	<b>Migration Route</b>	<b>Behavioral Activity</b>
<i>‘Anae-holo</i>	‘Ewa to Lā‘ie	Spawning migration, full-bodied
<i>‘Anaepali</i>	Lā‘ie to ‘Ewa	Return migration, skinny

from Nishimoto et al. 2007

# HAWAIIAN INTEGRATED FARMING SYSTEM



Costa-Pierce, 1987



Carol Araki Wyban

## 5th type

sea water fish pond, with no grates (found in Molokai prior to 1946 tsunami)

stocked with mullet fingerlings only once, than natural spawning

Hawaiian elders assure that mullets spawned regularly in these ponds and grew there successfully

## Sustainability concept

“Traditional fishermen have a wide knowledge of oceanography, fish biology and behaviour, and conservation and management practices that preserved the biological integrity of fish stocks for generations before the advent of modern gear or methods.

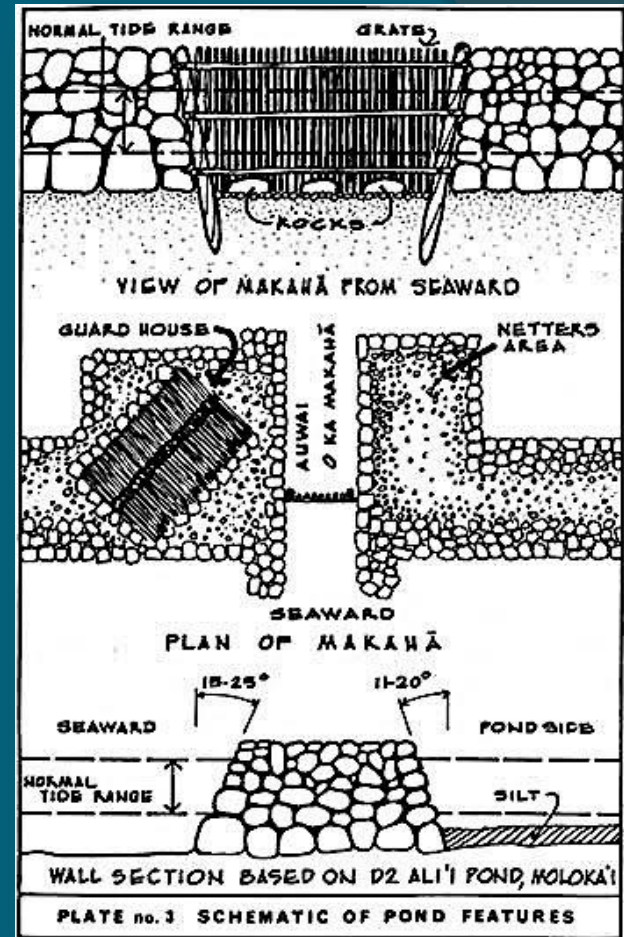
Traditional fishing and agriculture societies ecologically advanced (rather than technologically backward)”

canals in the walls for stocking, harvesting and cleaning the pond with minimum human effort

In the middle, the *makaha*, single immovable grate made of dense native wood, with timbers 0.5-2.0cm apart

=> natural recruitment

Later in history, canals modified to have one or two vertically movable *makaha*, lowered or raised to trap the fish that were simply netted out of the canal



elder Hawaiians:

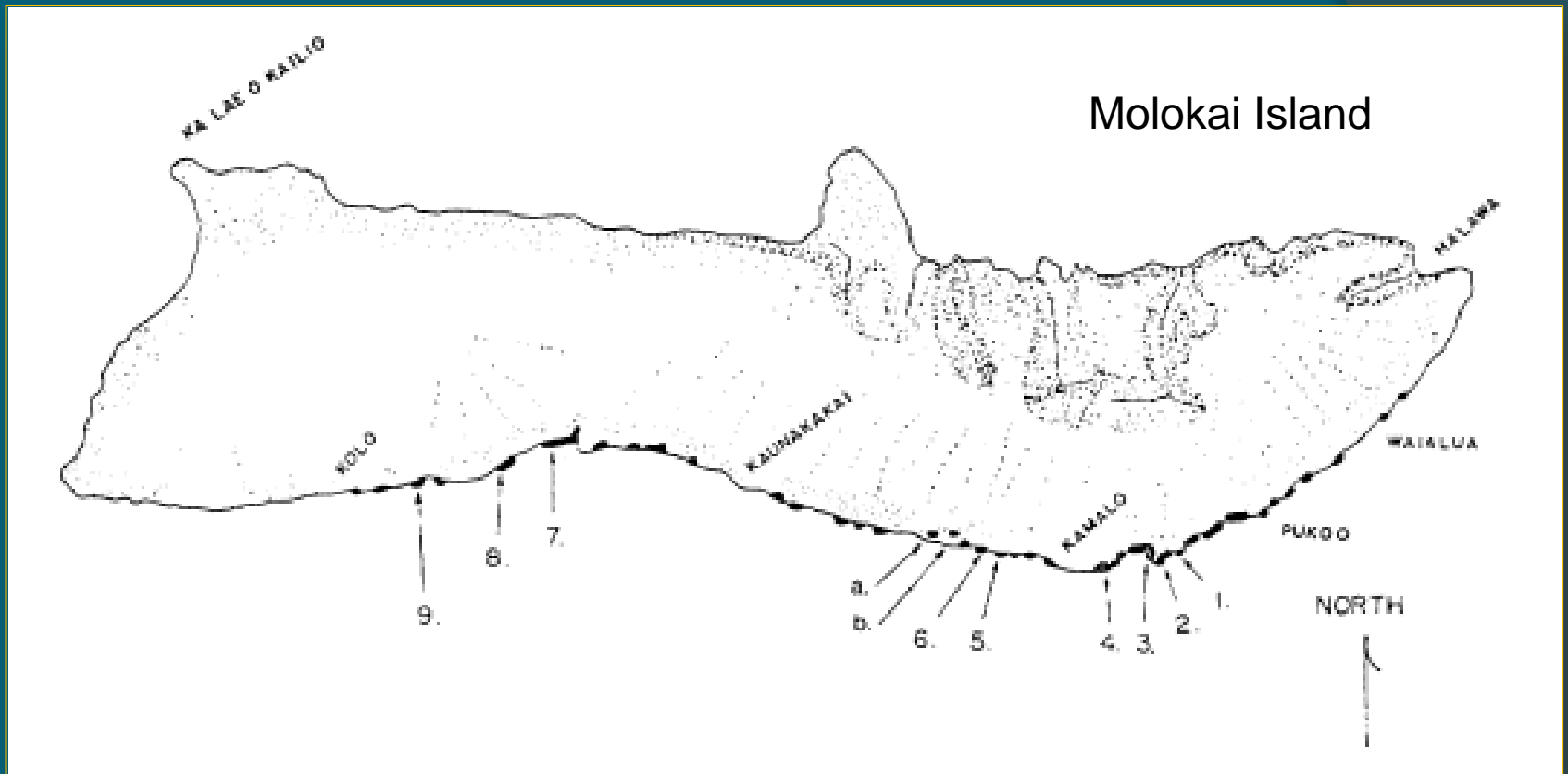
- keen observational skills
- knowledge of fish behaviour

