HY/T 0305-2021

Estimation method of maricultural seaweed and bivalve carbon sink

– Carbon stock variation method

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Background

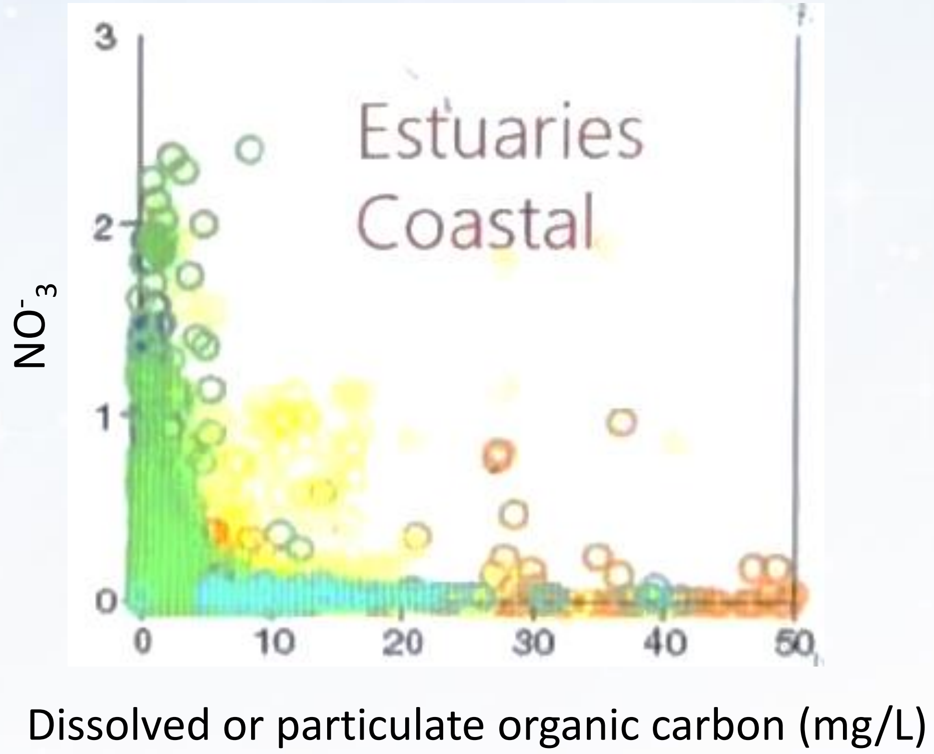
The anthropogenic release of CO_2 into the atmosphere has had negative consequences for environment.

Background

- The ocean is a major sink for anthropogenic CO_2 and had absorbed roughly 30% of anthropogenic CO_2 (Gruber et al., 2019; Takahashi et al., 2002).

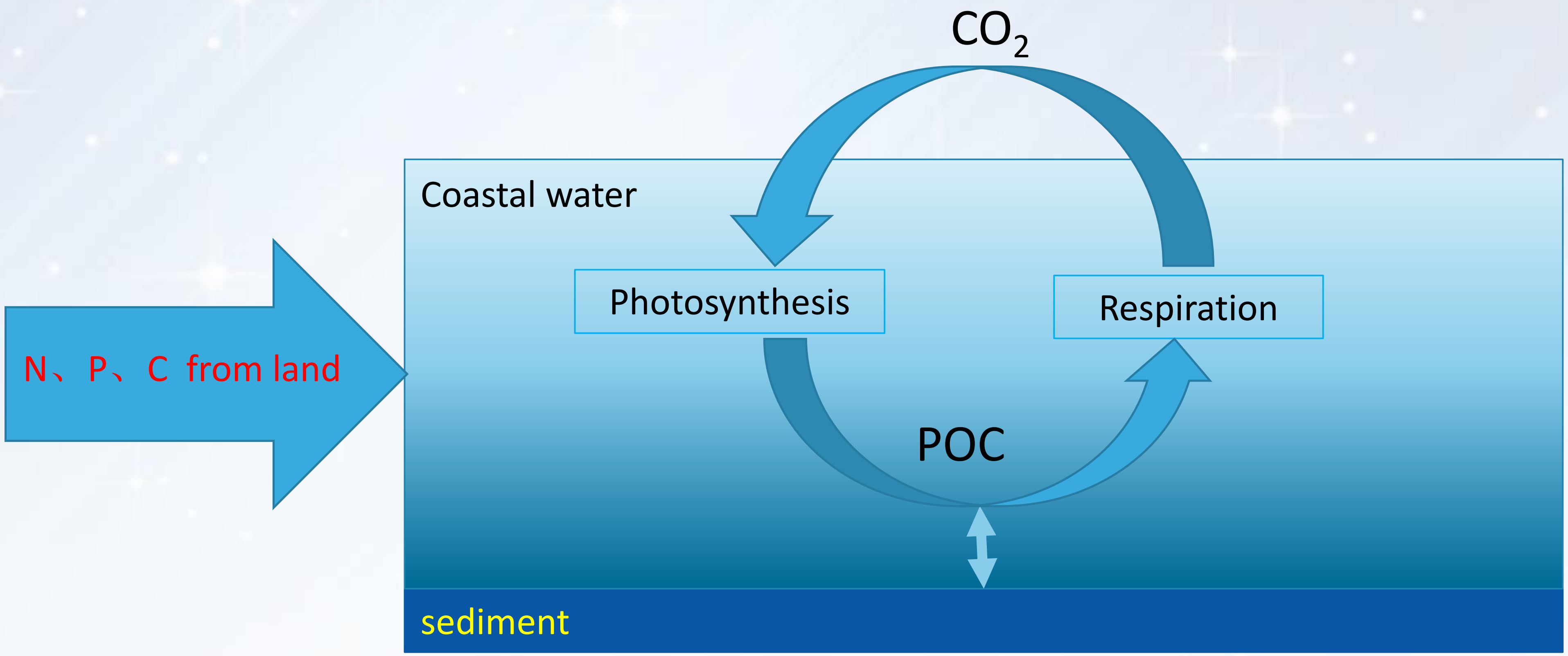
- The biological carbon pump of the ocean is an important process that absorb CO_2 from atmosphere and transports approximately three-quarters of the dissolved inorganic carbon (DIC) from the surface to the deep-ocean (Riebesell et al., 2007).

