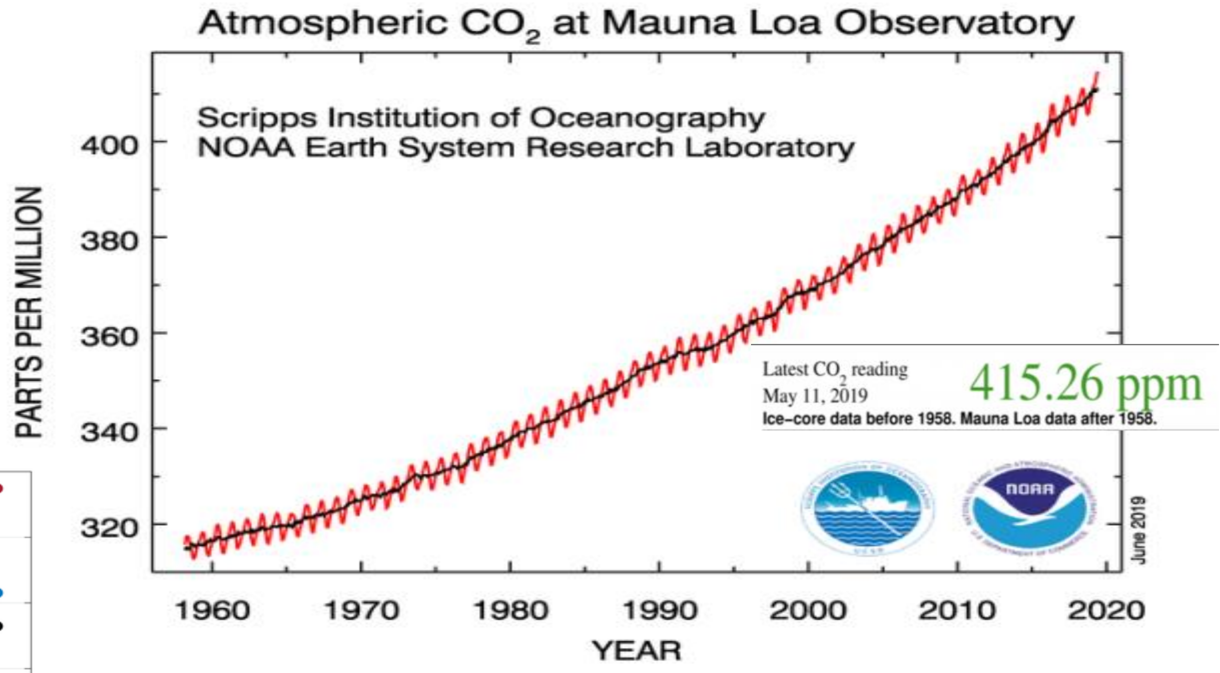
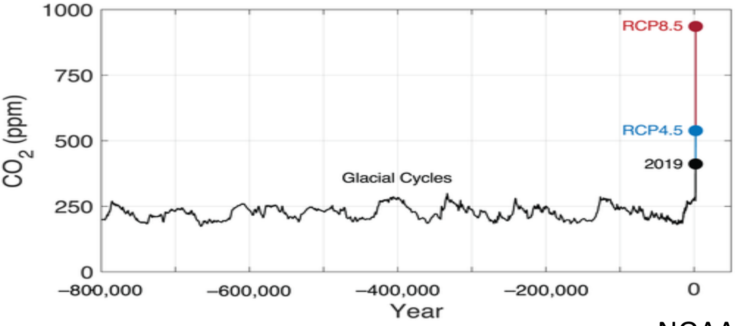
Interaction of climate change and macroalgae in a changing ocean

Speaker: Dr Guang GAO

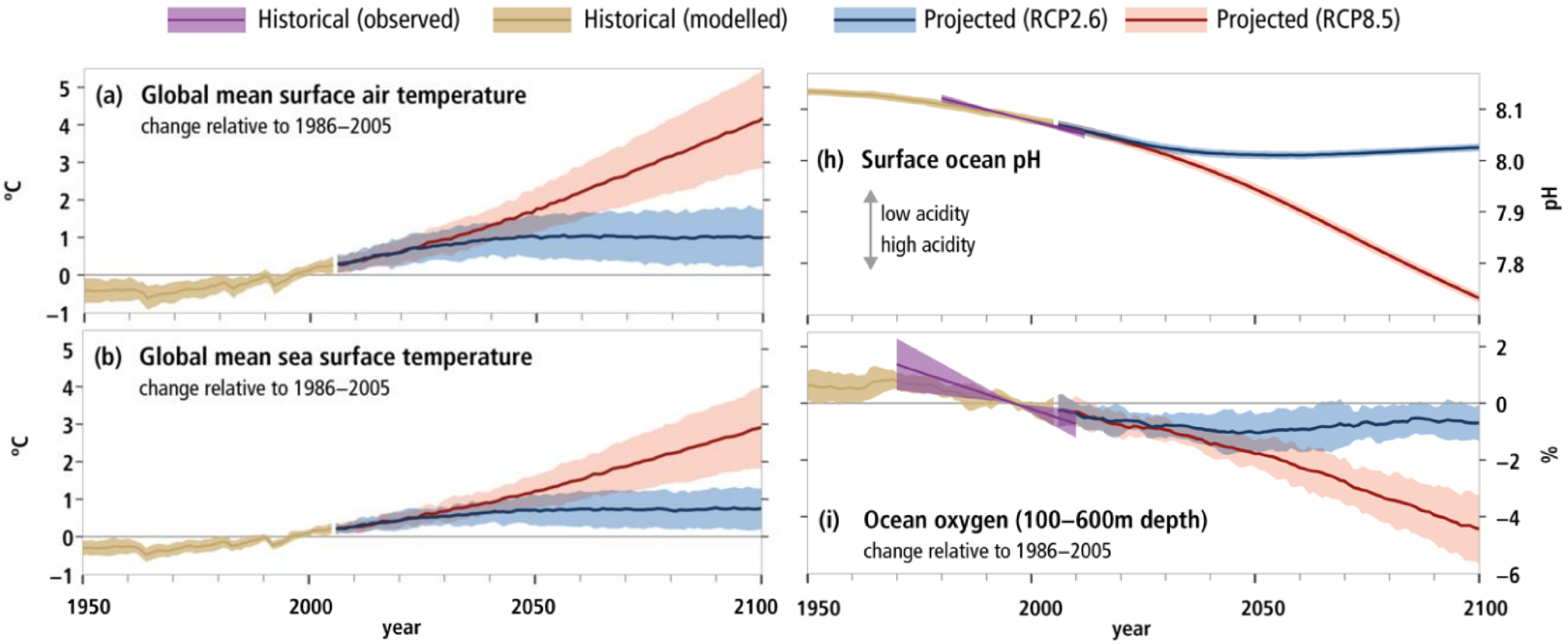
State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361005, China





NOAA

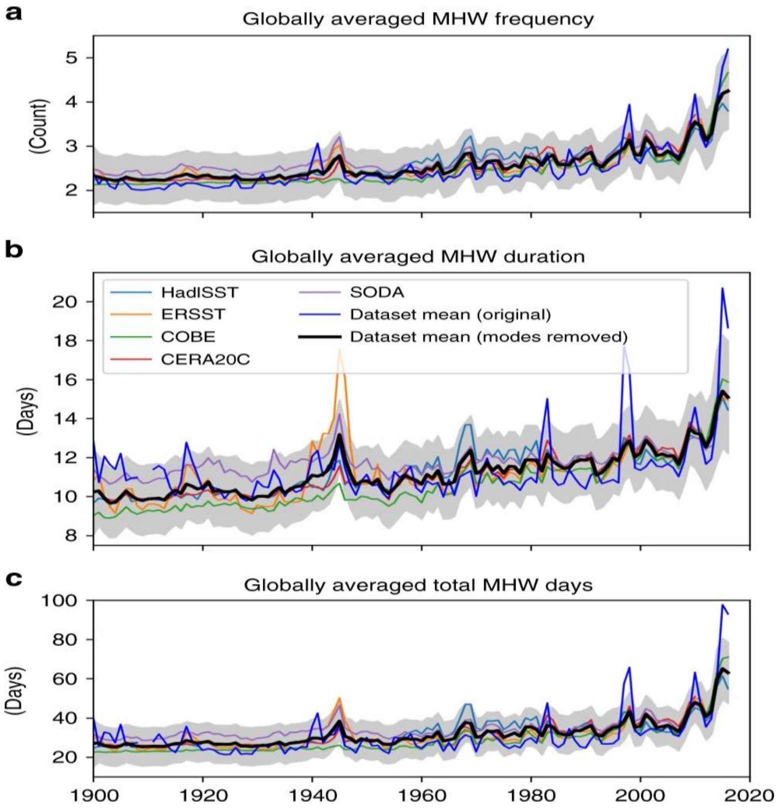
This is the first time in human history our planet's atmosphere has had more than 415ppm CO2.


Historical (observed)
Historical (modelled)
Projected (RCP2.6)
Projected (RCP8.5)
(a) Global mean surface air temperature
change relative to 1986–2005
°C
5
4
3
2
1
0
−1
(b) Global mean sea surface temperature
change relative to 1986–2005
°C
5
4
3
2
1
0
−1
1950
2000
2050
2100
year
(h) Surface ocean pH
low acidity
high acidity
8.1
8.0
7.9
7.8
pH
(i) Ocean oxygen (100–600m depth)
change relative to 1986–2005
2
0
−2
−4
−6
%
1950
2000
2050
2100
year

IPCC 2019

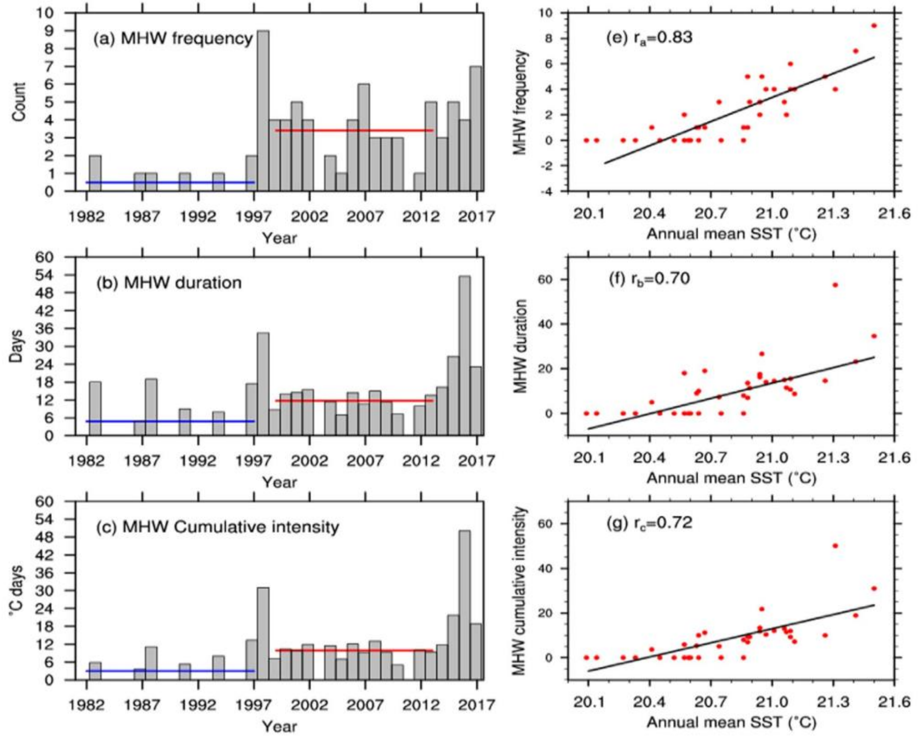
ARTICLE
DOI: 10.1038/s41467-018-03732-9 OPEN
nature COMMUNICATIONS

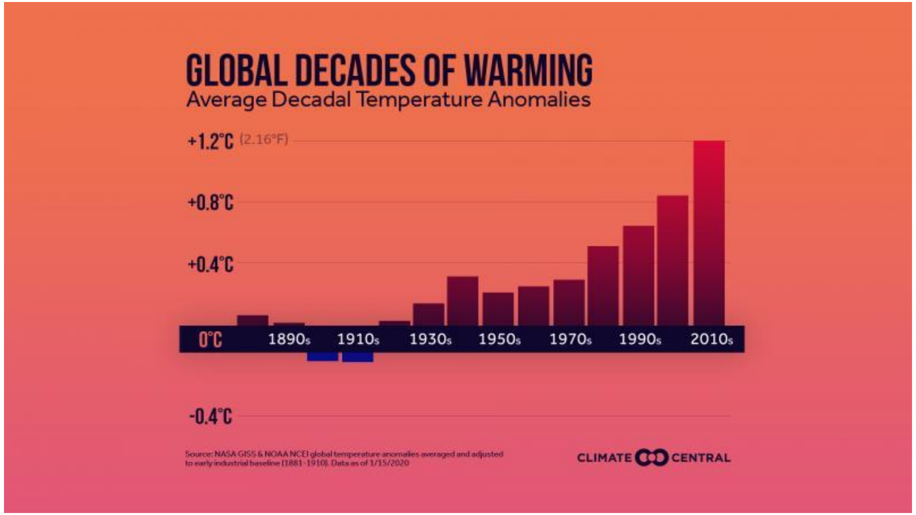
Longer and more frequent marine heatwaves over the past century



LETTER Environ. Res. Lett. **14** (2019) 104010

More extreme marine heatwaves in the China Seas during the global warming hiatus





2015年

The last decade is the hottest decade on record globally

Bill Gates says climate change 'could be worse' than COVID ...

"By 2060, **climate change** could be just as deadly as **COVID**-19," he said, "and by 2100 it could be five ...

Aug 5, 2020

海洋热浪被写入最新（2019）的IPCC《气候变化中的海洋和冰冻圈特别报告》

SCIENCE

HEAT WAVES HAPPEN IN THE OCEANS, TOO — AND THEY'RE GETTING WORSE

A major United Nations report shows how oceans are feeling the burn from climate change

By Justine Calma | @justcalma | Sep 25, 2019, 5:01am EDT

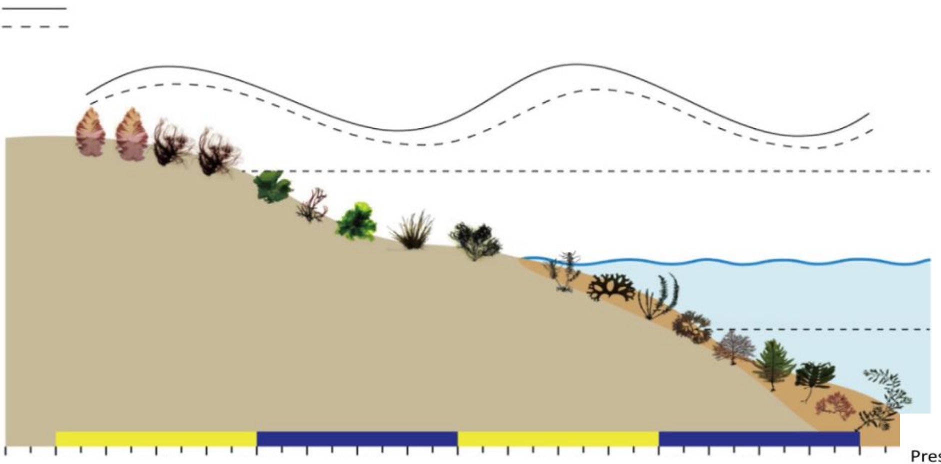
The Global Risks Report 2020

Top 10 risks in terms of

Likelihood

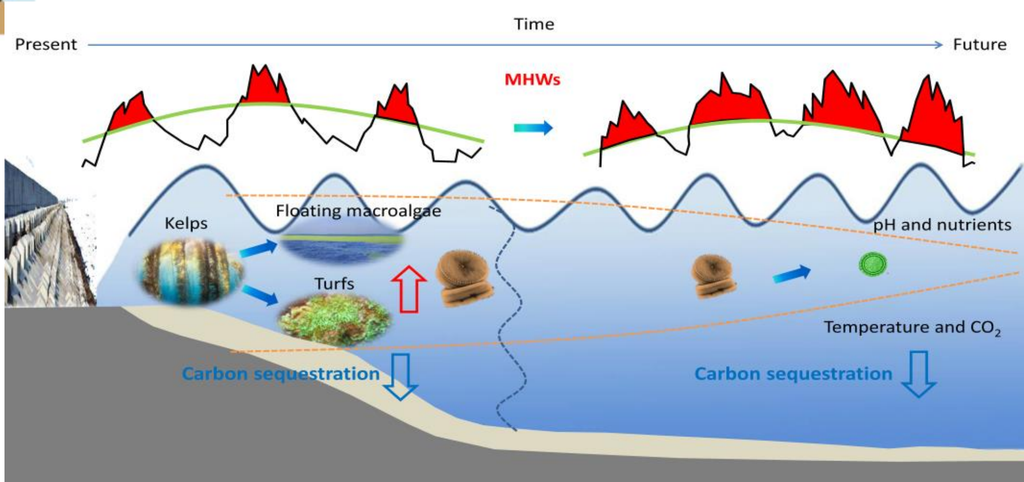
1. Extreme weather
2. Climate action failure
3. Natural disasters
4. Biodiversity loss
5. Human-made environmental disasters
6. Data fraud or theft
7. Cyberattacks
8. Water crises
9. Global governance failure
10. Asset bubbles