*kuapa*: seawall constructed of coral or lava rock

46-1,920 m long, commonly 366-610 m long  
average 955m<sup>3</sup> of rocks and fill

+ use of natural cement





: 28 marine fish ponds

a, b: BW fish ponds

1,.... 9 : fish traps

Estimated yields in these extensive systems: 336/kg/ha/year (1902)

### Estimated yields of Hawaiian aquaculture ponds before 1900.

Island	Number of ponds	Area in hectares*	Minimum yield† (kg)	Percent total
Oahu	175	1306	438,816	49
Hawaii	59	440	147,840	16
Molokai	56	418	140,448	16
Kauai	42	313	105,168	12
Maui	26	194	65,184	7
Lanai	1	7	2,352	<1
Niihau	1	7	2,352	<1
Total	360	2685	902,160	100

1900: in Honolulu fish market 25.6% of the fish sold were *ama ama* (Mc)

mullets were the most expensive fish on the market, sold at 25cents/lb

Land decision (Great Mahele) in 1848

=> decline of fish pond complexes and integrated farming system

- 1778: at least 360 fish ponds, 900 tonnes fish/year
- early 1900: 680,000 pounds of seafood delivered to Hawai'i markets from more than 100 fishponds
- 1977: 28 ponds still suitable for fish culture
- 1985: only 7, for a total production of 15-20 tonnes /fish /year
- present: renovation?

# Several projects to help revitalize Hawaiian Fishponds

**Pond officials have big plans for striped mullet**  
If all goes well, the native fish will be turning up on more people's plates



Strengthening the foundation one stone at the time



**HUI O KUAPĀ**  
kaunakakai, molokai

**Transitioning Traditional Hawaiian Fishponds Into Aquaculture Enterprises**



## *Egyptian hosha*

shallow earthen ponds built by erecting low mud and straw banks along the shores or around islands of coastal lagoons

one opening connecting with the lagoon

stocked with wild-caught fry

*hosha* closed and emptied periodically to harvest fish

annual productions: 192 -350 kg/ ha in fertilized ponds  
131 kg/ha without fertilization

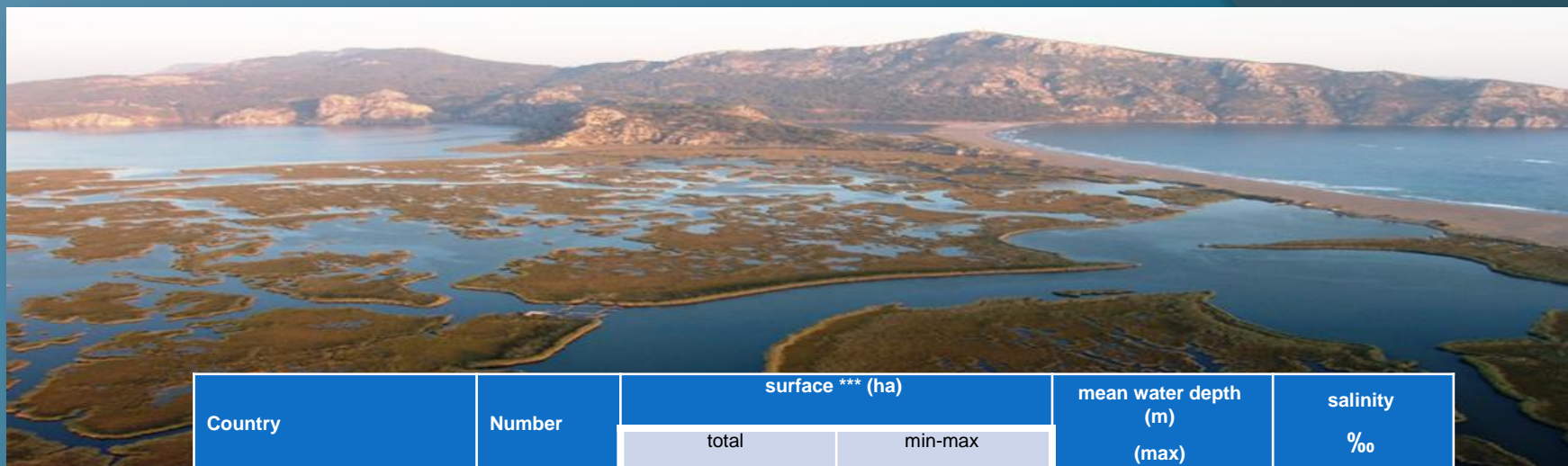
**mullet**s + other euryhaline species

expansion of land reclamation activities for agriculture => competition for land and water

intensification of culture

Egypt: 1° cultured mullet producer in the world (153,776 tonnes in 2016)