Most coastal area are sources rather than sinks of CO_2



Taylor et al., Nature (2010)

Background



- Due to the large amount of nitrogen, phosphorus and organic carbon release into coastal sea from land sources, eutrophication in coastal waters is serious.

- Seaweed and bivalve culture can use these nitrogen and phosphorus and particulate organic carbon, and remove C、N、P from the sea by harvest.

Background

Bivalves utilize oceanic carbon to enhance growing in two ways. One is using the HCO_3^- in seawater to generate the calcium carbonate shells. Another way for bivalves to utilize oceanic carbon is to filter the suspended particles of organic carbon as food.

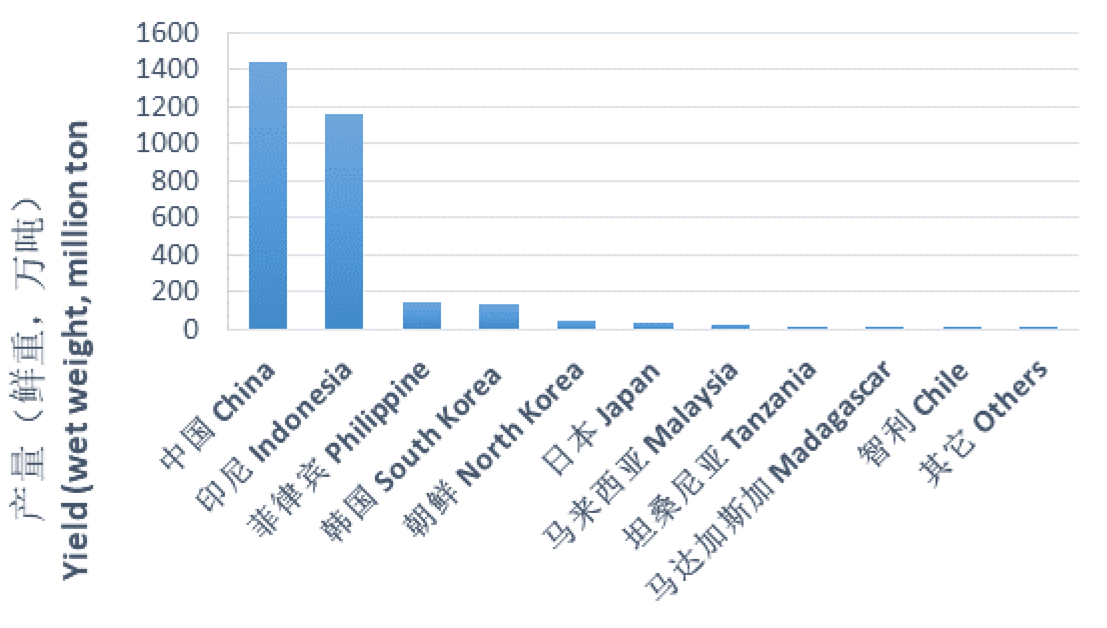
Seaweed can transform the dissolved inorganic carbon into organic carbon by photosynthesis, which can decrease the sub-pressure of CO_2 in seawater.

