Ecoengineering with Ecohydrology: lessons in estuarine restoration

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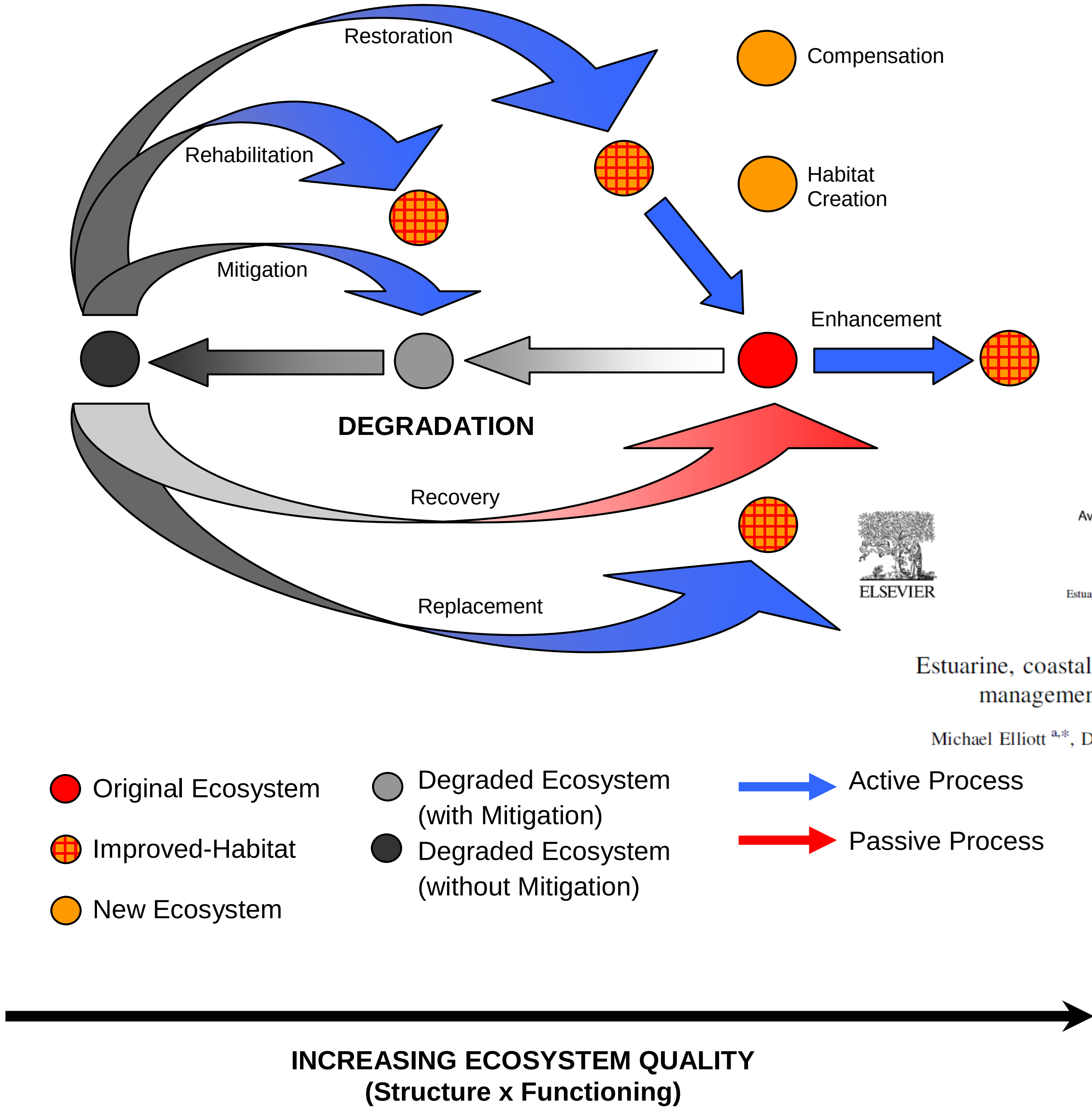