# Mediterranean coastal lagoons



Country	Number	surface *** (ha)		mean water depth (m) (max)	salinity ‰
		total	min-max		
Algeria	1	864		2,7 (6.40)	22.5-37.9
Albania	12	11,000	250- 9,352		78
Egypt	5	199,000	6,000-78,000	0.8-1.0 (3.0)	0 -120
France (Med coast)	20	52,164	86-15,000	0.4-4.5 (10,0)	
Greece	76	34,511	2-68,000		
Italy	198	167,000	1-57,000	0.6-5.5	10-47
Lybia	4	3,390	50-3,100		18-46
Morocco (Med coast)	1	11,500	11,500	1-8	36-42
Montenegro	2	1,642	150-1,492	01-0.8	used as salt pans
Spain (Med coast)	14	58,695	3.7-21,000		
Tunisia	6	50,000	150-23,000	<5 (10)	4-40
Turkey	58	34,250	4-6,400		
<b>Total</b>	<b>398</b>	<b>624,016</b>			

# Mediterranean

8 spp

*Chelon labrosus*

*Liza aurata*

*L. ramada* \*

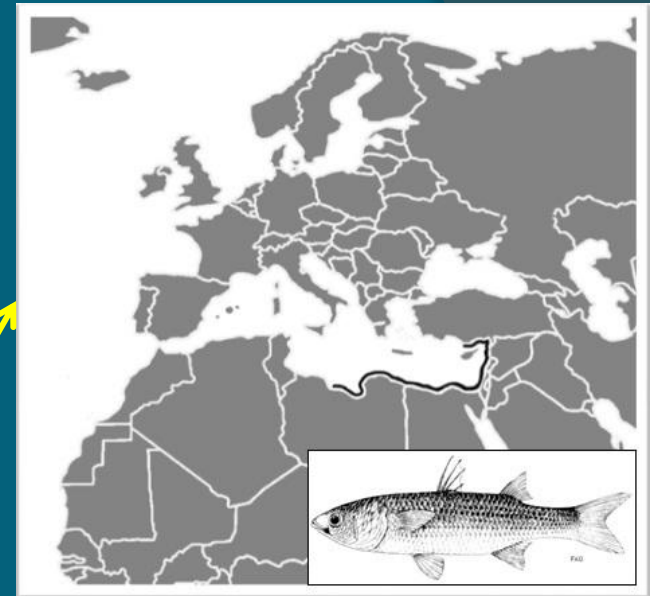
*L. saliens*

*Mugil cephalus* \*

*Oedalechilus labeo* sea

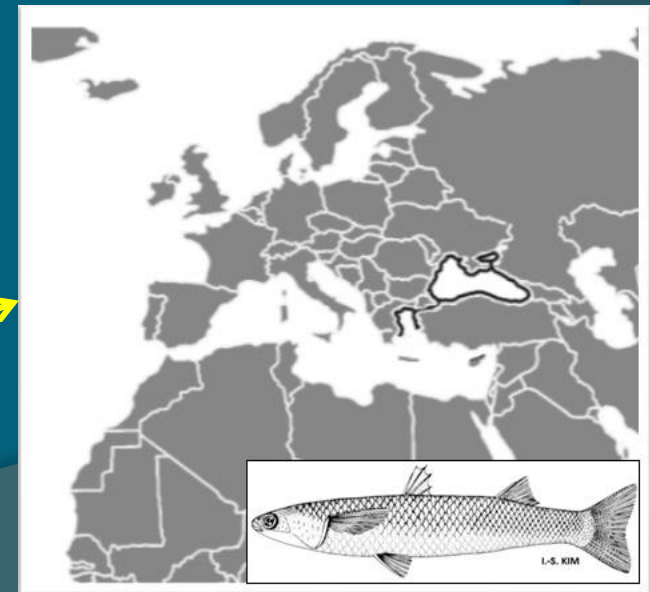
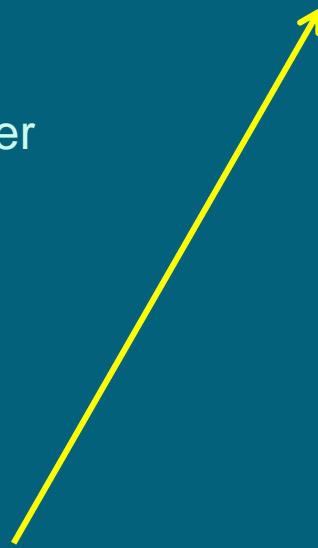
coastal lagoons  
estuaries