Macroalgae (seaweeds)



Ji and Gao, 2021

Gao et al, 2021



Green tides- *Ulva*

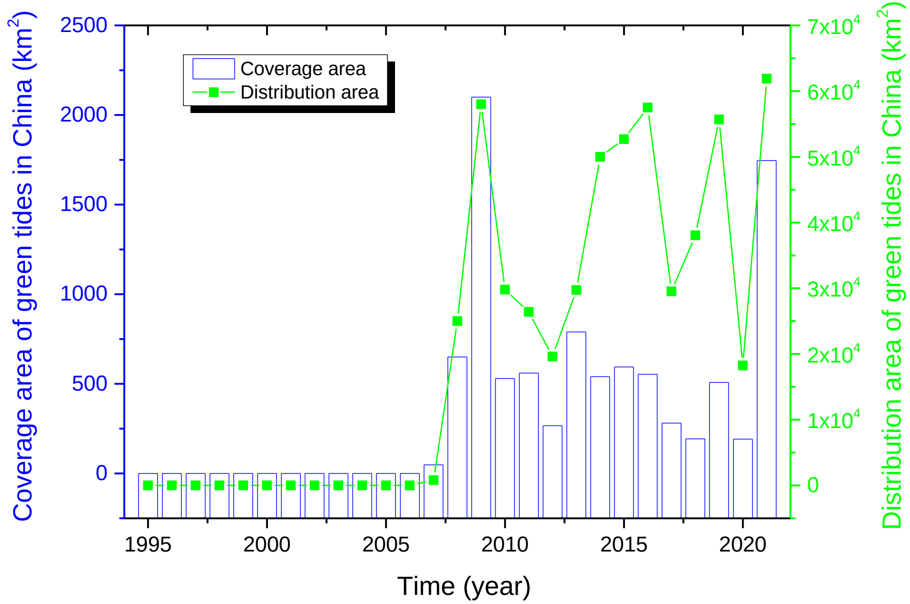
Smetacek and Zingone, 2013 *Nature*

Liu et al, 2013

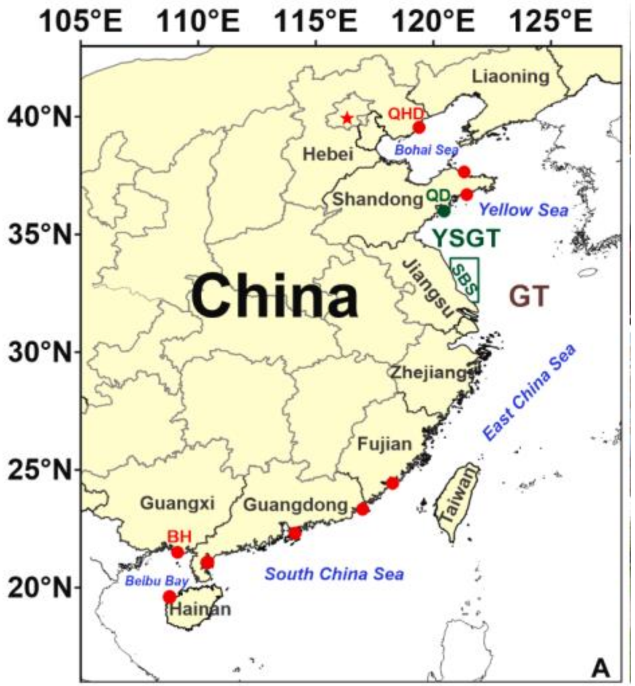
The green tide in 2008 led to the economic loss of 2 billion RMB for Qiangdao (Ye et al., 2011)

The occurrence of **green tides** in the **Yellow Sea** of China From 2008-2021 (中国海洋灾害公报）

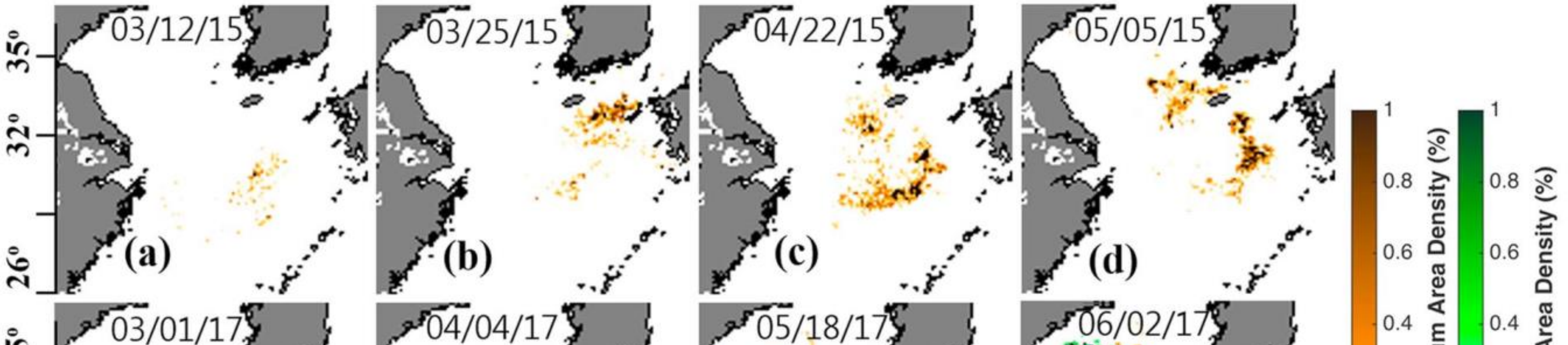
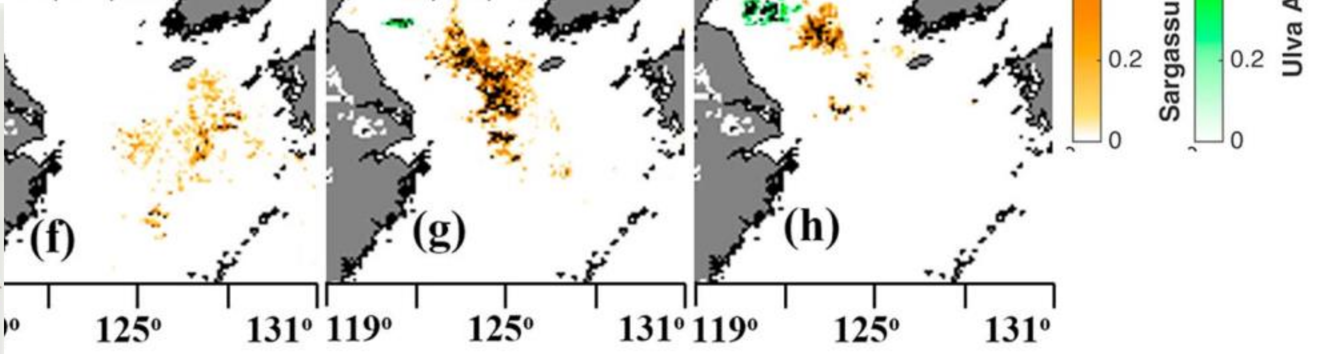
Year	Starting time	Ending time	Distribution area (km^2)	Coverage area (km^2)
2008	Middle May	Early Arg.	25 000	650
2009	Late March	Late Aug.	58 000	2 100
2010	Late April	Middle Aug.	29 800	530
2011	Late May	Late Aug.	26 400	560
2012	Late March	End Aug.	19 610	267
2013	Late March	Middle Aug.	29 733	790
2014	Early April	Middle Aug.	50 000	540
2015	Middle April	Early Aug.	52 700	594
2016	Early May	Early Aug.	57 500	554
2017	Middle May	Late July	29 522	281
2018	Late April	Middle Aug.	38046	193
2019	Late April	Early Sep.	55699	508
2020	Early April	Late July	18237	192
2021	Late April	Late Aug.	61898	1746

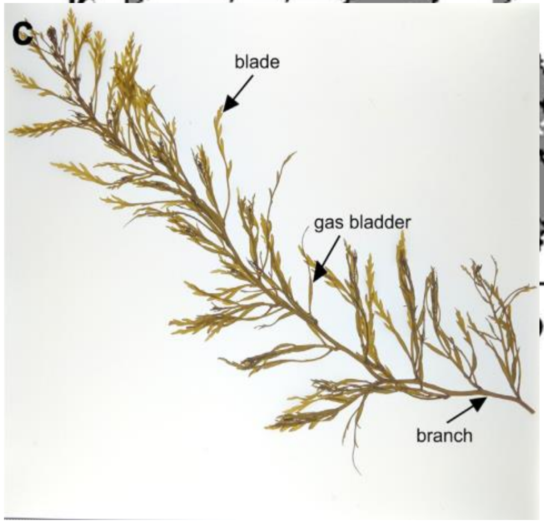


Unpublished data

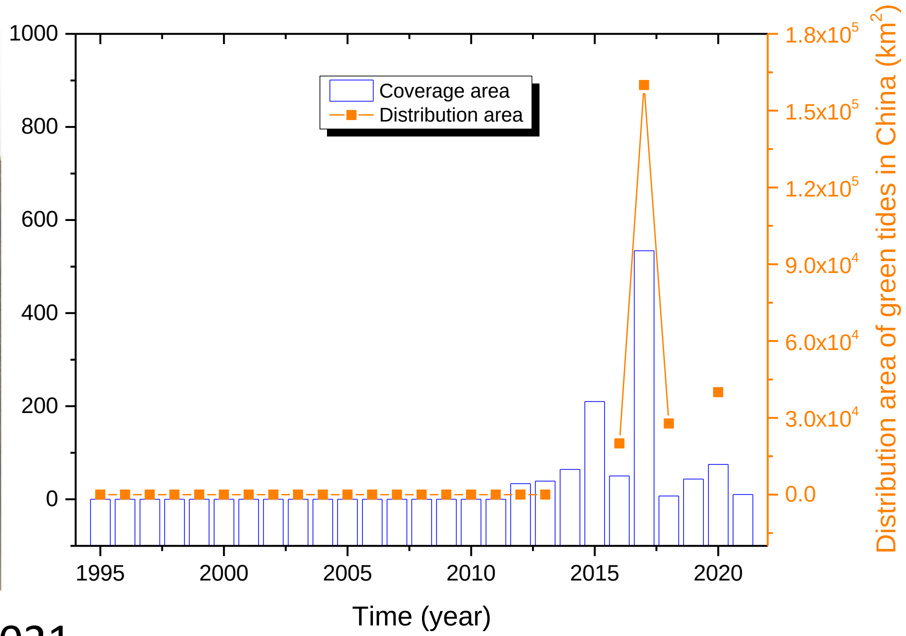


Xiao et al., 2021



03/12/15
03/25/15
04/22/15
05/05/15
03/01/17
04/04/17
05/18/17
06/02/17
(a)
(b)
(c)
(d)
(f)
(g)
(h)
35°
32°
26°
125°
131°
119°
Sargassum Area Density (%)
Ulva Area Density (%)
1
0.8
0.6
0.4
0.2
0


c
blade
gas bladder
branch

Qi et al., 2021



Becoming new normal

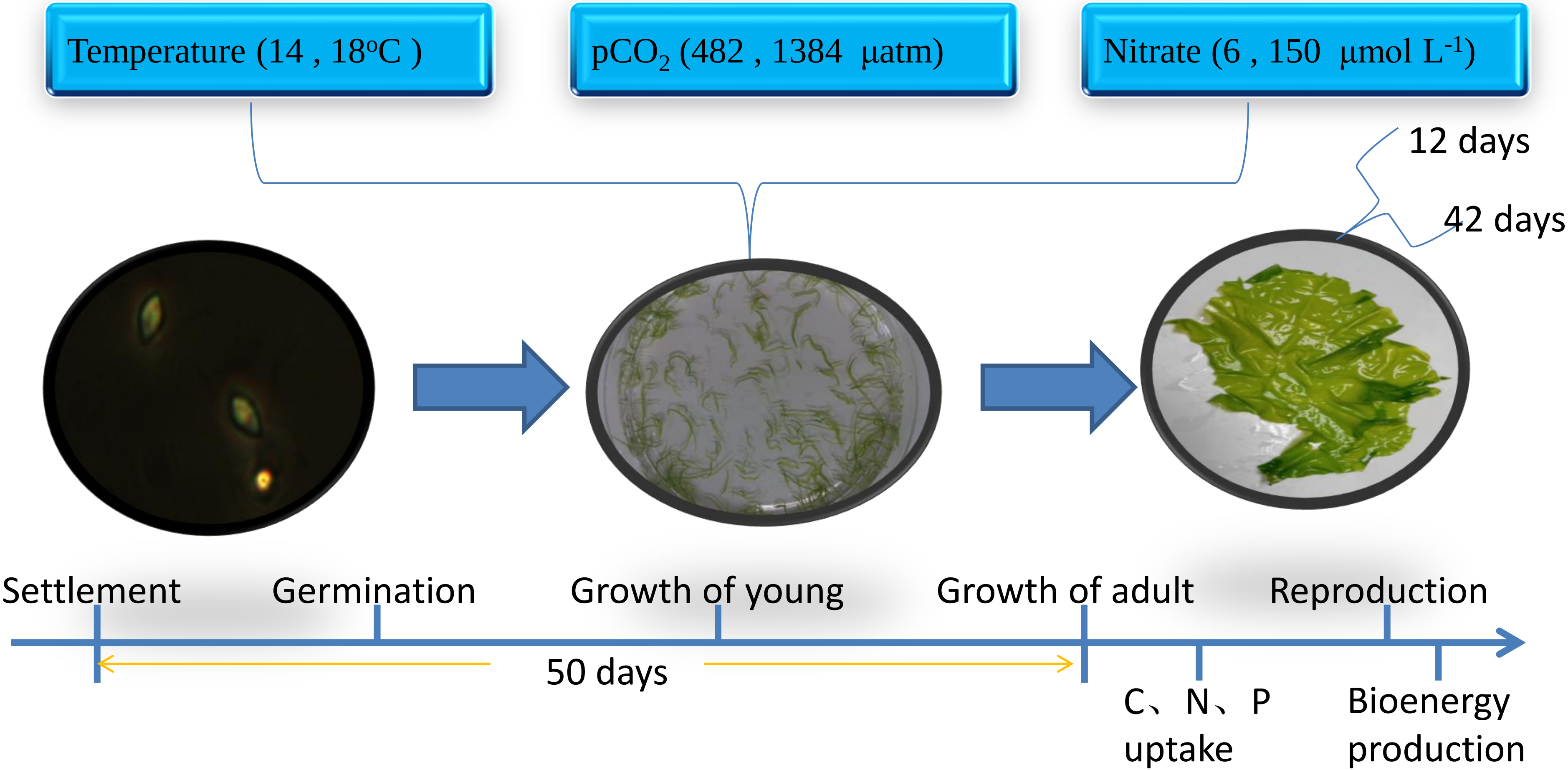
Liu et al., 2021

Unpublished data

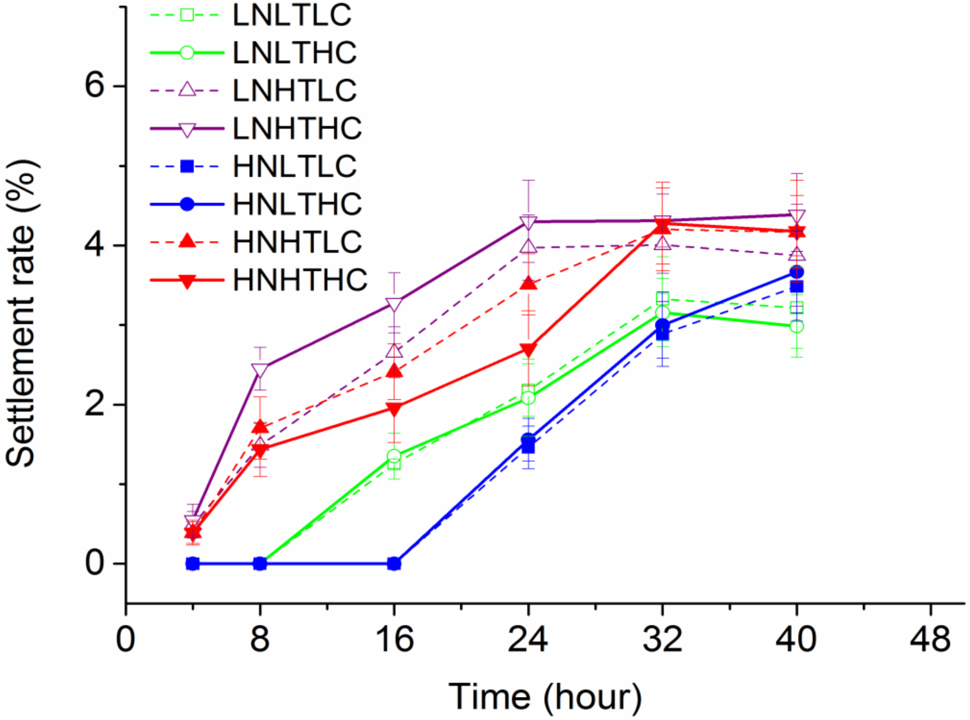
Research questions

- Are macroalgal blooms related to climate change?
- How to deal with them?

