The End

This is Fifi, living since 2002 in Ljubljana, Slovenia, in

This is Fifi, living since 2002 in Ljubljana, Slovenia, in a sealed glass globe.

I tell you this ...

Posted on: Monday, March 1, 2004

Hawai'i's little **red shrimp are a hot item**

Advertiser Science Writer

Tiny red Hawaiian shrimp that live in anchialine ponds and underground crevices are turning into a popular aquarium species.

Hawai'i's red pond shrimp, known in Hawaiian as **'opae 'ula**, have become a popular addition to aquariums. However, heavy collecting as well as predatory fish could threaten the tiny creatures.

because...

this “hot item”, the red shrimp **opae’ula**, or *Halocaridina rubra*, is an inhabitant of the Hawaiian **anchihaline** ponds

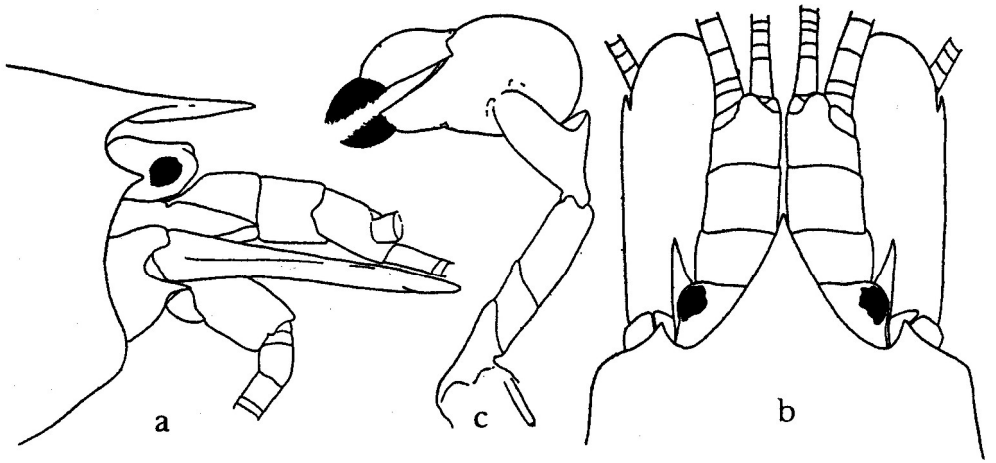
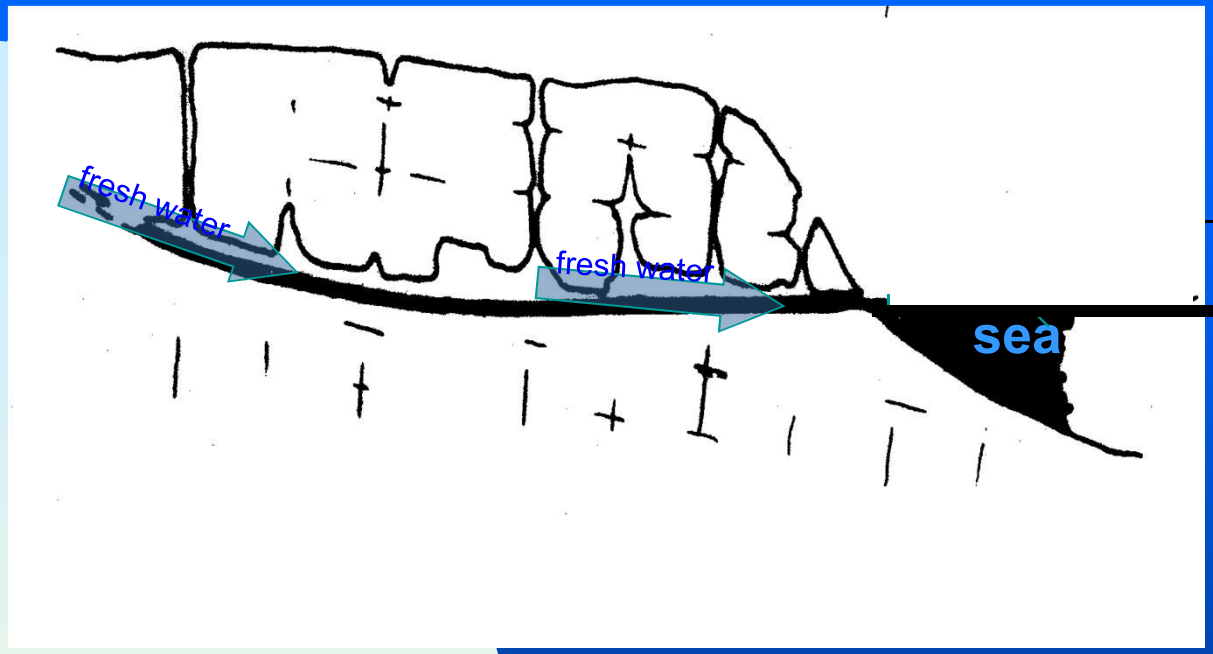


Fig. 35. *Halocaridina rubra* Holthuis, 1963. a, head region in lateral view; b, idem in dorsal view; c, first pereiopod. After Holthuis, 1963, Zool. Meded. Leiden, 38 (16): 262, fig. 1.

it exhibits some characters of cave animals,
like long life expectancy, reduced eyes ...

2000

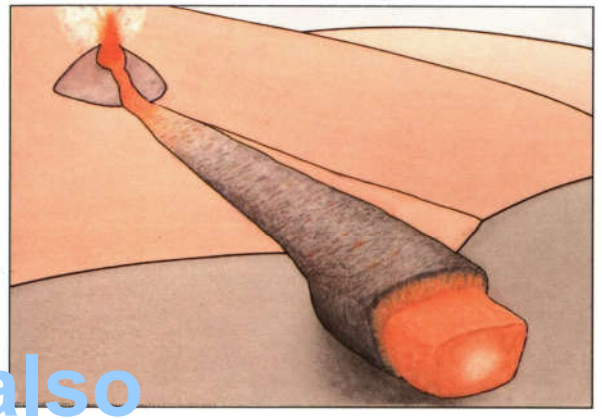
A cave system may occur at the sea coast



What is actually
“**anchihaline**”?

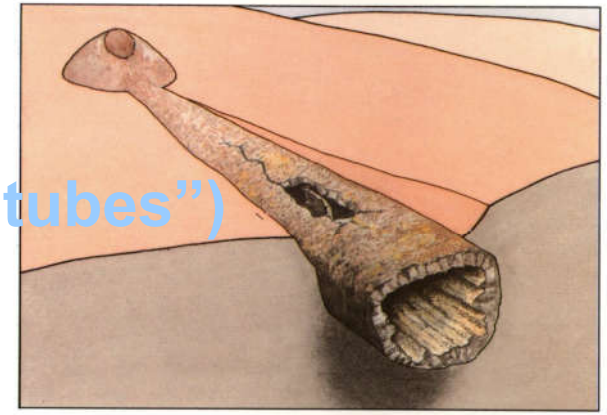
caves may
come into existence also
under volcanoes,
at the sea coast again ...

(we call them “lava tubes”)



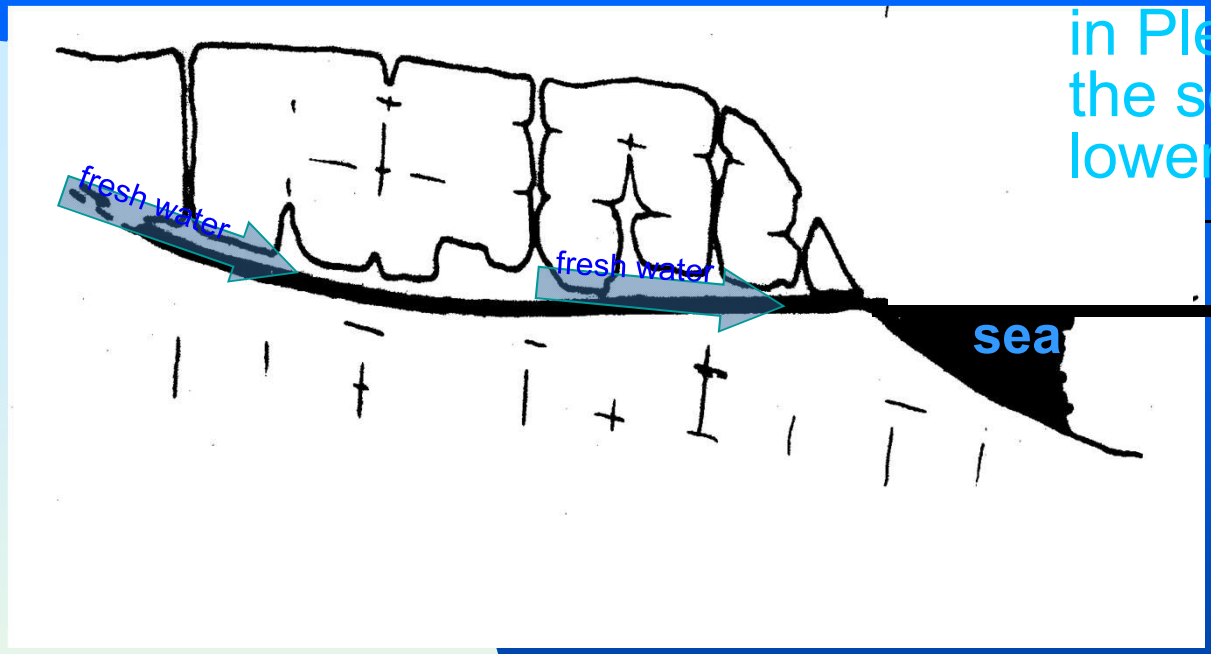
Al irse enfriando la superficie de las coladas fluidas, se va formando una costra más o menos solidificada, bajo la cual continúa fluyendo la lava aún caliente.

Esta puede sufrir un descenso de nivel al disminuir las emisiones del volcán, creándose de esta manera un vacío bajo la costra superficial.



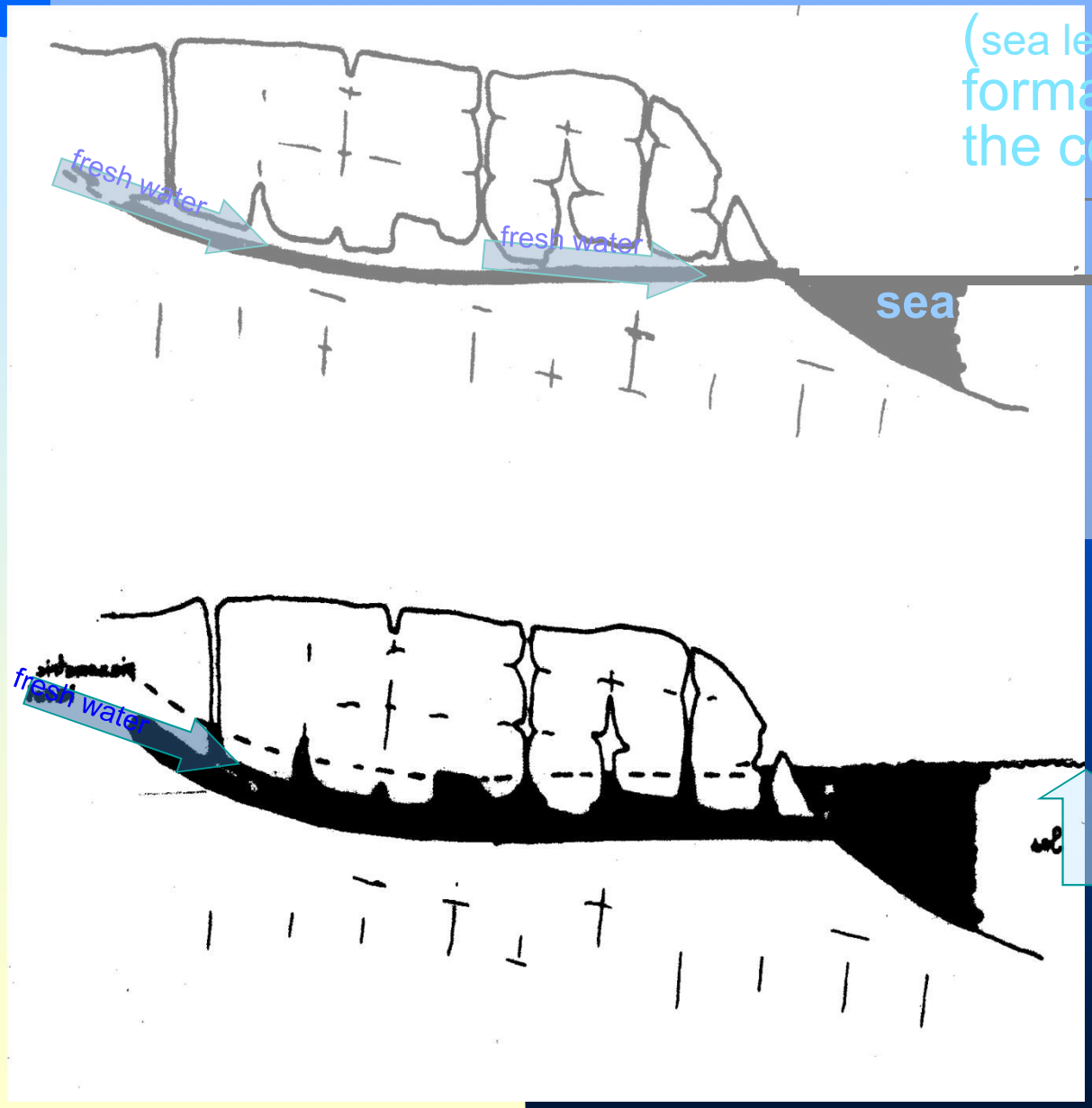
Cuando cesa la erupción y la lava ha terminado de discurrir queda constituido el tubo volcánico.

… at the sea coast



in Pleistocene, the sea level was lower (for 100 m!)

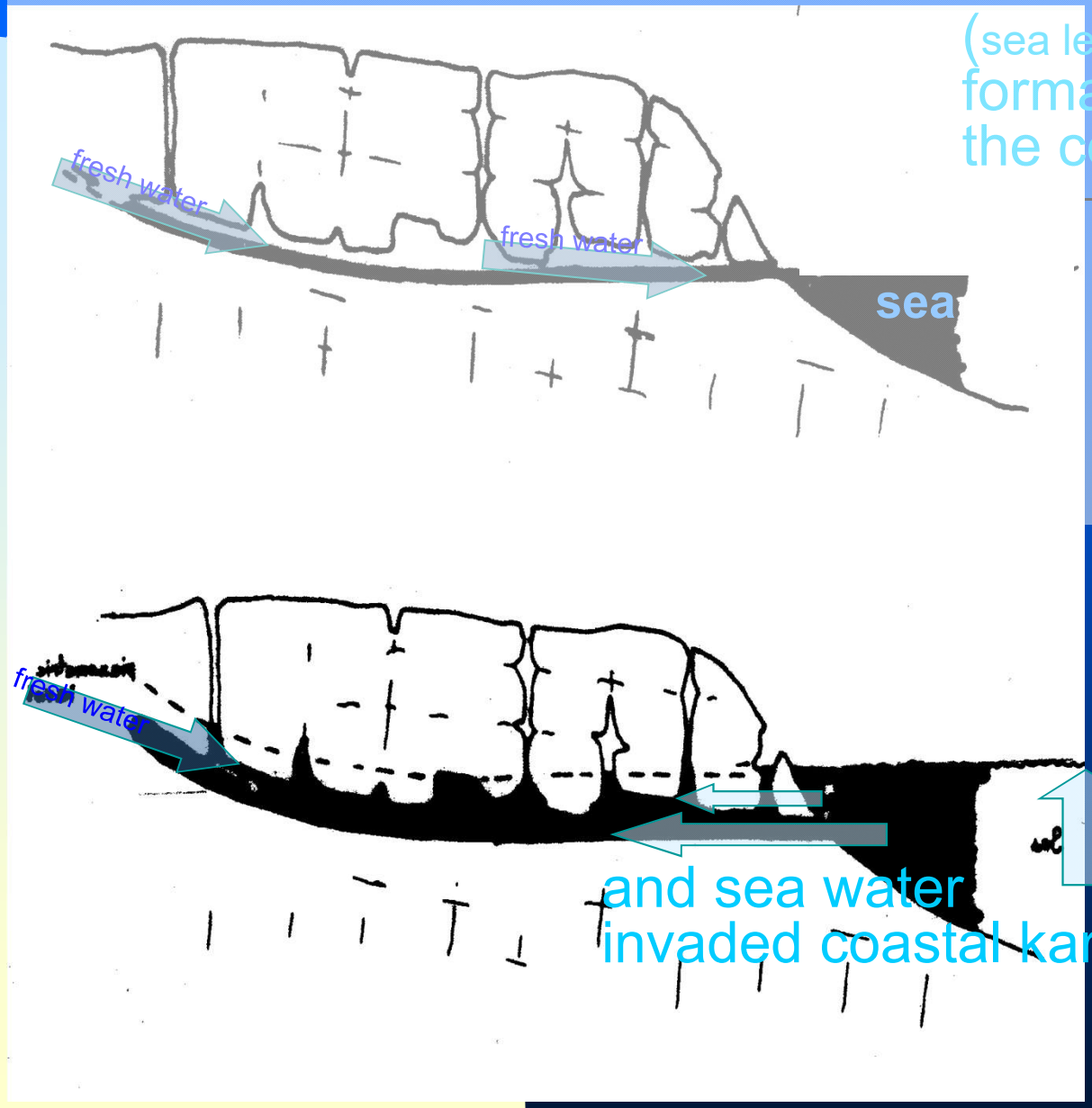
in Pleistocene,
(sea level was lower)
formation of a cave at
the coast ...



in Holocene

ocean levels rose

in Pleistocene,
(sea level was lower)
formation of a cave at
the coast ...



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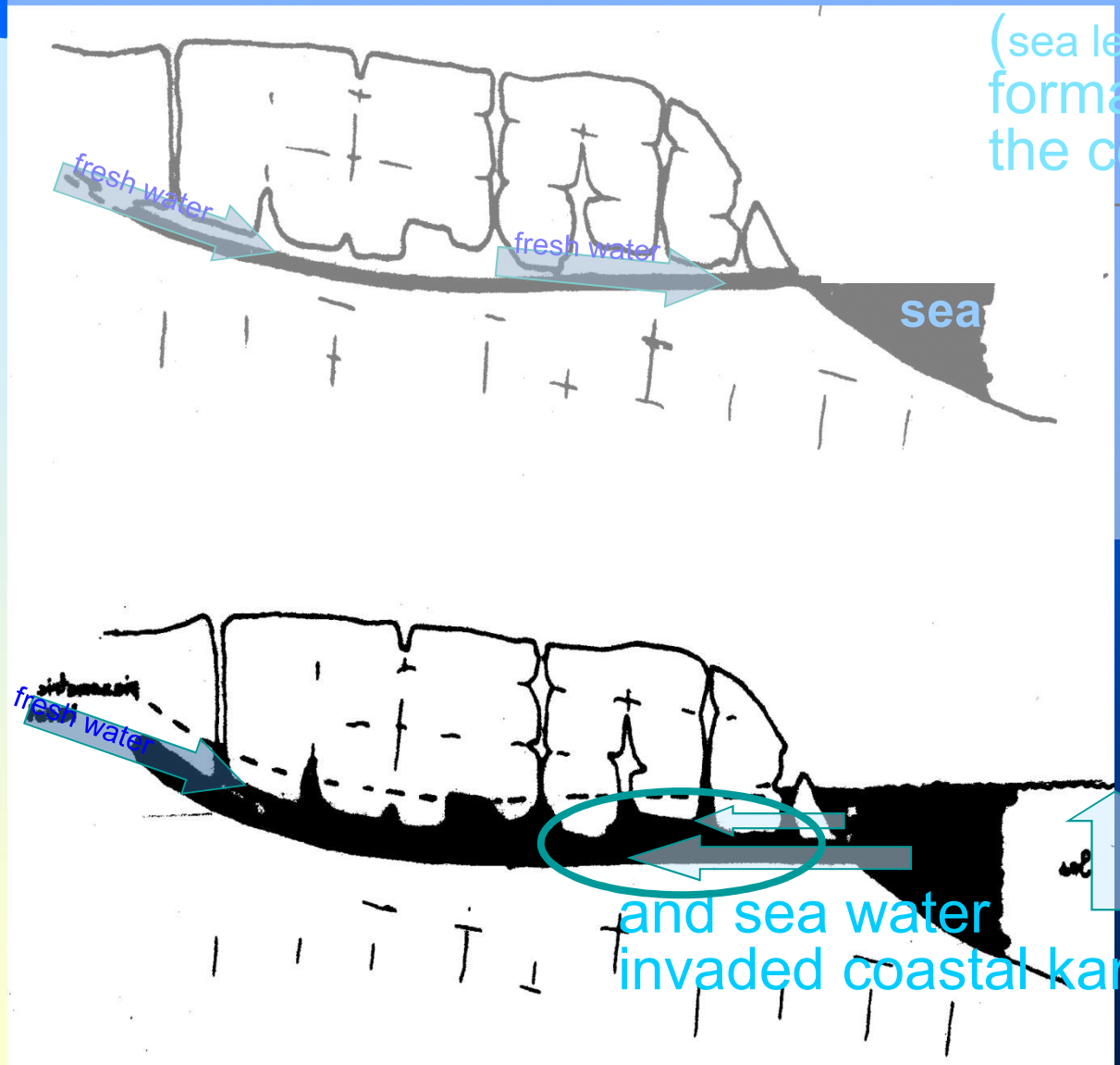
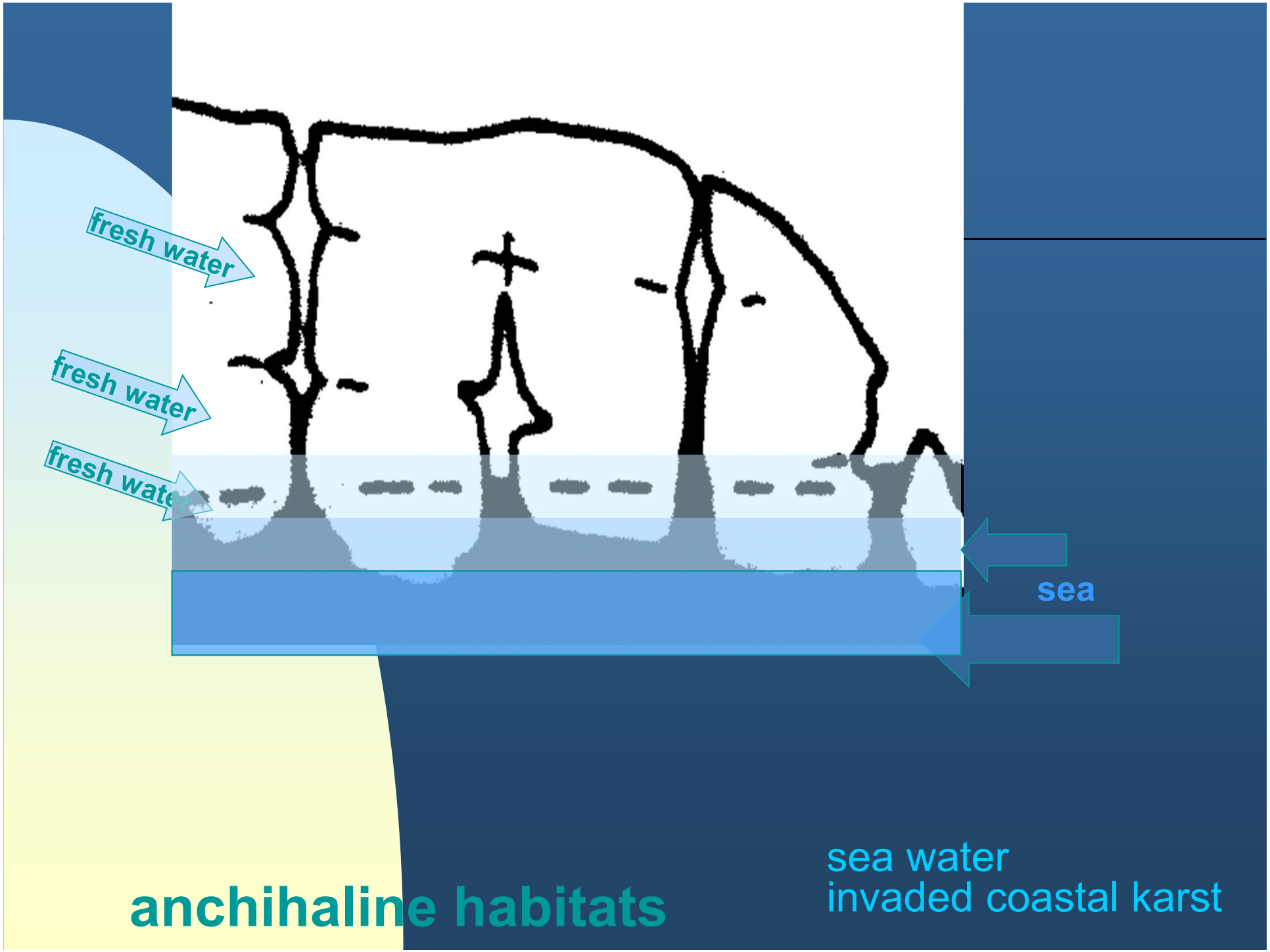