\* freshwater



+ *L. carinata*

Lessepsian sp



+ *L. haematocheila*

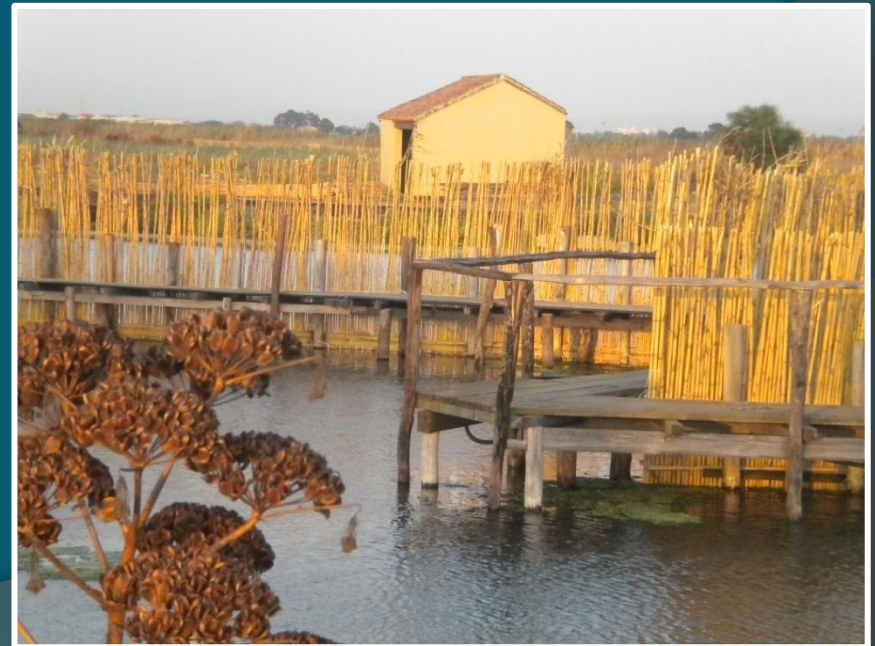
introduced into the Black Sea



traditional extensive culture

more or less confined coastal lagoons

IT: Valliculture (north Adriatic sea)



## North Adriatic valliculture - Italy

*valle*: from *vallum*, banks: lagoon area confined by banks (originally reeds and later earth banks) to culture fish.

valliculture: management system for North Adriatic *valli*

- water control
- dredging
- increasing production through restocking
- capture at fish barriers

surface: small (1-2 ha) to >10.000 ha (*valli* system, ex. Comacchio)

depth: mean 0.6 m, max 2 m

salinity: 10-40 ‰



annual production: 20-150 kg/ha



## *Peschiere*

Long narrow and deep (4-5 m) ponds for

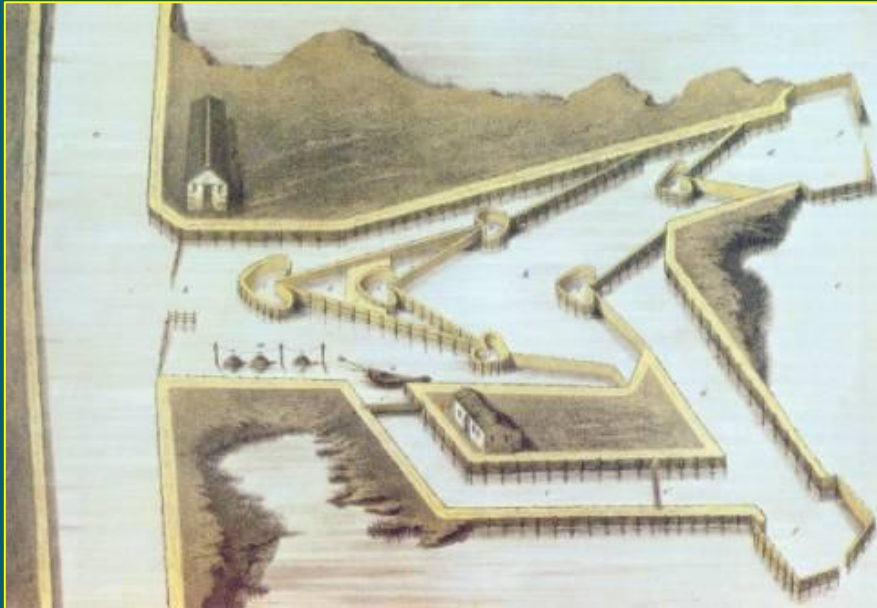
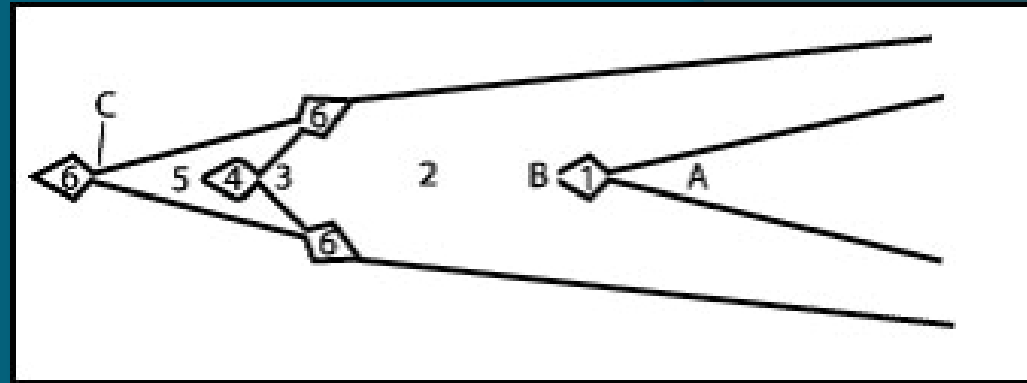
- stocking captured fish
- wintering of undersized fish
- prefattening of wild mullet fry in spring.