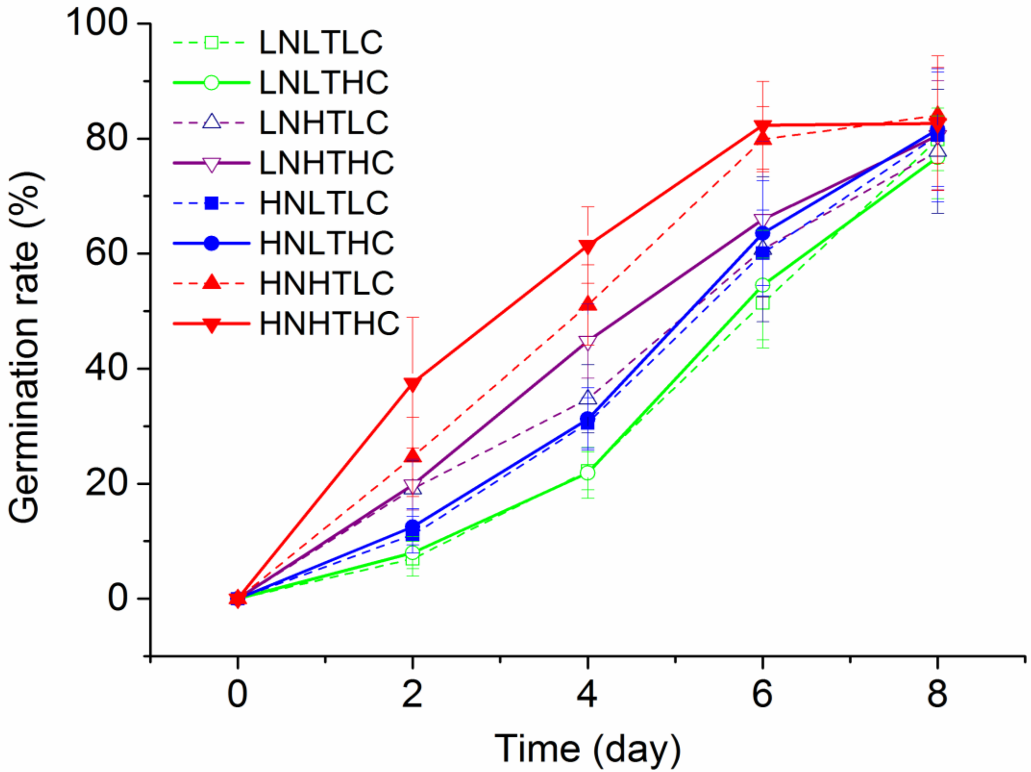
Materials and methods



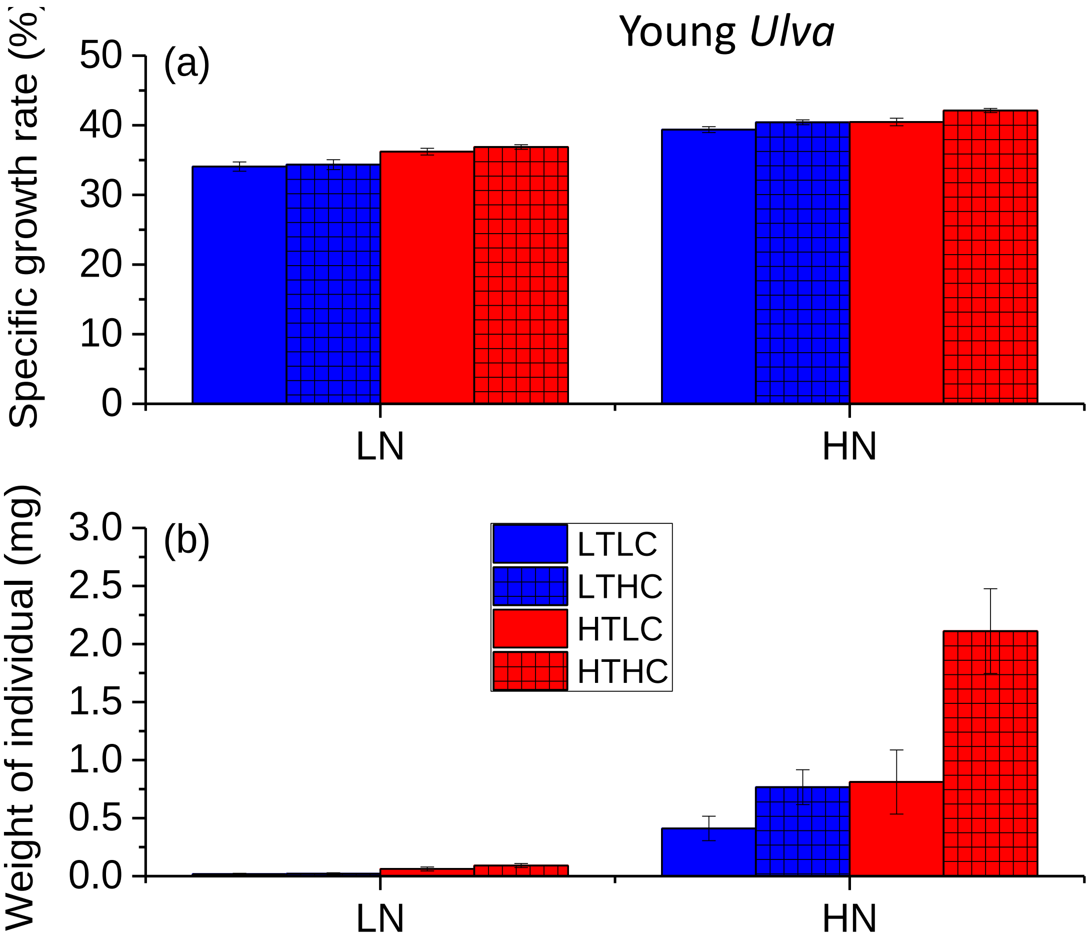
Results



- High temperature enhanced Settlement.
- High nitrate reduced it.
- CO_2 did not affect Settlement.

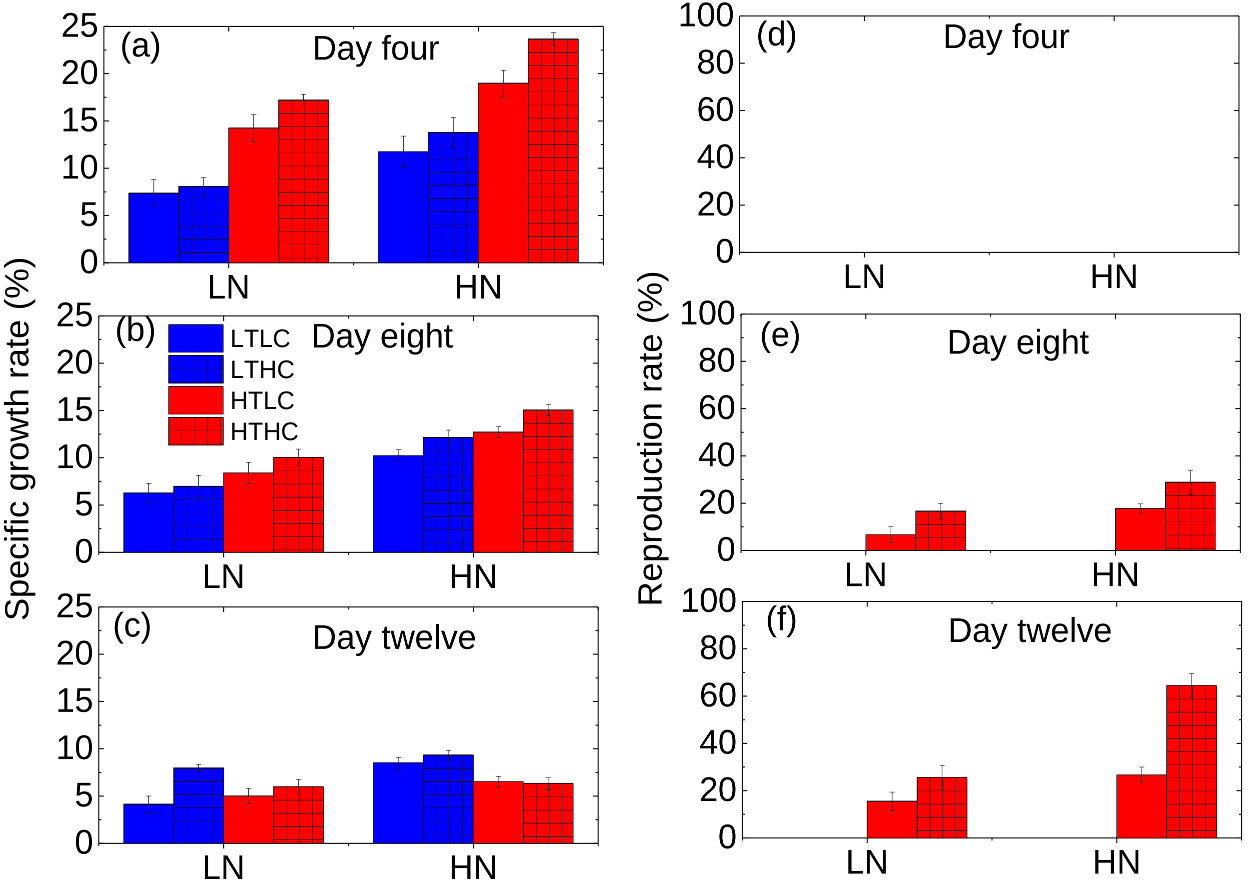


- Each factor enhanced germination by days 2 and 4.
- By day six, the germination-promoting effect of the elevated pCO_2 was lost.
- There were no significant differences in germination rates across all treatments by day 8.

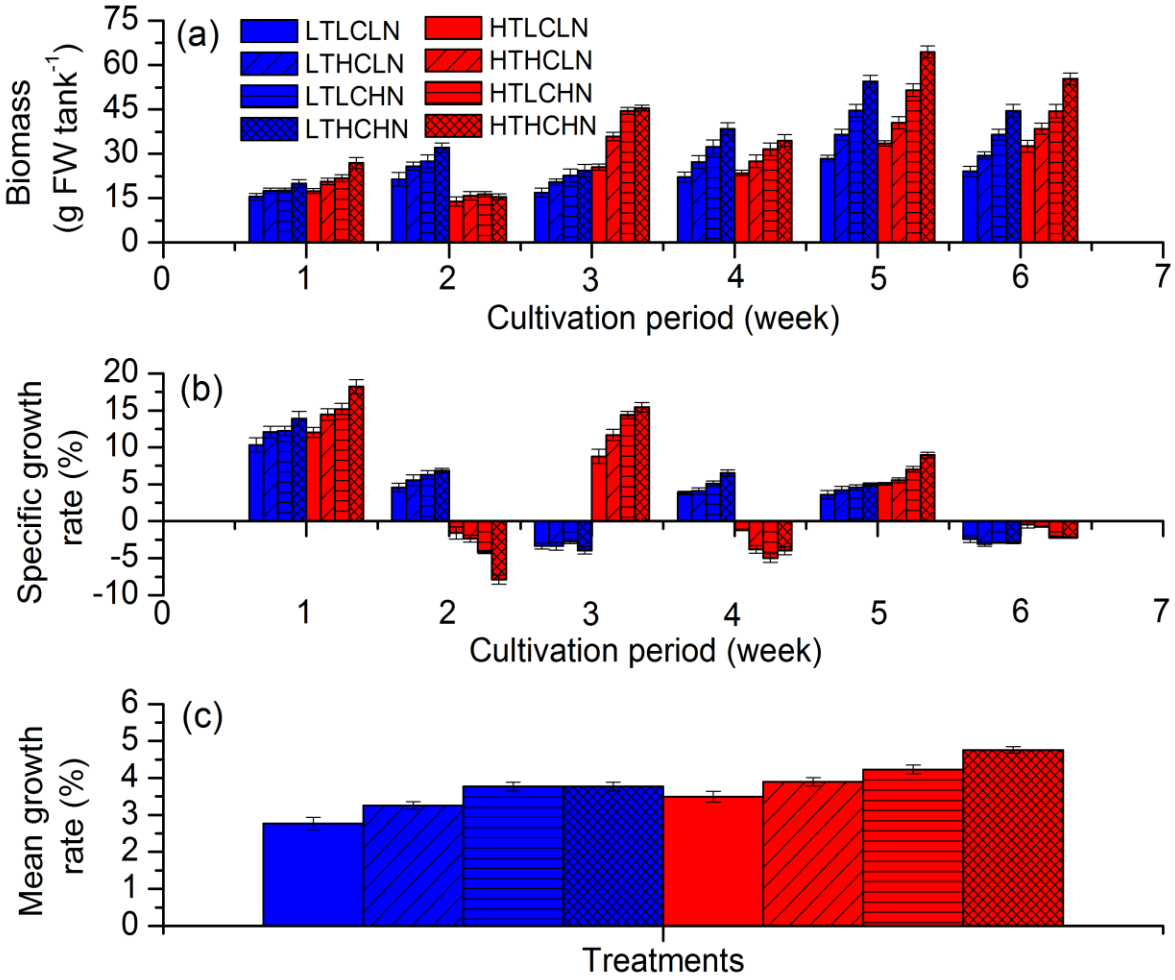


- Nitrate had the strongest effect on growth, followed by temperature.
- Higher pCO_2 only promoted growth under the higher nitrate conditions.
- The mass of individual germlings under HTHNHC was around 100-fold higher than that under LNLTLC.