in Holocene

ocean levels rose

this was the origin of **anchihaline habitats**



anchihaline habitats

sea water
invaded coastal karst

and here starts the history of investigations of the anchihaline habitats

anchihaline habitats

1936 Cenotes & caves in Yucatan, Mexico,
by A.S Pearse et al.

1850 may be mighty phenomena

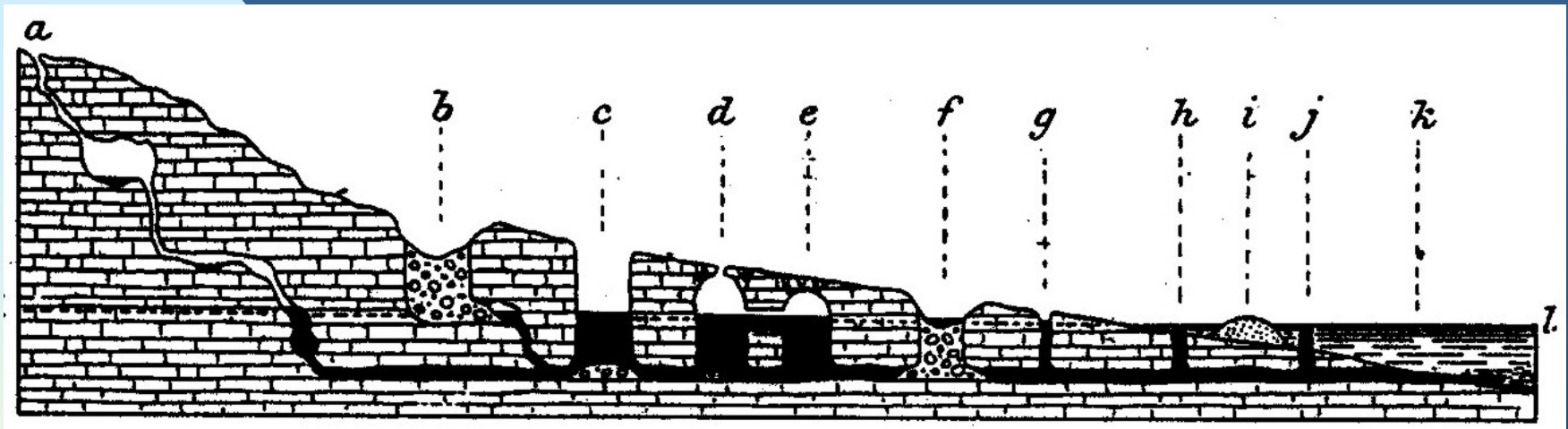


FIG. 7—Cole's (1910) figure: "Schematic north-south section from the '*sierra*' to the coast illustrating types of cenotes and caverns, relations of water-level, subterranean connections, etc. *a*, hill cavern, with passages and pools of water held in impervious depressions; *b*, an old age cenote ('holla') holding water only temporarily after rains; *c*, typical cenote; *d*, *e*, young cenotes or dome-shaped caverns connected by a passage at water-level; *f*, old age cenote with permanent pool of water ('aguada'); *g*, water hole near coast, where water level is very near the surface; *h*, fresh-water spring in a brackish lagoon or cienaga; *i*, coastal sand reef on which coastal towns are located; *j*, fresh-water spring a short distance from shore; *k*, Gulf of Mexico; *l*, sea-level."

... Mexico ... or Australia

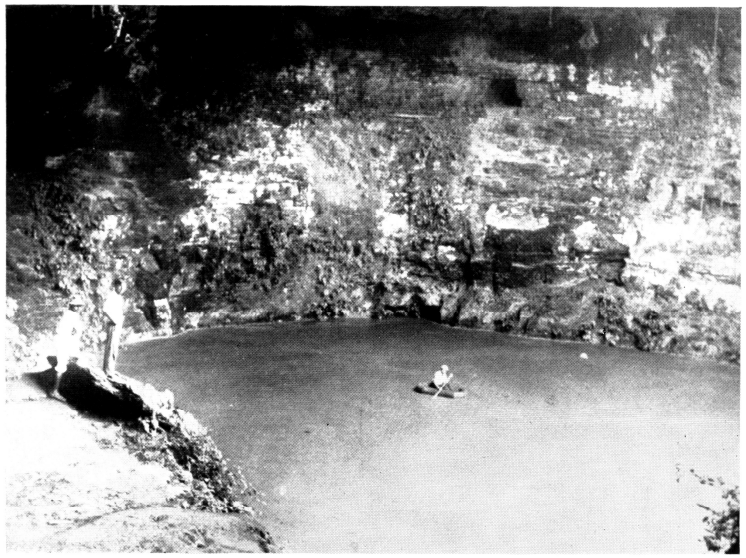


FIG. A—Hall in the Santa Ana Cenote, Valladolid.

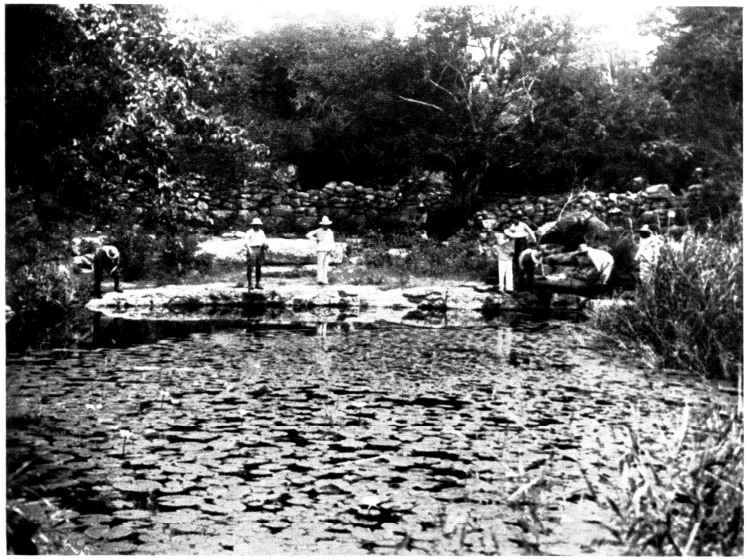


FIG. B—Xlaka Cenote, Hacienda Xcanatun, between Merida and Progreso. Surface of water is only slightly below that of land. On far side a crevice slants downward under ledge; water there is 7 meters deep.

1850

1900

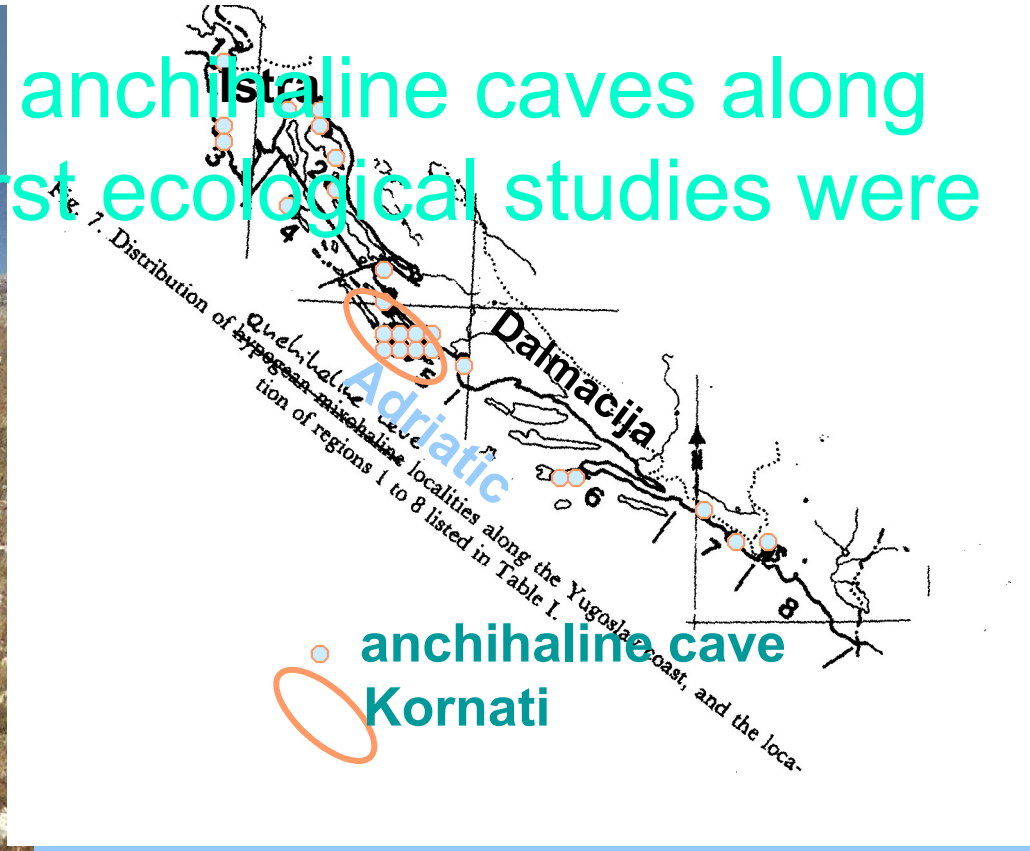
1936 Cenotes & caves in Yucatan, Mexico,

by A.S Pearse et al.

1950

2000

more modest are anchihaline caves along Adriatic, where first ecological studies were done



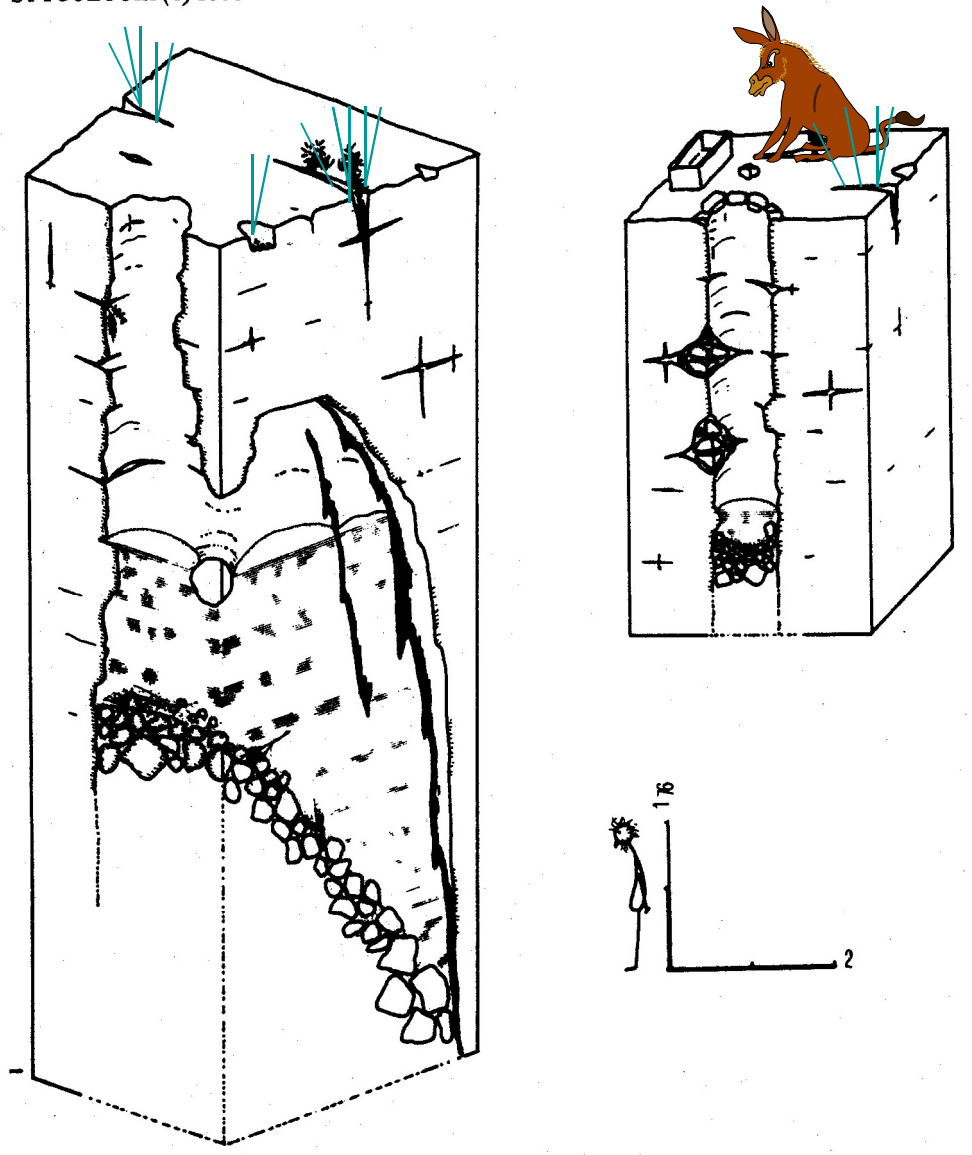
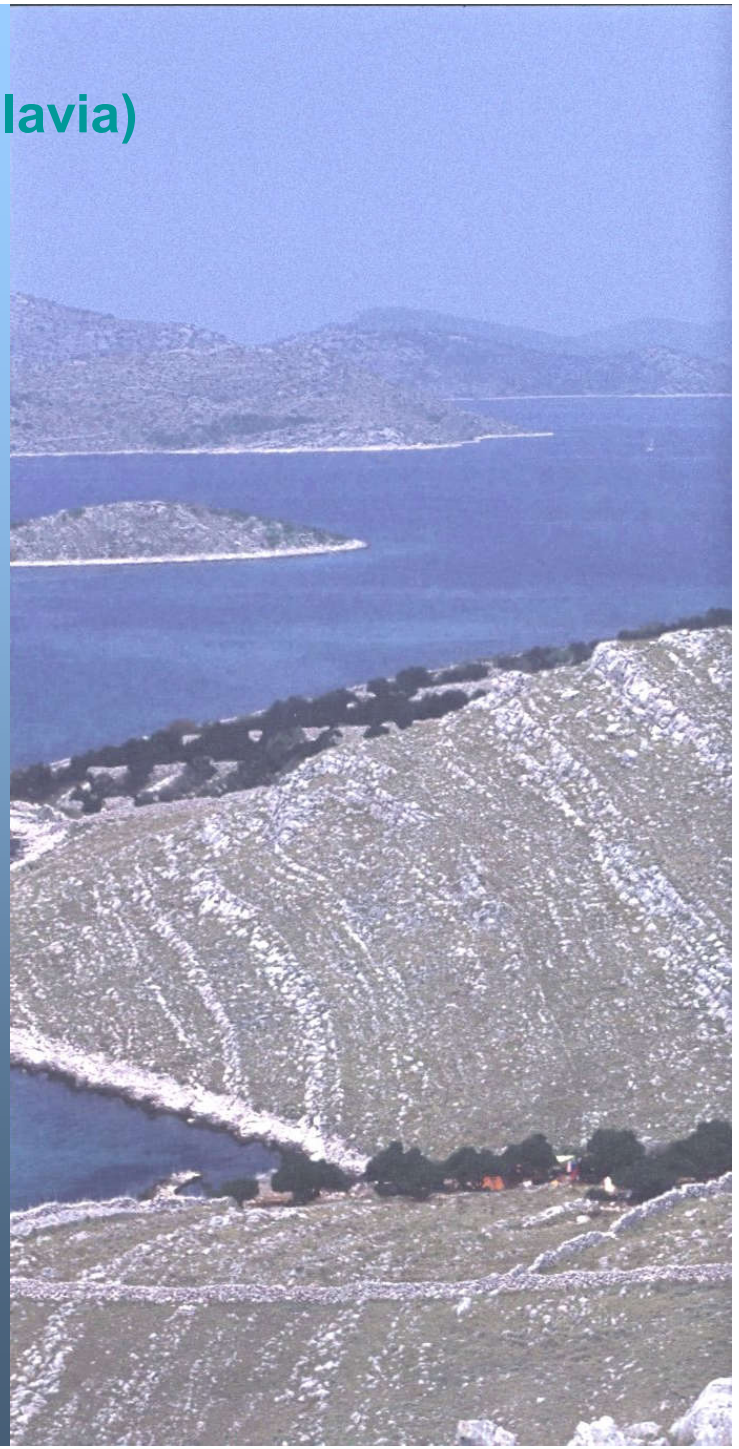


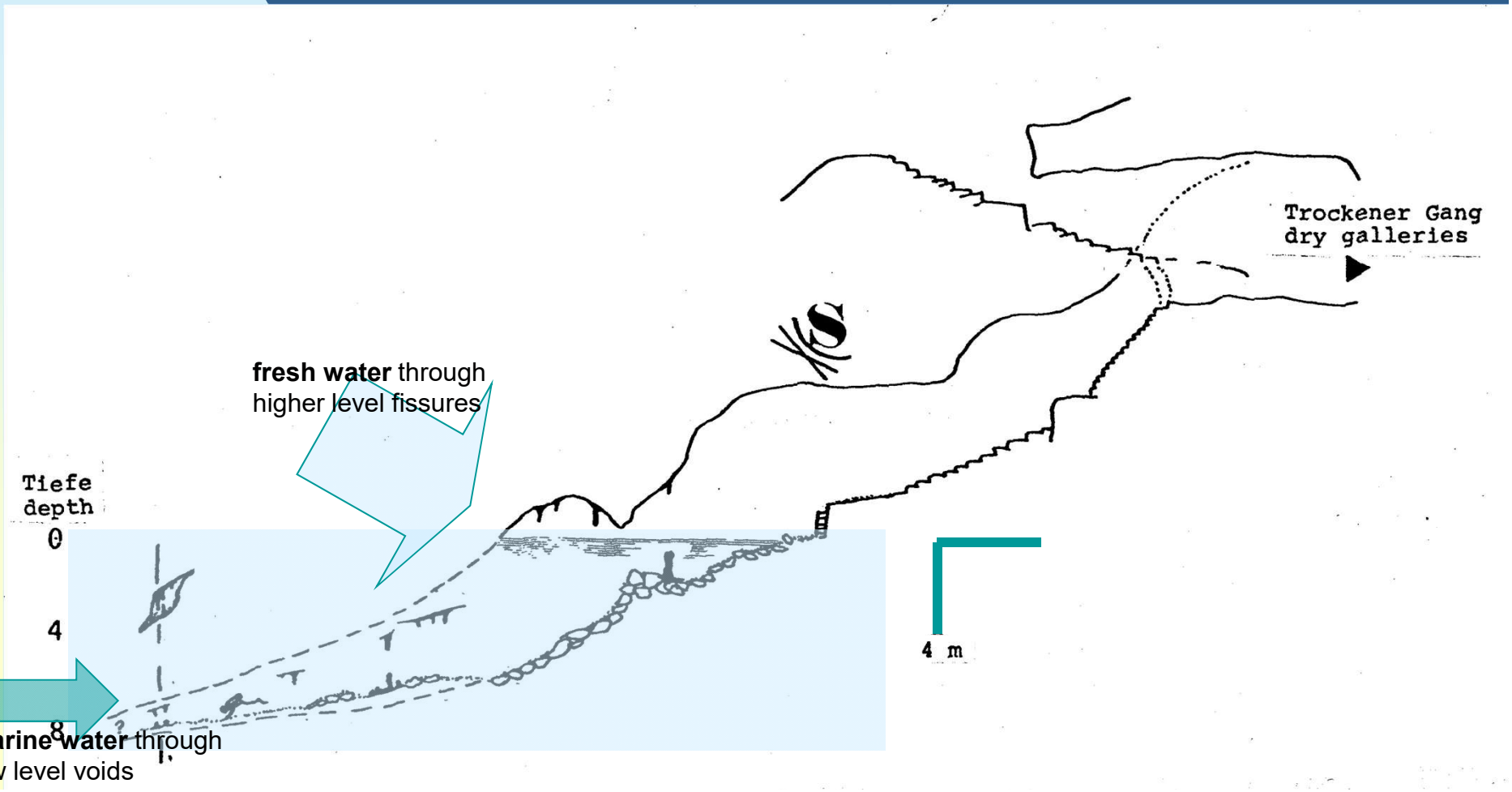
Fig. 1. Diagrammatic representation of the most common "cave" types in the central Dalmacija (Kornati Islands).