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Estuarine, coastal and marine ecosystem restoration: Confusing management and science – A revision of concepts

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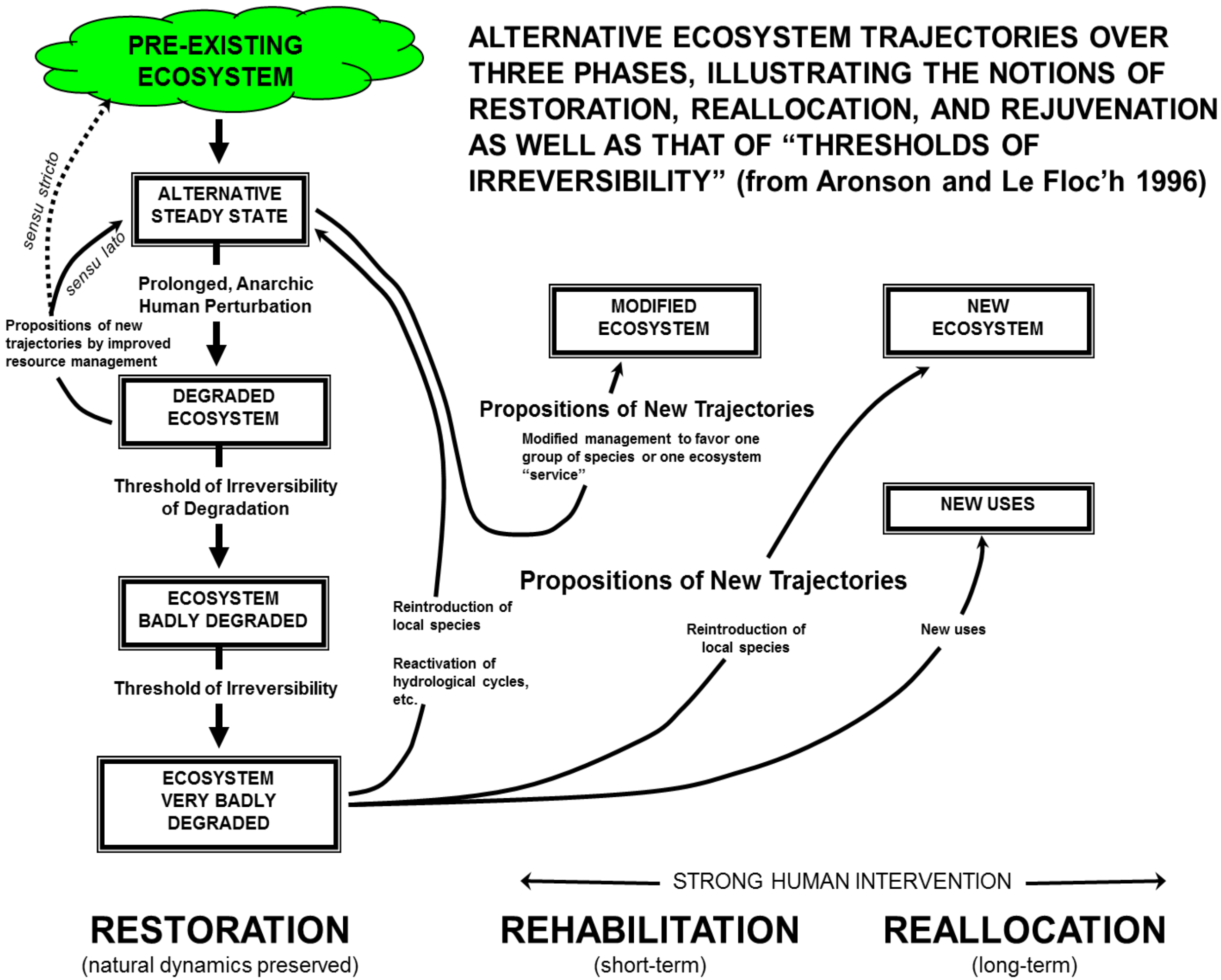
ALTERNATIVE ECOSYSTEM TRAJECTORIES OVER THREE PHASES, ILLUSTRATING THE NOTIONS OF RESTORATION, REALLOCATION, AND REJUVENATION AS WELL AS THAT OF "THRESHOLDS OF IRREVERSIBILITY" (from Aronson and Le Floc'h 1996)



Restore/Recreate what?