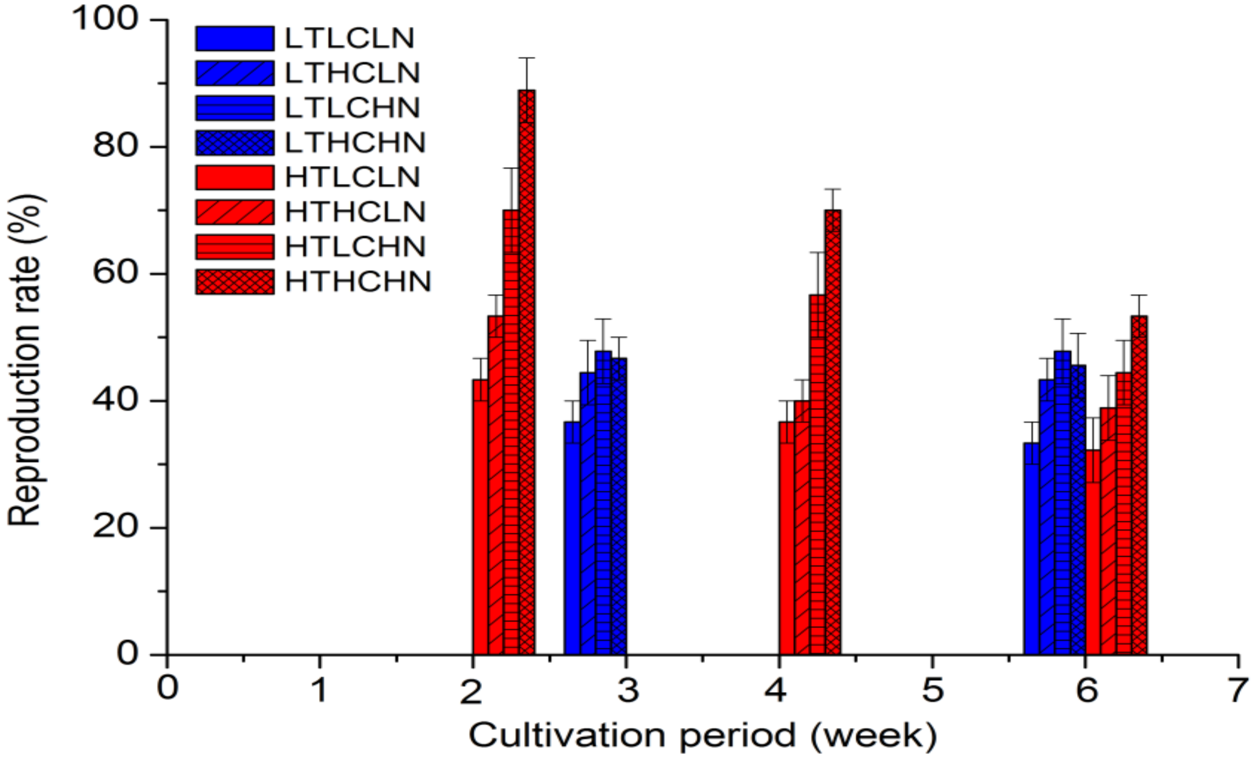
Adult *Ulva*



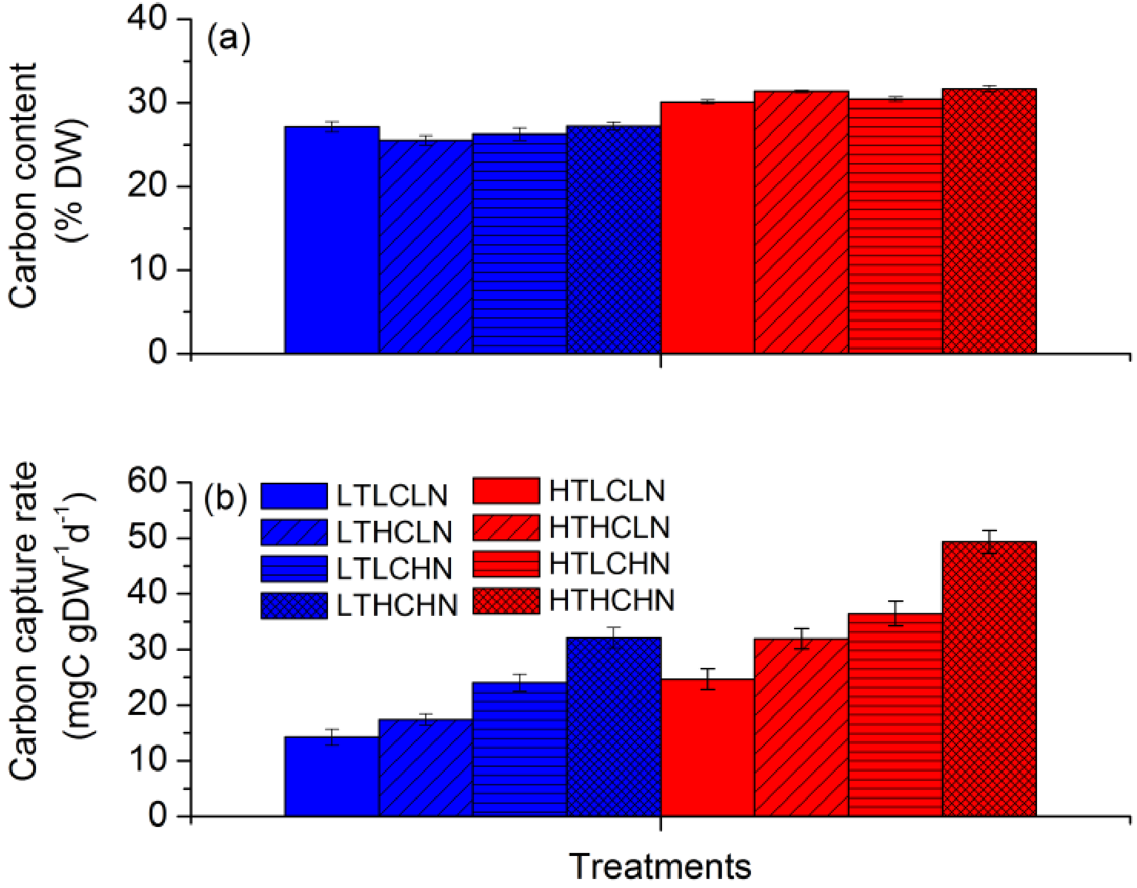
- High temperature and high CO_2 increased growth of adult *Ulva* on days 4 and 8 but reduced it on day 12.
- High temperature induced reproduction of *Ulva* on days 8 and 12; high CO_2 Amplified it.



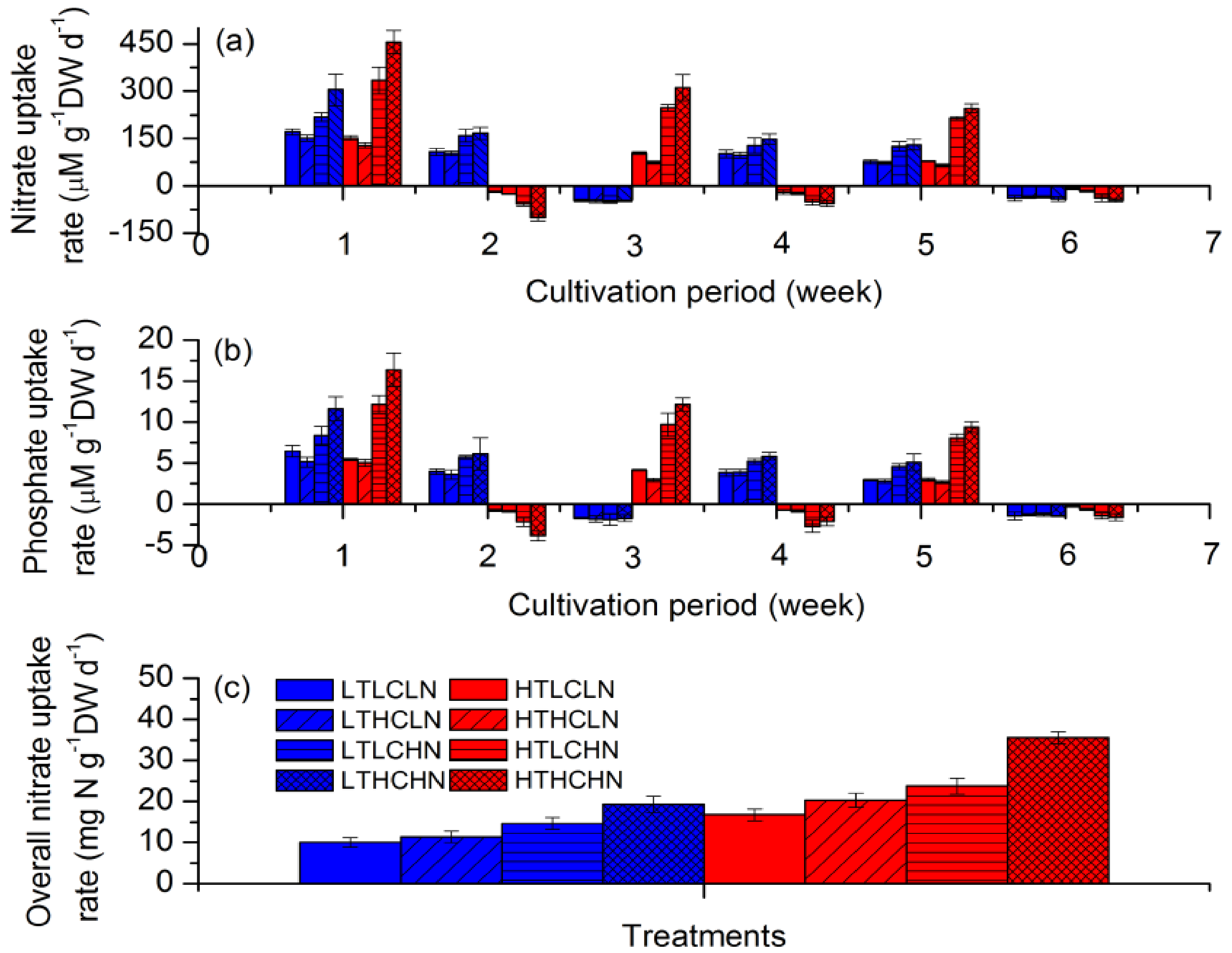
- High temperature increased growth by weeks 1, 3, 5 but reduced it by weeks 2, 4, 6.
- Low temperature resulted in negative growth by weeks 3 and 6.
- All three factors positively affected the mean growth rate.



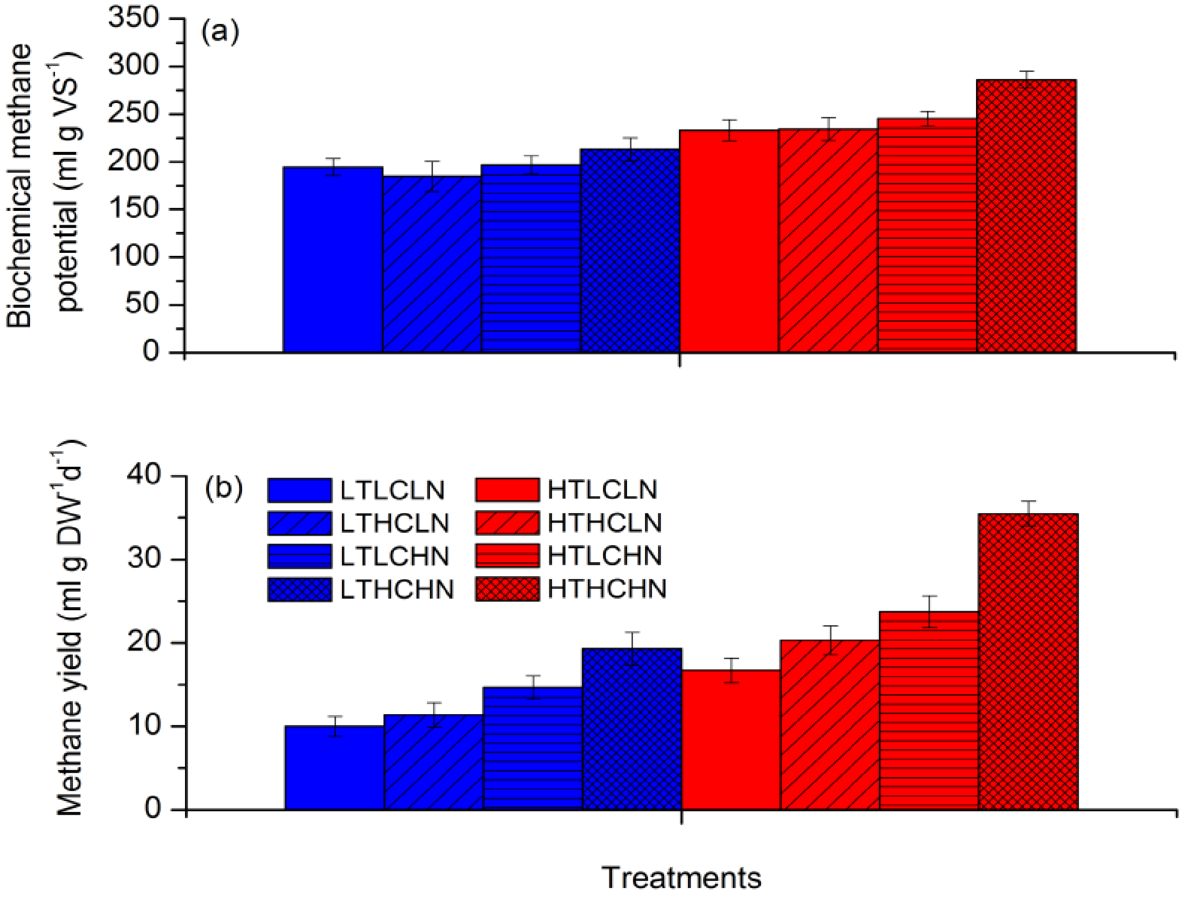
- ➢ The thalli grown at HT had reproductive events in weeks 2, 4 and 6.
- ➢ Those grown at LT were reproductive in weeks 3 and 6.



- HT increased the carbon content.
- HC increased the carbon content at HT.
- Each factor alone increased carbon capture rate .
- They resulted in a further increase when they worked together.