Kornati Islands, Croatia (Yugoslavia)

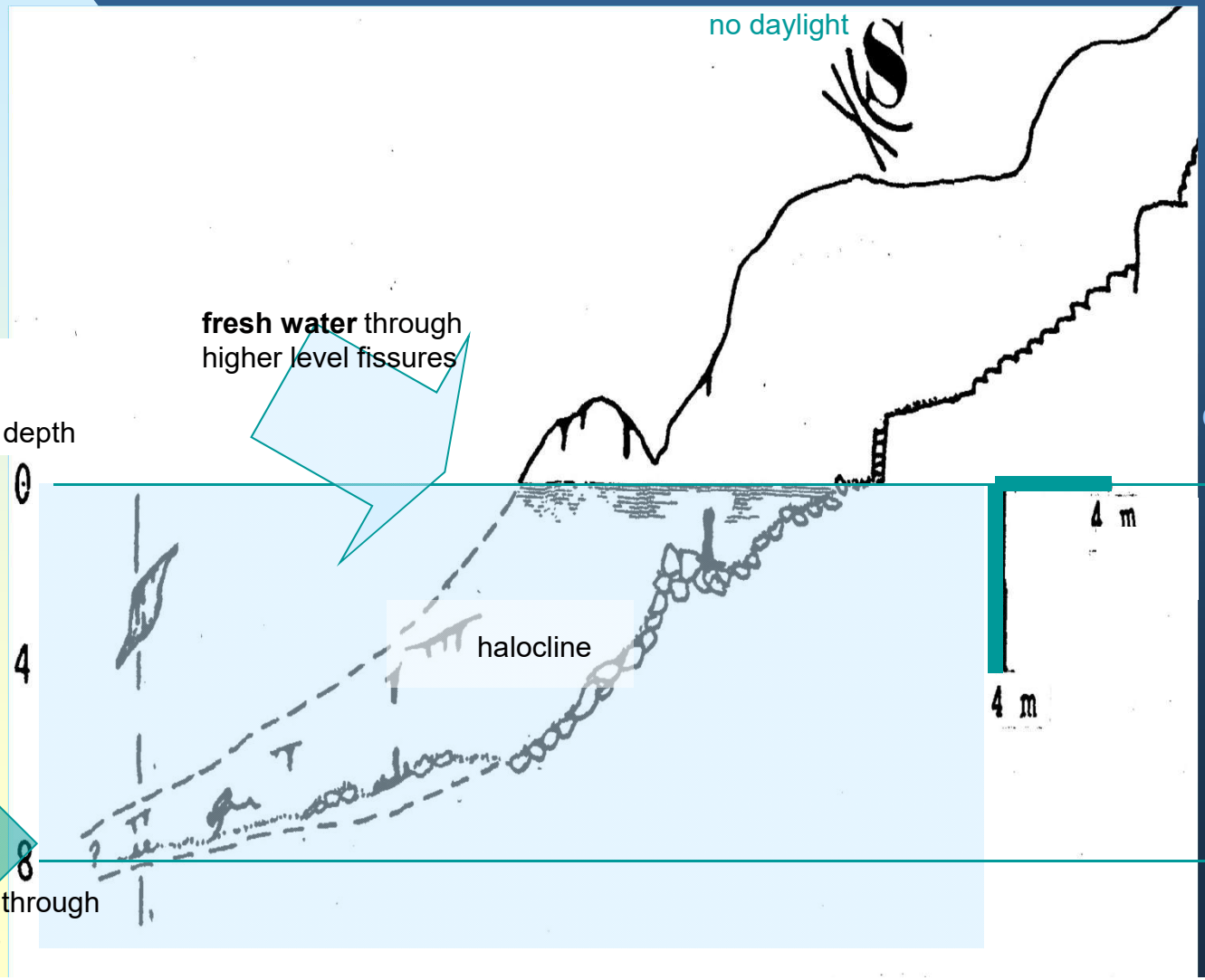


an actual anchihaline cave

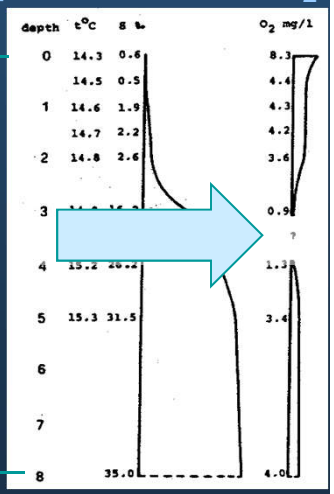
cave Šipun in Cavtat, southern Dalmacija, Croatia



most interesting is a common occurrence of a **deoxygenated layer ...**

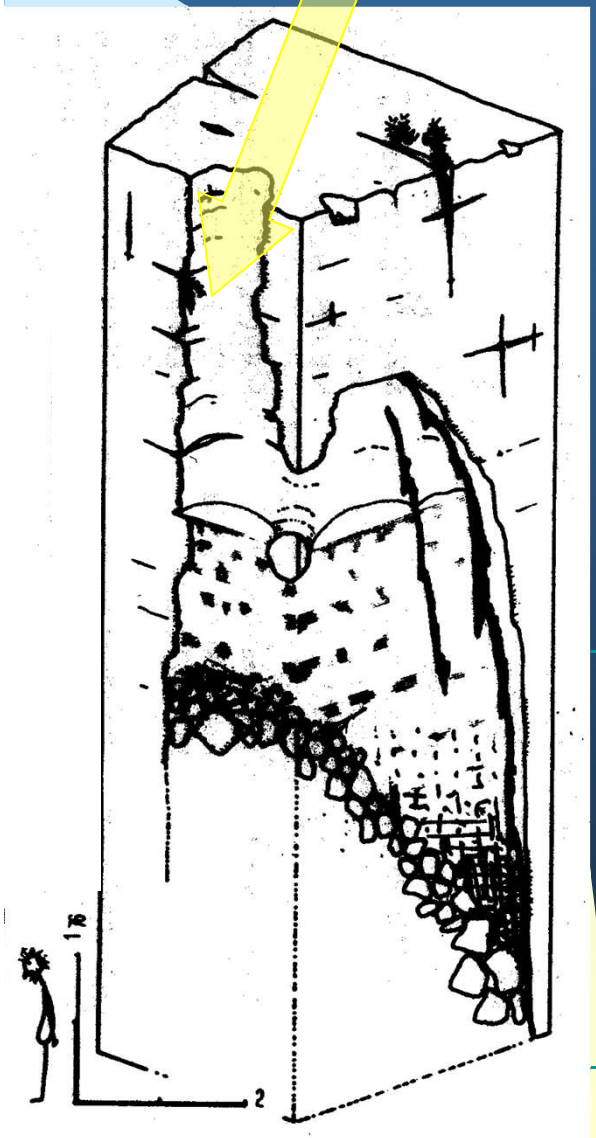


depth t salin O_2



the deoxygenated layer sometimes **with H_2S**

sunlight
(and food)



cave Živa voda, Panitula, Kornati, Croatia

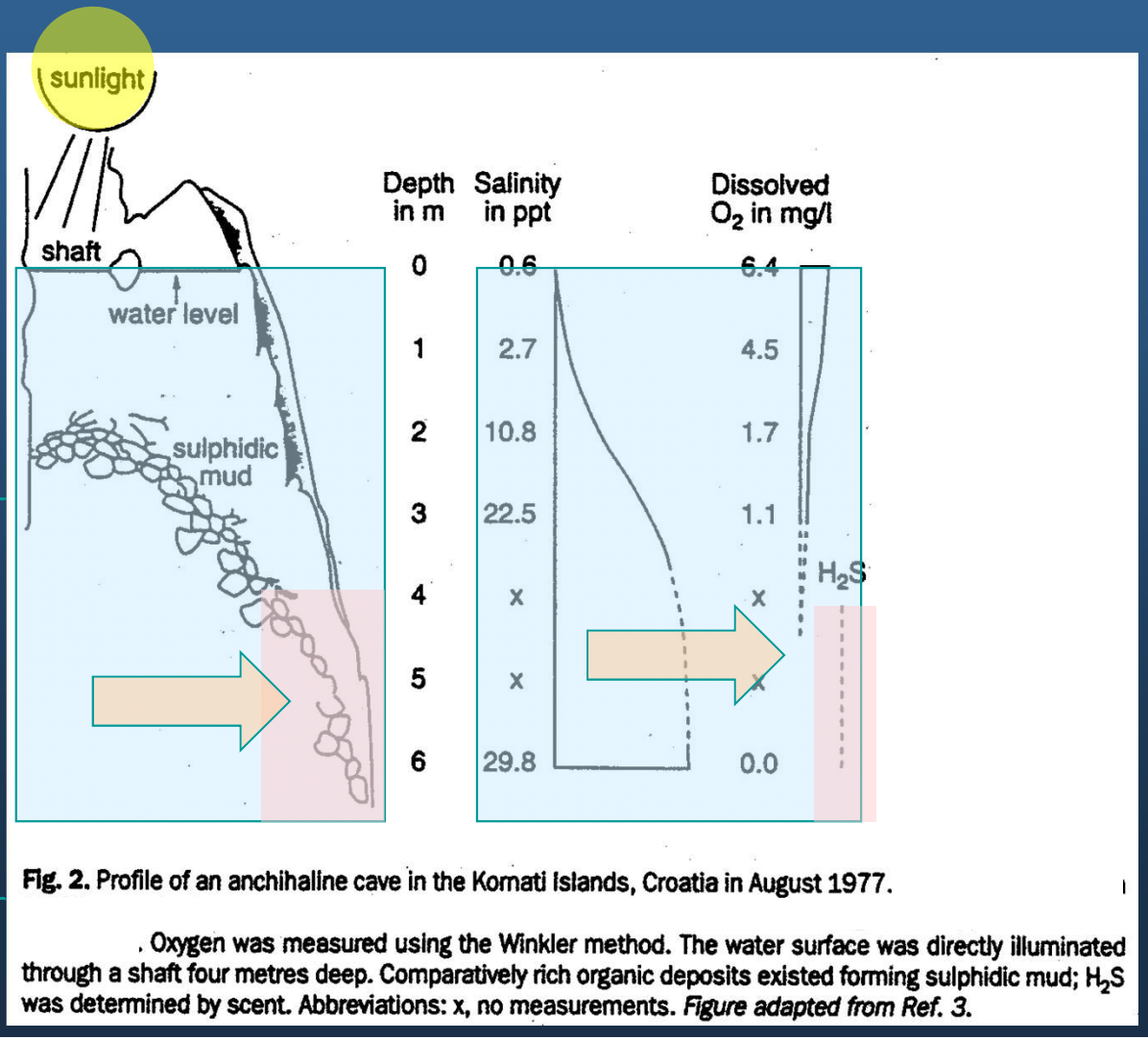
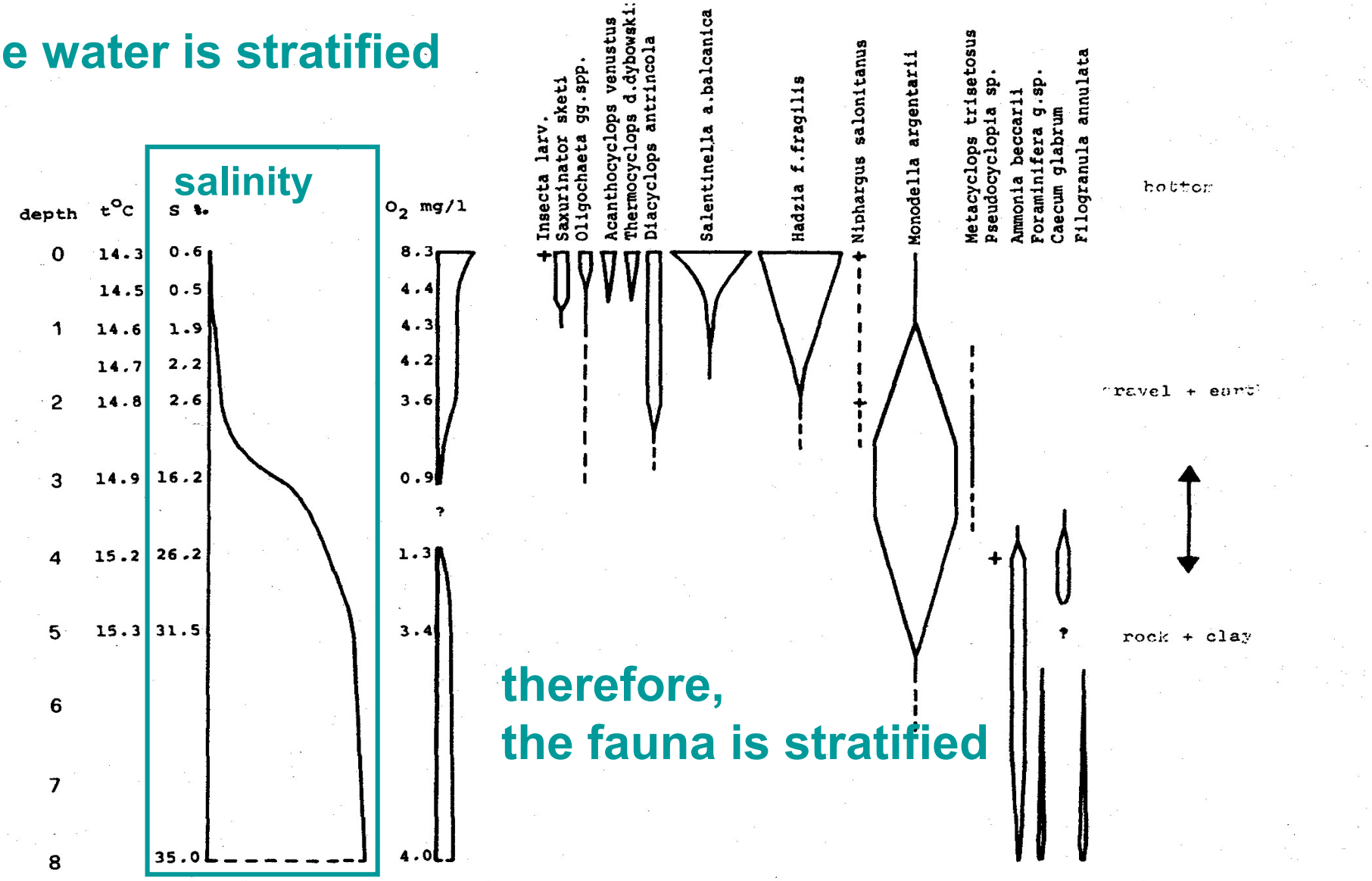


Fig. 2. Profile of an anchihaline cave in the Kornati Islands, Croatia in August 1977.

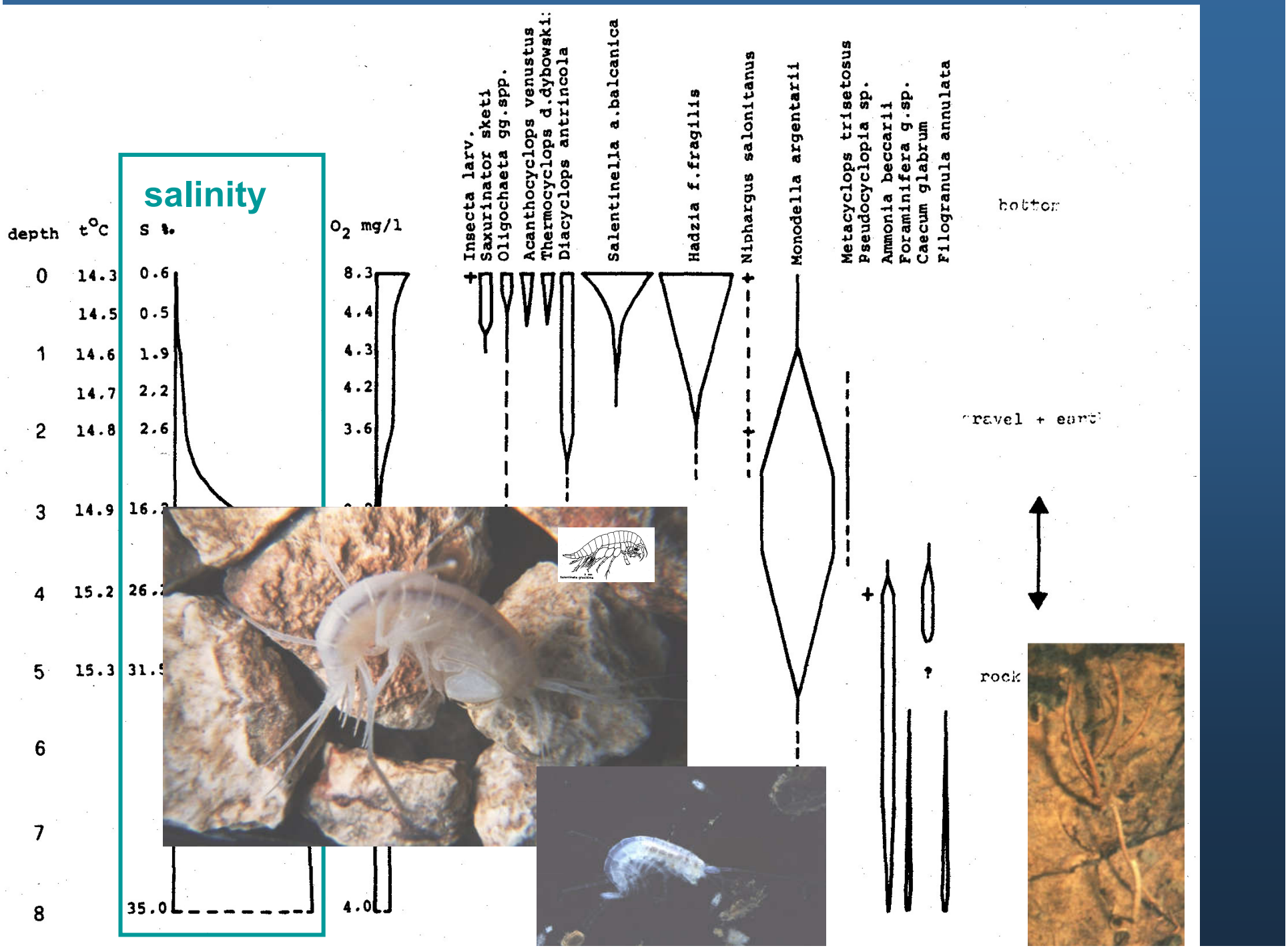
. Oxygen was measured using the Winkler method. The water surface was directly illuminated through a shaft four metres deep. Comparatively rich organic deposits existed forming sulphidic mud; H_2S was determined by scent. Abbreviations: x, no measurements. *Figure adapted from Ref. 3.*

the water is stratified



therefore, the fauna is stratified

Fig. 6. First part of legend as for fig. 3. A water-body in the dark part of a larger cave in Cavtat; bottom covered partly by organically enriched soil and wood debris in the upper parts, and by fine, pure clay in the deeper ones; good communication with the sea.


salinity
depth
t°C
S ‰
O2 mg/l
0
1
2
3
4
5
6
7
8
14.3
14.5
14.6
14.7
14.8
14.9
15.2
15.3
0.6
0.5
1.9
2.2
2.6
16.2
26.2
31.5
35.0
8.3
4.4
4.3
4.2
3.6
4.0
Insecta larv.
Saxurinator sketi
Oligochaeta gg.spp.
Acanthocyclops venustus
Thermocyclops d.dybowski
Diacyclops antrincola
Salentinella a.balcanica
Hadzia f.fragilis
Niphargus salonitanus
Monodella argentarii
Metacyclops trisetosus
Pseudocyclopia sp.
Ammonia beccarii
Foraminifera g.sp.
Caecum glabrum
Filogranula annulata
bottom
gravel + sand
rock

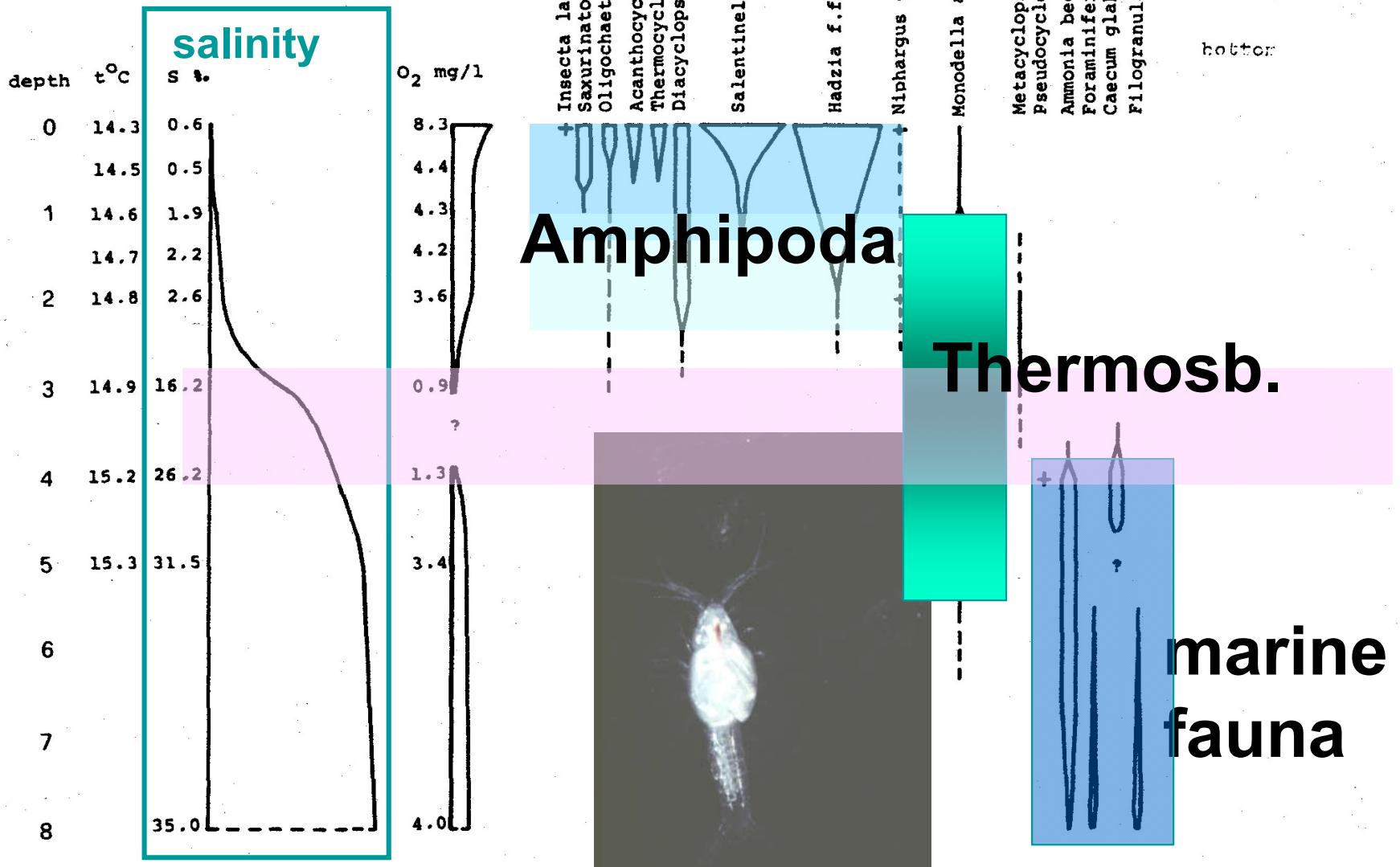
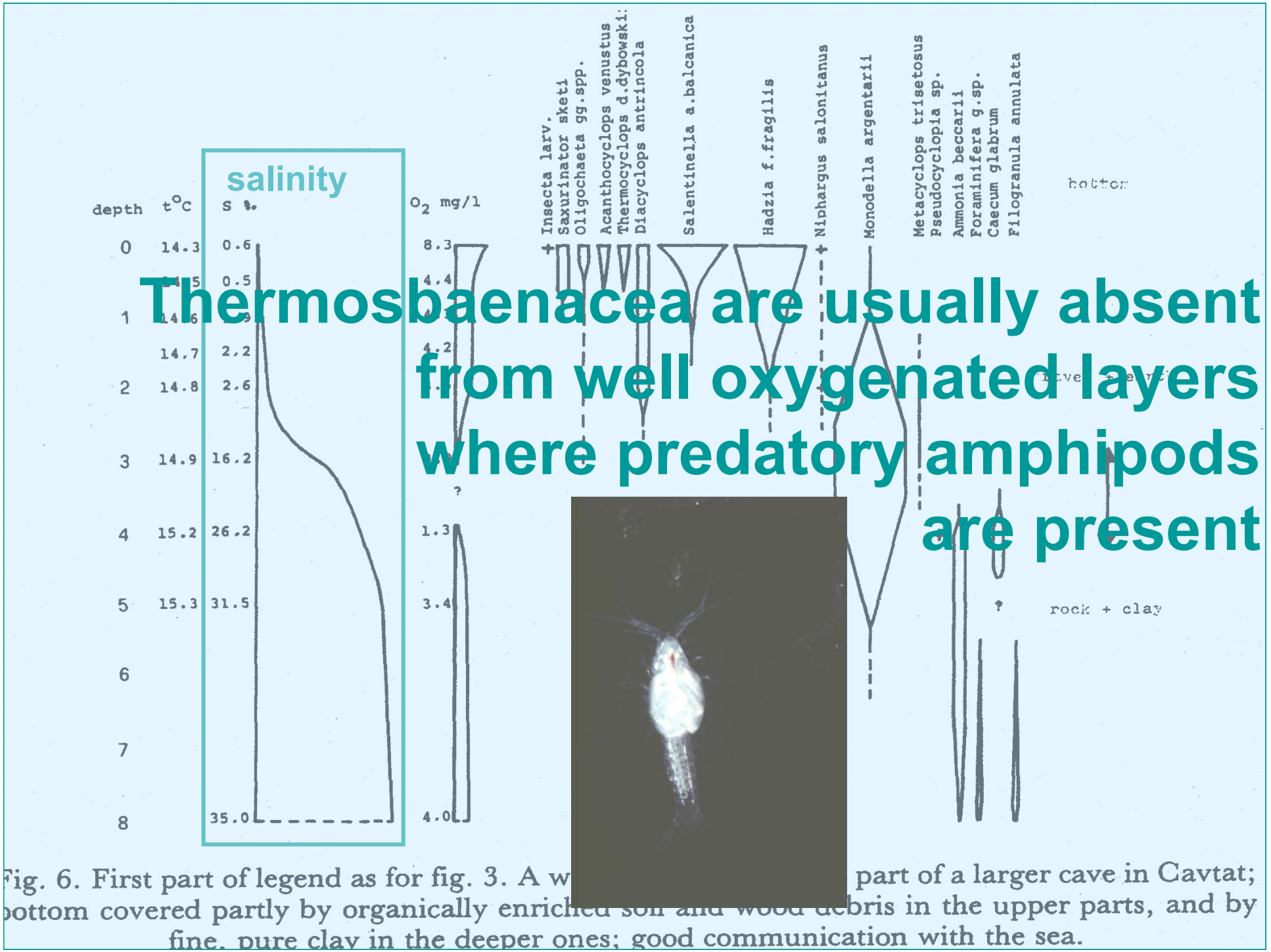


Fig. 6. First part of legend as for fig. 3. A w part of a larger cave in Cavtat; bottom covered partly by organically enriched soil and wood debris in the upper parts, and by fine, pure clay in the deeper ones; good communication with the sea. Sket, 1986



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distribution of species within a water body

caused by extreme euryoecity of species

and competition

some cave animals,
Niphargus hebereri in particular,
can support adverse conditions:

- full sunlight,
- oxygen depletion,
- presence of H_2S,
- oil pollution
- etc ?