Shape + connectivity
- Hydrodynamics - Ecotones - Supply of water - Supply of organic matter - Supply of recruiting organisms

Surface area
- Biogeochemical/ storage area, sequestration (reactive surface) - productive surface (feeding area, nursery area) - resistance to anthropogenic change (size, water storage, RSLR)

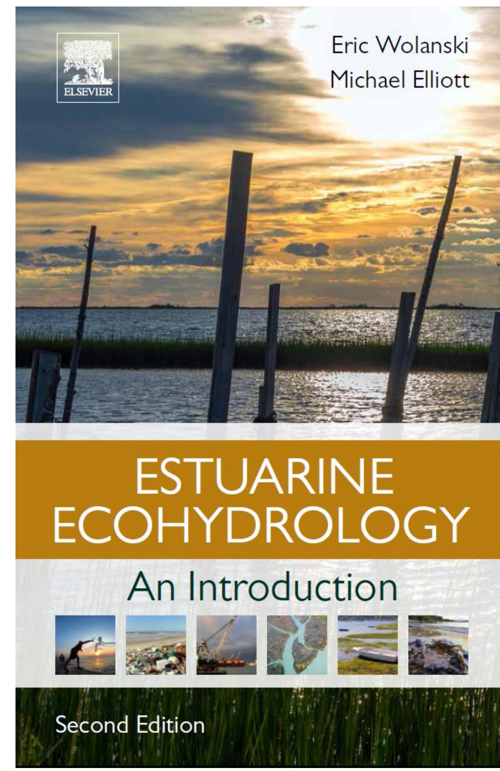
Habitat complexity (ecotones)
- refuge area/nursery areas -Productive surface -Resilience - 'Spillover' - nursery delivery to external fishery/populations

Box 1 Estuarine Ecohydrology

The science and understanding of the links between the physical functioning and the means by which it creates the appropriate ecological functioning of an estuary. It assumes that the ecology is primarily driven by the physics, which in turn affects the biological processes operating within a system.

It includes changing the physiography and manipulating the freshwater flows from the catchment and it is also influenced by the anthropogenic users and uses of the estuary, some of which will have modified and impacted both the physics and the ecology.

It is that knowledge which guides the management of the entire river basin from the headwaters down to the coastal zone, which Ecohydrology views as an ecosystem.



Box 2 Estuarine Ecological Engineering

Uses the ecohydrology knowledge to modify and achieve our ecological aims for an area by Engineering:

(1) the physics, including changing the physiography and manipulating the freshwater flows from the catchment, to produce the ecological niches which in turn lets the ecology and habitats develop, especially if the colonising species are ecological engineers (Type A ecoengineering).

(2) by engineering the ecology by restocking or replanting, in turn creating habitats or letting the ecological engineer species modify habitats, thus enhancing the physical-biological links (Type B Ecoengineering).

Ecoengineering initiatives often aim to accelerate natural rehabilitation and sometimes harness dynamic variability. However, they often only achieve establishing a static system (the desired state) even if this does not include all natural successional processes and stages.