FW thin layer on top => ice as isolation (3-4°C inside)

## (North Adriatic) fish barriers

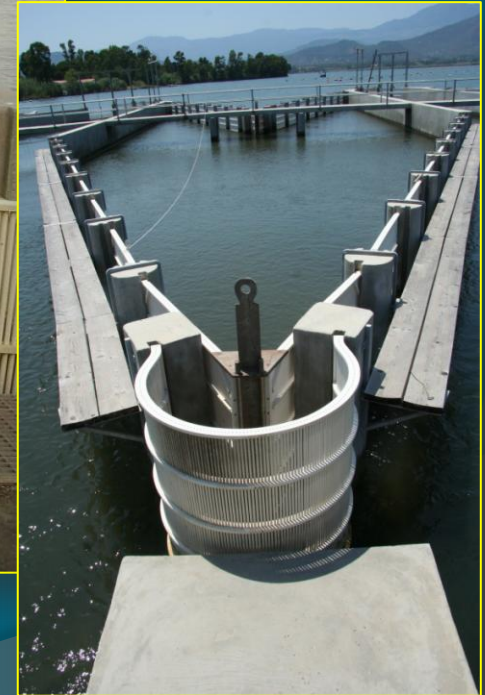
the most advanced fish trap in lagoons

selective fishing gear











capture during GM spawning migration back to sea







natural recruitment of fry and juveniles

stocking with fry and juveniles captured in the wild

cormorants



*Valle*: 50-150kg/ha of mullets

Growth rate

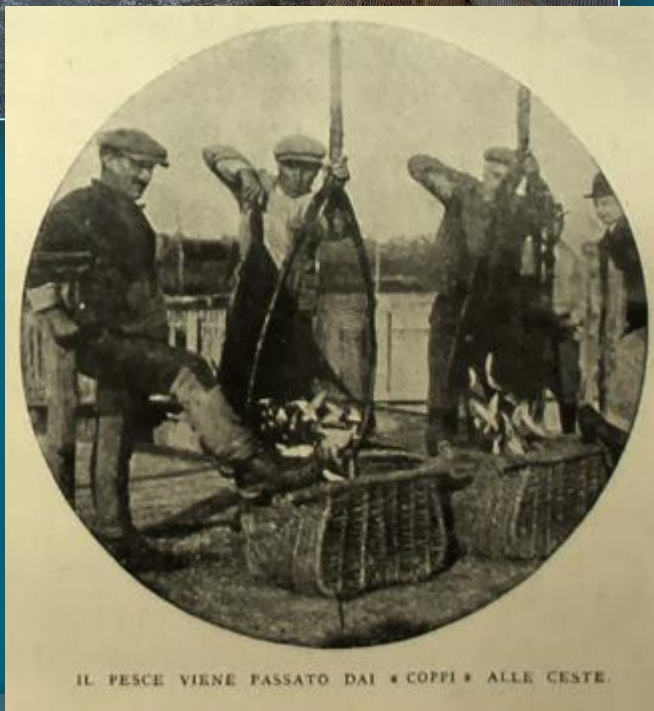
*M.c.* 3 years 600g

*C.I.* 3 years 500g

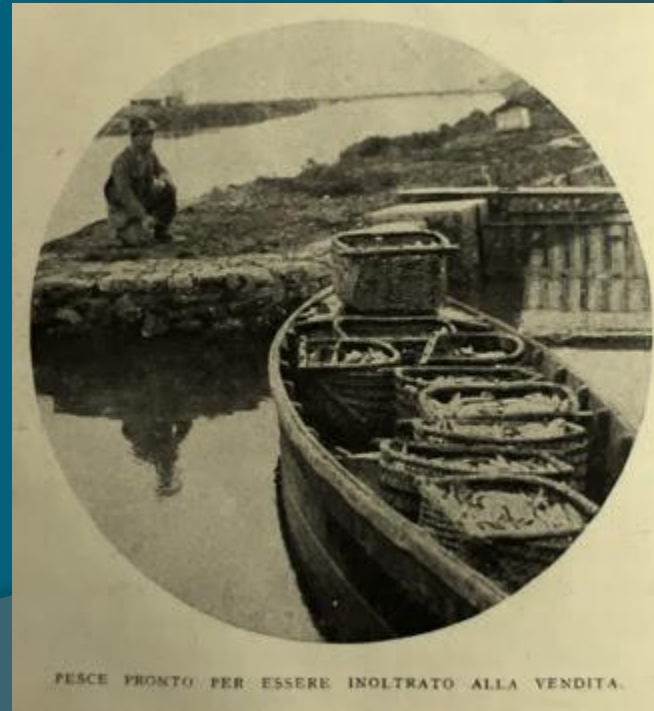
(Ravagnan, 1980)