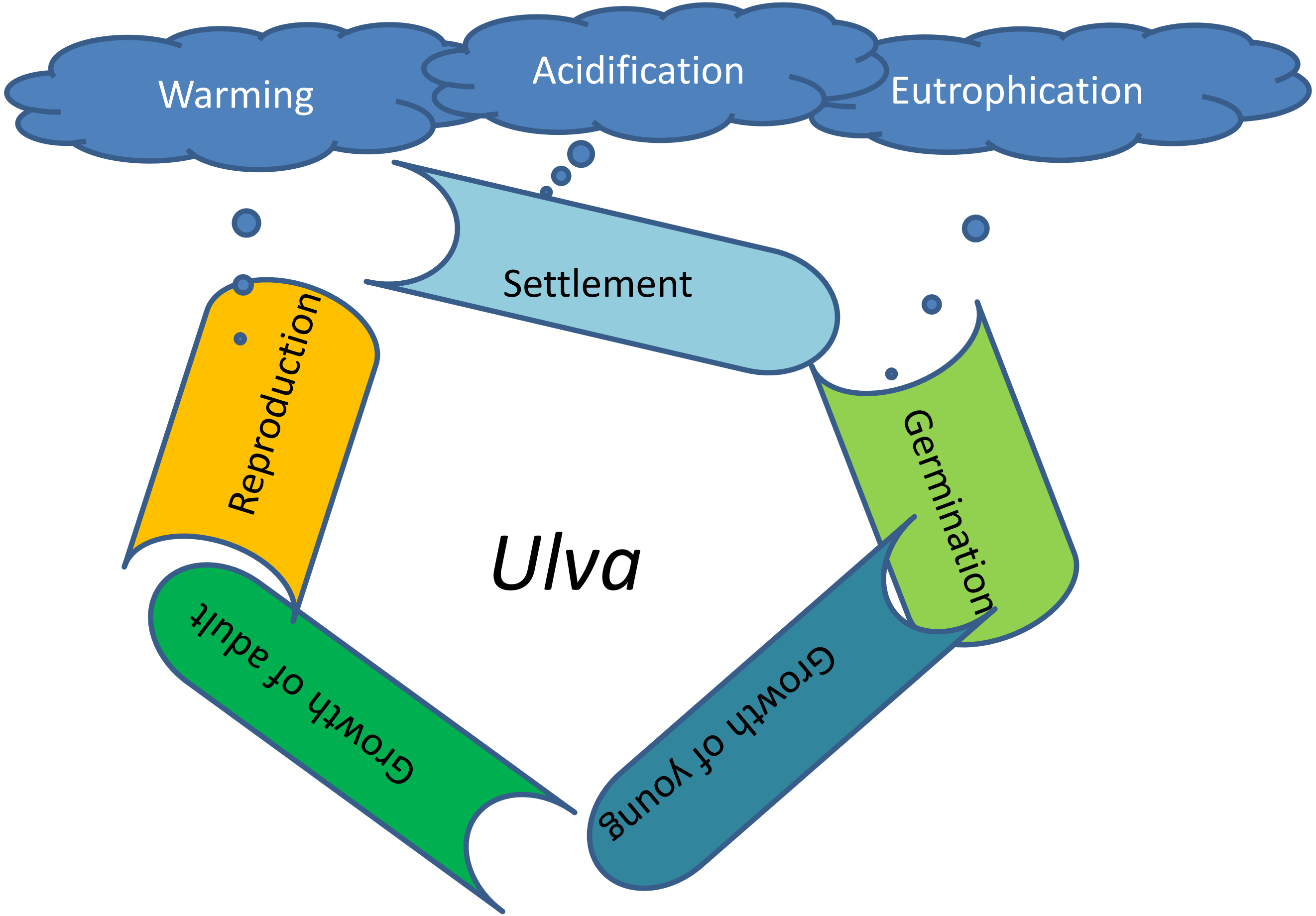


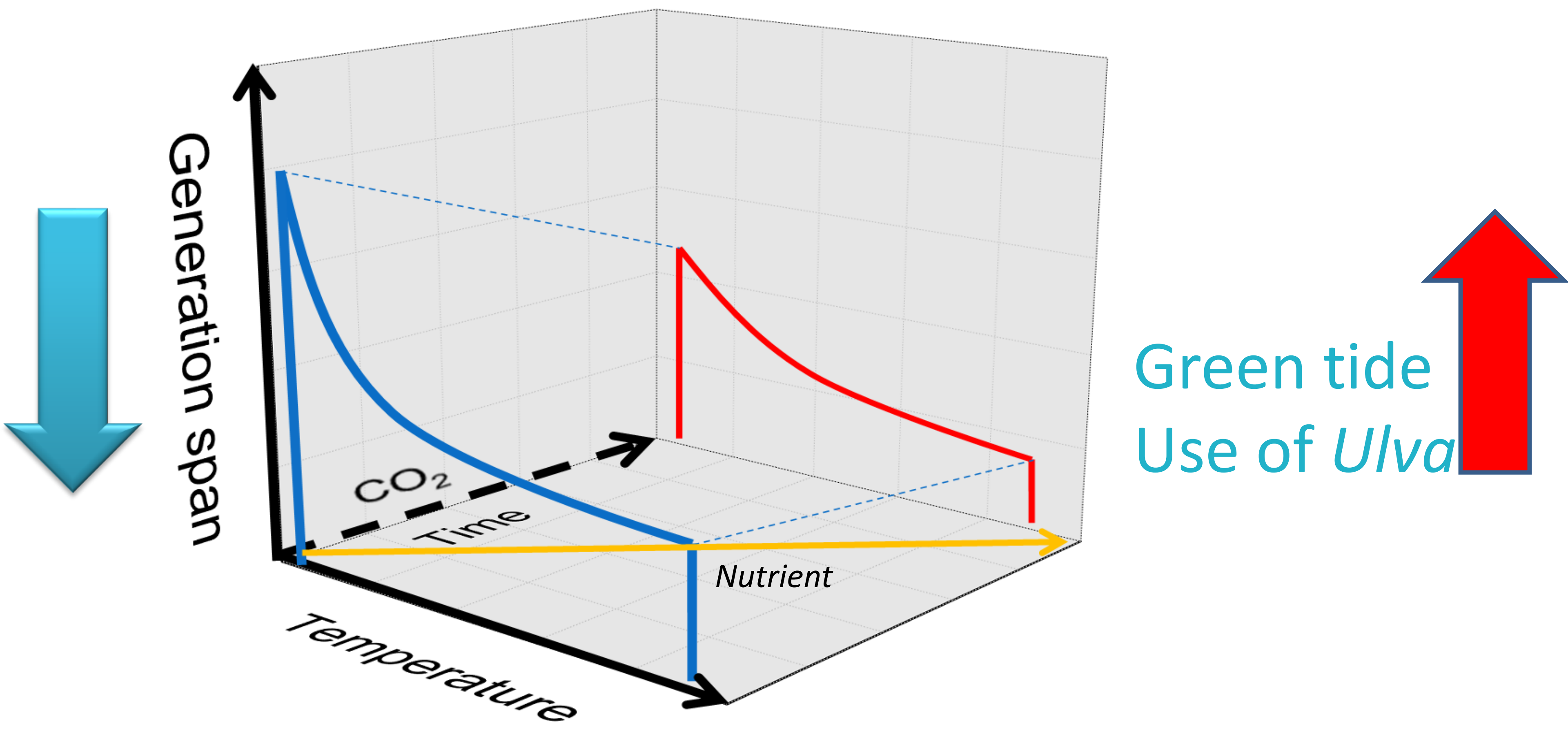
- HT increased N&P uptake by weeks 1, 3 and 5.
- HT led to negative N&P uptake rates by weeks 2, 4 and 6.
- All three factors showed positive effects on overall nitrate uptake.

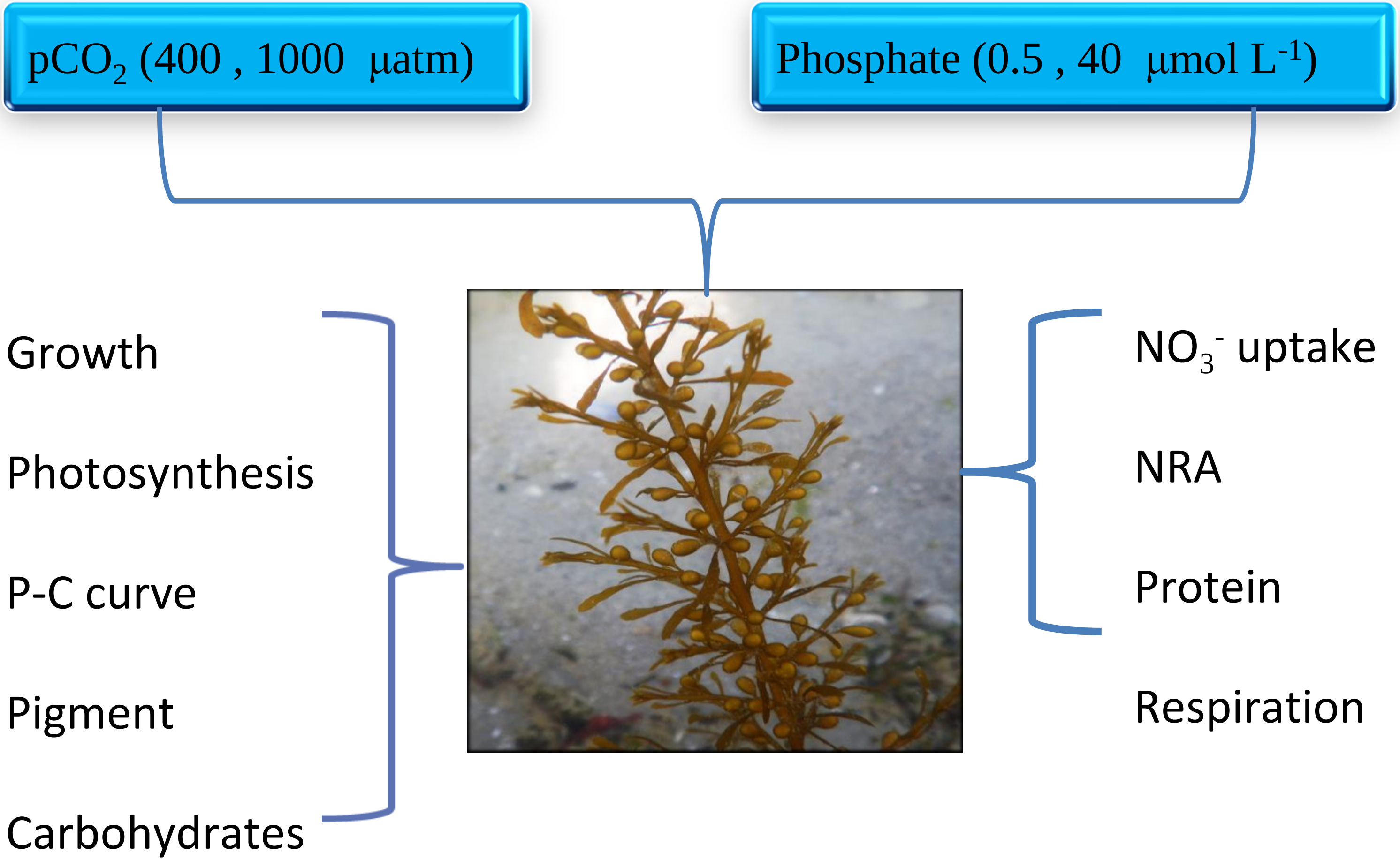


- HT increased the BMP.
- HN did not affect the BMP at LC, but increased it by at HC.
- All three factors increased methane yield.

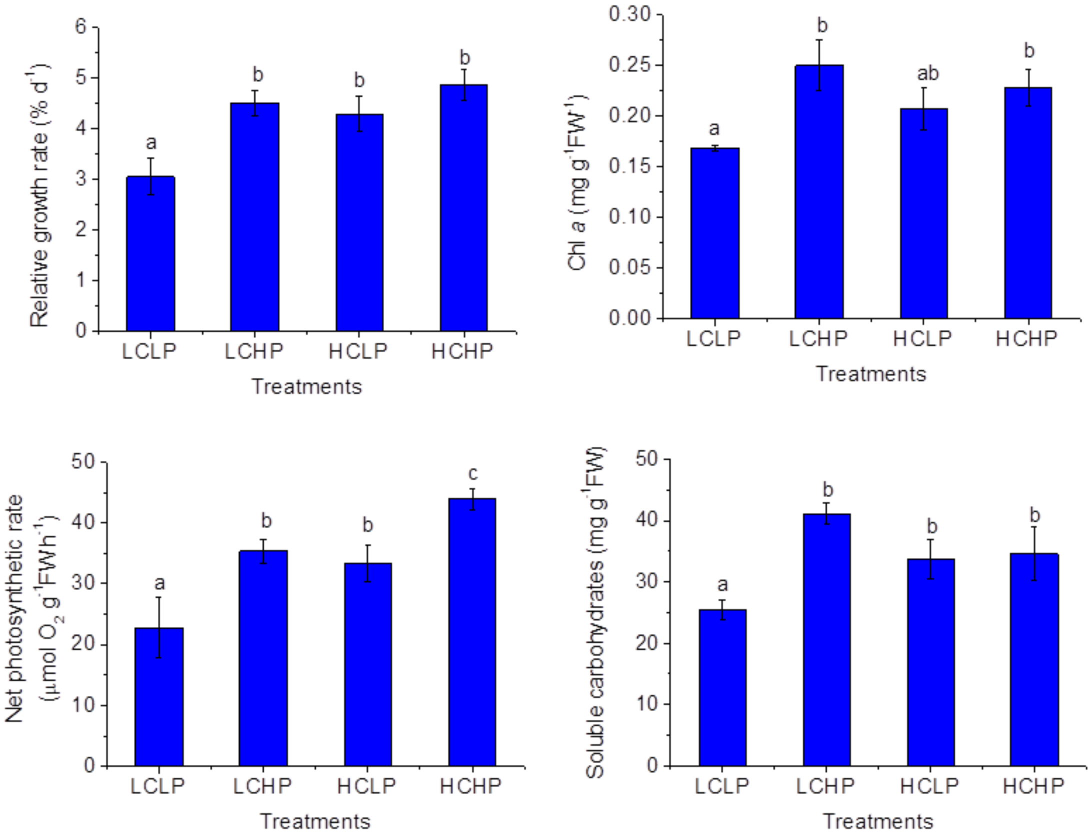
Conclusions



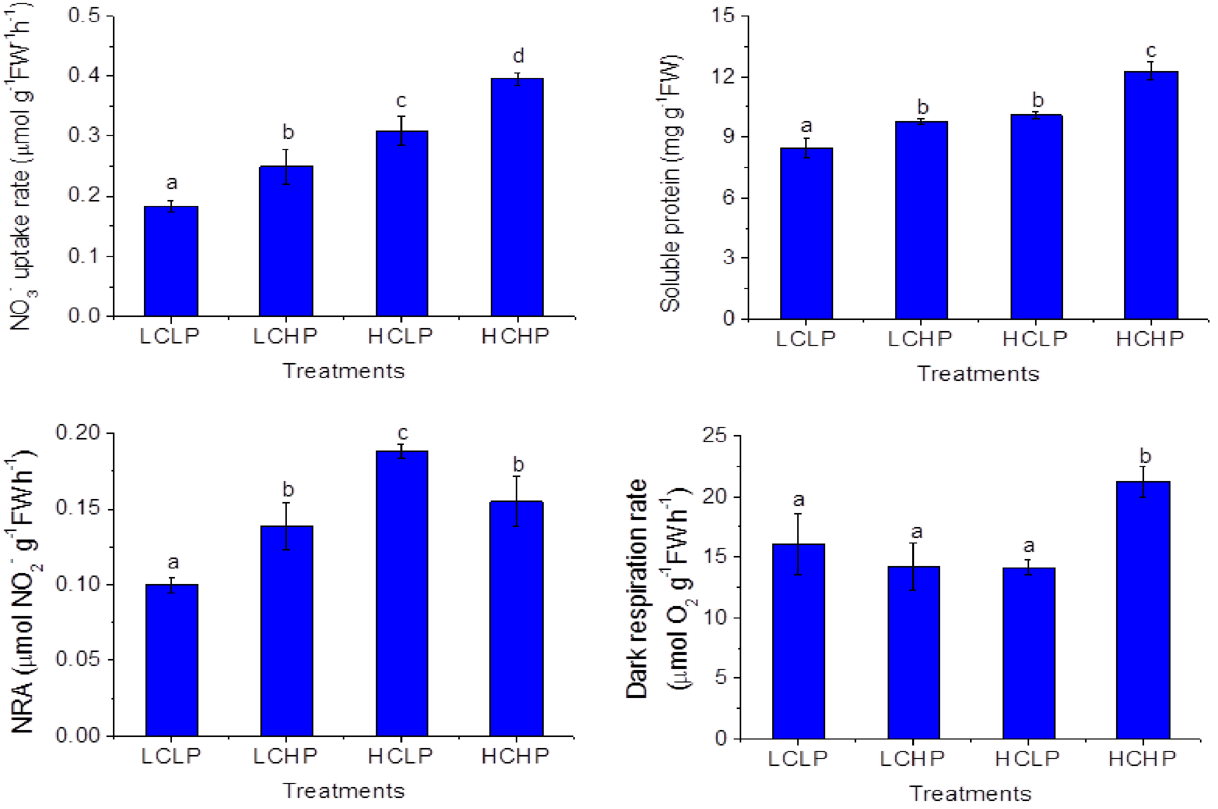

Generation span
CO2
Time
Temperature
Nutrient
Green tide
Use of *Ulva*



pCO_2 (400 , 1000 µatm)
Phosphate (0.5 , 40 µmol L^{-1})
Growth
Photosynthesis
P-C curve
Pigment
Carbohydrates
NO_3^- uptake
NRA
Protein
Respiration