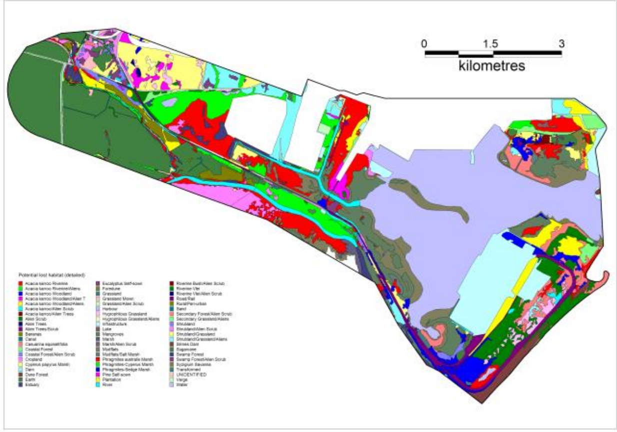
Box 3 Ecohydrology with Ecoengineering

While Ecohydrology aims to operate across the whole catchment-coast continuum, Ecoengineering usually occurs at a smaller scale and will seldom recreate pristine estuaries given the huge human populations living on their shores, but it aims to create ecosystems with at least some attributes of the original systems.

It should be accompanied by regulating certain human activities and is more than just integrated river basin management. Primarily it aims to improve the ecology, and provide benefits for the economy and the safety of society (i.e., so-called triple wins).

Box 3 Ecohydrology with Ecoengineering (cont.)

It aims to redress the balance after adverse historical changes, especially coastal and estuarine wetland removal, without unacceptable environmental trade-offs. Ideally, it provides relatively low-cost technologies for mitigating the impact on estuaries and coasts of human activities throughout the river basin, for using and enhancing the natural capacity of the water bodies to absorb and process excess nutrients and contaminants, and for increasing ecosystem resilience to accommodate global stressors such as climate change.



In essence Ecohydrology is the underlying process/ abiotic drivers into which Ecoengineering fits and by which Ecoengineering is delivered, i.e. Ecohydrology provides the underlying science and Ecoengineering is the mechanism for creating the ecology.

Ecological Engineering - Principles:

(1) ecohydrological principles should be used to ensure a suitable and sustainable physico-chemical system
(2) the design should encompass local features and so be site-specific
(3) the design parameters and features should be kept simple in order to deliver the functioning required
(4) the design should use energy inside the system or coming from outside, such as flow conditions and working with nature, and that the system should be kept simple to minimise the information required for it execution, and lastly
(5) the EcoEng design should aid the natural and social systems and so should have an ethical dimension; this may involve ‘over-engineering the design in order to protect human safety and property.

This therefore ensures the wins for safety, economy & ecology

(Modified from Bergen et al 2001 Ecol. Eng. 18: 201-210)

Ecohydrological measure categories
(see Elliott et al 2016 for examples)

Category	Ecohydrological measure type
Hydrology / Morphology	Measure to reduce tidal range, asymmetry and pumping effects and/or dissipate wave energy
	Other measures for flood protection
	Other measures to stabilise coasts or improve morphological conditions
	Measure to decrease the need for dredging
	Zoning measures
	Measures to stop or reverse subsidence due to extraction of water and minerals
	Measure to restore longitudinal or lateral connectivity

Ecohydrological measure categories

(see Elliott et al 2016 for examples)

Category	Ecohydrological measure type
Physical / Chemical Quality	Measure to reduce nutrient loading (point and diffuse sources)
	Measure to reduce persistent pollutant loading (point and diffuse sources)
	Measure to improve oxygen conditions
	Measure to reduce physical loading (e.g. heat input by cooling water entries)
	Measure to reduce sediment inputs and sediment loading

Ecohydrological measure categories

(see Elliott et al 2016 for examples)

Category	Ecohydrological measure type
Biology/ ecology	Measure to develop and/or protect specific habitats
	Measure to develop and/or protect specific species
	Measures to retain or restore natural gradients & processes, transition & connection
	Measure to prevent introduction of or to eradicate/ control against invasive species
	Measure for direct human benefit of ecological attributes
Human safety	Measure for early warning/evacuation of natural disasters
	Measure for improved resilience of housing and industry