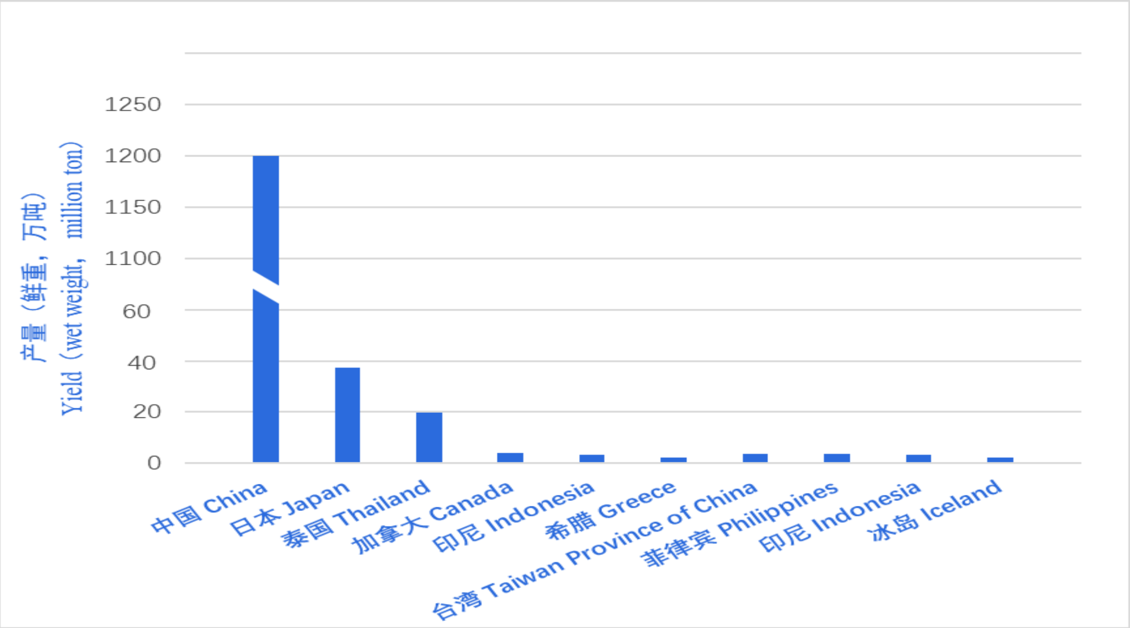
Seaweed provides numerous ecosystem services including carbon capture and nitrogen sequestration (Krak, 2021). Seaweeds and bivalves mariculture activities can improve the carbon absorption capacity in coastal sea by removing carbon from the coastal ecosystem by harvesting (Tang et al., 2011).

Background

Current status of seaweed and bivalve maricultue in the world

- Seaweeds represent 51.3% of total production of marine and coastal aquaculture.
- Over 80% of seaweed and bivalves mariculture production are concentrated in Asia.





FAO, 2020.

Background

Ocean negative carbon emission

The value of the seaweed and bivalves aquaculture sector could be much larger, especially if a monetary value was attributed to the ecosystem services provided by seaweeds and bivalves.

Mariculture is possible options for enhancing marine CO_2 uptake and storage, both from a national and a global perspective.

Development of marine carbon accounting standard

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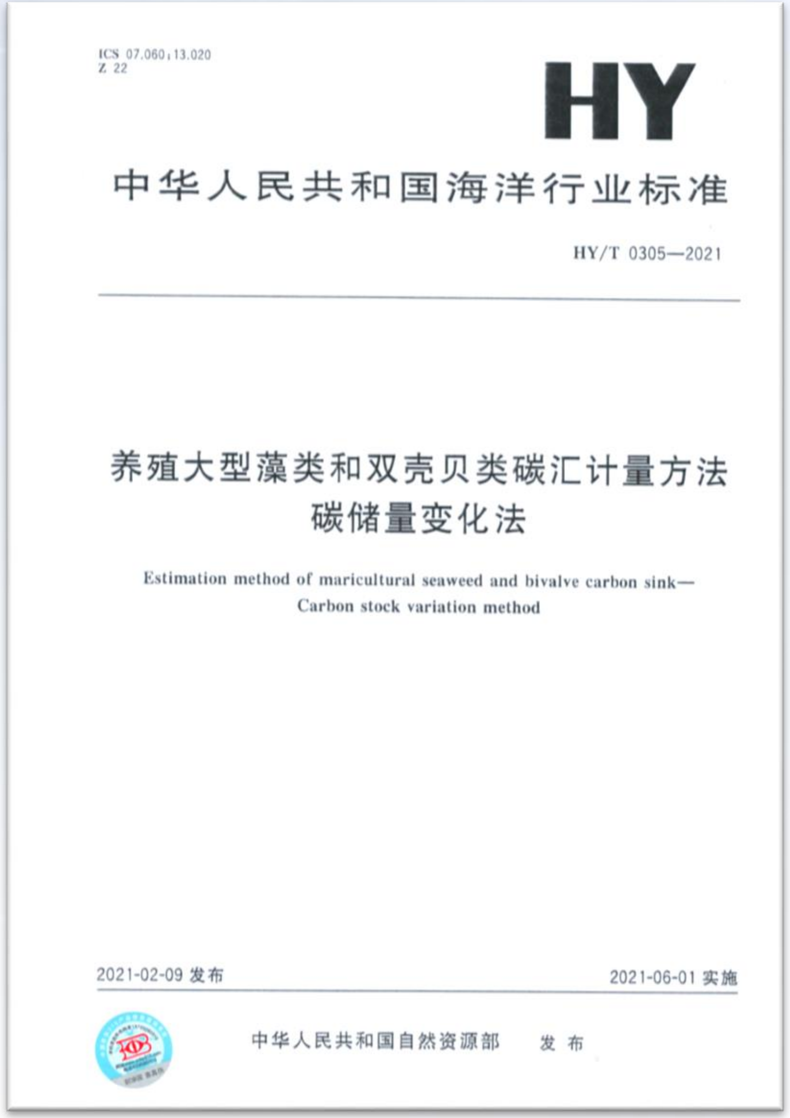
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中华人民共和国海洋行业标准