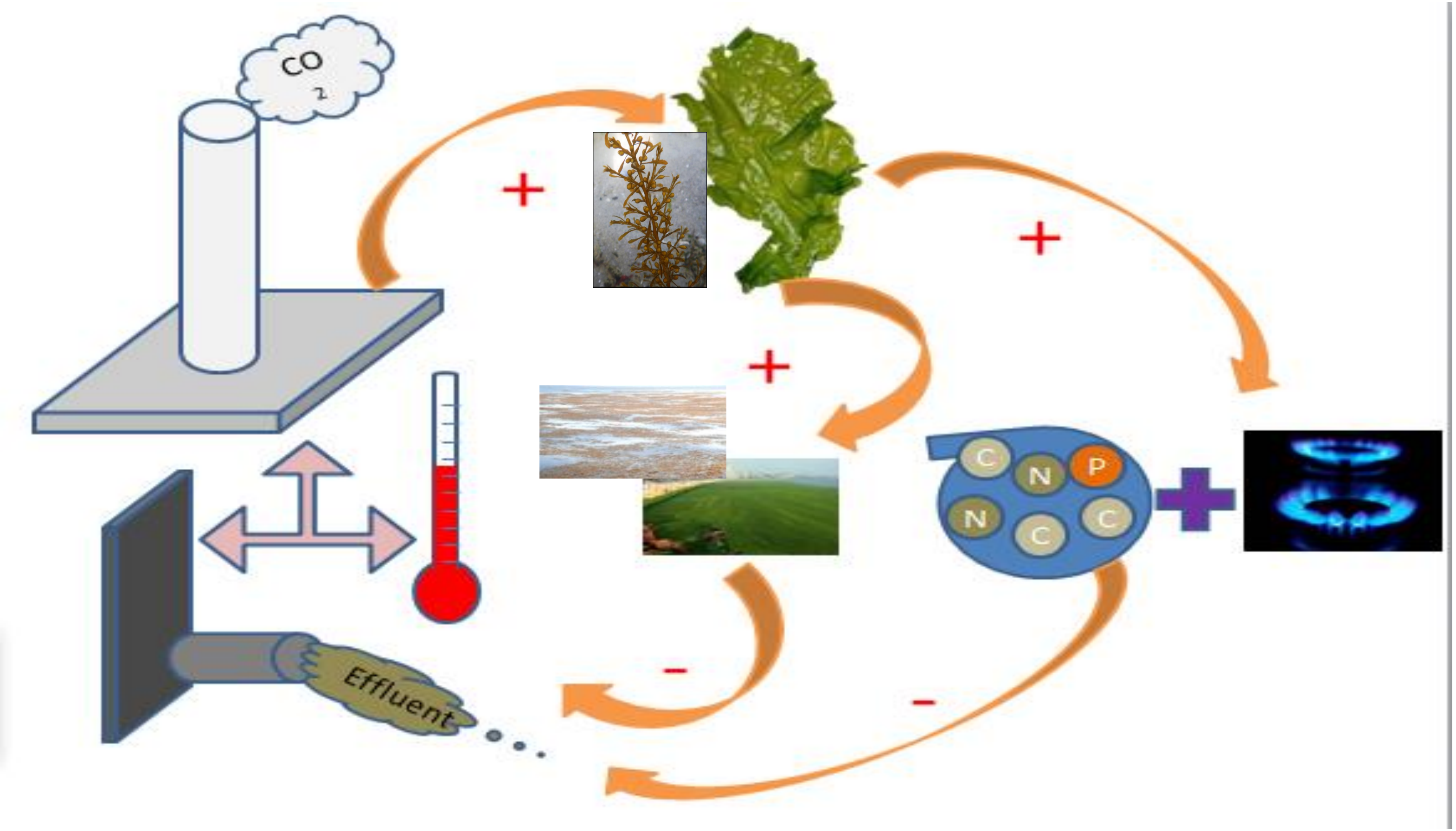


- Both HP and HC increased growth, Chl *a* and carbohyrates.
- Both HP and HC increased photosynthetic rate and HPHC resulted in further increase.



- Both HP and HC increased nitrate uptake rate and soluble protein. HPHC resulted in further increase of them.

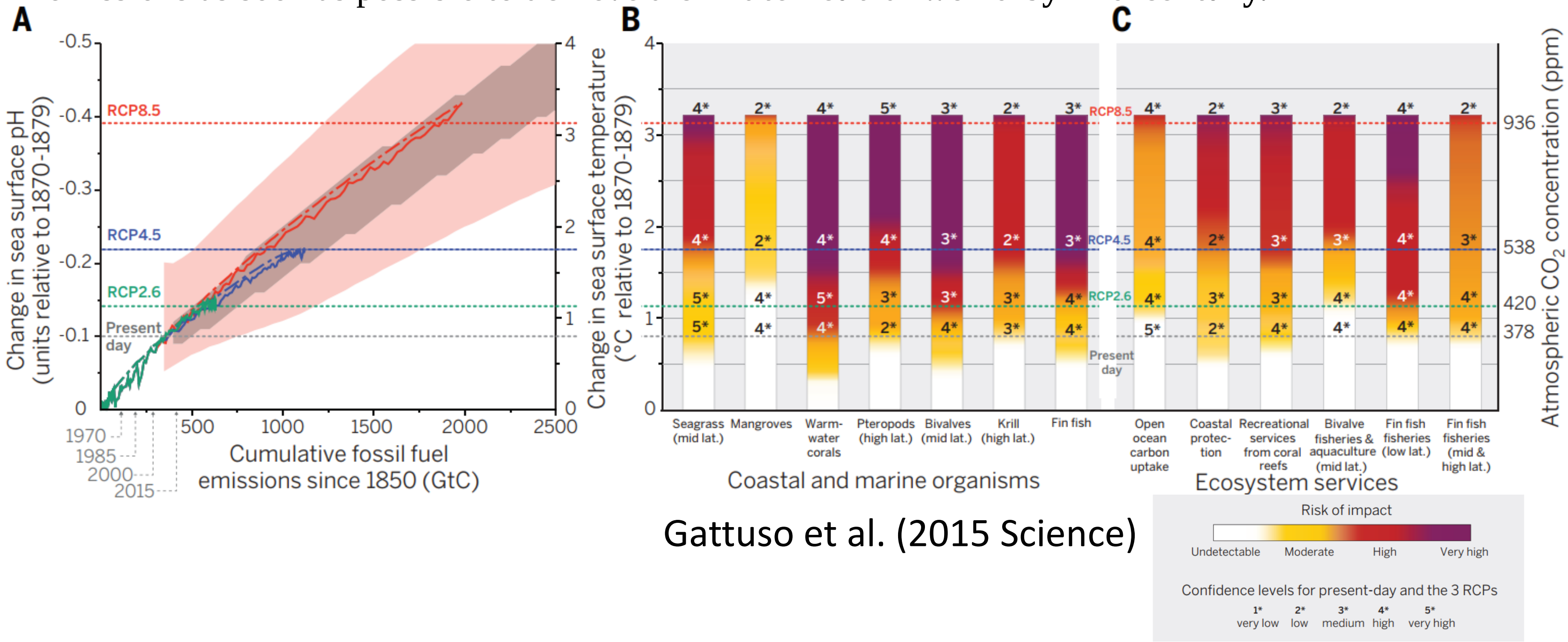
- Both HP and HC increased nitrate reductase activity.


CO2
+
+
+
C
N
P
N
C
C
Effluent
-
-

Carbon neutrality

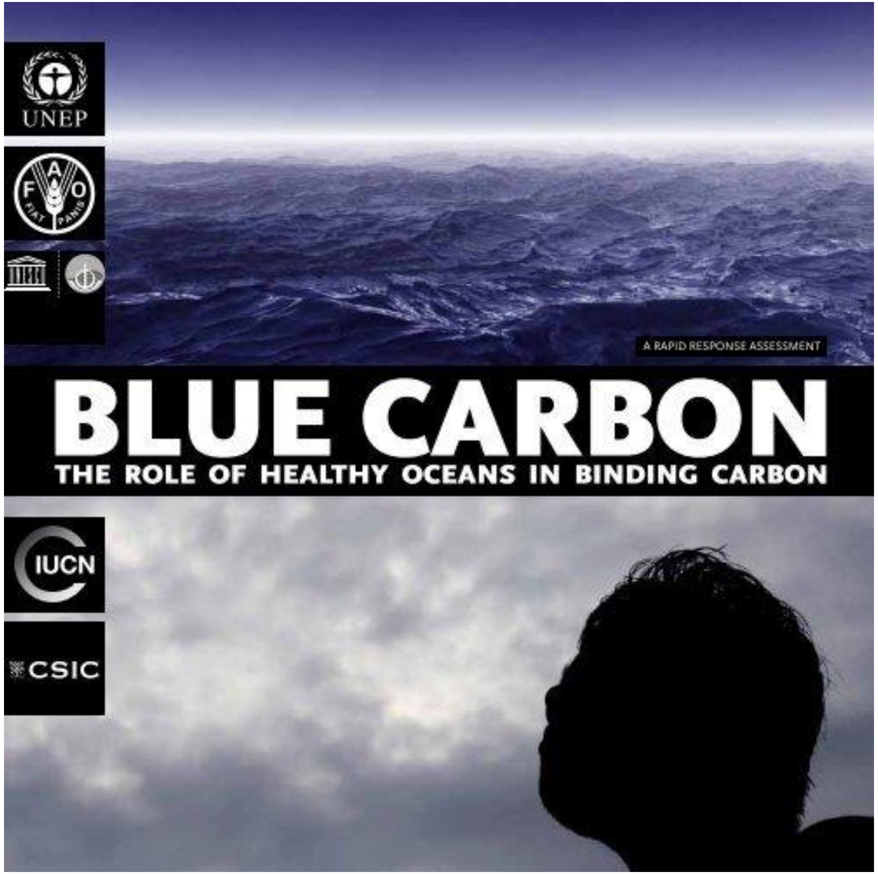
The Paris Agreement (2015)

- To **limit global warming** to well below 2, **preferably to 1.5 degrees Celsius**, compared to pre-industrial levels.
- To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible **to achieve a climate neutral world by mid-century.**



Gattuso et al. (2015 Science)

The term Blue Carbon (BC) was first coined a decade ago to describe the disproportionately
large contribution of coastal vegetated ecosystems to global carbon sequestration



Nellemann C., et al (2009)

nature > nature communications > perspectives > article

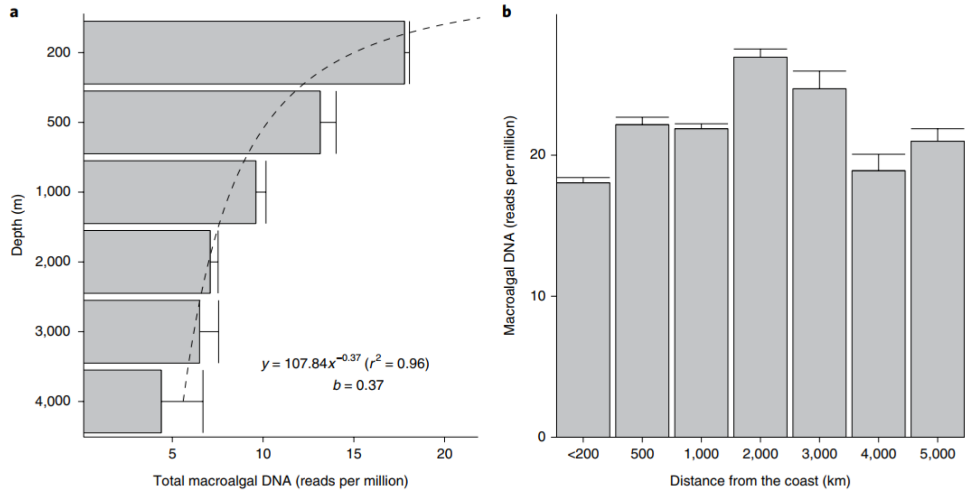
Perspective | Open Access | Published: 05 September 2019

The future of Blue Carbon science

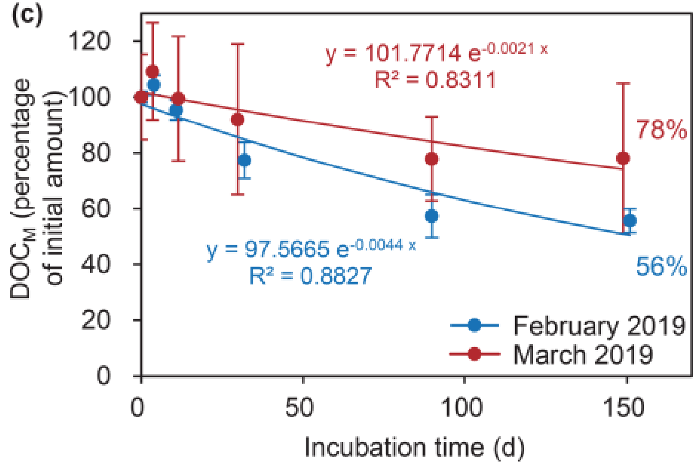
Peter I. Macreadie, Andrea Anton, ... Carlos M. Duarte + Show authors

Q3. What is the global importance of macroalgae, including calcifying algae, as Blue Carbon sinks/donors?

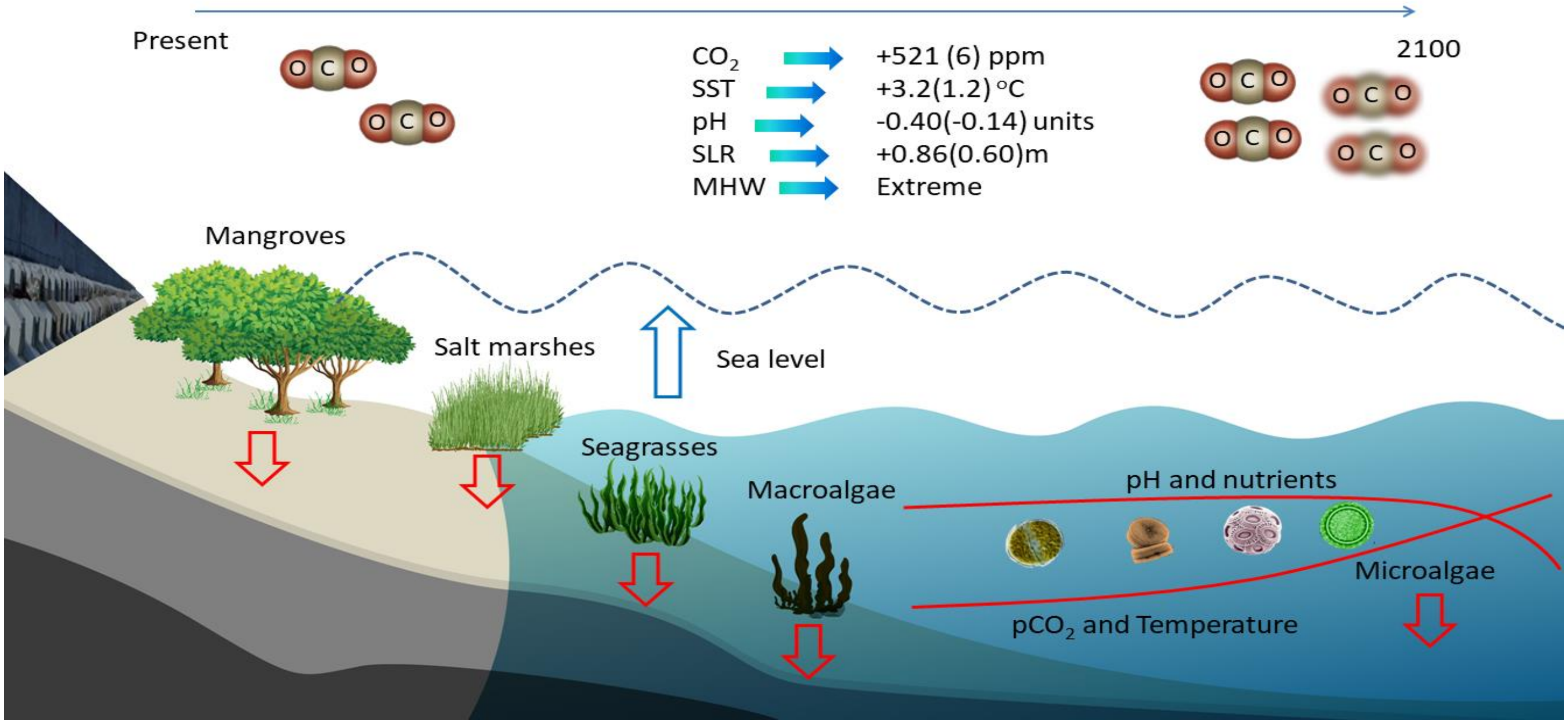
Macroalgae are highly productive (Table 2) and have the largest global area of any vegetated coastal ecosystem[48]. Yet only in a relatively few cases have macroalgae been included in BC assessments. Unlike angiosperms, which grow on depositional



Export of macroalgae to the deep and open ocean. Twenty four orders were founded. (Ortega et al., 2019 *Nat. Geosci.*)



56 %–78 % of macroalgal DOC was refractory
DOC (RDOC) that persisted for 150 d
(Watanabe et al., 2020)