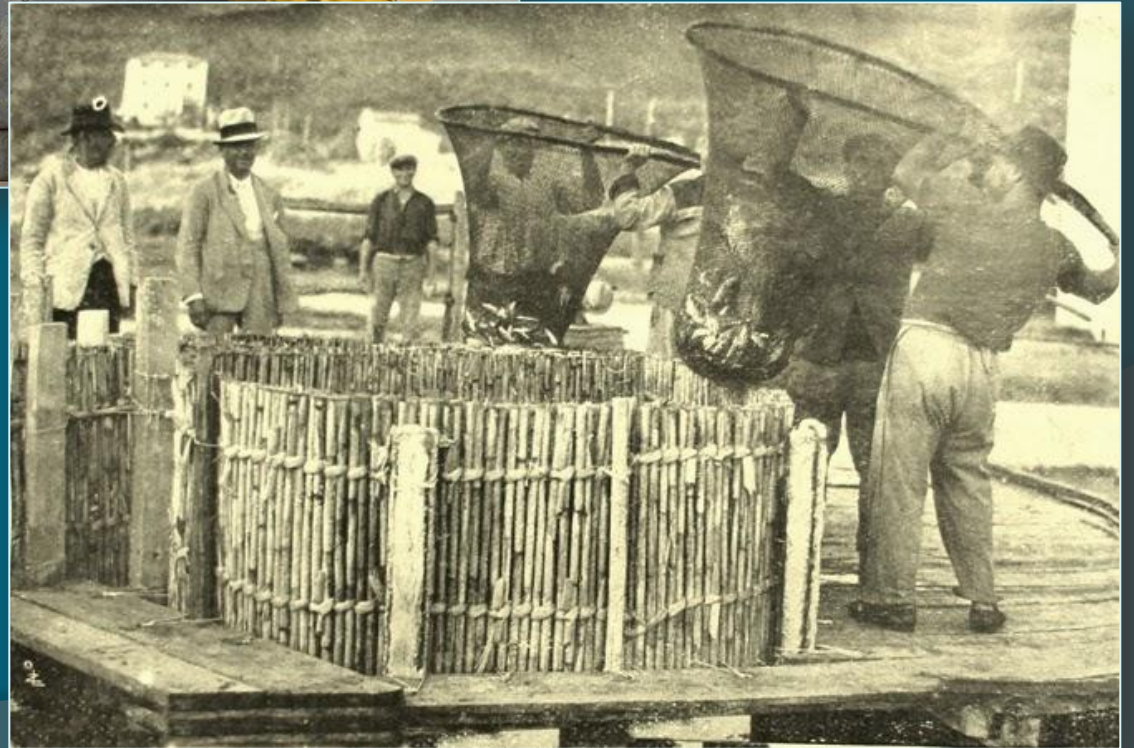




IL PESCE VIRNE PASSATO DAI « COPPI » ALLE CESTE.

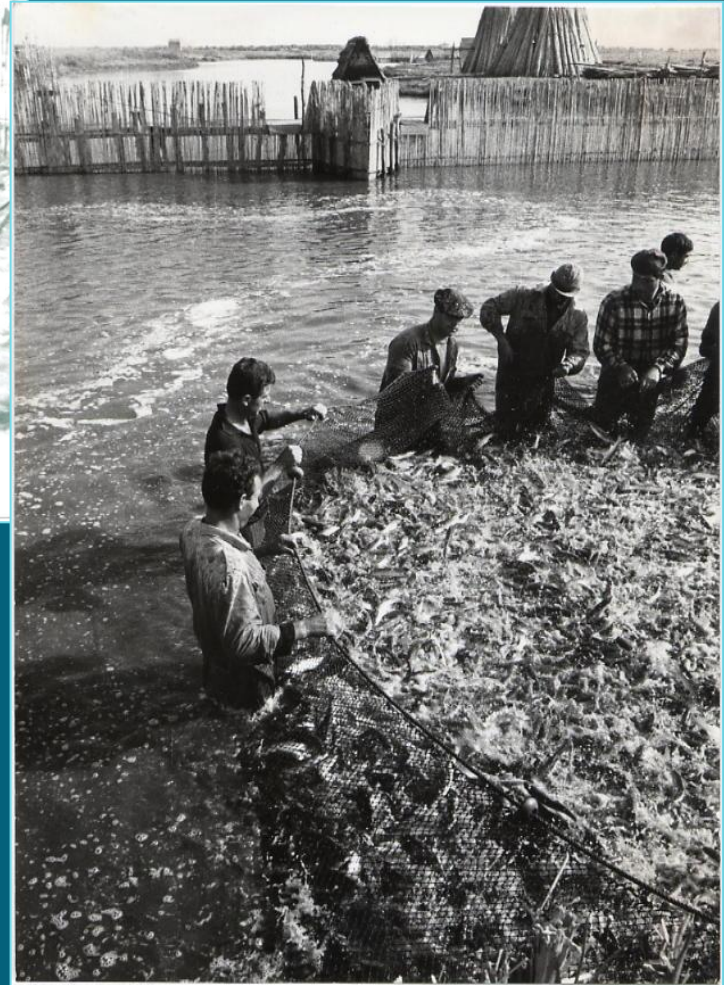


PESCE PRONTO PER ESSERE INOLTRATO ALLA VENDITA.