Habitat Restoration - Managed Realignment

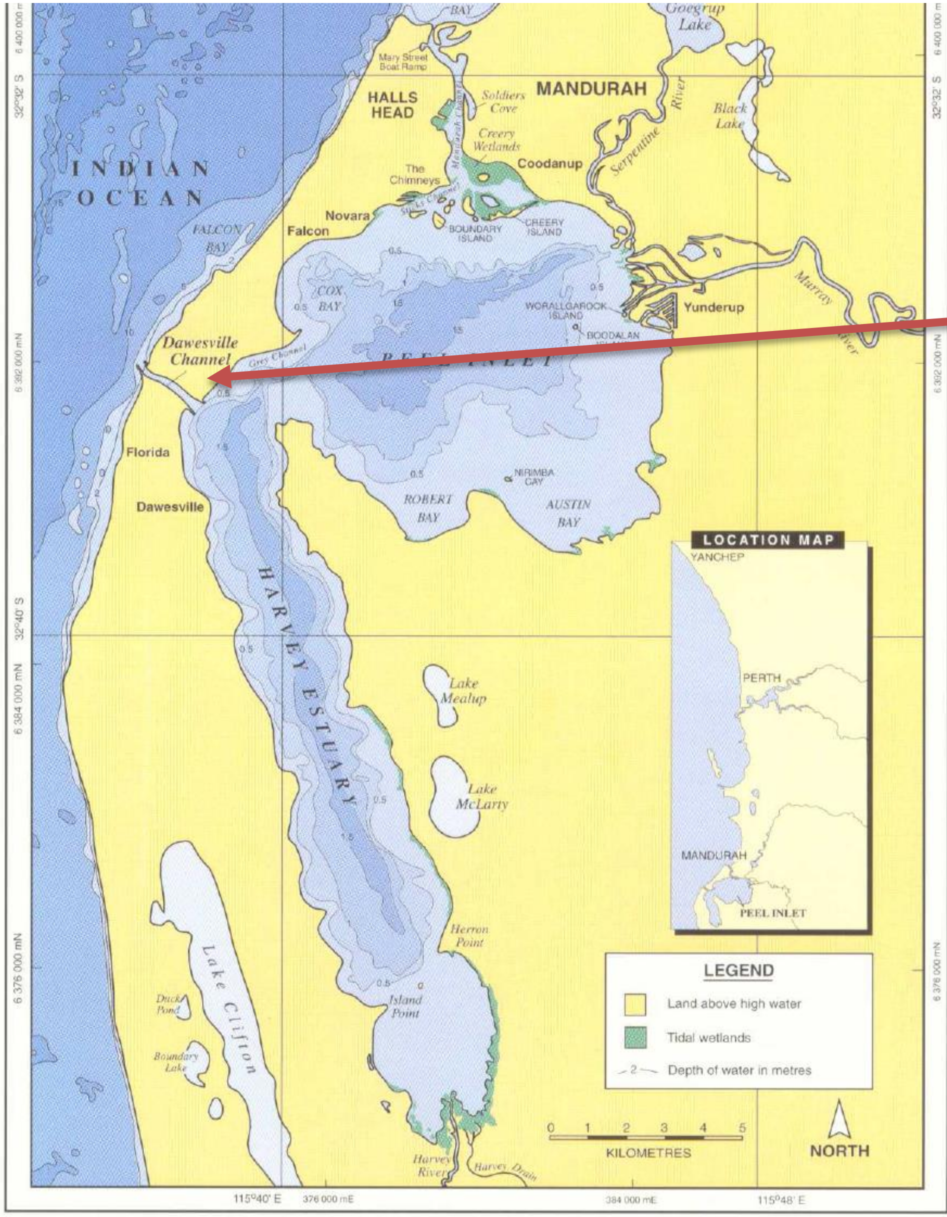
Humber Estuary - Chowder Ness, June 2006