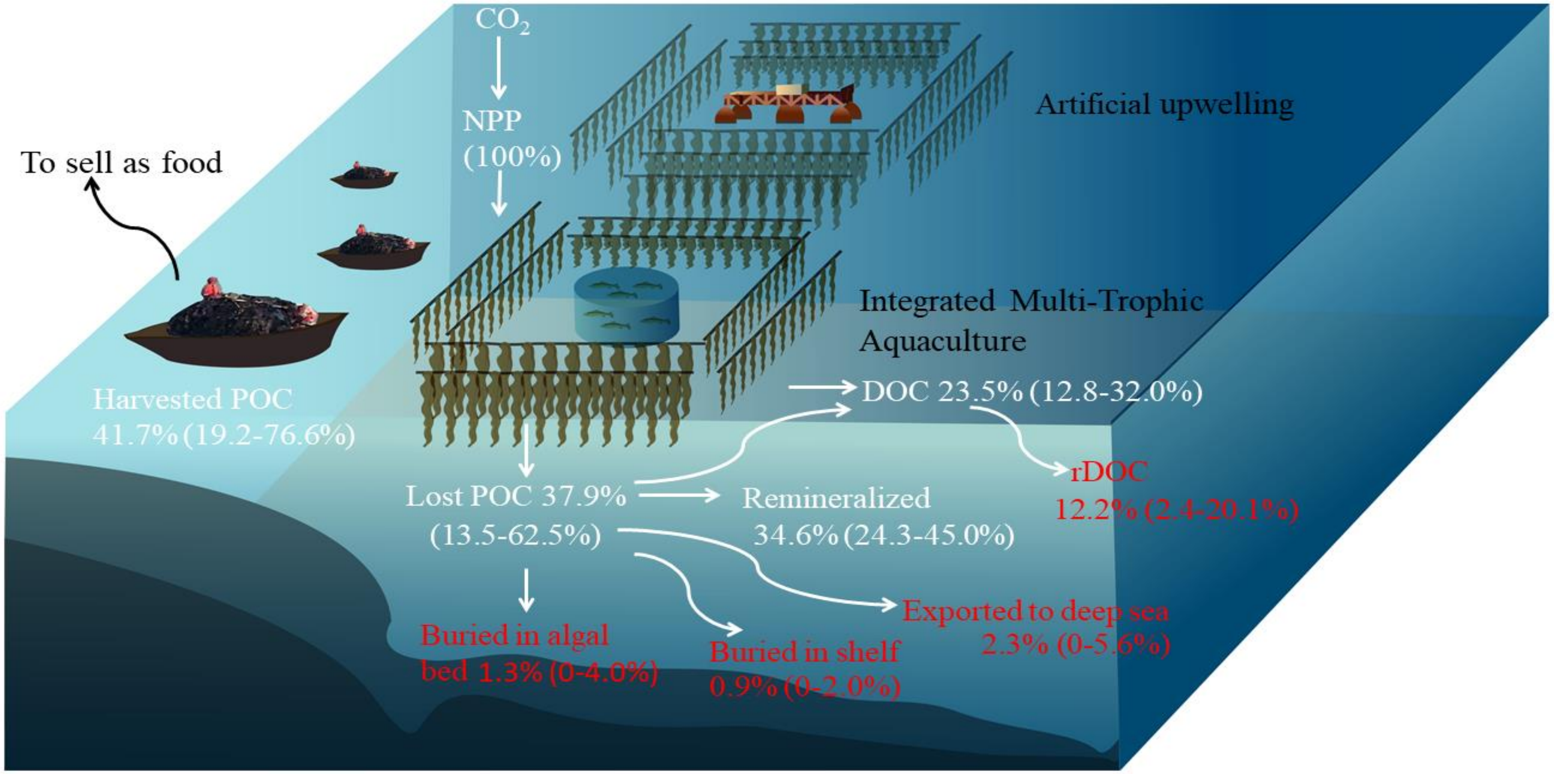
Climate changes by the end of this century according to stringent (RCP2.6) and high business-as-usual (RCP8.5) CO_2 emissions scenarios and the changes of marine primary production and carbon sequestration.

Gao et al., 2022

Table 1 Net primary production (NPP) and carbon sequestration of marine primary producers and the potential to mitigate climate change

Type	Global area (million km²)	NPP (g C m^{-2} yr^{-1})	CO_2 sequestration density (g C m^{-2} yr^{-1})	Total NPP (Tg C yr^{-1})	Total CO_2 sequestration (Tg C yr^{-1})	Required area for CO_2 sequestration (million km²)[a]	Available area (million km²)	References
Mangroves	0.14±0.004	1,355±179	168±23	195±26	24.2±3.4	6.49±0.90	0.128±0.002	[17-30]
Salt marshes	0.18±0.06	1,226±207	224±34	222±84	40.6±15.0	4.87±0.73	0.128±0.002	[17, 22,26,31-34]
Seagrasses	0.22±0.04	461±111	117±19	102±30	25.8±6.0	9.35±1.51	4.10±0.04	[17,21,27,32,35-41]
Wild macroalgae	3.21±0.74	569±114	62±21	1,826±561	199±82	17.57±6.01	2.50±0.74	[27,32, 40, 42-48]
Cultured macroalgae	1.49±0.30×10^{-3}	1,425±251	238±42	2.13±0.20	0.36±0.03	4.59±0.81	48.00±9.59	[27, 49-54]
Microalgae	361±0.38	128±13	2.30±0.24	46,275±4759	833±86	473±49	0	[55-61]

[a]To sequester 4 Gt CO_2 yr^{-1} that is required to limit warming to 2°C above preindustrial conditions in Representative Concentration Pathway (RCP) 2.6.[4] - represents the data incalculable at present.



Pathways for carbon sequestration of cultivated macroalgae in open oceans where nutrients are supplied through artificial upwelling or integrated multi-trophic aquaculture.

Gao et al., 2022

China's annual emissions surpass those of all developed nations combined, report finds

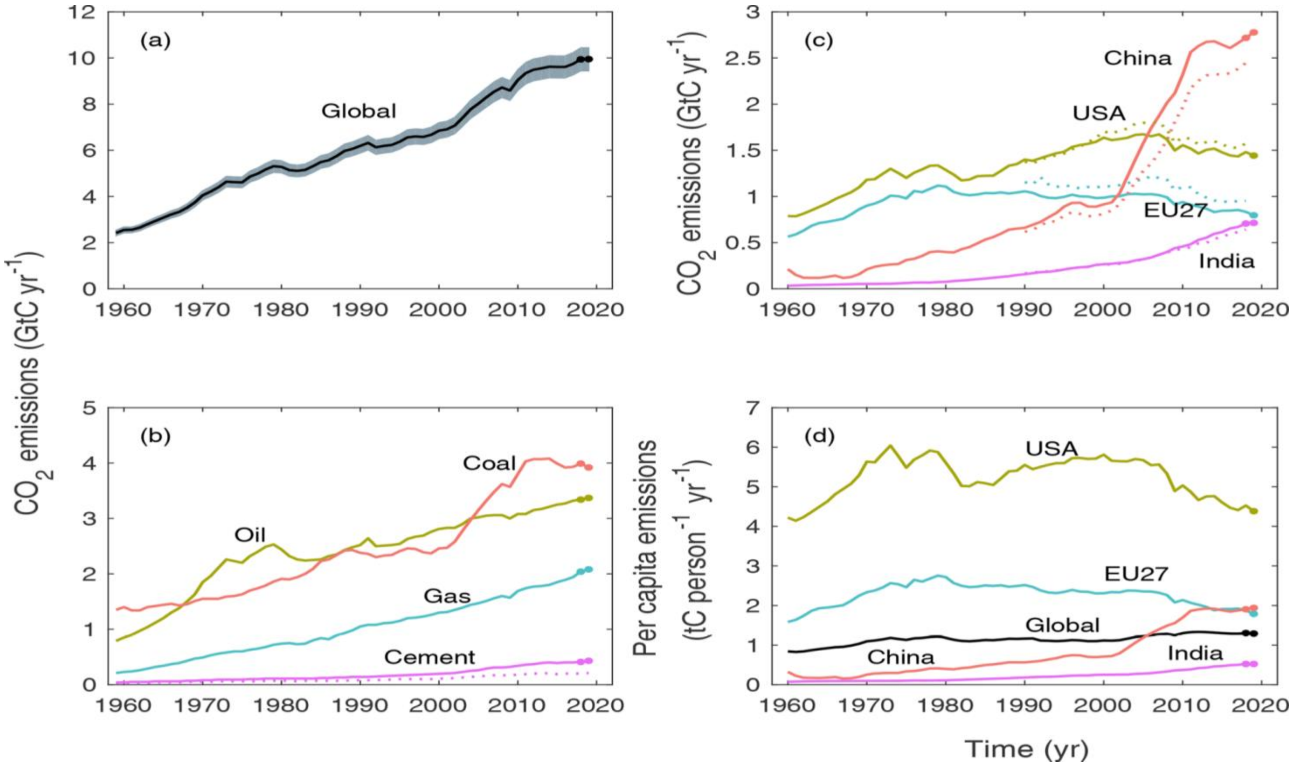
 

By Laura Smith-Spark and Ivana Kottasová, CNN

Updated 9:38 AM ET, Fri May 7, 2021

搜狐新闻 > 国内要闻 > 时事

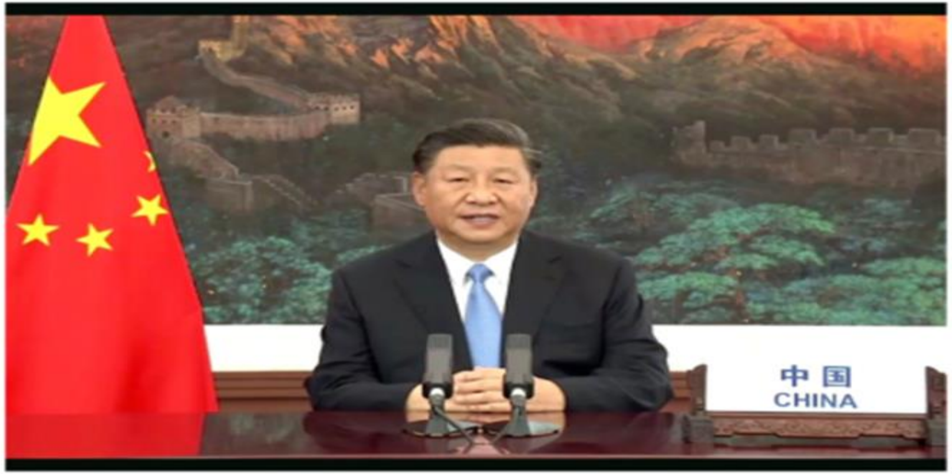
中国不应该被视作碳排放大国而屡受指责



Global Carbon Budget 2021

China's Xi pledges to ax carbon emissions by 2060

"We aim to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060," Xi said.



Chinese President Xi Jinping speaks in a prerecorded message which was played during the 75th session of the United Nations General Assembly. | UNTV via AP

2020年9月22日第七十五届联合国大会一般性辩论上

We aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060

Abstract

China's pledge to reach carbon neutrality by 2060 is ambitious and could provide the world with much-needed leadership on how to achieve a +1.5ºC warming target above pre-industrial levels by the end of the century. But the pathways that would achieve net zero by 2060 are still unclear

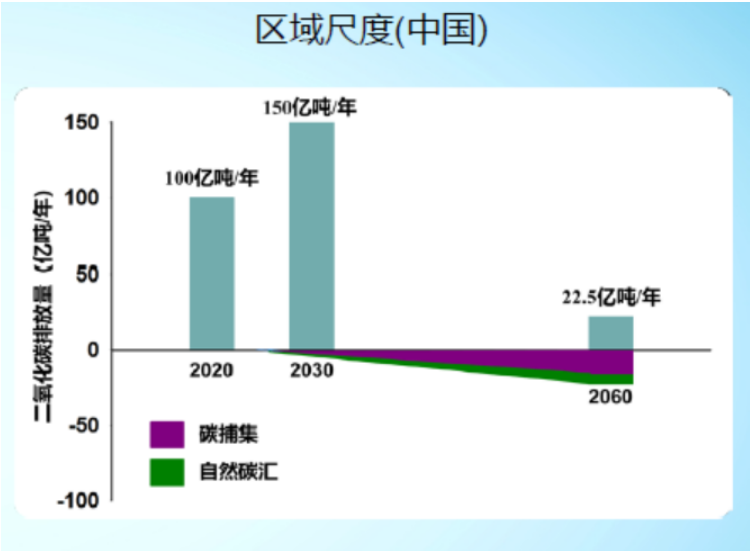
Non-peer reviewed EarthArXiv preprint

China's 2060 carbon neutrality goal will require up to 2.5 $GtCO_2$/year of negative emissions technology deployment

Jay Fuhrman[1], Andres F. Clarens[1], Haewon McJeon[2], Pralit Patel[2], Scott C. Doney[3], William M. Shobe[4], Shreekar Pradhan[1*]

[1] Department of Engineering Systems and Environment, University of Virginia, Charlottesville, Virginia, USA
[2] Joint Global Change Research Institute, University of Maryland and Pacific Northwest National Laboratory, College Park, Maryland, USA
[3] Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia, USA
[4] Batten School of Leadership and Public Policy, University of Virginia, Charlottesville, Virginia, USA
[*]Corresponding author, email: shreekar@virginia.edu

October 13, 2020

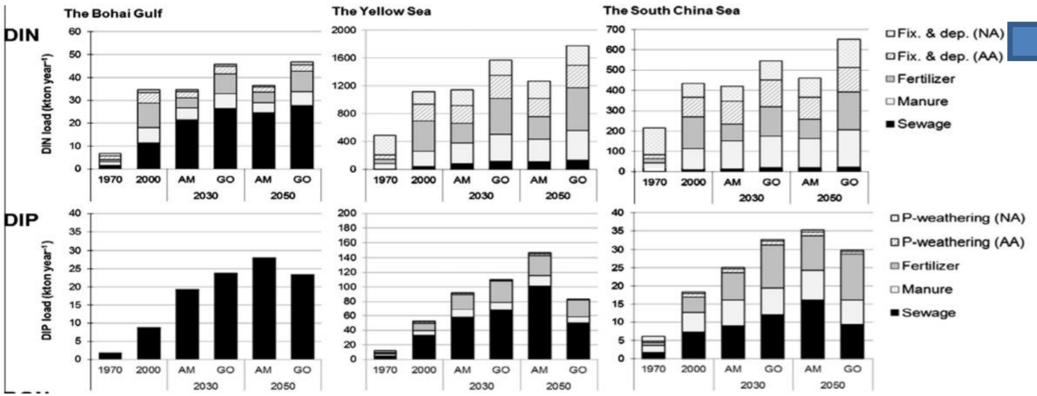


于贵瑞等

MPB 2014

Increasing eutrophication in the coastal seas of China from 1970 to 2050

Maryna Strokal [a,*], He Yang [a], Yinchen Zhang [a], Carolien Kroeze [a,b], Lili Li [c], Shengji Luan [c], Huanzhi Wang [c], Shunshun Yang [c], Yisheng Zhang [c]