HY/T 0305—2021

养殖大型藻类和双壳贝类碳汇计量方法
碳储量变化法

Estimation method of maricultural seaweed and bivalve carbon sink—
Carbon stock variation method

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3.10 maricultural bivalve carbon sink amount

4. Principle and methodology

4.1 Principle

The standard based the method of carbon storage variation, that is, carbon storage in harvested seaweed /bivalves subtracting the seeding carbon storage in a mariculture cycle.

4.2 Sampling and measurement methods

4.2.1 Sampling of seedlings and adults of seaweed

4.2.2 Sampling of seedlings and adults of bivalve

4.2.3 Yields

4.2.4 Measurement the dry-wet ratio and carbon content of seaweed

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4.3 Calculation method

4.3.1 The calculation method of carbon sink for cultured seaweed

4.3.1.1 The initial carbon storage of seaweed seedlings

$$C_{SS} = N_{sq} \times W_{si} \times C_{sa} \times 10^{-6} \quad \text{......} (1)$$

Where:

C_{SS}—The amount of carbon in the cultivation of seaweed seedlings (t/hm^2);

N_{sq}—the density of seedlings (ind/hm^2);

W_{si}—the dry weight of individual seedlings (g/ind);

C_{sa}—The carbon content of seedlings.

4. Principle and methodology

4.3.1.2 Carbon storage in harvested seaweed

$C_{SH}=W_{sy}\times R_{ssdw}\times C_{aa}$……………………………………(3)

Where:

C_{SH}—the amount of carbon storage in harvested seaweed (t/hm2);；
W_{sy}—the unit yield of seaweed (t/hm^2)；
R_{ssdw}—the dry-to-wet ratio of harvested seaweed;
C_{aa}—The carbon content of harvested seaweed.

4.3.1.3 Variation in carbon storage
Calculated according to formula (4):
$\Delta C=(C_{SH}-C_{SS})/T$ ……………………………………………(4)

where：
ΔC—the variation in carbon storage of seaweed during the maricultural cycle ($t/(hm^2\cdot a)$)；
T—one mariculture cycle (a)

4. Principle and methodology

4.3.1.4 Carbon sinks

The total carbon sink is calculated according to formula (5)

$\Delta C_{sink}=1/r\times\Delta C$ ……………………………………………(5)

where：

r—The conversion coefficient between carbon and carbon dioxide, 12/44.

Main part of the Specification

4. Principle and methodology

4.3.2.2 Carbon storage of harvested bivalves

$C_{BH}=W_{by}\times R_{adw}\times(R_{ash}\times C_{ash}+R_{am}\times C_{am})\times 10^{-3}$……………………………….(9)

where：
W_{by}—The bivalves yields of unit mariculture area, (kg/hm^2)；
R_{adw}—the dry-to-wet ratio of bivalve；
R_{ash}—the mass ratio of shell to total body；
C_{ash}—the carbon content of shell；
R_{am}—The mass ratio of soft tissue to body；
C_{am}—The carbon content of soft tissue.

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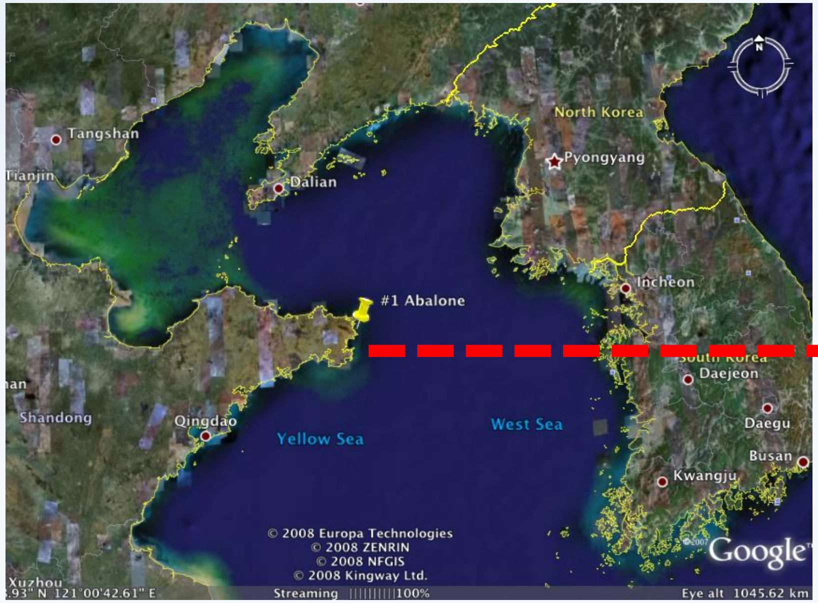
Application---case in Sungo Bay