NB Compensation Scheme (with Welwick saltmarsh) for Port Development (gain:loss = 2.5:1)

Chowder Ness, 2007

Chowder Ness, 2015

Peel-Harvey Estuary (WA) – EcoEng to solve a WQ problem:



Opening of Dawesville Channel in 1994

+ve

better water quality, fewer odour problems, better recreation fishery, more residential areas

-ve

poorer prawn fishery, still circulation problems, increased mosquitos, still eutrophication in certain areas, remediation not accompanied by land-use changes

Ecological Engineering (1):

- It will never recreate pristine estuaries but it is aimed at creating ecosystems partly with some attributes of the original systems.
- It should be accompanied by regulating human activities on land.

- It is more than integrated river basin management and it aims to improve the ecology, provide benefits for the economy and the safety of society (i.e. so-called triple wins).
- Aims to redress some elements of the balance after adverse historical changes, especially wetland removal.

Ecological Engineering (2):

- It provides for low-cost technologies for mitigating the impact on the estuaries and coastal zone of human activities throughout the river basin.
- These are using and enhancing the natural capacity of the water bodies to absorb or process excess anthropogenic nutrients and pollutants, and
- for increasing the estuarine and coastal resilience to accommodate global stressors such as climate change.

The 10-tenets:

To be successful, management measures or responses to changes resulting from human activities should be:

- Ecologically sustainable
- Technologically feasible
- Economically viable
- Socially desirable/tolerable
- Legally permissible
- Administratively achievable
- Politically expedient
- Ethically defensible (morally correct)
- Culturally inclusive
- Effectively communicable

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Editorial

The *10-tenets* for integrated, successful and sustainable marine management

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journal homepage: www.elsevier.com/locate/envsci

The 10-tenets of adaptive management and sustainability: An holistic framework for understanding and managing the socio-ecological system

*Steve Barnard *, Michael Elliott*

Main Messages:

- We now have good examples worldwide

of good and bad practice

- Problem of poor long term vision,

objectives, definition of success

- Some schemes are just ‘gardening’ (“*good for the ecologist not the ecology?*”)
- Once you start managing the system then you have to keep managing it
- Essence is connectivity (good water conditions, ecological well-being, conditions fit-for-purpose)
- Estuarine and catchment measures have to be used together

But (and there is always a '*but*'):

- If you get the hydrology right then the ecology will follow, *but ...*

- if you don't understand the hydrology then you don't get a sustainable ecology

- *Help is at hand to understand the EcoEng with EcoHyd!*

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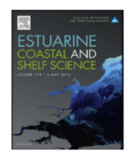

Ecoengineering with Ecohydrology: Successes and failures in estuarine restoration

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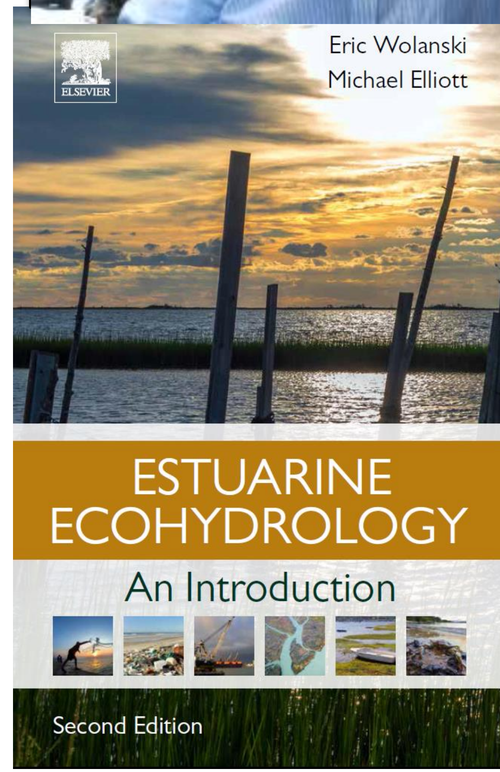

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