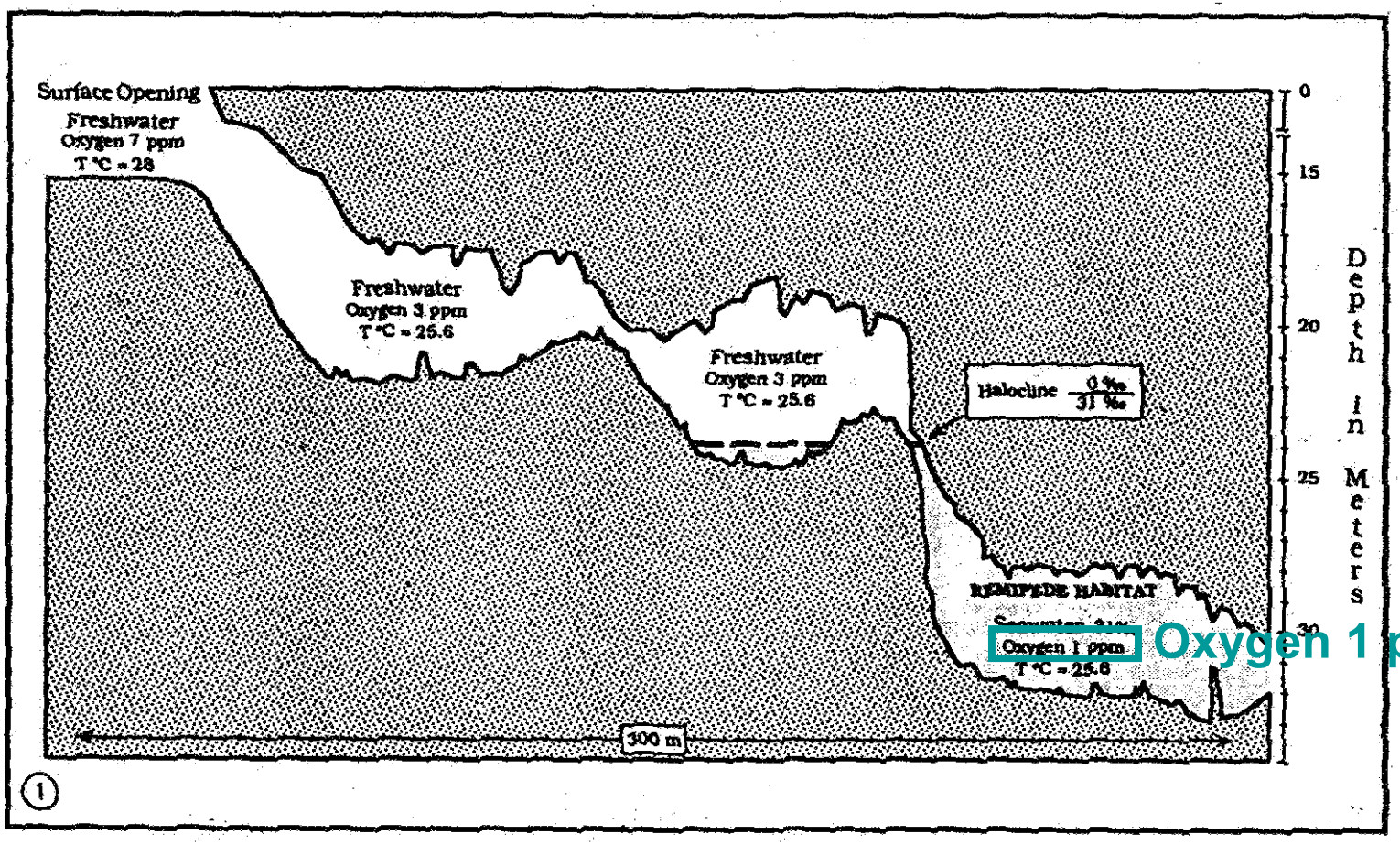


Fig. 1. Schematic representation of the anchialine habitat of the remipede *Speleonectes tulumensis*.

Oxygen 1 ppm

2000

Blue holes in Bahamas

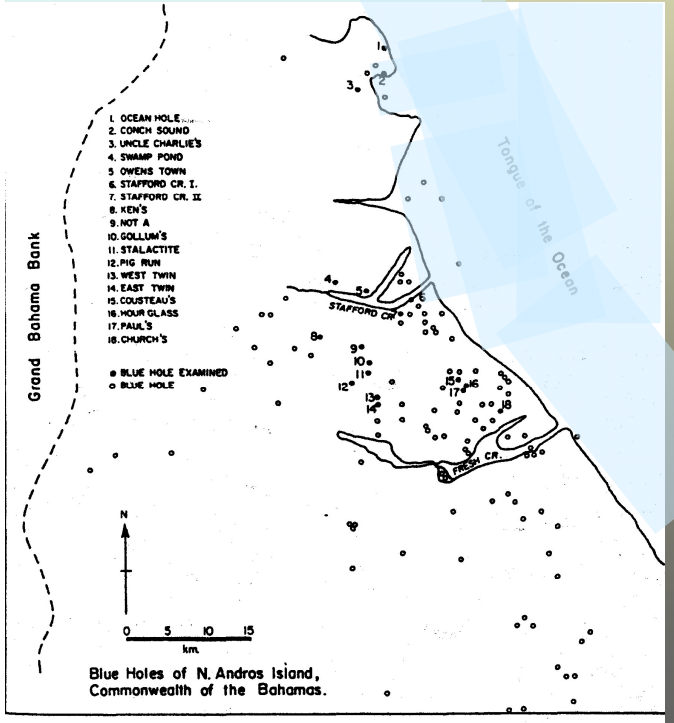


Figure 1. Blue holes on Andros Island studied by Smart (1984).

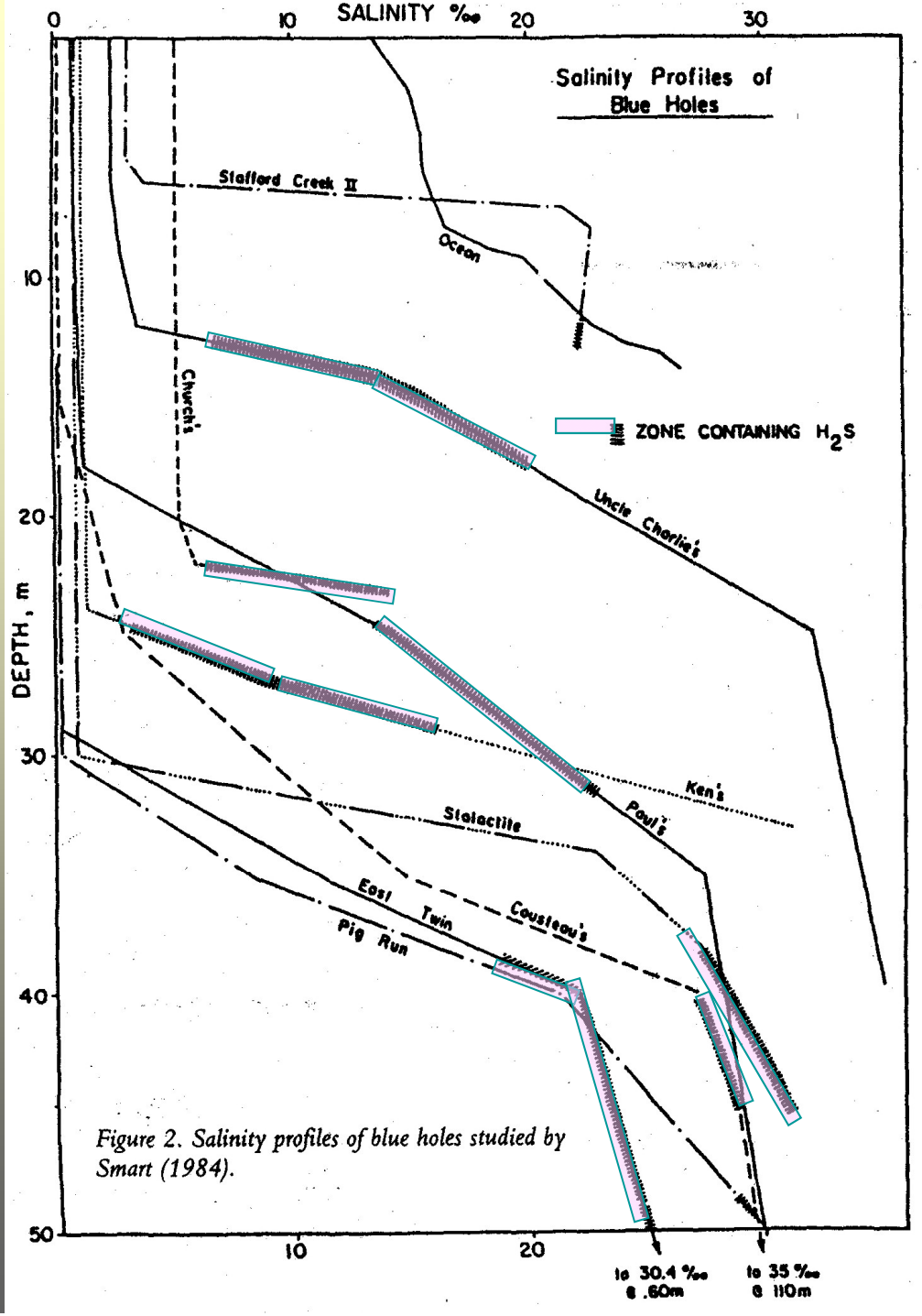


Figure 2. Salinity profiles of blue holes studied by Smart (1984).

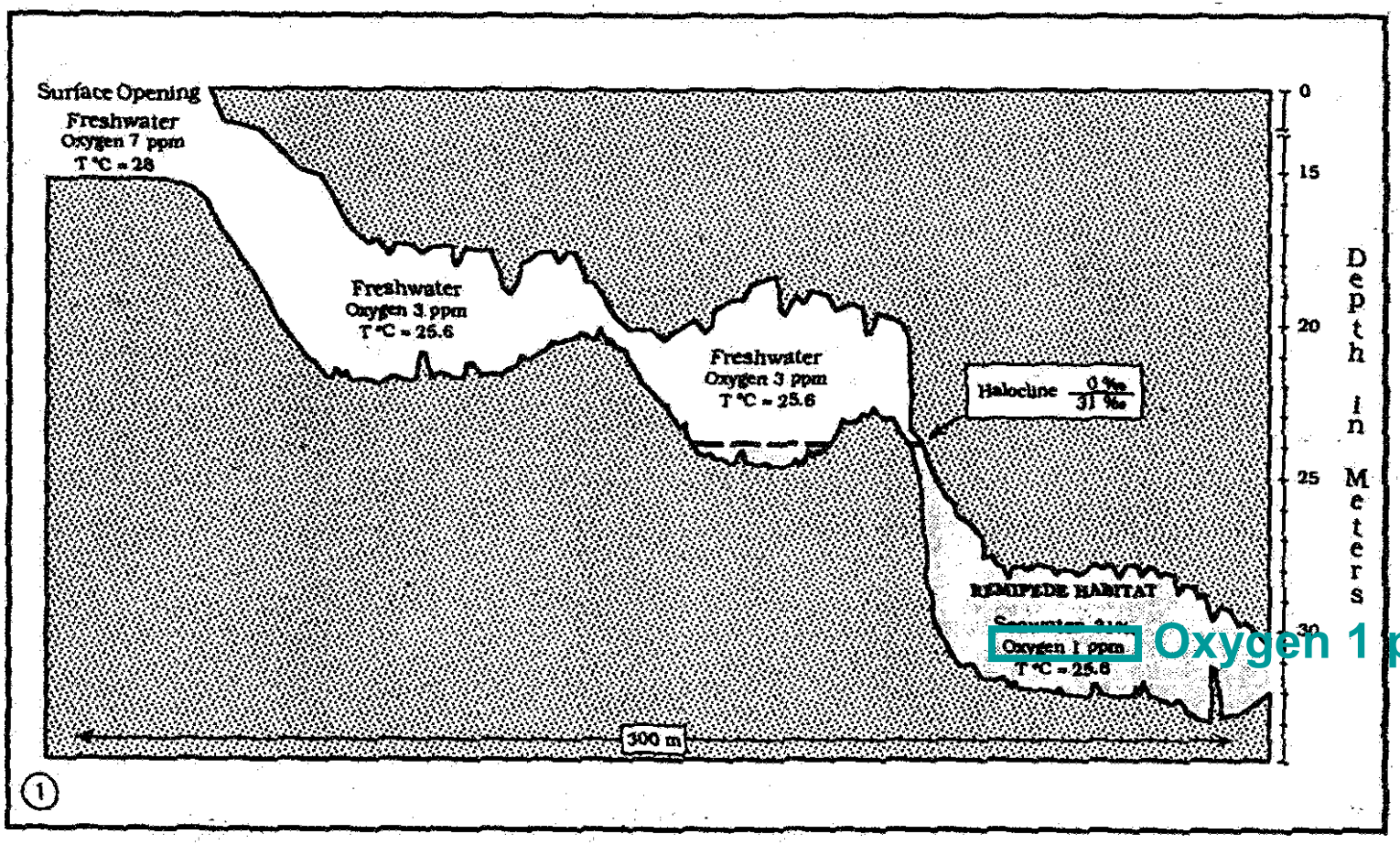
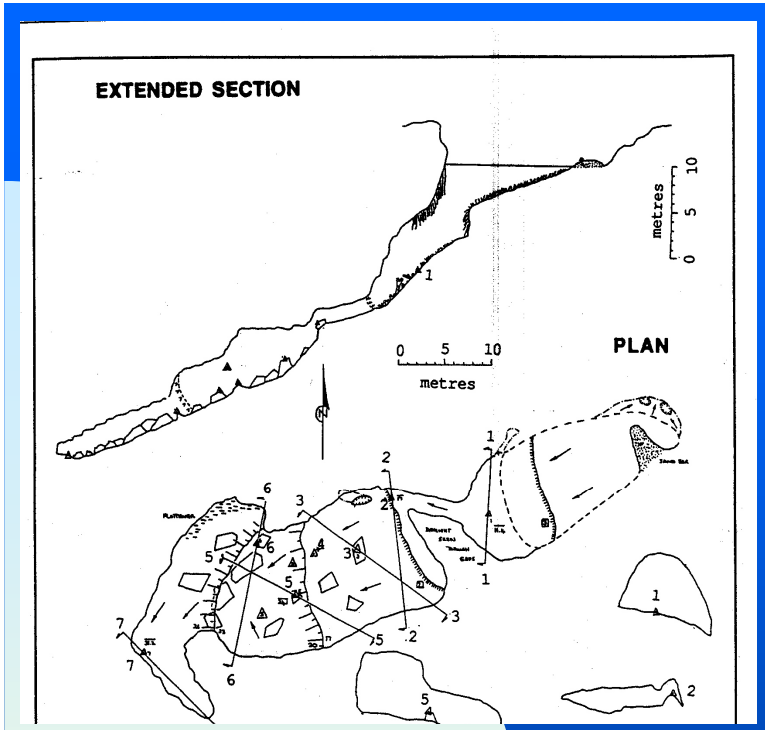


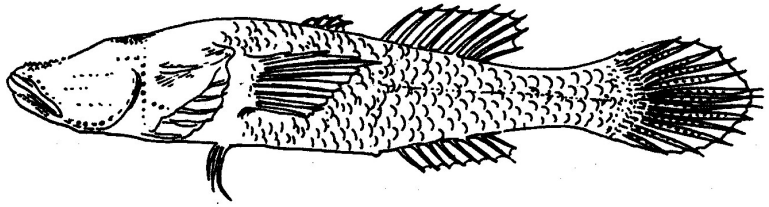
Fig. 1. Schematic representation of the anchialine habitat of the remipede *Speleonectes tulumensis*.

Oxygen 1 ppm

2000

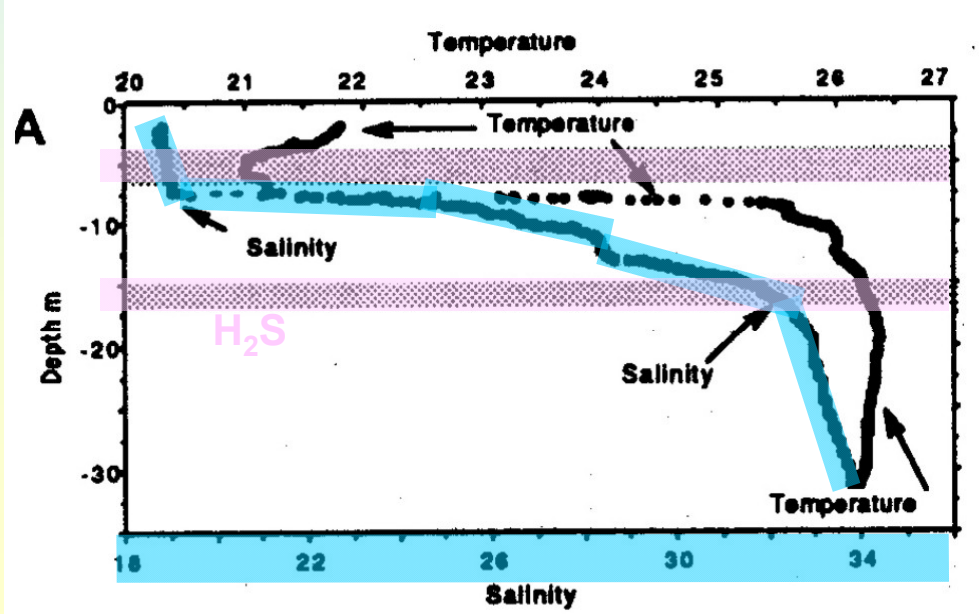
Humphreys, 1999
Bundera Sinkhole

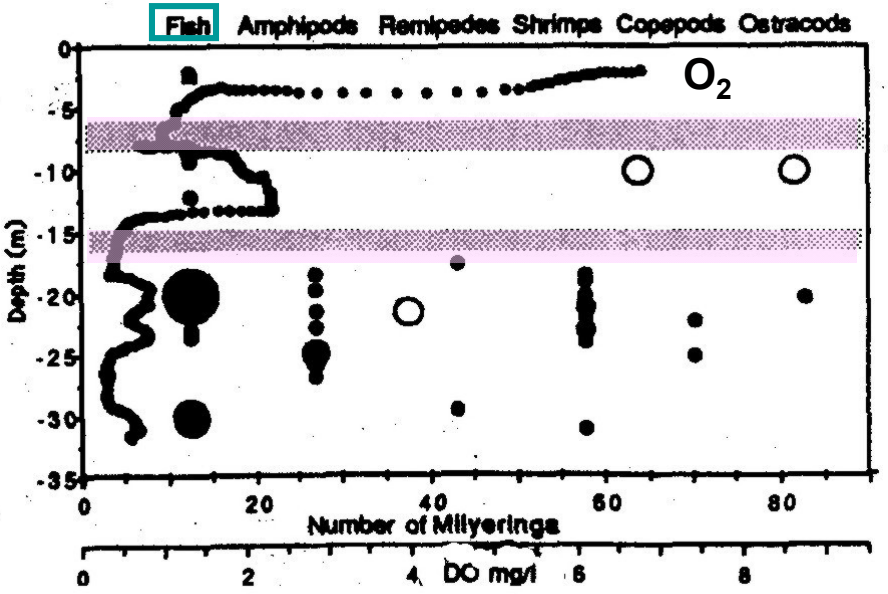




Milyeringa veritas Whitley (d'après WHITLEY, 1945),

Milyeringa





why deoxygenated layers?
why oxygen used can not be compensated?
what prevents mixing of water layers?

density of

pure water		brackish water	
20 °C	998 g/		
10 °C	999 g/l	S 0 ‰	999 g/l
4 °C	1.000 g/l	10 ‰	1.009 g/l
		20 ‰	1.019 g/l