Scientific evidence about the mariculture seaweed and bivalves being carbon sink

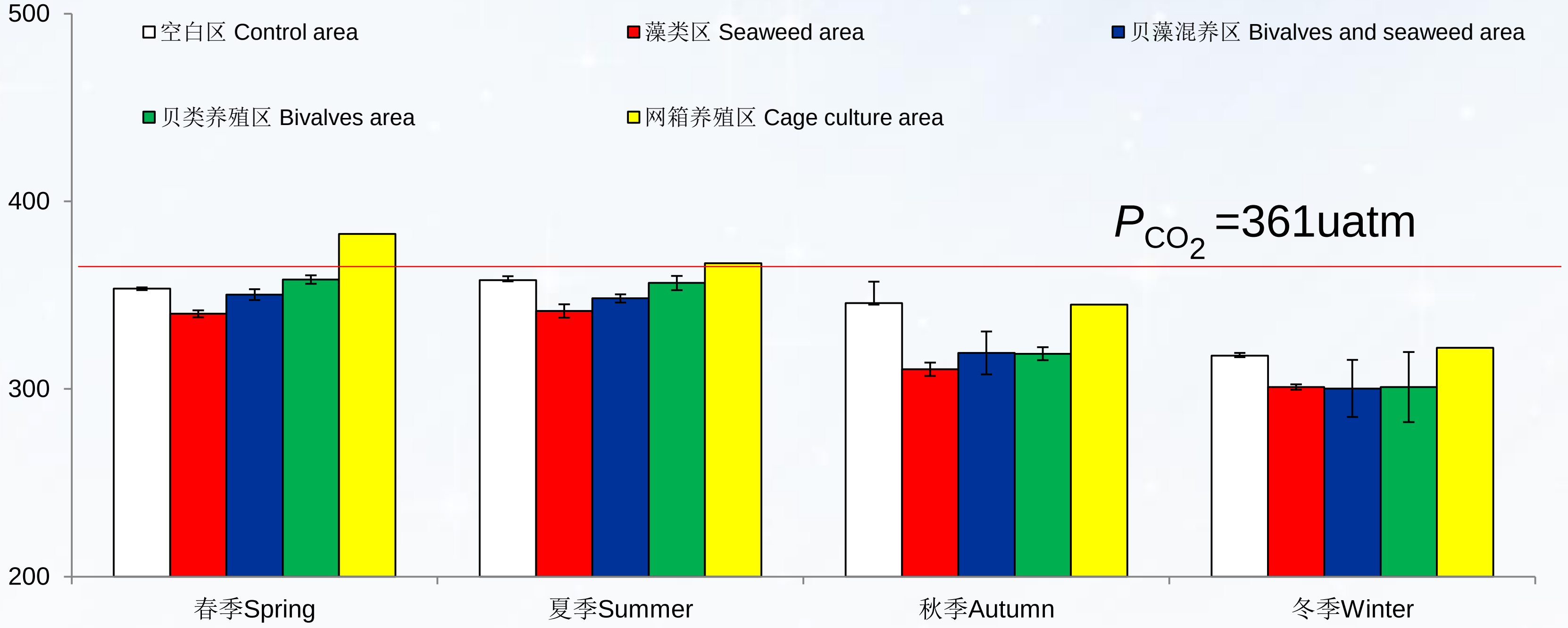


Annual production:
Kelp: 80,000 tones in dry weight
Oyster: 120,000 tones in fresh weight with shell
Scallop: 10,000 tones in fresh weight with shell

Application---case in Sungo Bay

The variation of the seawater carbonate system parameters were measured in four seasons in Sungo Bay.