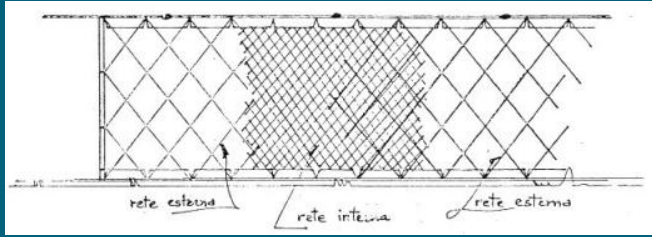




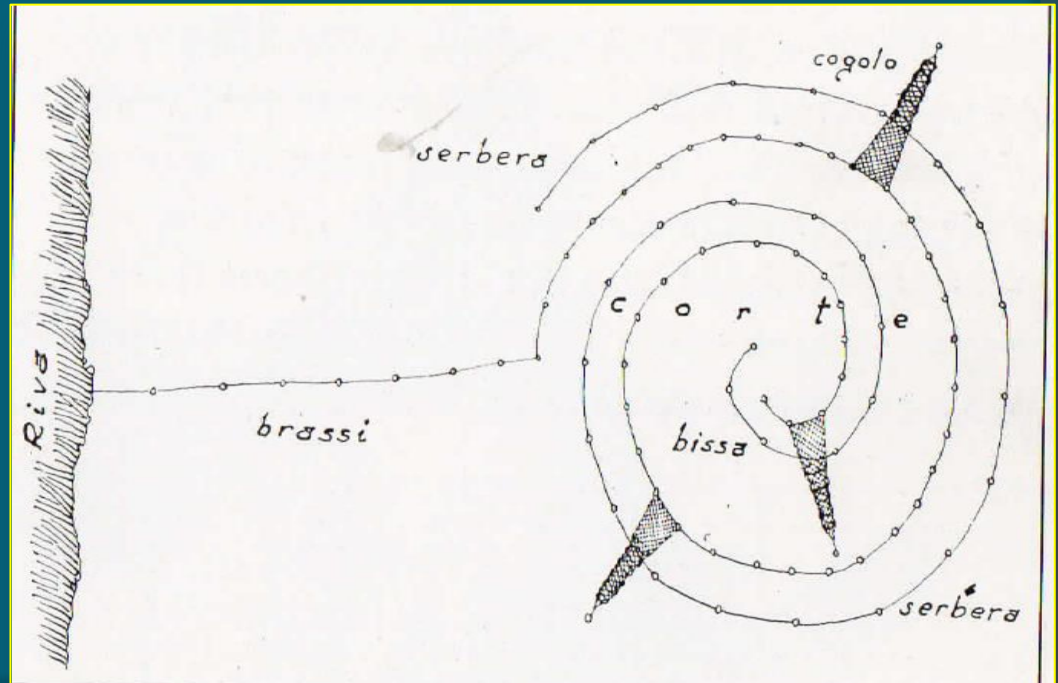
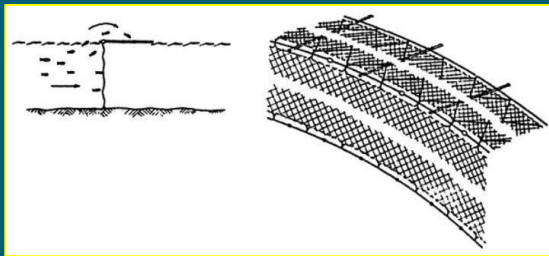
# Mullet harvest in the capture chamber of a fish barrier in Cabras Lagoon (1950' )



# Trammel nets



# Monotwine net



## Fry capture in the wild

Seasonal fisheries- *pescenovellanti*

In coastal lagoons or at river mouths to stock *valli*, lagoons (insufficient natural recruitment) or for intensive rearing



no large commercial hatchery production of mullet fry/juveniles

=> compulsory use of wild caught fry/juveniles

stress from capture, handling and transport

=> high mortality

up to 70% IT

up to 96% Egypt

up to 70% Taiwan



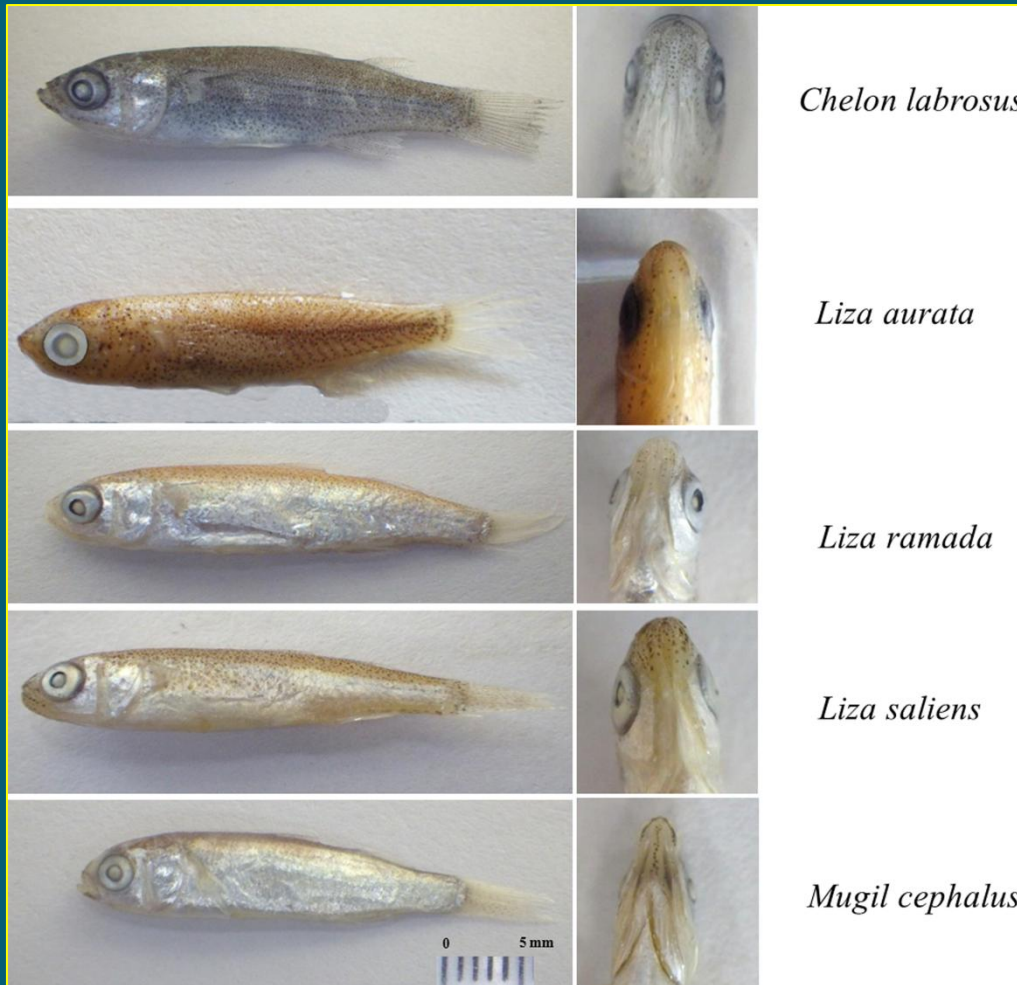
acclimation to different salinities/temperature

transport: barrels

- sealed plastic bags with water and O<sub>2</sub> (< 10.000 ind)
- for large quantities: special trucks, with areated (or + pure O<sub>2</sub>) tanks (up to 200,000 ind/tank)