(in waters of a homogene salinity,
cooling of surface layers would cause mixing)

anchihaline habitats are a special kind of subterranean habitats

+_ closed space

food input limited

darkness

access humpered

stable conditions

no photophiles

few autotrophs

scarce food

only modest immigrants

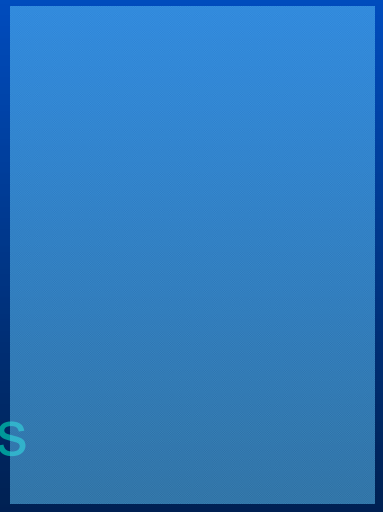
few species

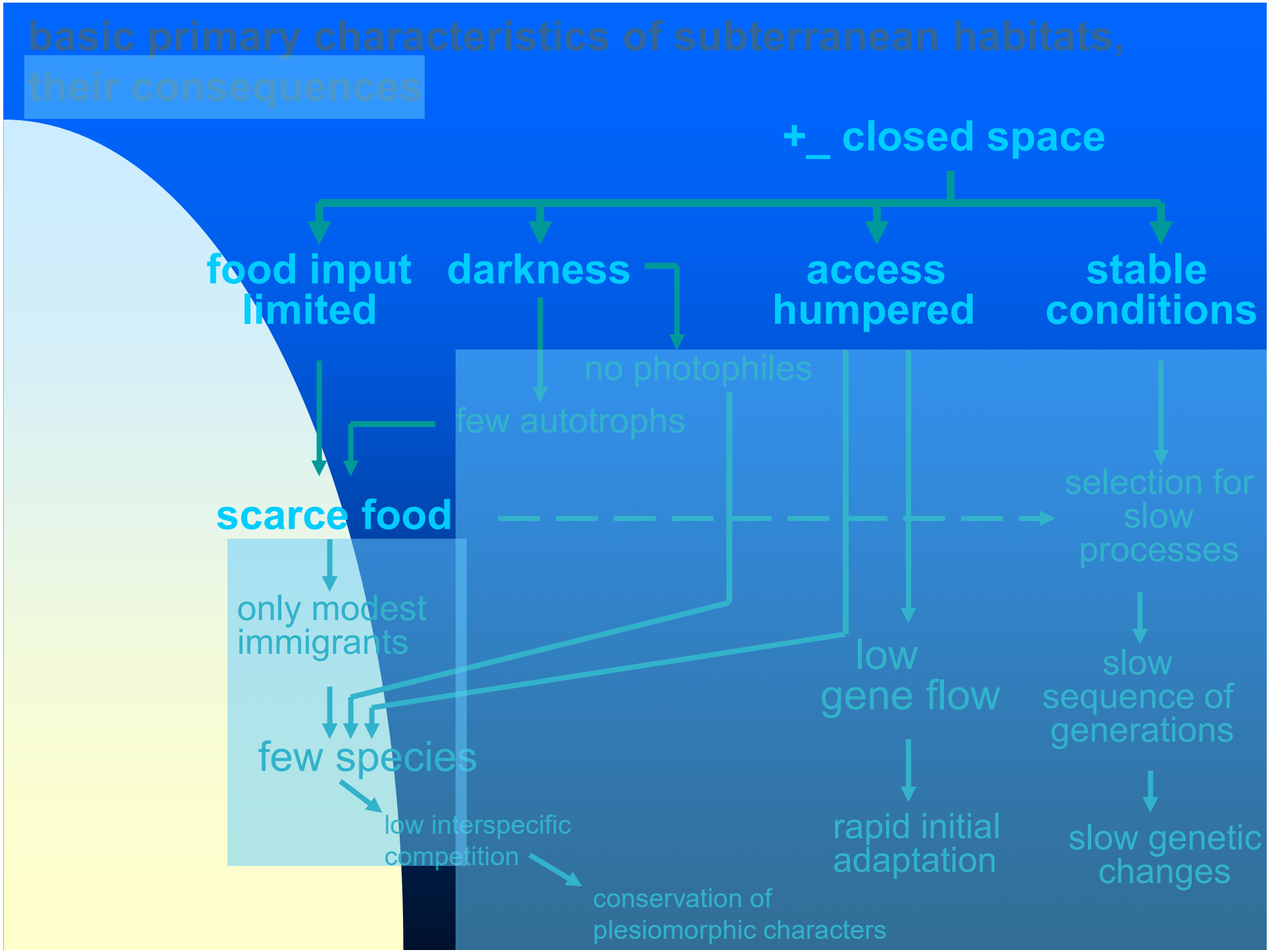
low interspecific competition

low gene flow

slow sequence of generations

conservation of plesiomorphic characters




basic primary characteristics of subterranean habitats,
their consequences
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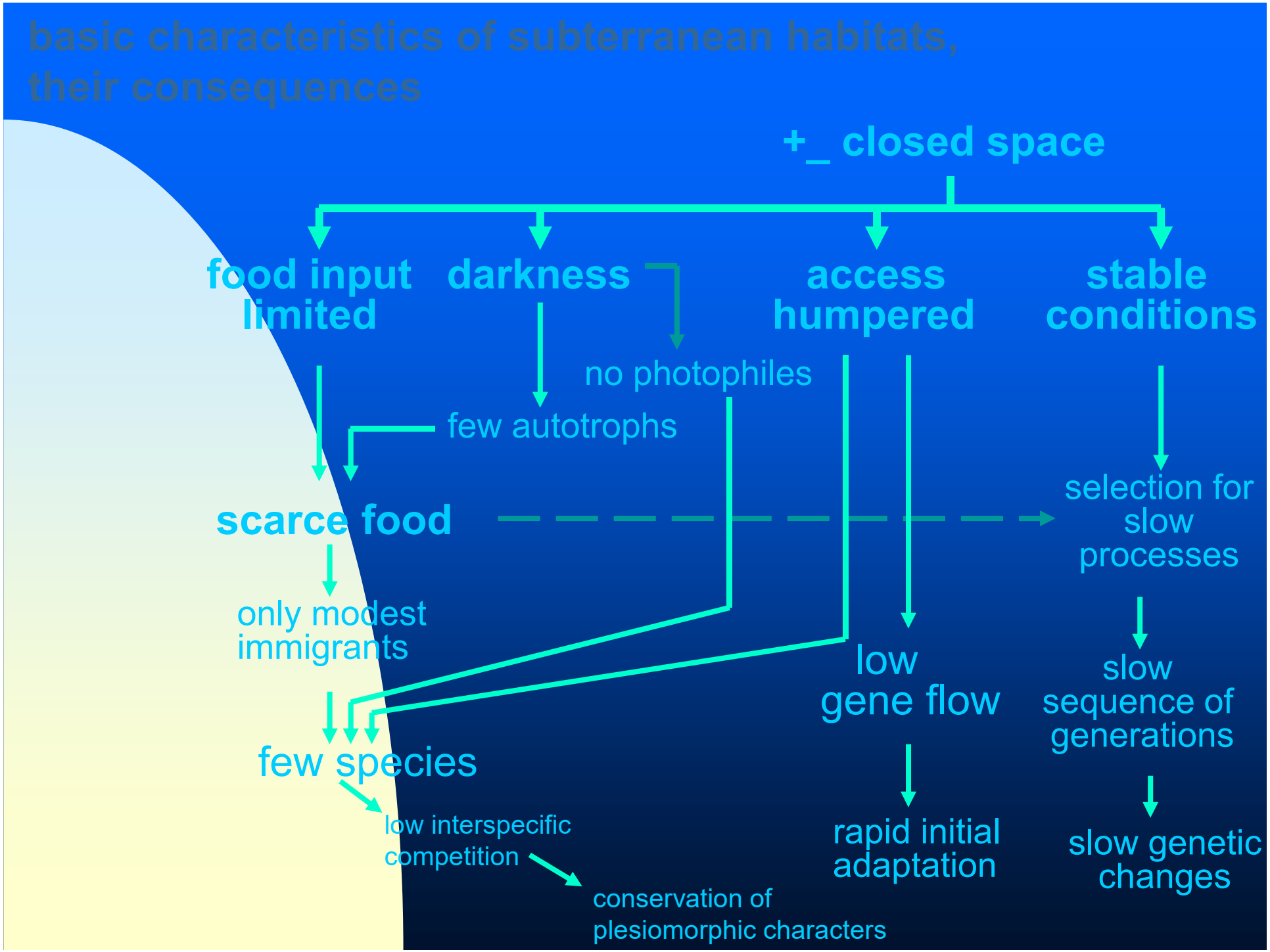
food input limited
darkness
access humpered
stable conditions
no photophiles
few autotrophs
scarce food
selection for slow processes
only modest immigrants
low gene flow
slow sequence of generations
few species
low interspecific competition
rapid initial adaptation
slow genetic changes
conservation of plesiomorphic characters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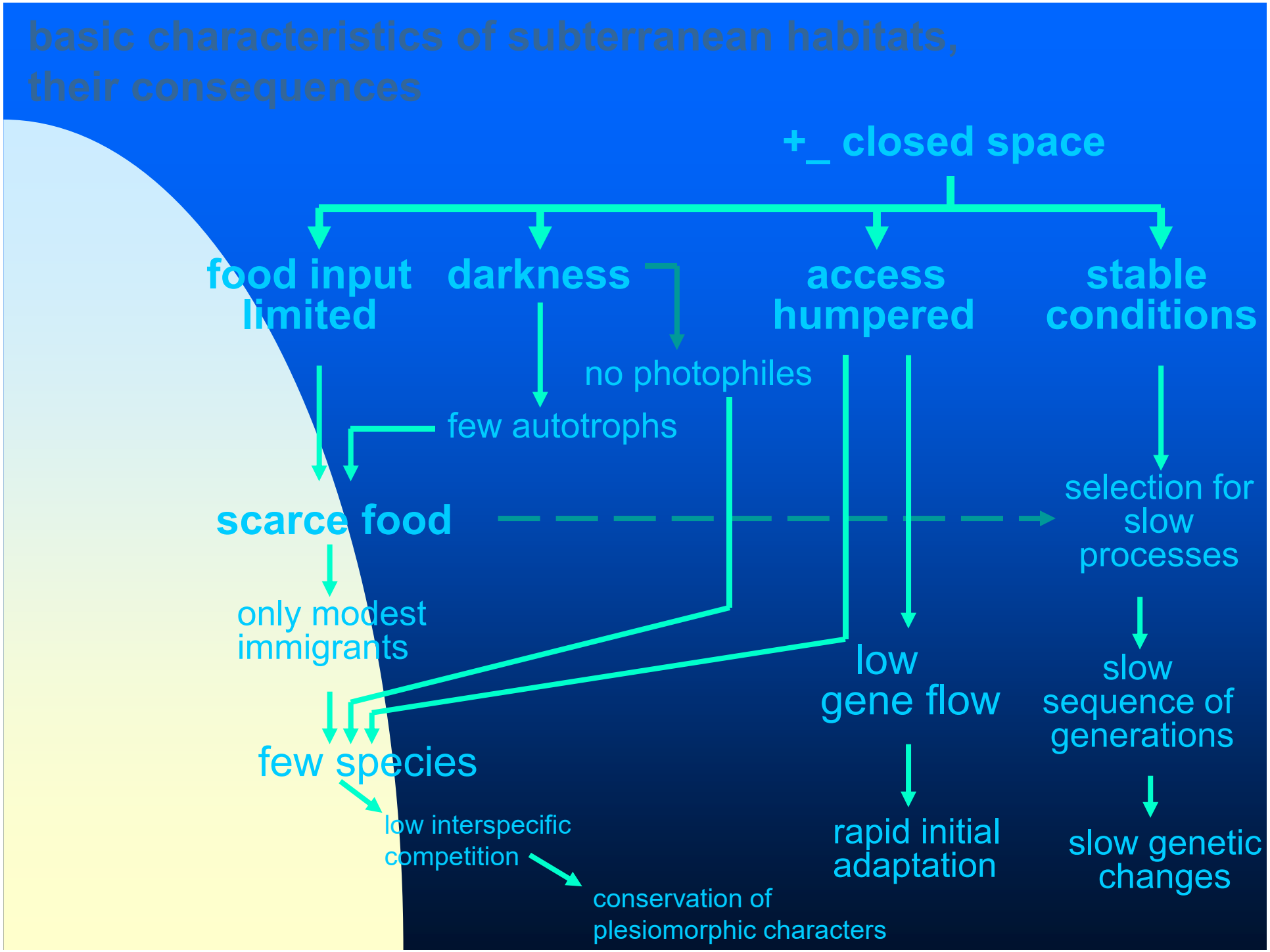
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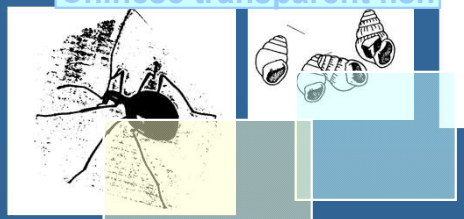
conservation of plesiomorphic characters

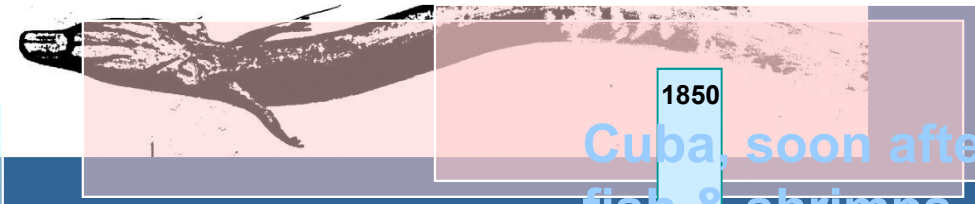
Anchihaline habitats as Ramsar wetlands?

What inhabits these "wetlands"?

Boris **Sket**
Oddelek za biologijo,Univerza v Ljubljani
Ljubljana, SLOVENIA

Chinese transparent fish



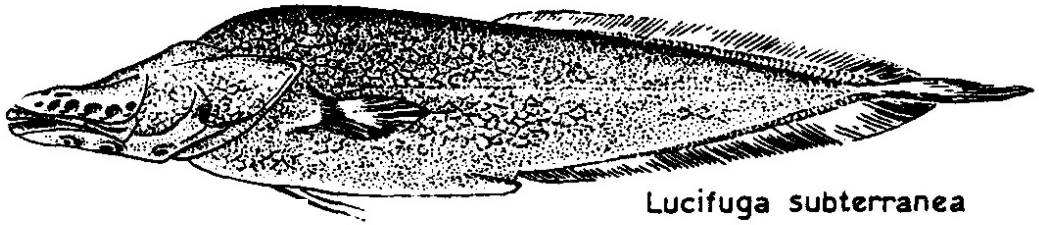


1850

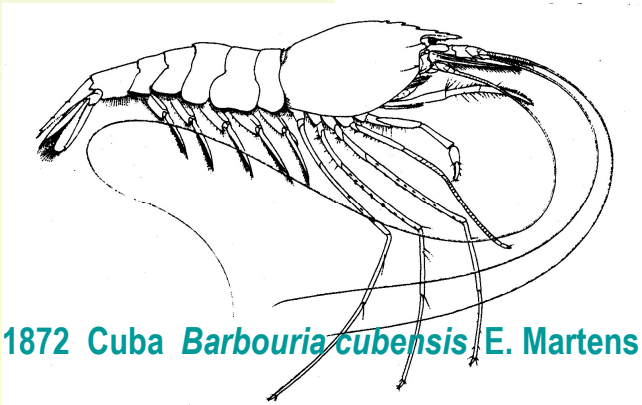
Cuba, soon after 1850
fish & shrimps

research of anchihaline waters started with discoveries in Cuba

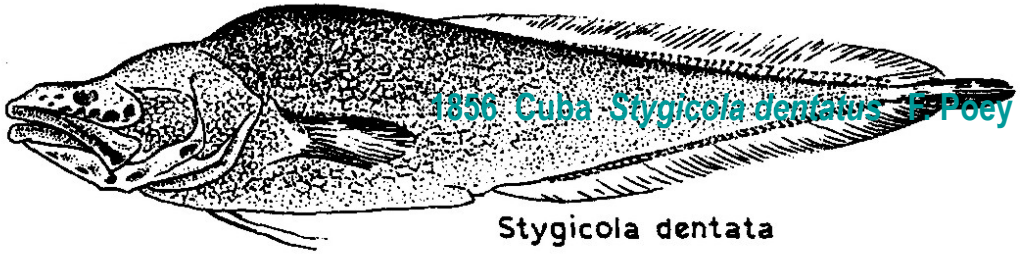
1900



Lucifuga subterranea



1872 Cuba *Barbouria cubensis* E. Martens



1856 Cuba *Stygicola dentatus* F. Poey

Stygicola dentata

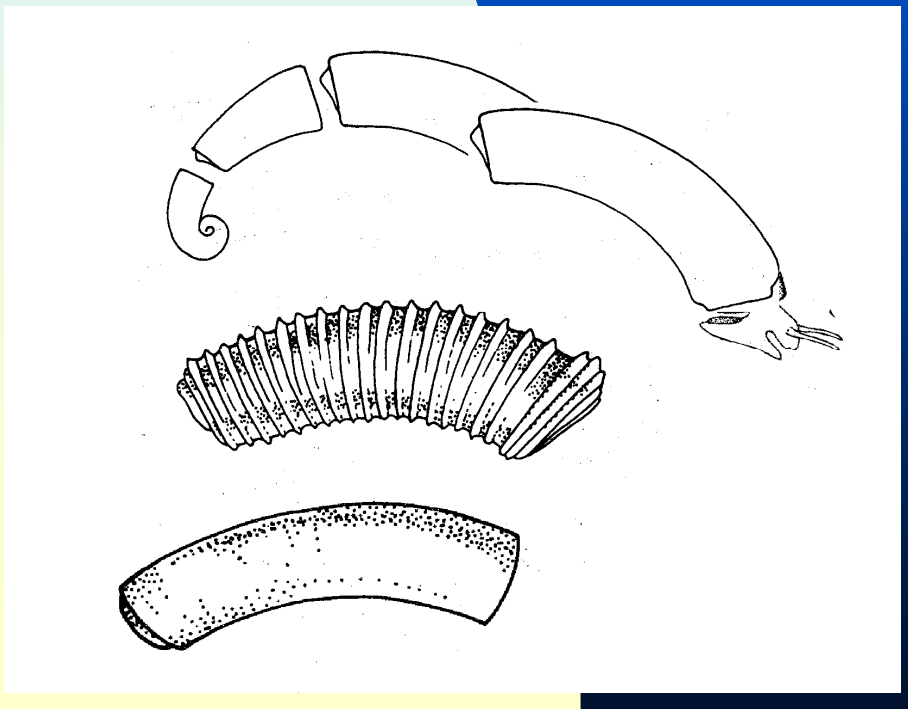
2000

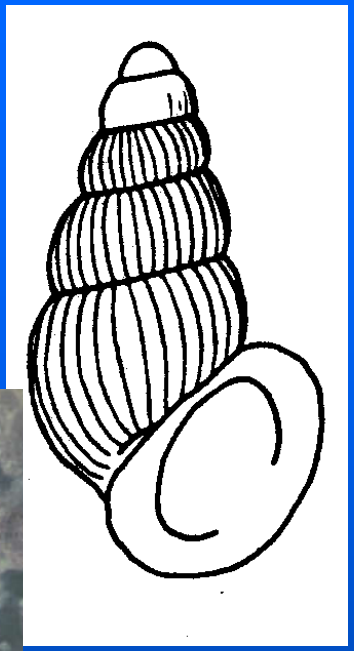
sponges (Porifera)

some marine, some mixohaline

***Higginsia ciccaresei* (Pansini & Pesce, 1998)**

Mollusca: Gastropoda

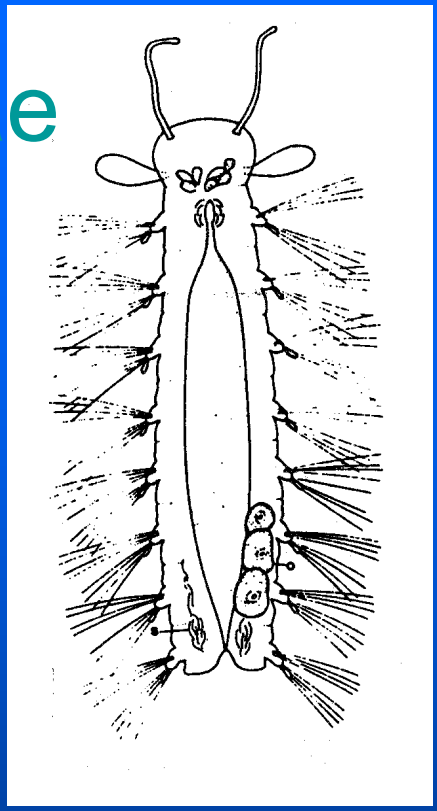




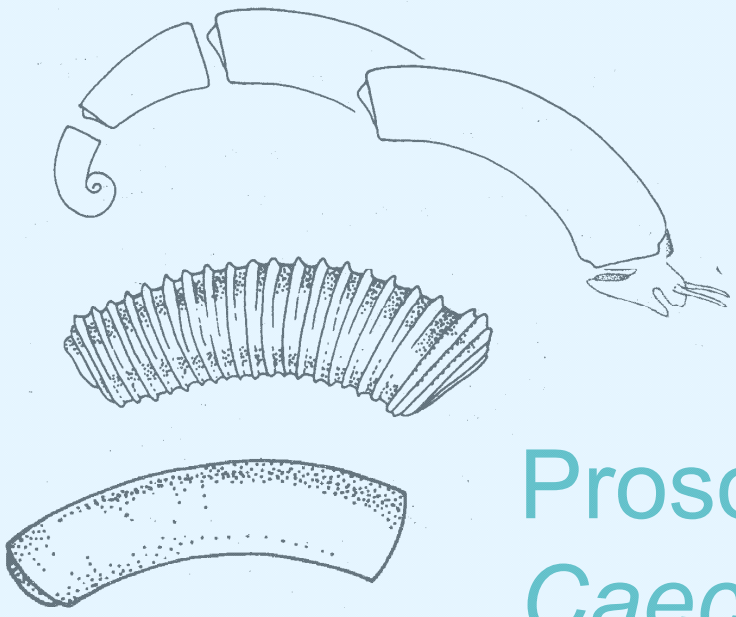
Opistobranchia
Saxurinator

Prosobranchia
Caecum

Polychaeta: Nerillidae



Mollusca: Gastropoda

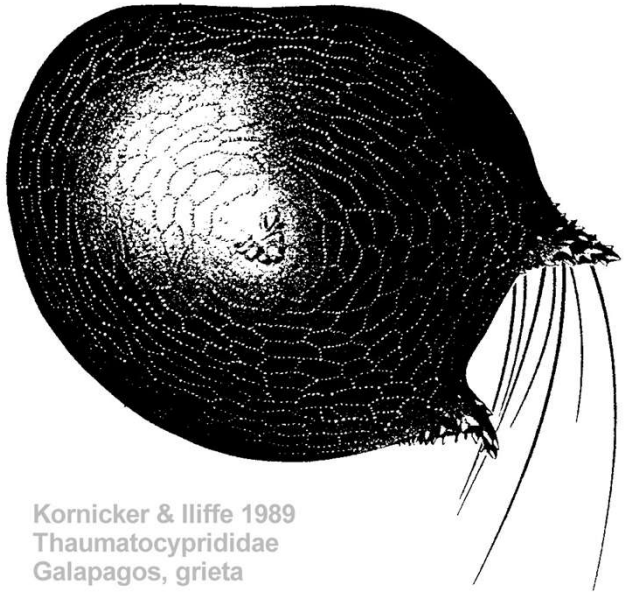


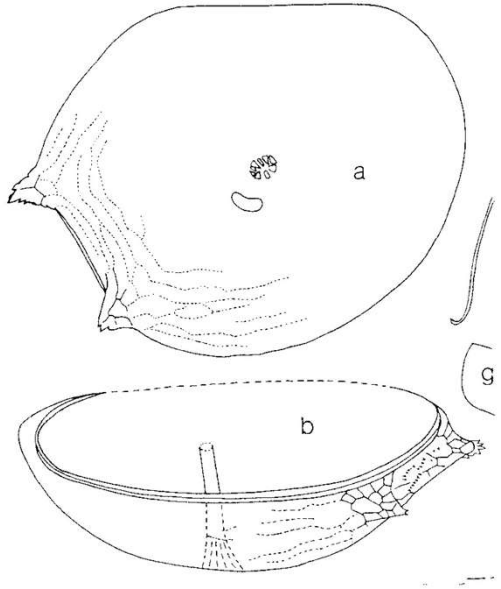
Prosobranchia

Caecum

Ostracoda

FIGURE 15.—*Danielopolina styx*, new species, USNM 193421, paratype, instar III, complete specimen from right side, length including anterior process, 0.57 mm.