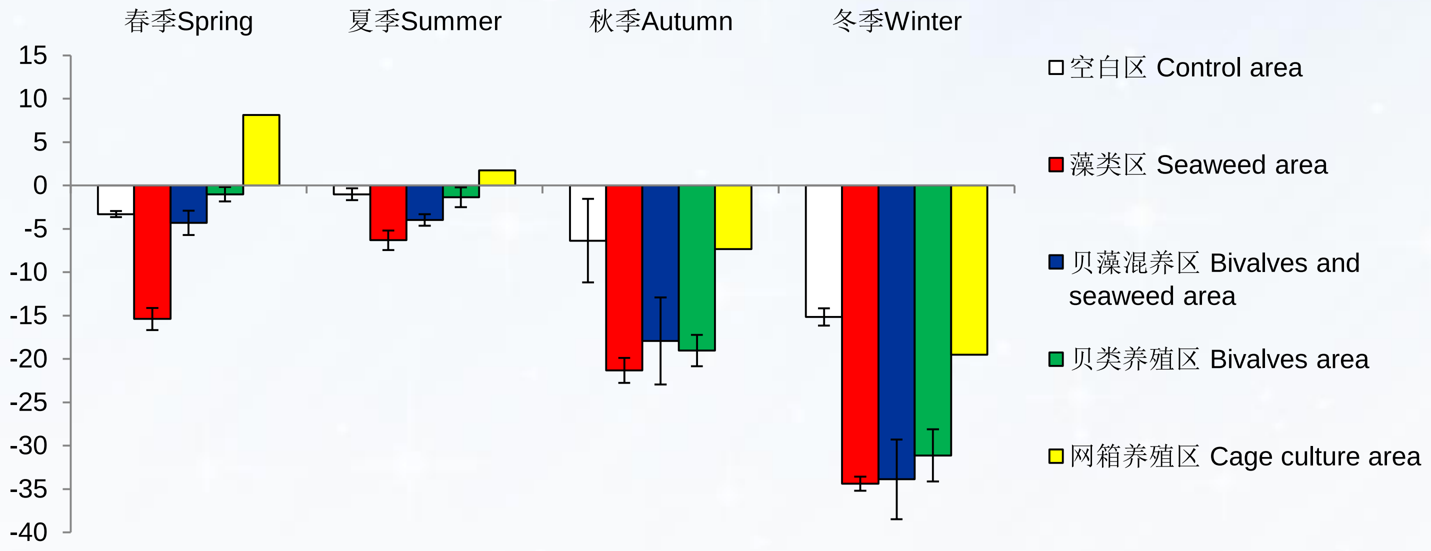
The CO_2 partial pressure (P_{CO_2}) in seaweed and bivalves mariculture areas were lower than the that in atmosphere.



Season variation of P_{CO_2} in Sungo Bay

Application---case in Sungo Bay

1. The annual average air-sea CO_2 flux (F_{CO_2}) of Sungo Bay was -11.47 mmol/(m^2·d);
2. Sungo Bay acts as a potential CO_2 sink totally, and CO_2 fixation in the seaweed and bivalves area were the contributors to CO_2 flux .



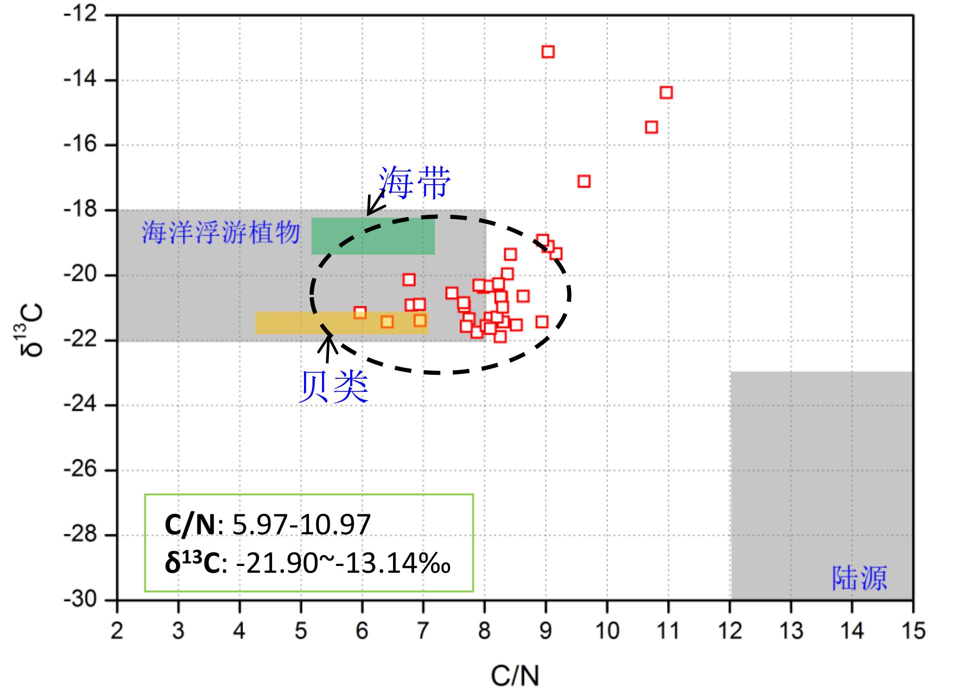
Seasonal variation of Air-Sea CO_2 Flux in different maricultural areas of Sungo Bay