# Euryhaline fish fry



## Italy

Wild fry collection already regulated in the Ancient Venetian Laws, “.. *pescar cefali novelli..*” (dated 8 March 1314)

importance increases with development of valliculture in late 18th century

Venice Lagoon (late 19th cent)

3 months of fry collection

37,000 man/d

21-22 million fry annually stocked in Venetian *valli*

Stocking in Venetian *valli* (1898)

4,314,000 *Liza aurata*

564,000 *L. saliens*

5,116,000 *L. ramada*

48,000 *Chelon labrosus*

Today

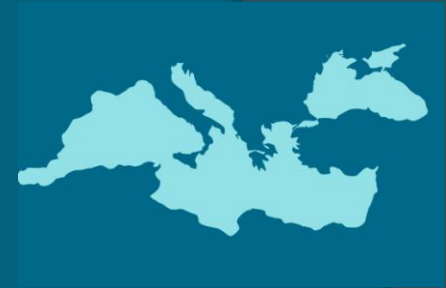
- “special fisheries” aimed at culture or restocking, authorised 2x / year (aut/spring)
- 2014: 24 Licences for 1-3 fishing zones, with quotas (32 fishing zones, no Sardinia & Sicily)
- 1988-2000: 30-58 million fry/year



Decrease of fry collection with the development of induced spawning and fry production in hatcheries (sbr & sb)



## Mediterranean



Fry collection authorised in Albania, Egypt, Greece, Israel, Italy, Spain, Tunisia  
no in Croatia, Cyprus, France, Morocco, Turkey (from 2000)

Egypt : licences by GAFRD in 12 collection sites, 5 collecting stations, Law 124/1983  
460 licensed fry fishers in 2005

2002-2012: 40-109 million fry/year (92 million in 2016)

+ illegal fisheries: 400-500 million fry/year (?)

about 80% from black market, price 2,5-7,5 x official fixed price  
high mortalities, often unequipped trucks

Turkey 1999: 1,050 fry fishers - 20 million fry/year

Tunisia 1999: 300 fry fishers - 3-5 million fry/year

Decrease of fry collection with the development of induced spawning and fry production in hatcheries (sbr & sb)



## Processed products

salted & dried egg roe (mainly *M.c.*)

*bottarga* , *boutargue*, *poutarque*  
*bot-ah-rik* (arabic term for dried fish eggs)

*karasumi* (SE Asia)

- capture during spawning migration
- along the coast (Australia/Mauritania)
- at fish barriers (Mediterranean)
- culture until egg roe maturation (Taiwan)



GSI 16-17%



*Avgotaracho Messolongiou* PDO

\$ 125 per 250g (on line)

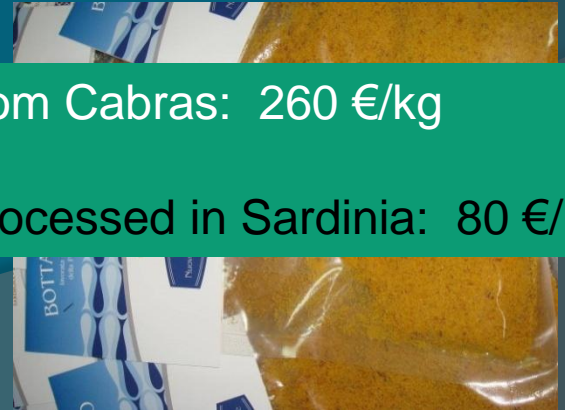
500 – 1,000	kg/year Orbetello (IT)
600 – 920	kg/year Missolongi (EL)
17,000 – 90,000	kg/year Taiwan

product with high added value



Cabras/Orbetello  
bottarga: 260€/kg

# Cabras lagoon (Sardinia, Italy) – bottarga processing



Bottarga from Cabras: 260 €/kg

Bottarga processed in Sardinia: 80 €/kg



other products



smoked fillets



tichtar => lekhelee

salted and dried fillets



fresh testis & egg roe



gizzards



## Hawaii - fresh mullet



Makoa and the Mullet, print by Dietrich Varez. Note live mullet in hand being carried from Waiākea Pond in Hilo to the young King Kamehameha in Kawaihae, south Kohala. Used here with permission from the artist via Volcano Art Center, Volcano, Hawai'i.



Cabras lagoon (Sardinia, IT)



## Sagra su Mugheddu de Marisceddu

Giovedì 2 Giugno 2016  
Località Sant'Antonio di Santadi

**Durante la manifestazione sarà presente un  
Raduno di Auto d'Epoca, Fiat 500 e Vespe**

Programma:  
ore 12,30 Pranzo tipico a base di pesce  
Pasta Cozze e Arselle, Muggini arrosto, Fritto misto, Pane e Vino.

durante la manifestazione intrattenimento musicale.  
info e prenotazioni: pro loco tel. 349 6296942

*su mugheddu*: gutted  
**mullet** salted in brine and  
later smoked in dried  
*Helichrysum*  
...secret recipe



*sa merca*: steamed **mullet** preserved in salt  
and packed in lagoon herbs (*ziba*).

Phoenician recipes?



grilled ungutted mullet

## Egypt



*feseekh*: fermented, salted and dried mullets sold in special shops that process the fish and sell it

- traditional dish at Easter time

New development of grey mullet culture taking into account traditions and cultural heritage ?