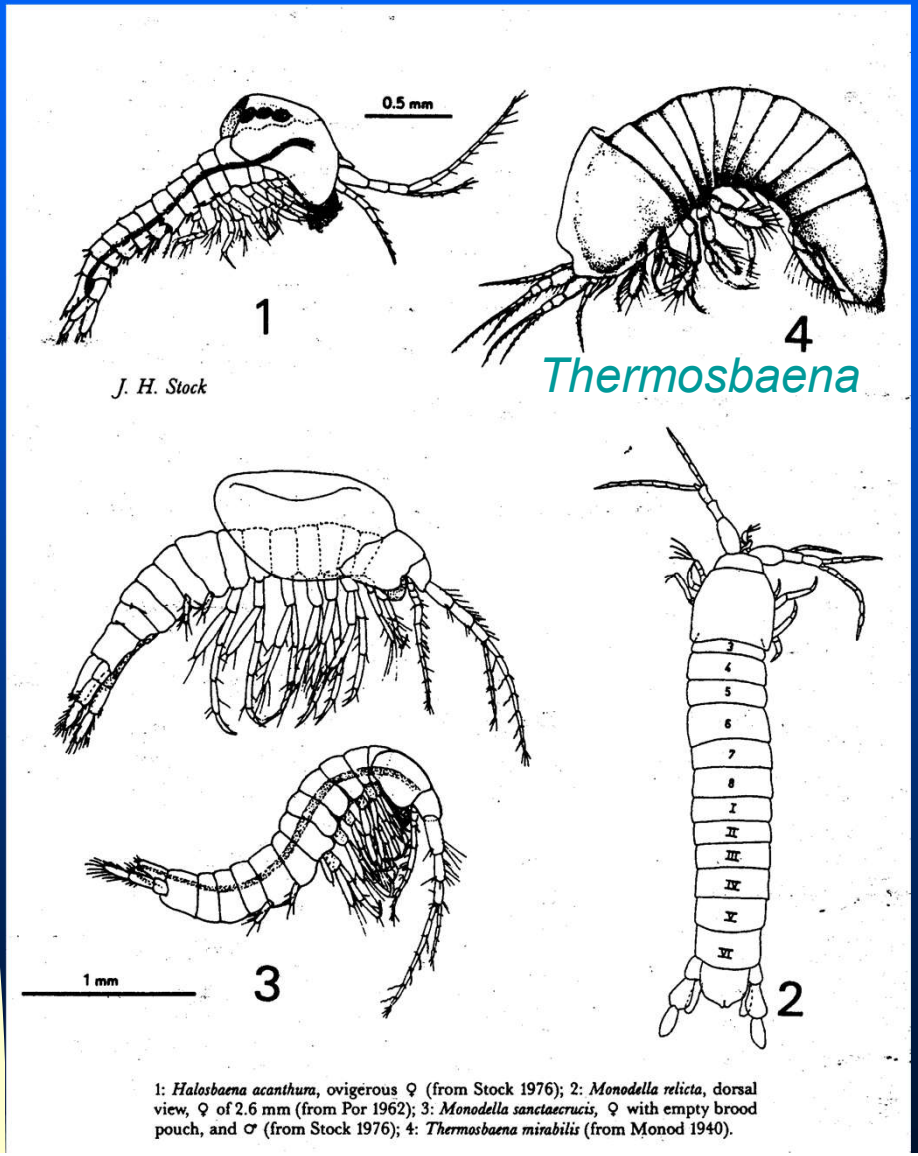




Kornicker & Iliffe 1989
Thaumatocypprididae
Galapagos, grieta

Thermosbaenacea

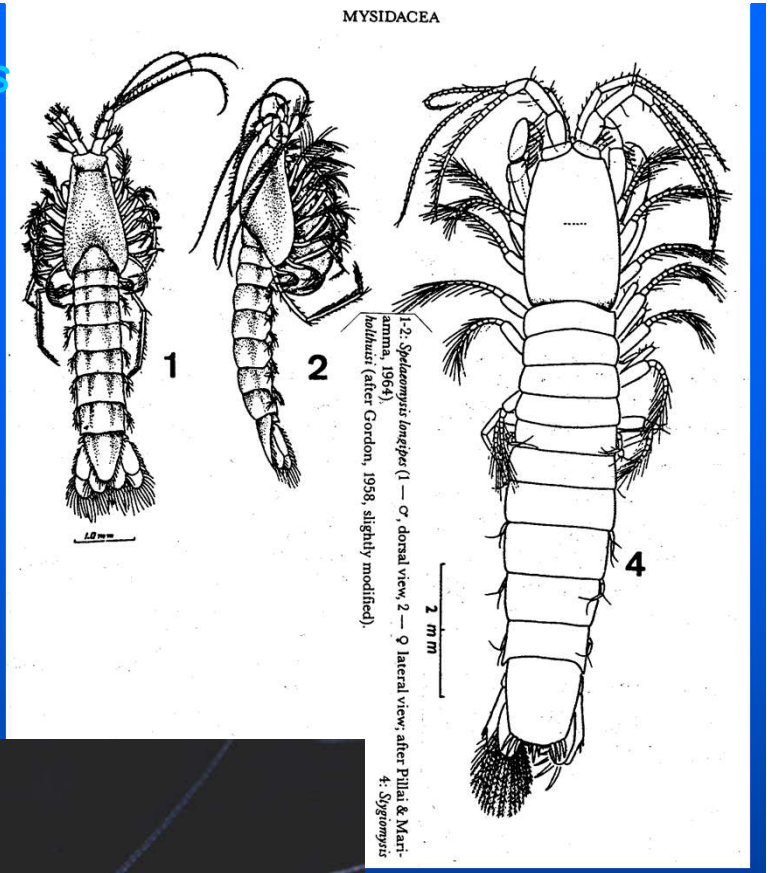
Monodella halophila
body length 3,5 mm



1: *Halosbaena acanthura*, ovigerous ♀ (from Stock 1976); 2: *Monodella relicta*, dorsal view, ♀ of 2.6 mm (from Por 1962); 3: *Monodella sanctaecrucis*, ♀ with empty brood pouch, and ♂ (from Stock 1976); 4: *Thermosbaena mirabilis* (from Monod 1940).

Mysidacea

Spelaeomysis



1-2, *Spelaeomysis longipes* (1 — ♂, dorsal view, 2 — ♀ lateral view; after Pillai & Mariamma, 1964). *holthuzi* (after Gordon, 1958, slightly modified). 4: *Stygiomysis*

Troglomysis vjetrenicensis

Mysidae

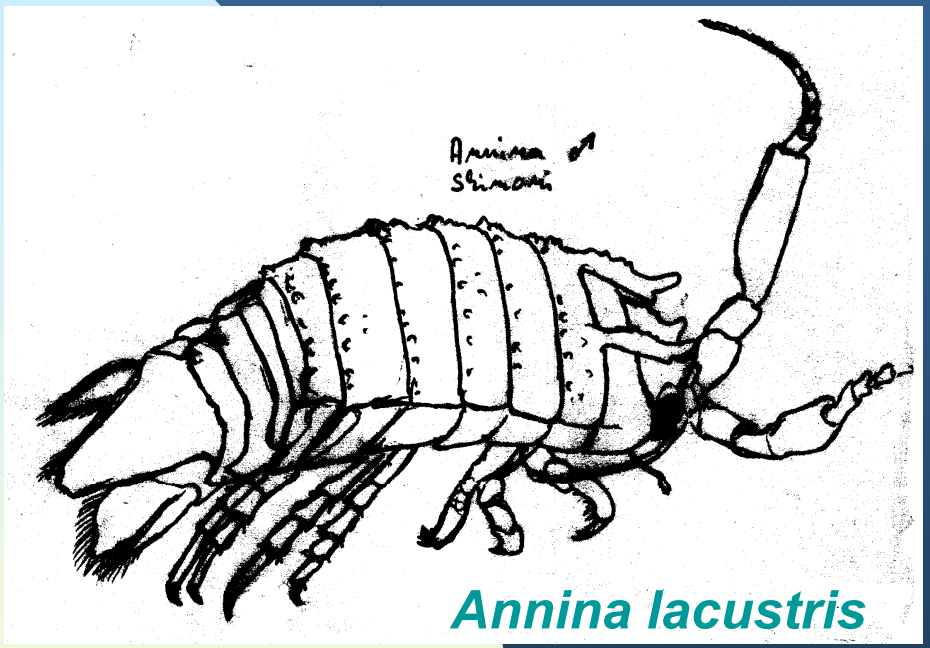
Stygiomysis

1850

1900

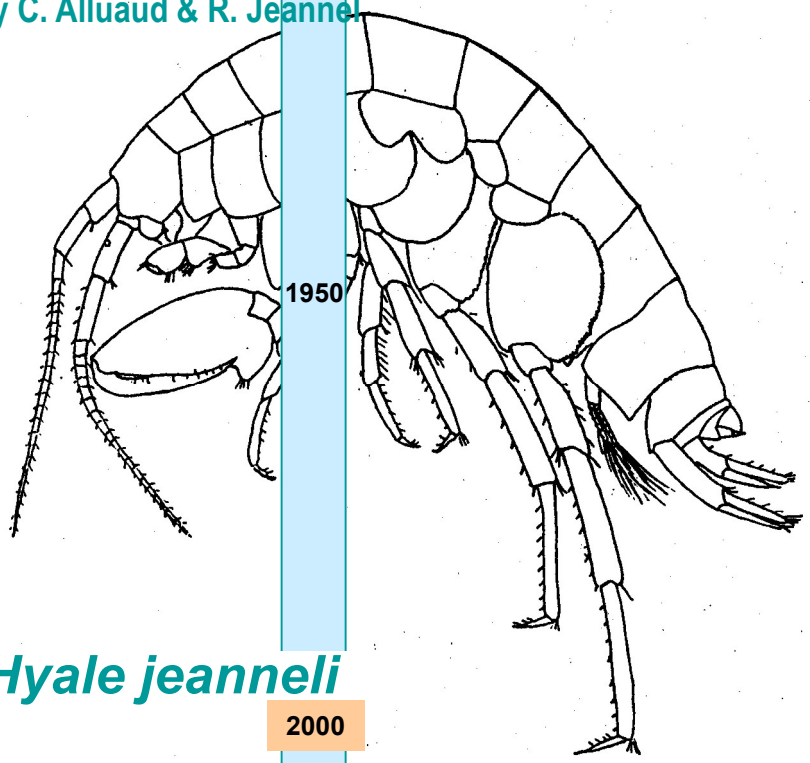
1912 Zanzibar & Shimoni (Kenya)

by C. Alluaud & R. Jeannel

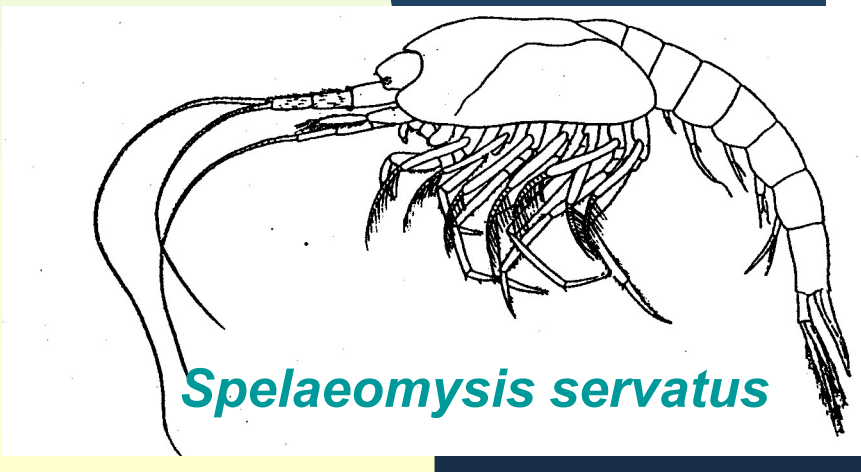


Annina lacustris

1950



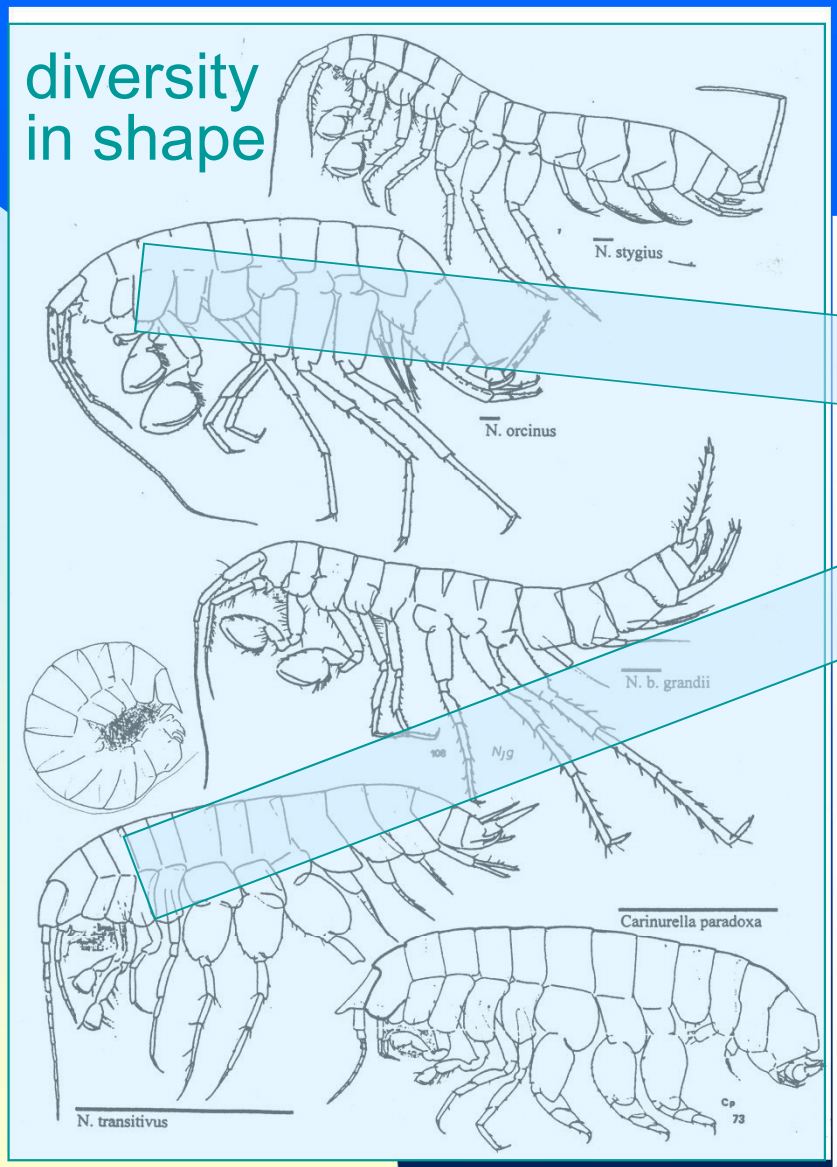
Hyale jeanneli



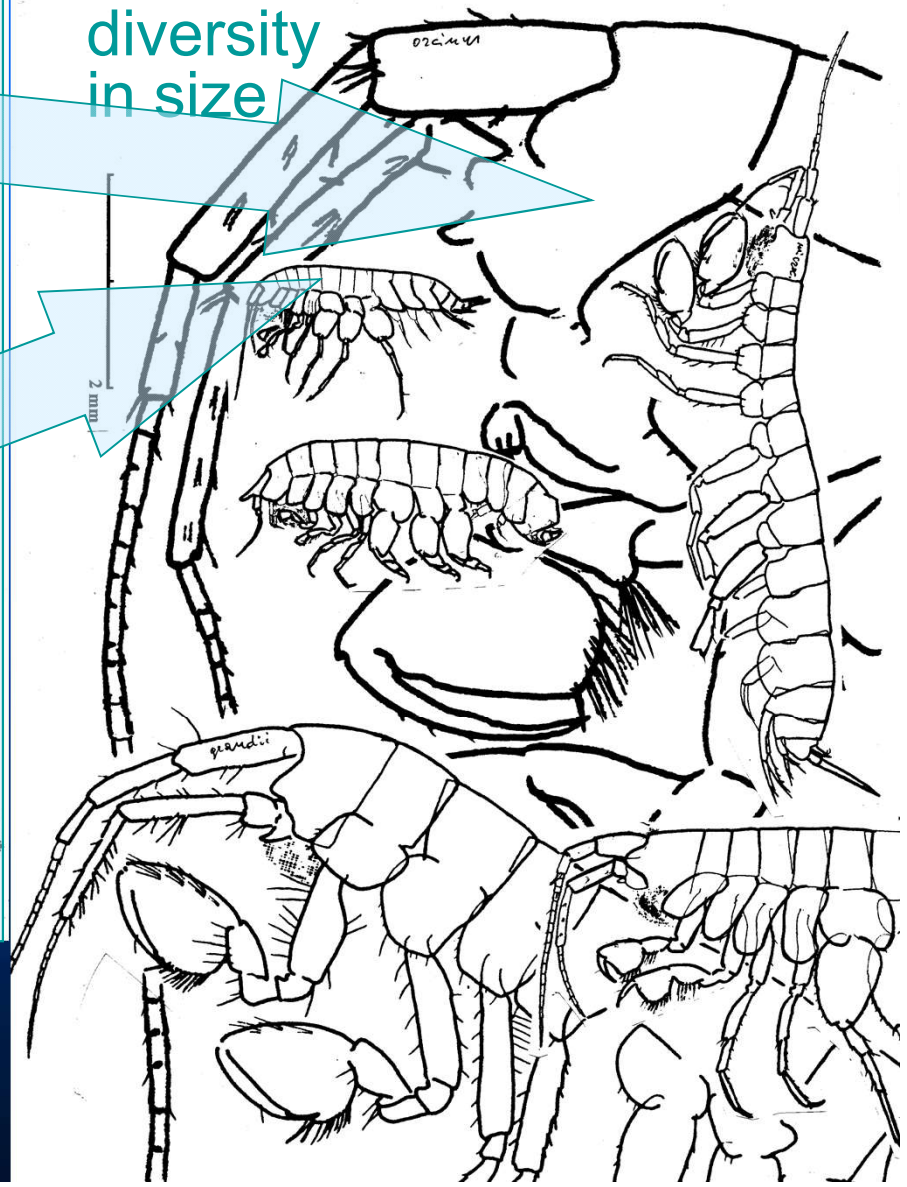
Spelaeomysis servatus

2000

diversity
in shape



diversity
in size



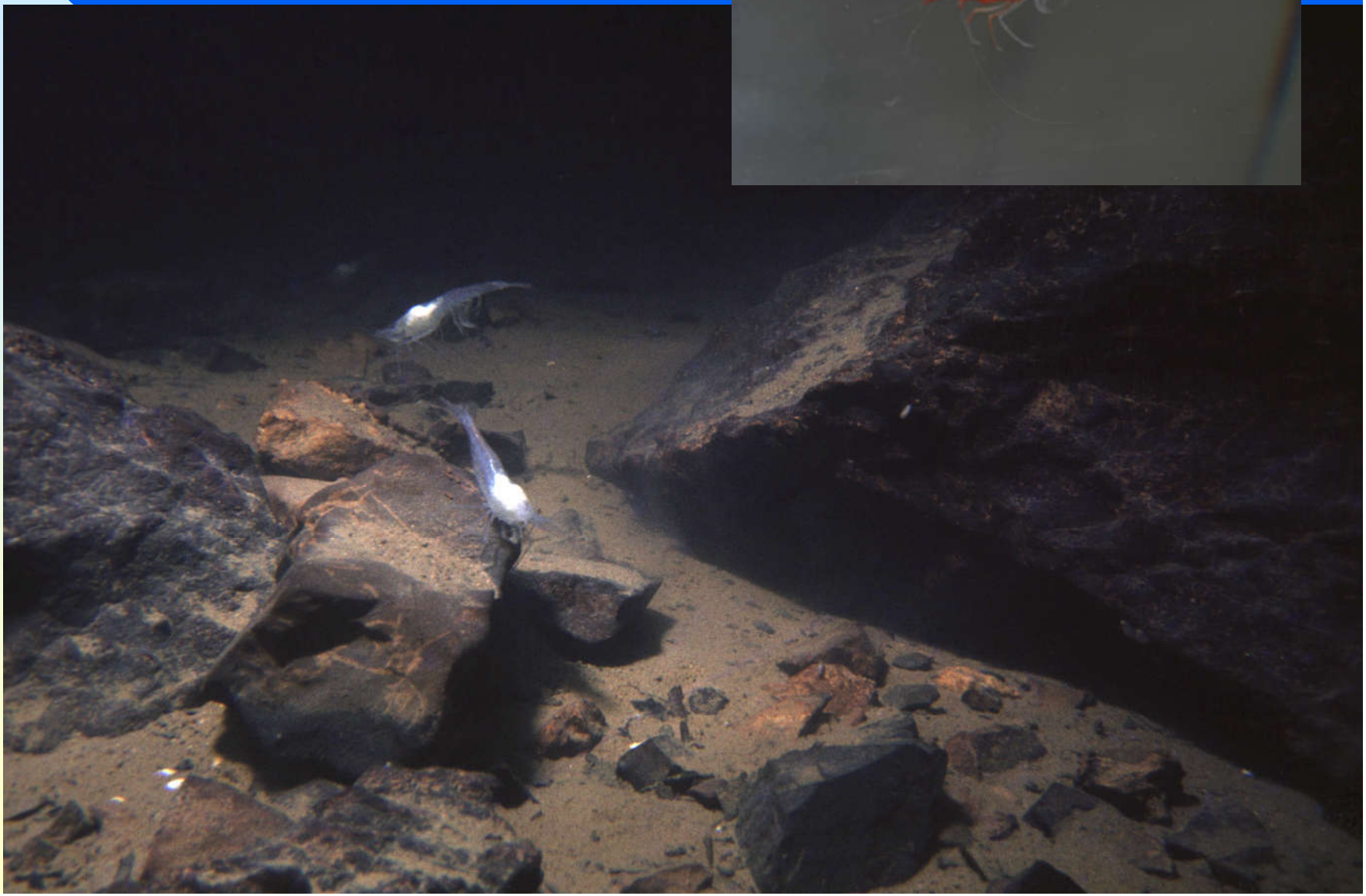
Amphipoda:
Niphargidae

Niphargus spp.