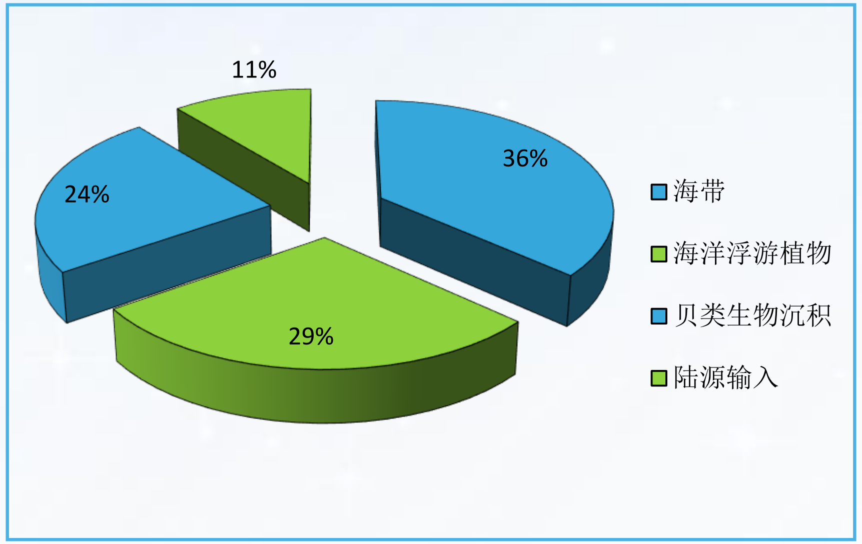
Application---case in Sungo Bay

Sediment cores collected from the mariculture area in Sungo Bay. Elemental composition (C and N), stable isotopic composition ($\delta^{13}C$ and $\delta^{15}N$), and ^{210}Pb activities were analyzed.

- In the surface sediments, source contribution were dominated by mariculture seaweed and bivalves derived organic carbon, which on average accounts for 60.4 % of TOC.
- Seaweed and bivalves mariculture enhanced TOC and carbon burial fluxes.

stable isotope ($\delta^{13}C$ and $\delta^{15}N$) mixing model methods

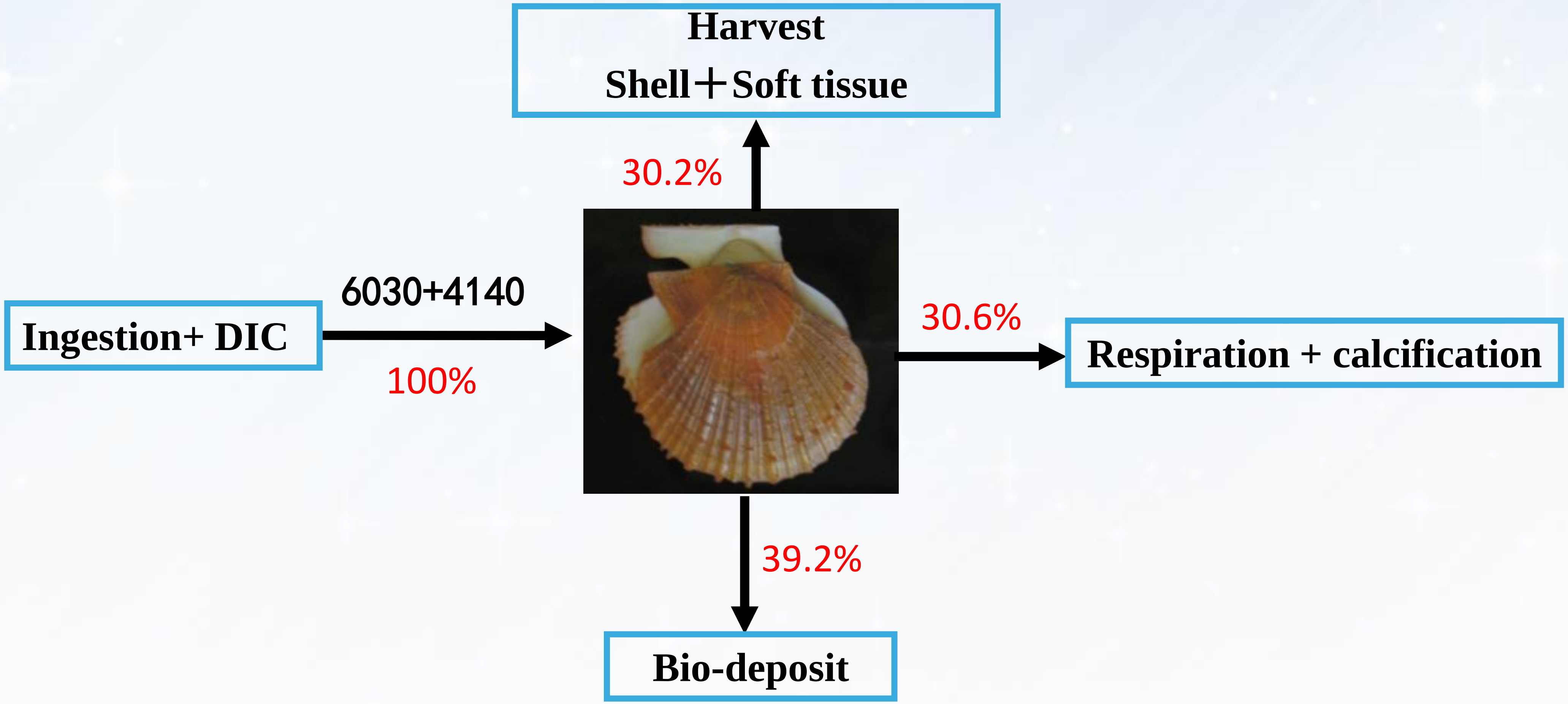




Contribution of kelp debris and bio-deposits of bivalves to organic carbon in surface sediments of Sungo Bay