... diversity in biology
e.g. for 0 – 35 ppt salinity

Niphargus pectencoronatae

(Troglocaris anophthalmus
Decapoda: Atyidae)



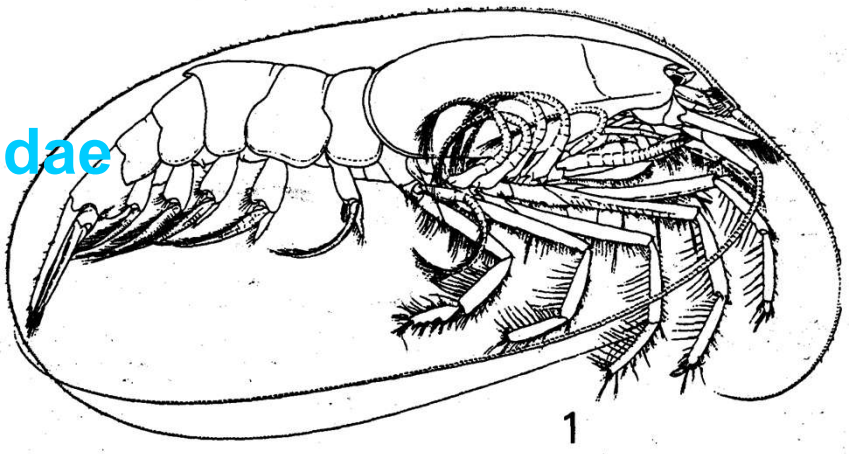
Halocaridina rubra,
opae'ula,
Atyidae

Decapoda: Caridea

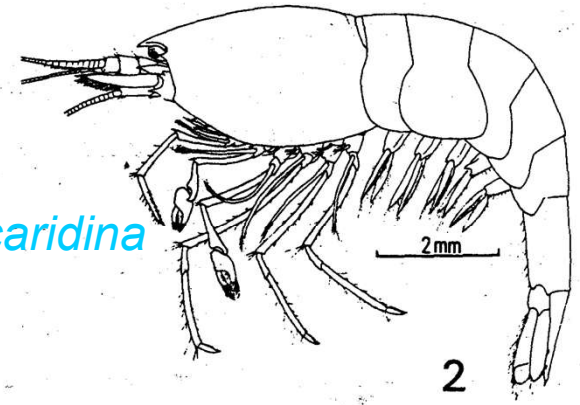
Procarididae

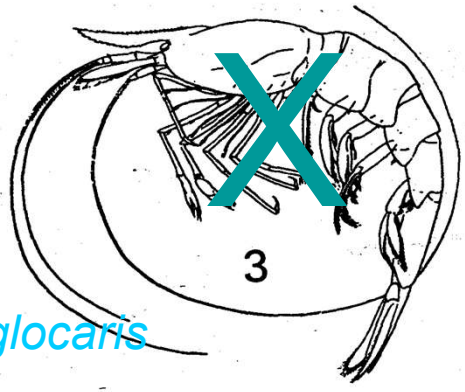
Procaris

Atyidae

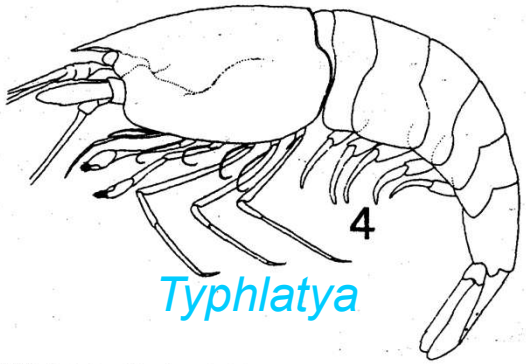


Antecaridina





Troglocaris

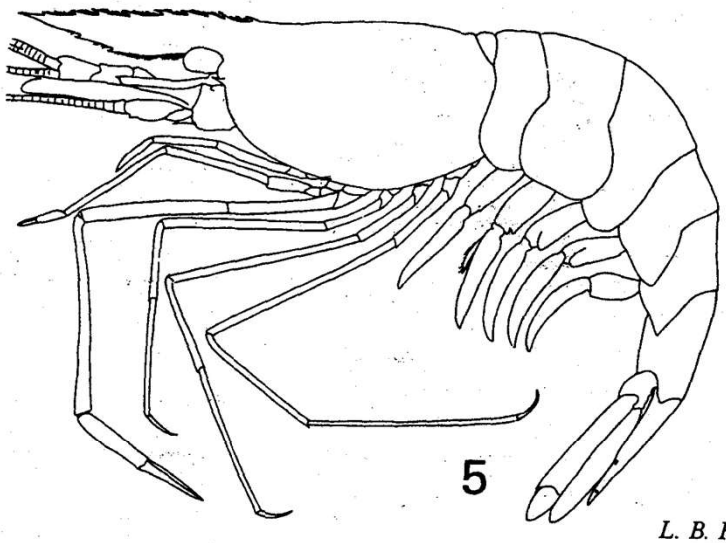


Typhlatya

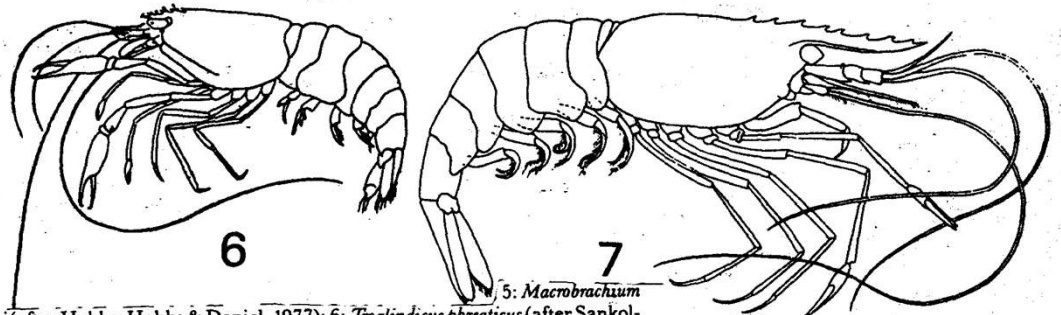
1: *Procaris ascensionis* (after Chace & Manning, 1972); 2: *Antecaridina lauensis* (after Suzuki, 1980); 3: *Troglocaris a. anophthalmus* (after Stammer, 1932, Zool. Jb. Syst., 63 (5/6): 606); 4: *Typhlatya pearsei* (after Hobbs, Hobbs & Daniel, 1977).

Decapoda:
Caridea:

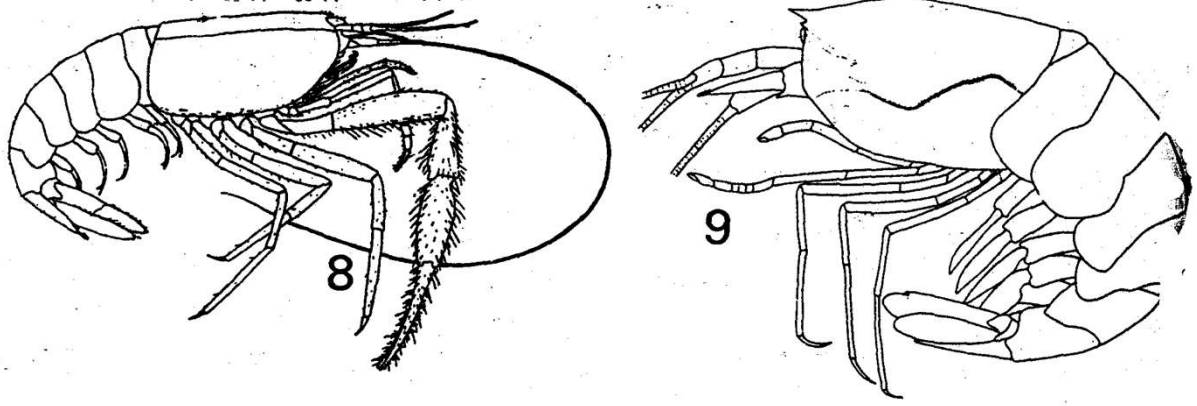
Palaemonidae
Alpheidae



L. B. Holthuis



5: *Macrobrachium villalobosi* (after Hobbs, Hobbs & Daniel, 1977); 6: *Troglindicus phreaticus* (after Sankolli & Shenoy, 1979); 7: *Troglocubanus eigenmanni* (after Hobbs, Hobbs & Daniel, 1977); 8: *Typhlocaris galilea* (after Calman, 1909, Trans. Linnean Soc. London, Zool. (2) 11 (5): pl. 19); 9: *Potamalpheops stygicola* (after Hobbs, Hobbs & Daniel, 1977);



1850

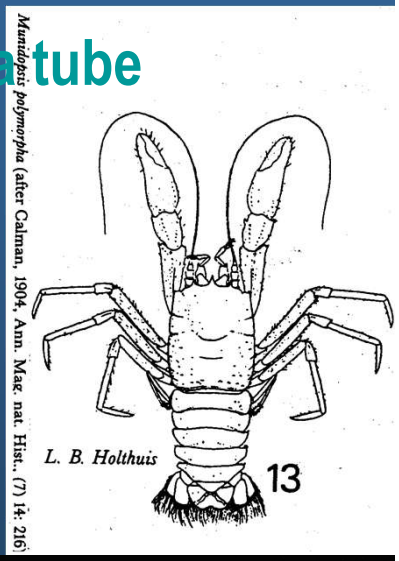
1900

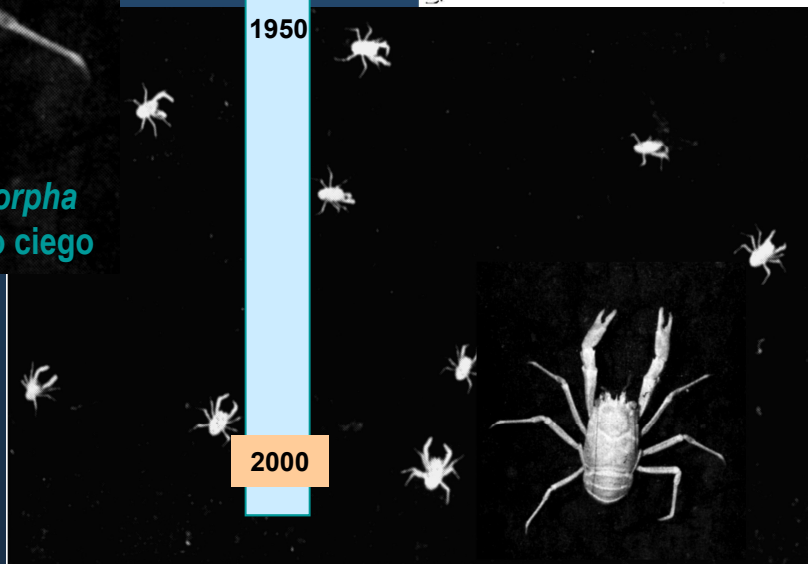
1950

2000

1892 Islas Canarias, in a lava tube

Munidopsis polymorpha
jameito or cangrejo ciego



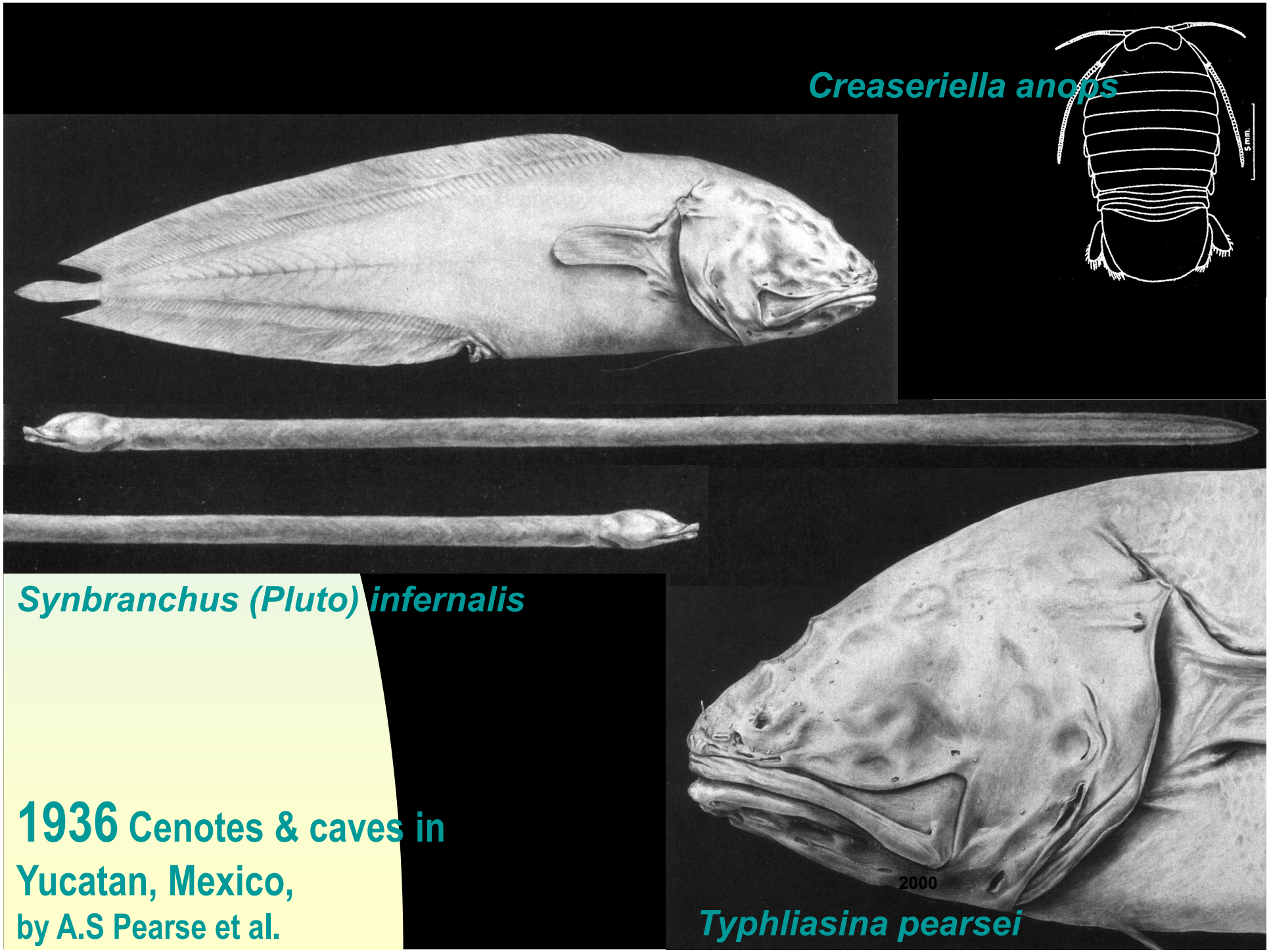


Although otherwise being the corollary group in anchihaline waters,
some groups of Crustacea are gleaming by their absence there.

Isopoda: Sphaeromatidae

Monolistra – a species rich freshwater genus

belonging
to a virtually marine
family,
virtually absent in anchihaline
waters


Creaseriella anops
5 mm.
Synbranchus (Pluto) infernalis
1936 Cenotes & caves in
Yucatan, Mexico,
by A.S Pearse et al.
2000
Typhliasina pearsei

		acc to Riedl **1966**	acc to Botosaneanu **1986**	Sket **1997**	**2004** ca
sponges	**Porifera**			3	4
flatworms	**Turbellaria**			1	1
snails	**Gastropoda**			5	5
annelids	**Annelida**			10	10
arrowworms	**Chaetognatha**			4	4
mites	**Acari**				3
crustaceans	**Crustacea**	26		305-350	410
fish	**Pisces**	5		10	10
		31	**150**	**339-384**	**445**

1966 > > > 2004

90% are Crustacea

known composition of anchihaline fauna

biogeography (only by-the-way):

circumtropical elements,
Tethyan elements
endemics

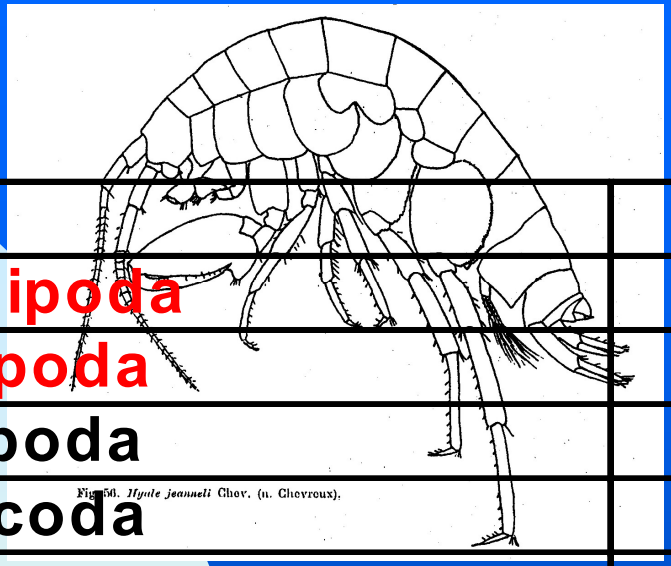
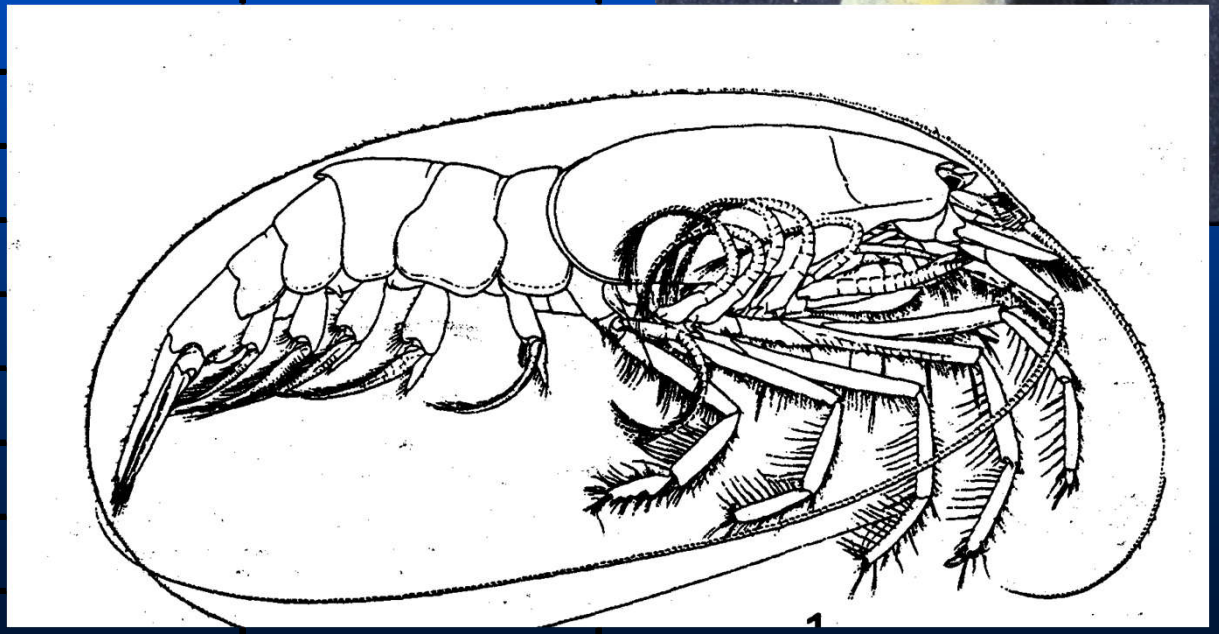


Fig. 50. *Hyale jeanneli* Chev. (n. Chevreux).

Amphipoda	100
Copepoda	60
Decapoda	50
Ostracoda	45
Mysidacea	40
Isopoda	40
Thermosbaenac	
Cumacea	
Remipedia	
Tanaidacea	
Mictacea	
Syncarida	
Leptostraca	
Tantulocarida	



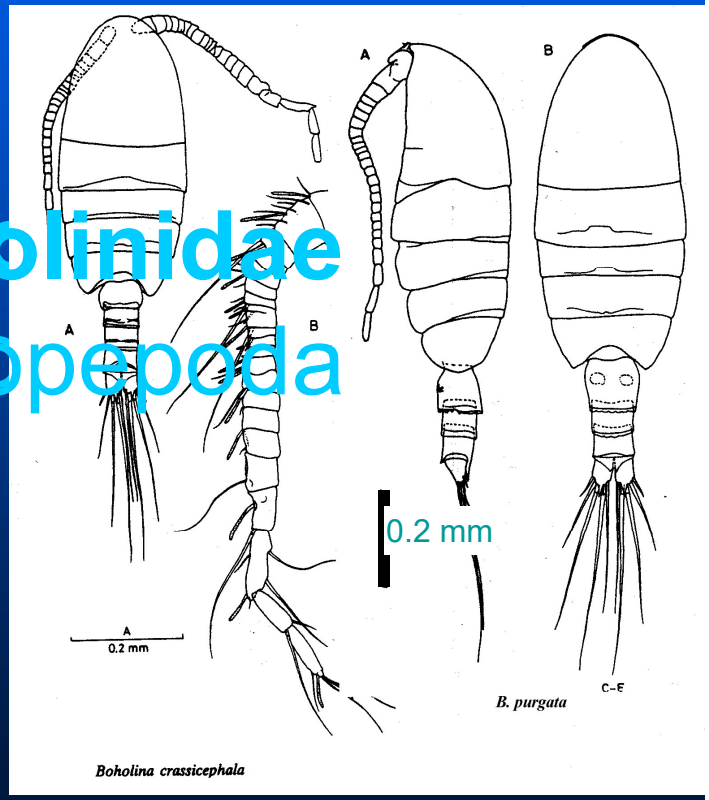
some families of different crustacean groups are endemic to anchihaline habitats

Amphipoda	**100**
Copepoda	**60**
Decapoda	**50**
Ostracoda	**45**
Mysidacea	**40**
Isopoda	**40**
Thermosbaenac	**35**
Cumacea	15
Remipedia	15
Tanaidacea	4
Mictacea	2
Syncarida	2
Leptostraca	1
Tantulocarida	1

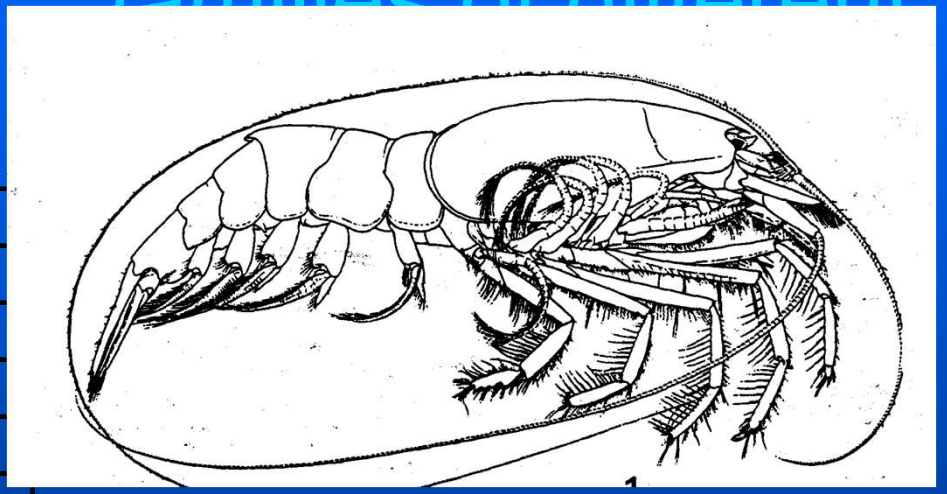
Amphipoda	100
Copepoda	60
Decapoda	50
Ostracoda	45
Mysidacea	40
Isopoda	40
Thermosbaenac	35
Cumacea	15
Remipedia	15
Tanaidacea	4
Mictacea	2
Syncarida	2
Leptostraca	1
Tantulocarida	1

Entirely anchihaline are some families of different crustacean groups, like:

Boholinidae of Copepoda



Entirely anchihaline are some families of different



peculiar **Procarididae** of Decapoda

Amphipoda	**100**
Copepoda	**60**
Decapoda	**50**
Ostracoda	**45**
Mysidacea	**40**
Isopoda	**40**
Thermosbaenac	**35**
Cumacea	15
Remipedia	15
Tanaidacea	4
Mictacea	2
Syncarida	2
Leptostraca	1
Tantulocarida	1

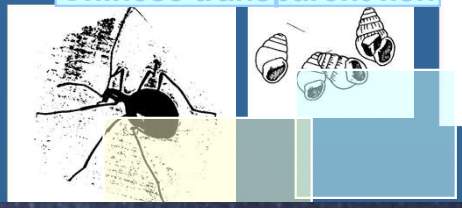
Genus ***Typhlatya*** and relatives are the only (marginally) marine members of the family **Atyidae** which is successful today **in fresh waters**

Amphipoda	**100**
Copepoda	**60**
Decapoda	**50**
Ostracoda	**45**
Mysidacea	**40**
Isopoda	**40**
Thermosbaenac	**35**
Cumacea	15
Remipedia	15
Tanaidacea	4
Mictacea	2
Syncarida	2
Leptostraca	1
Tantulocarida	1

but, REMIPEDIA are the only taxonomic group above family level, bound to anchihaline waters.