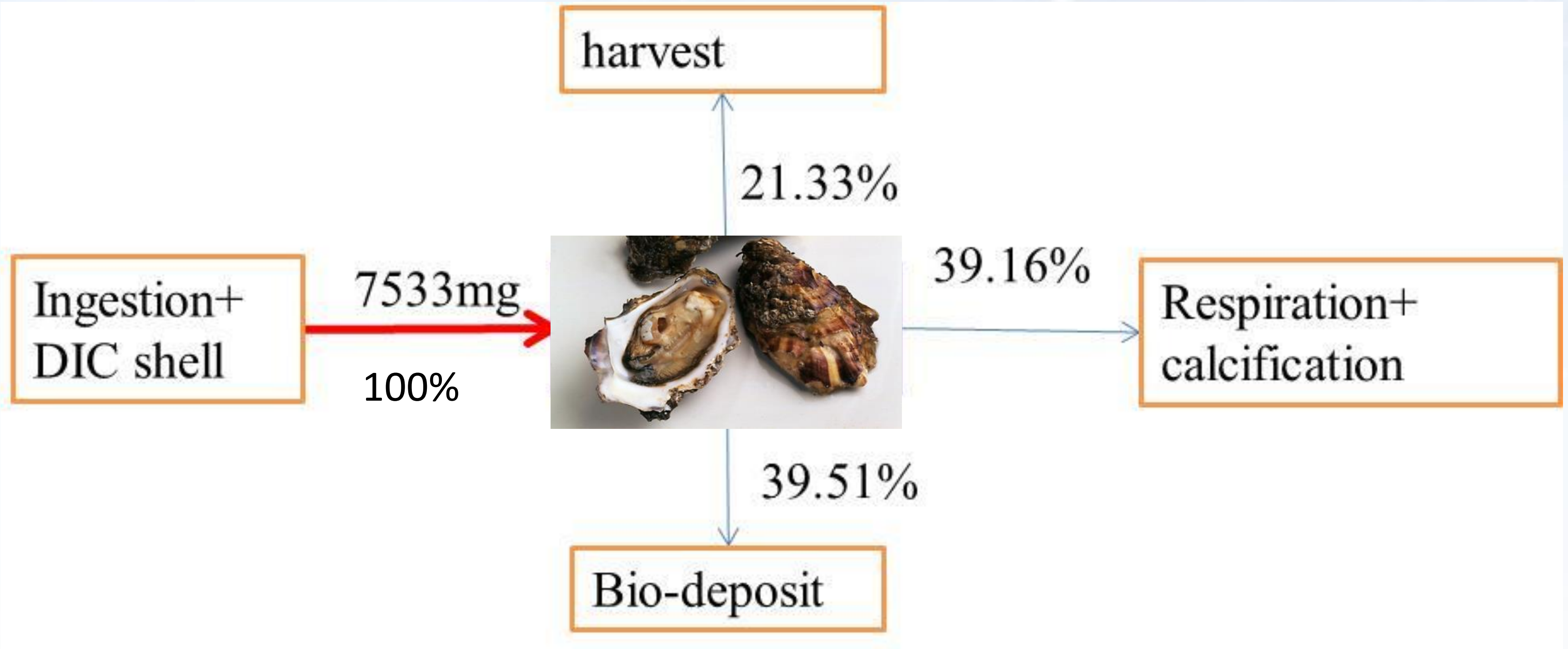
Application---case in Sungo Bay

Carbon budget during a farming cycle of scallop *Chlamys farreri* (unit: mg C)



Application---case in Sungo Bay

Carbon budget during a farming cycle of pacific oyster *Crassostrea gigas* (unit: mg C)



Application---case in Sungo Bay

Carbon storage in harvest bivalves and seaweed

Species	Yield (*W*by)	dry-to-wet ratio of bivalve （*R*adw）	mass ratio of shell to total body （*R*ash）	mass ratio of soft tissue to body （*R*am）	carbon content of shell （*C*ash）	carbon content of soft tissue （*C*am）	carbon storage variation (ΔCb)	carbon sink ($t/hm^2.a$)
Grassastrea gigas	29100	0.651	0.98	0.02	0.115	0.449	2.305118	8.45
Chlamys farreri	25500	0.639	0.886	0.14	0.114	0.438	2.644988	9.69

Kelp *Saccharina japonica*

Yield： 130 t/hm^2

Dry –to –wet ratio of kelp: 15.5%;

Carbon content: 0.23

Carbon sink: 17.2 $t/hm^2.a$

Summery

Seaweed and bivalves mariculture are complete process:

- Organic-inorganic interactions
- Biotic-abiotic interactions
- Carbon element flux between Water column and sediment, atmosphere and water column, mariculture ecosystem and nature ecosystem, land-coast-ocean
- Fates of harvest seaweed and bivalves

Suggestion:

- Application the standard in the eutrophic area
- Bivalve and seaweed mariculture under ecological carrying capacity

Thanks for your attention