Amphipoda	**100**
Copepoda	**60**
Decapoda	**50**
Ostracoda	**45**
Mysidacea	**40**
Isopoda	**40**
Thermosbaenac	**35**
Cumacea	15
Remipedia	15
Tanaidacea	4
Mictacea	2
Syncarida	2
Leptostraca	1
Tantulocarida	1

Chinese transparent fish



1850

1856 Cuba *Stygicola dentatus* F. Poey

1872 Cuba *Barbouria cubensis* E. Martens

1892 Islas Canarias *Munidopsis polymorpha* by K. Koelbel

1900

1904 Coves del Drac *Typhlocirolana moraguesi* by E. Racoviţă

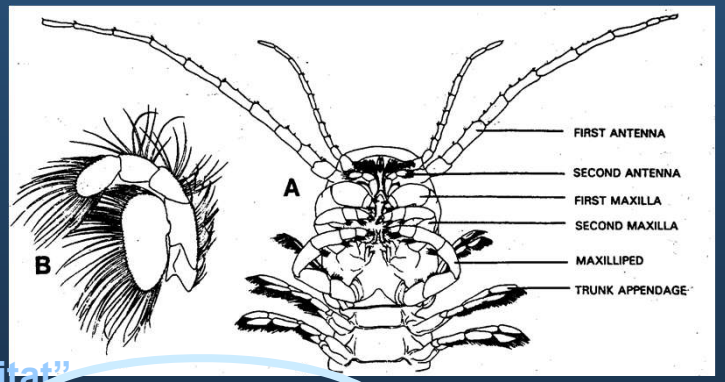
Zanzibar & Shimoni (Kenya) by C. Alluaud & R. Jeannel

1900

etc.

etc.

1950



etc.

Holthuis 1973

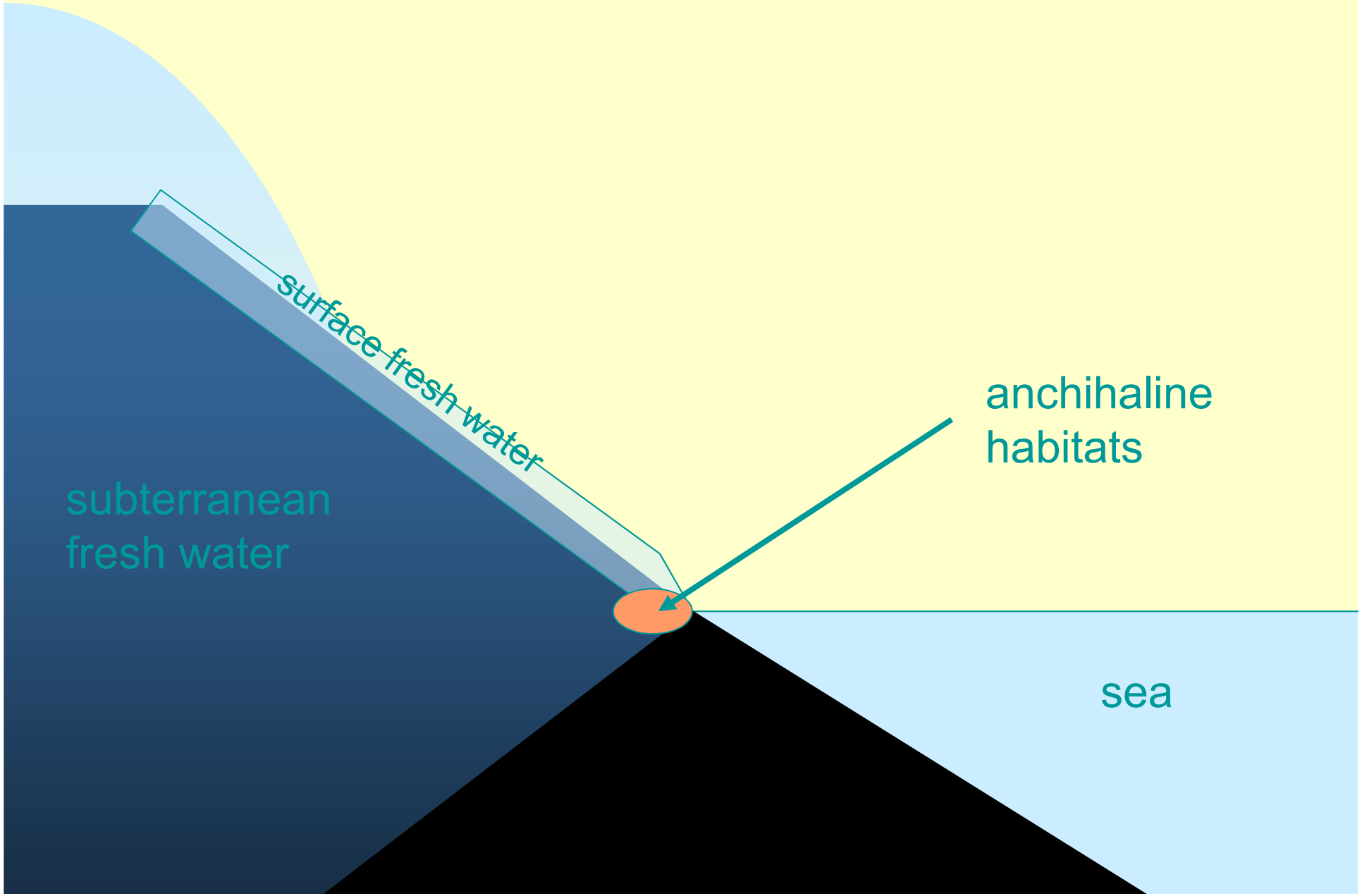
"anchialine habitat"

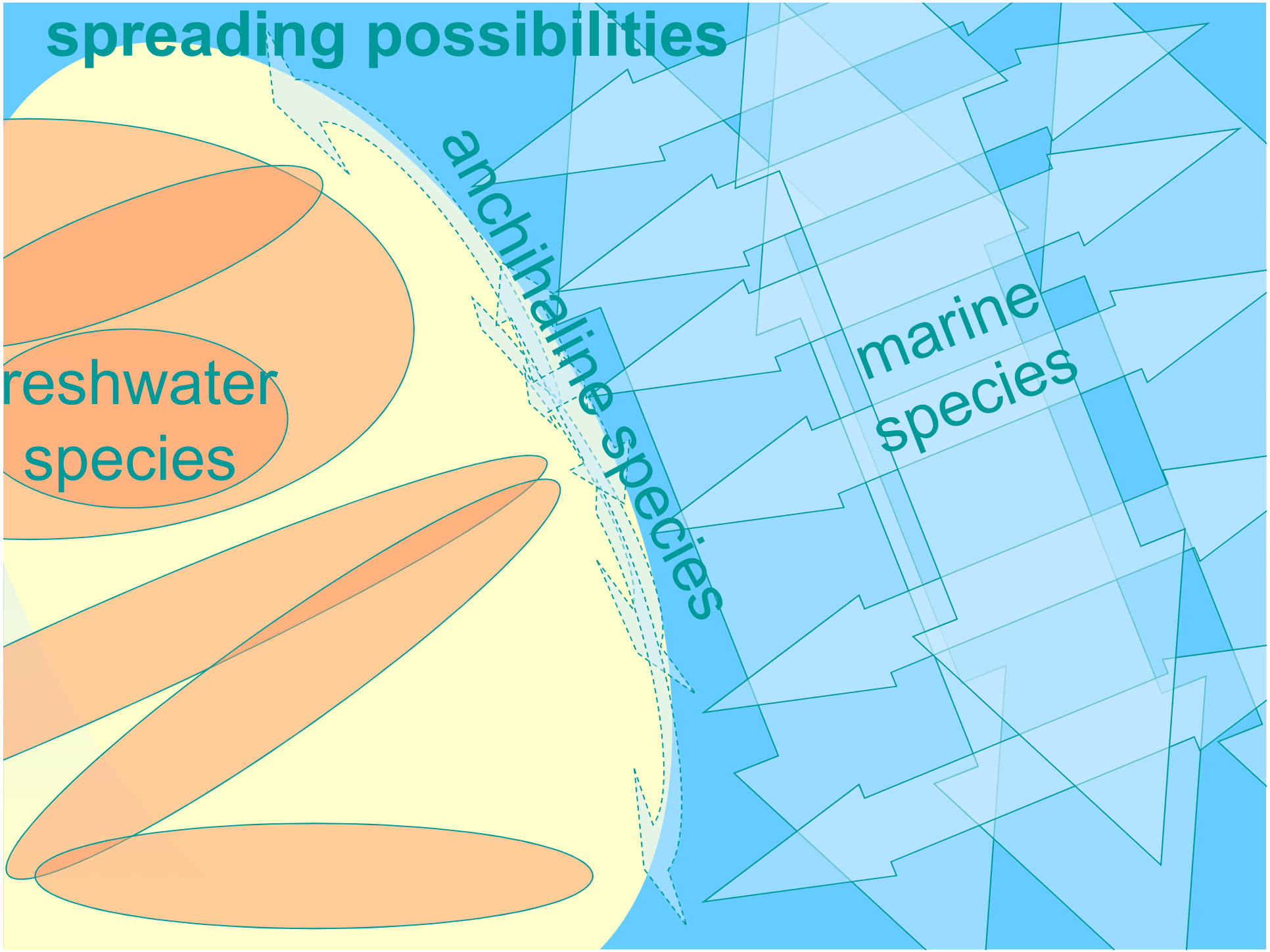
1981 Bahamas – group REMIPEDIA J. Yager

etc.

2000

the anchihaline realm is very restricted




spreading possibilities
reshwater species
anchihaline species
marine species

Anchihaline habitats as Ramsar wetlands?

Boris **Sket**
Oddelek za biologijo,Univerza v Ljubljani
Ljubljana, SLOVENIA

To protect them?

Why?

(Is it necessary?)

threats

Actual and potential threats to anchihaline sites.

- excessive pumping of fresh water ?
- damming up of coastal underground water corridors
- use of any pesticides within the drainage area
- infrastructure development (particularly for the booming “tourist industry” in coastal sites),
- inappropriate landscape shaping (for the same purpose),
- extraction of the rock (limestone in limestone poor

threats

Actual and potential threats to anchihaline sites.

- excessive pumping of fresh water ?
- damming up of coastal underground water corridors
- use of any pesticides within the drainage area
- infrastructure development (particularly for the booming “tourist industry” in coastal sites),
- inappropriate landscape shaping (for the same purpose),
- extraction of the rock (limestone in limestone poor areas),
- extraction of other earth born goods in the area (oil, phosphates, ..),

poor areas),
- extraction of other earth born goods in the area (oil, phosphates, ..),
- pollution of groundwater (and dumping in caves or karst depressions), including by excessive fertilization of fields,
- excessive pumping of fresh water in hydrographically closed areas, (otherwise it might in some cases widen the anchihaline realm)
- use of any pesticides within the drainage area.

threats

threats

ORNAMENTAL FISH PONDS AS PART OF LANDSCAPING

Colorful Japanese Koi are popular fish to grow in natural anchialine ponds in the hotel and resort areas. The beautiful natural lava formations provide a stunning pond bottom and the fish thrive. Such fish ponds are attractive and ideal for both businesses and residences where these ponds exist naturally. These are on the grounds of a hotel in Hilo's Banyan Drive. ML anchialine 4 Liliukalani Hilo Aug 03.jpg (31849 bytes) Hilo's famed Liliuokalani Gardens on Banyan Drive is one of the larger Japanese style gardens that was originally a series of anchialine ponds where opae-ula was once the only inhabitant. ML anchialine 2 Seaside Hilo Aug 03.jpg (29666 bytes) Some anchialine ponds are large and

Posted on: Monday, March 1, 2004

Hawai'i's little **red shrimp are a hot item**

Advertiser Science Writer

Tiny red Hawaiian shrimp that live in anchialine ponds and underground crevices are turning into a popular aquarium species.

Hawai'i's red pond shrimp, known in Hawaiian as **'opae 'ula**, have become a popular addition to aquariums. However, heavy collecting as well as predatory fish could threaten the tiny creatures.

Since...

this “hot item”, the red shrimp opae’ula, or *Halocaridina rubra*, is an inhabitant of the Hawaiian anchihaline ponds

To protect them?

What for?

(Is it worth doing?)

- anchihaline habitats are **peculiar** and very **restricted**

- their fauna is **unique**, although not particularly rich

- their fauna **helps us to understand** the colonisation of “extreme habitats”*

* marine ➡ freshwater
surface ➡ subterranean

To protect them?

How?

(Is it possible, feasible?)

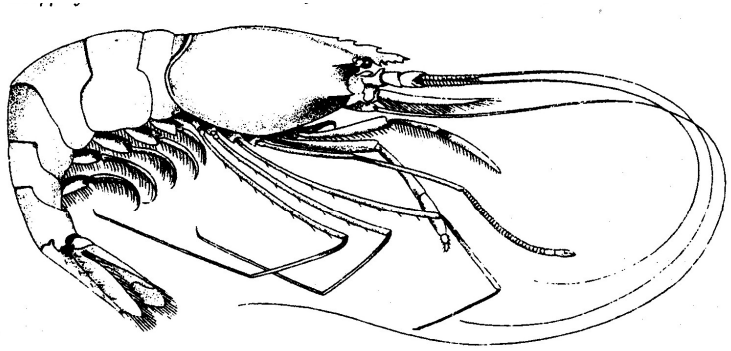


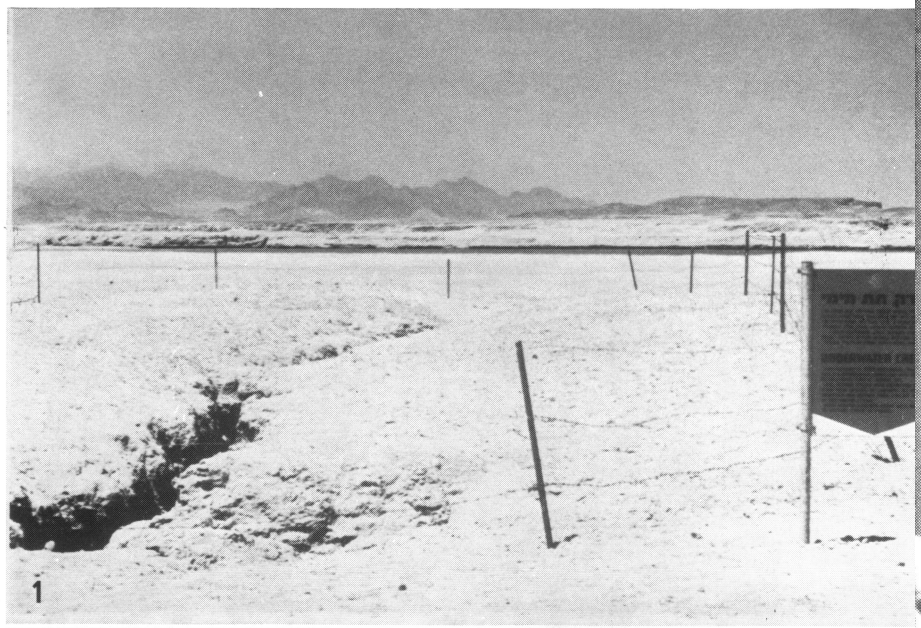
Fig. 244. *Parhippolyte uveae* Borradaile, 1899. After Borradaile, 1899, Willey's Zool. Results, 4: pl. 38 fig. 11a.

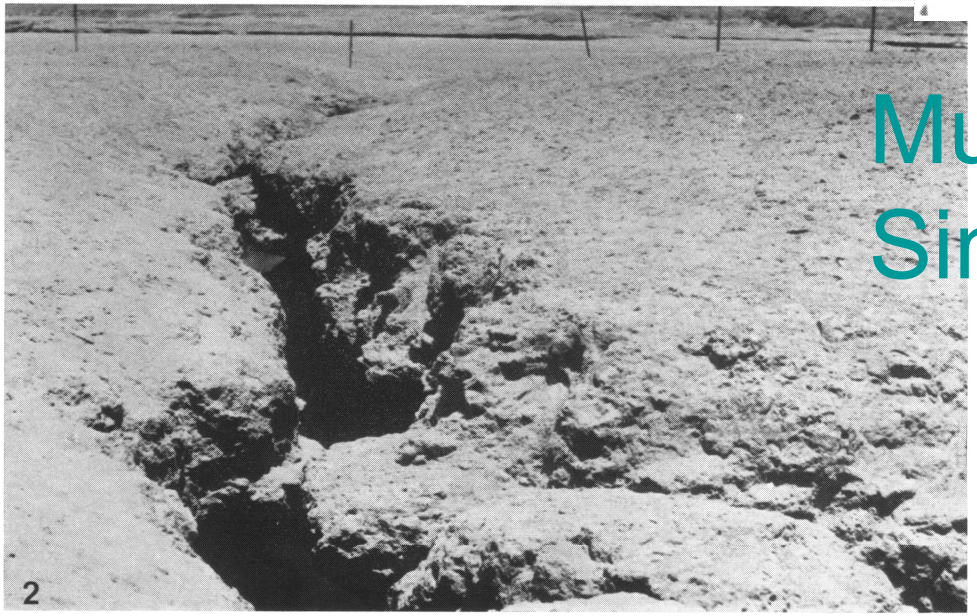
naïve nature protection

No One May Harm Vatulele's Long-whiskered Prawns—Taboo!

Possibly because of their bright color, these salt-water crustaceans are held sacred. A paramount chief raised the taboo long enough for pictures to be taken. The goggled diver caught four prawns (below) in the pool, then freed them.

555





Muhammad Crack, Sinai Peninsula

2000

Anchialine pools restoration

Project leader: West Hawaii Explorations Academy and University of Hawaii Sea Grant Extension Service in West Hawaii.

Anchialine ponds are one of Hawaii's most threatened ecosystems. Anchialine pools are landlocked brackish ponds located close to the shoreline connected to the ocean via subterranean tunnels. Characterized by tidal fluctuations, these rare and fragile ponds are home to unusual plants and animals such as Halocardinia sp.

In the U.S., this habitat exists only in the Hawaiian Islands and, of the approximately 700 known anchialine pools, the majority are located on the island of Hawaii. Formed by volcanic activity, these pools are home to a unique assemblage of invertebrate and

THE AMAZING HAWAIIAN MICRO-LOBSTERS!™
MICRO-LOBSTER BASICS SECTION
THE ANCHIALINE PONDS

Opae-ula are destined to become much more well known and in demand as more people learn about them. Fuku-Bonsai's **captive breeding program** is a step in an **appropriate direction** and we have begun research to create a mass cultural system. A **public exhibit** has been created at the Waikiki Aquarium in Honolulu. We will develop Micro-Lobster **educational programs**, offer breeder tanks, and serve as a resource. This will help assure the future of the species which currently depends upon anchialine ponds.

FUKU-BONSAI CULTURAL CENTER & HAWAII STATE BONSAI REPOSITORY

		acc to Riedl **1966**	acc to Botosaneanu **1986**	Sket **1997**	**2004** ca
sponges	**Porifera**			3	4
flatworms	**Turbellaria**			1	1
snails	**Gastropoda**			5	5
annelids	**Annelida**			10	10
arrowworms	**Chaetognatha**			4	4
mites	**Acari**				3
crustaceans	**Crustacea**	26		305-350	410
fish	**Pisces**	5		10	10
		31	**150**	**339-384**	**445**

The interest is growing

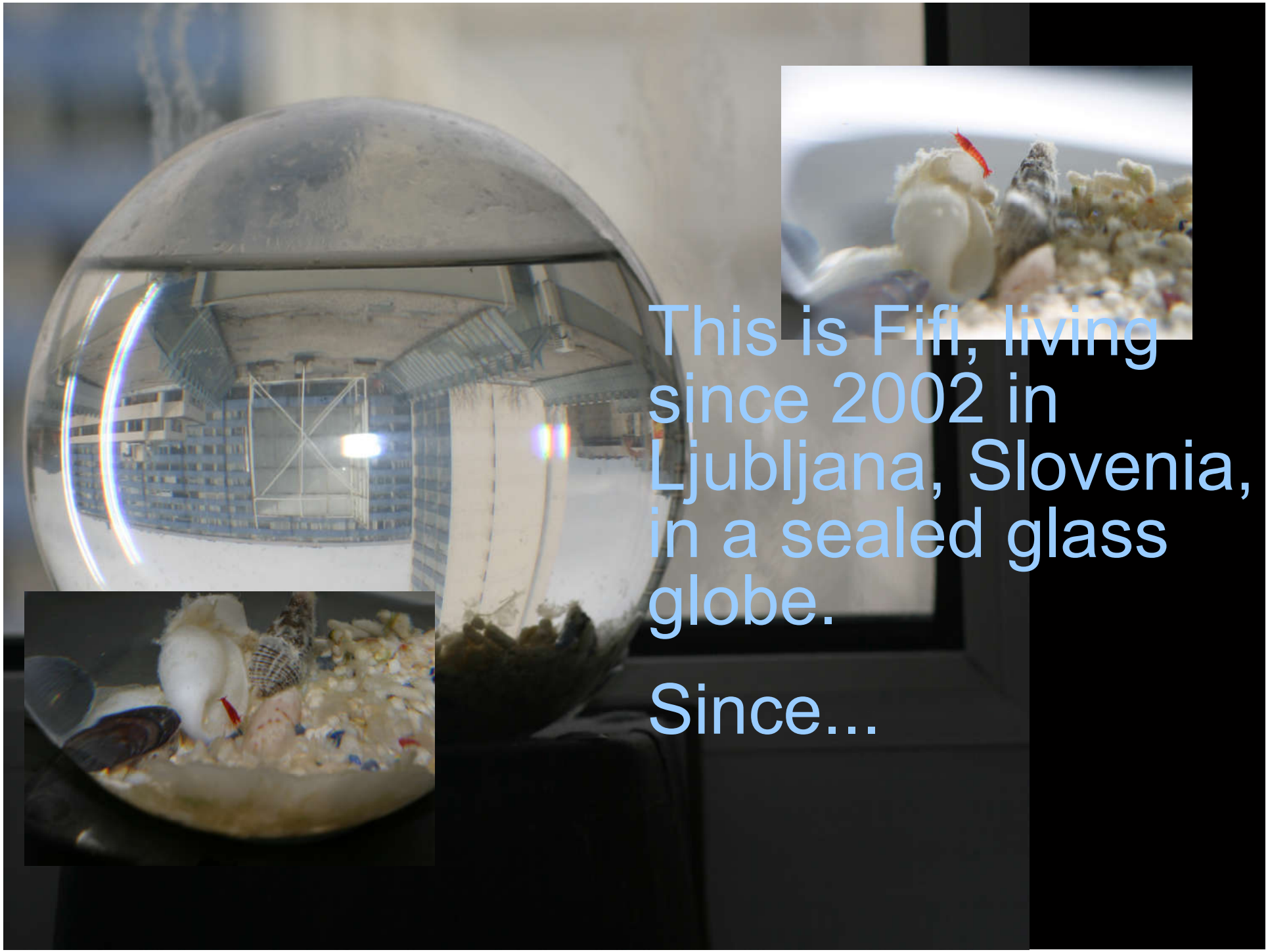
Internet, July 2004

"anchialine" **548** hits

+ "anchihaline" **85** hits

1966 > > > 2004

much of this about conservation; nice!


This is Fifi, living since 2002 in Ljubljana, Slovenia, in a sealed glass globe.
Since...

The End

This is Fifi, living since 2002 in Ljubljana, Slovenia, in ...