Lucid waters and lush mountains are invaluable assets

中国经济网

Environmental Science & Technology

Article

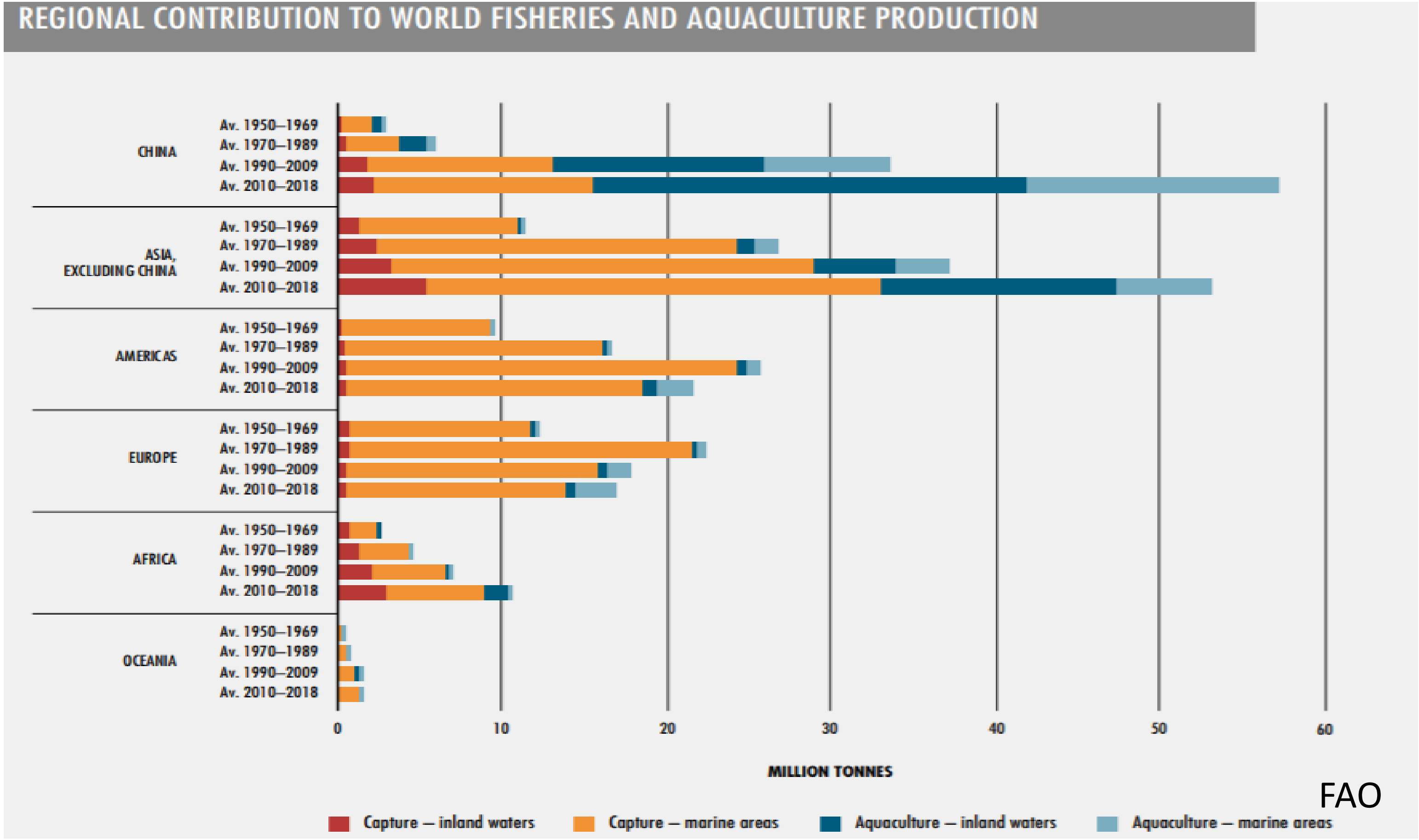
pubs.acs.org/est

Eutrophication-Driven Hypoxia in the East China Sea off the Changjiang Estuary

Hongjie Wang,[†,‡] Minhan Dai,[*,†] Jinwen Liu,[†] Shuh-Ji Kao,[†] Chao Zhang,[†] Wei-Jun Cai,[§] Guizhi Wang,[†] Wei Qian,[†] Meixun Zhao,[‖] and Zhenyu Sun[†]

人民网

To Build Ecological Civilization



In 1989, China's aquatic product output jumped to the first place in the world; in 2020, China's farmed aquatic products account for more than 60% of the world's total aquatic production.

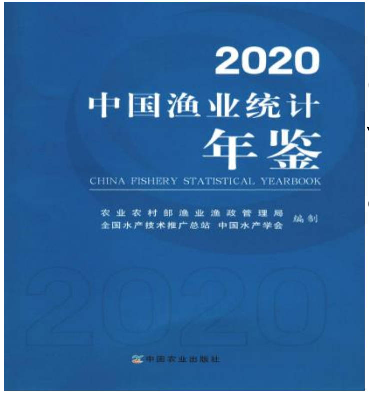
AQUACULTURE PRODUCTION OF AQUATIC ALGAE BY MAJOR PRODUCERS

FAO

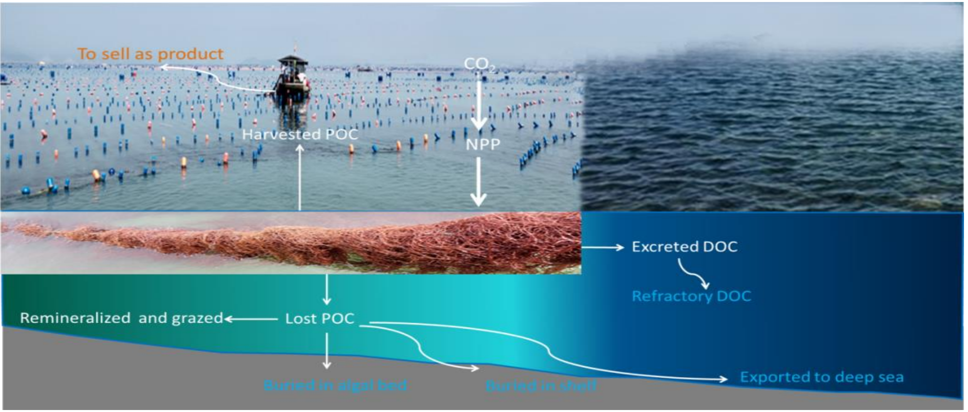
	2000	2005	2010	2015	2016	2017	2018
	(thousand tonnes, live weight)						
China	8 227.6	10 774.1	12 179.7	15 537.9	16 427.4	17 461.7	18 505.7
Indonesia	205.2	910.6	3 915.0	11 269.3	11 050.3	10 547.6	9 320.3
Republic of Korea	374.5	621.2	901.7	1 197.1	1 351.3	1 761.5	1 710.5
Philippines	707.0	1 338.6	1 801.3	1 566.4	1 404.5	1 415.3	1 478.3
Democratic People's Republic of Korea	401.0	444.3	445.3	491.0	553.0	553.0	553.0
Japan	528.6	507.7	432.8	400.2	391.2	407.8	389.8
Malaysia	16.1	40.0	207.9	260.8	206.0	203.0	174.1
Zanzibar, United Republic of Tanzania	49.9	73.6	125.2	172.5	111.1	109.8	103.2
China	...	48.5	93.6	81.2	73.4	71.9	69.6
Chile	33.5	15.5	12.2	12.0	14.8	16.7	20.7
Viet Nam	15.0	15.0	18.2	13.1	11.2	10.8	19.3
Solomon Islands	...	2.6	7.1	12.2	10.6	4.8	5.5
Madagascar	0.7	0.9	4.0	15.4	17.4	17.4	5.3
India	...	1.1	4.2	3.0	2.0	4.9	5.3
Russian Federation	3.0	0.2	0.6	2.0	1.2	1.5	4.5
Other producers	33.4	37.3	25.6	29.8	25.1	25.2	21.0
Total	**10 595.6**	**14 831.3**	**20 174.3**	**31 063.8**	**31 650.5**	**32 612.9**	**32 386.2**

Chinese output accounts for ~60% of the global volume of seaweed

Materials and Methods



China Fishery Statistical Yearbook for the years of 2000-2020



Krause-Jensen and Duarte, 2016

Carbon sequestration (Cs) = $POC_{b1}+POC_{b2}+POC_e+rDOC$

Net primary productivity (NPP) = $POC_h+POC_l+DOC_e$

The published data from 27 papers & our data

Removal (C, N, P) = P × C

$6CO_2+6H_2O \rightarrow C_6H_{12}O_6+6O_2$ (4), when every tonne of carbon is fixed, 2.67 tonnes of O_2 are generated

---

Nr (or Pr) = F × C × (1-R)

F = P × Fc

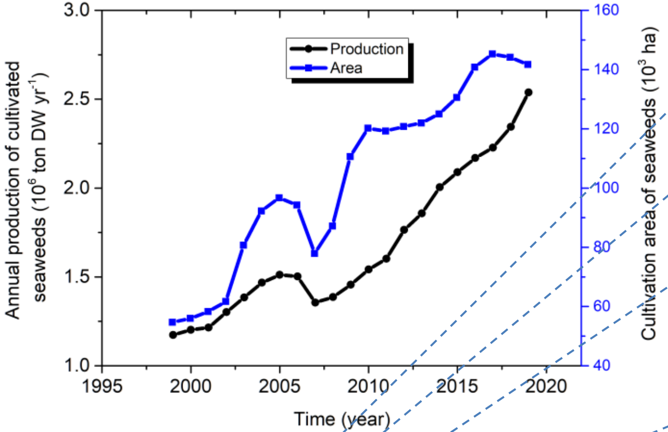
F= feed amount, C= content of N or P in feeds, R= retention rate of feed N or P in fish, P= fish production, and Fc= feed coefficient.

$A_{Ci} = T_C / Csi$

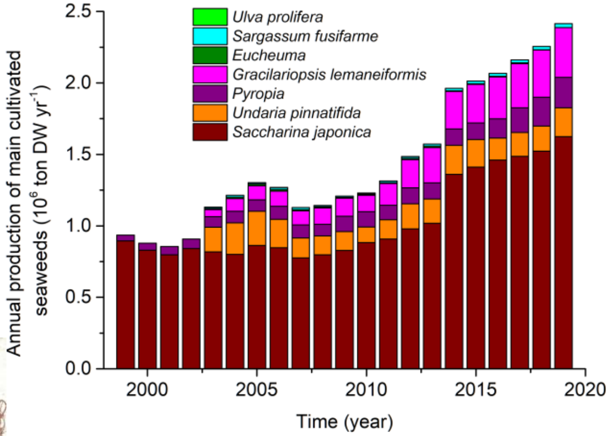
T_C = 2.5 Gt CO_2

Gao et al. 2021 ERL

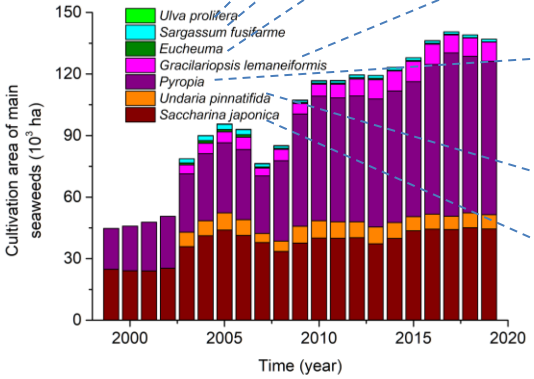
Results and Discussions



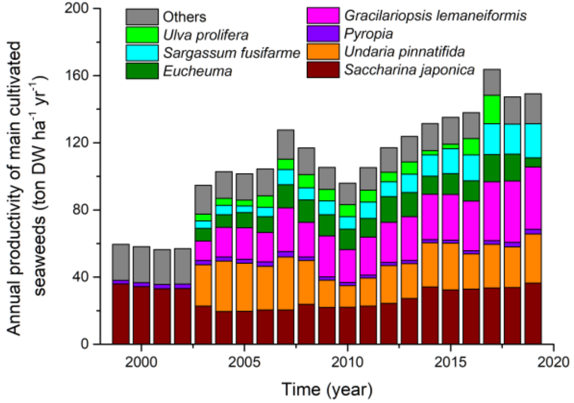
More than doubled for both production and area during past 21 years



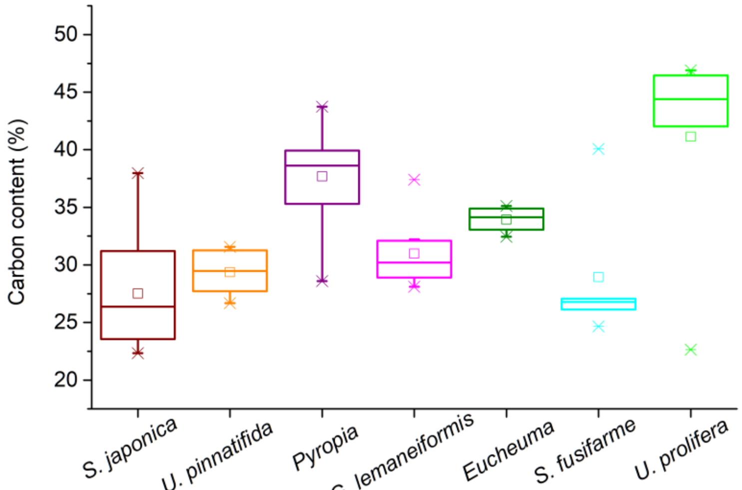
S. japonica ranks No.1 and *G. lemaneiformis* becomes No. 2

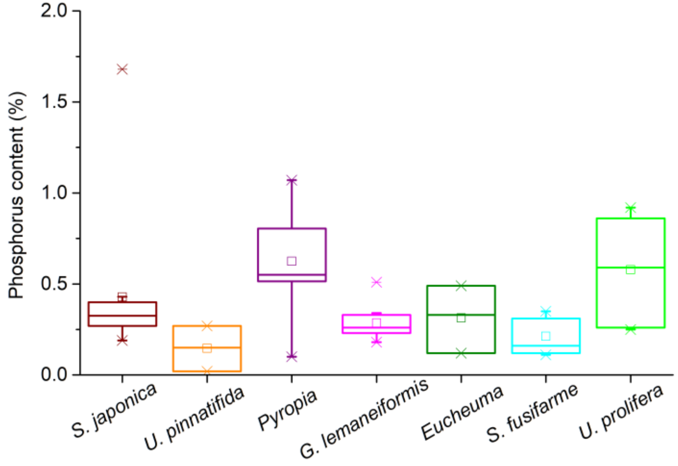


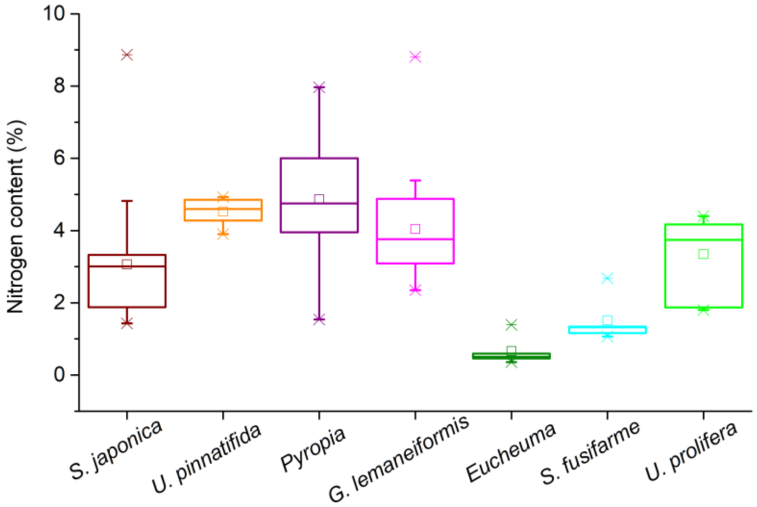
Pyropia in 2019 is about 4-fold larger than 21 years ago, replacing *Saccharina japonica* as the largest one



G. Lemaneiformis > *S. japonica* > *U. pinnatifida*







C: *S. japonica* (26.38%) < *S. fusifarme* (26.79%) < *U. pinnatifida* (29.48%) < *G. lemaneiformis* (30.20%) < *Eucheuma* (33.93%) < *Pyropia* (38.70%) < *U. prolifera* (44.39%)

N: *Eucheuma* (0.55%) < *S. fusifarme* (1.32%) < *S. japonica* (2.99%) < *U. prolifera* (3.74%) < *G. lemaneiformis* (3.76%) < *U. pinnatifida* (4.60%) < *Pyropia* (4.78%)

P: *U. pinnatifida* (0.15%) < *S. fusifarme* (0.16%) < *G. lemaneiformis* (0.26%) < *S. japonica* (0.325%) < *Eucheuma* (0.33%) < *Pyropia* (0.55%) < *U. prolifera* (0.59%)

Table 1 Carbon sequestration capacity of seven cultivated seaweeds and required areas to achieve carbon neutrality. Carbon removal means removed carbon by harvested biomass. Carbon seq. means carbon sequestration according to equation (1).

Species	Carbon content[a] (%)	Carbon removal (tonne yr^{-1})	Carbon seq. (tonne yr^{-1})	Oxygen release (tonne yr^{-1})	NPP (g C m^{-2} yr^{-1})	Carbon removal capacity (tonne $ha^{-1}yr^{-1}$)	Carbon seq. capacity (tonne ha^{-1} yr^{-1})	Oxygen release capacity (tonne ha^{-1} yr^{-1})	Required area[b] (10^7 ha)	Required area[c] (10^7 ha)
Saccharina japonica	27.51	398486	226351	1666231	3119	9.17	5.21	38.35	13.09	4.74
Undaria pinnatifida	30.04	53499	30389	223703	2560	7.53	4.28	31.47	15.95	5.78
Pyropia	37.25	55158	31331	230639	261	0.77	0.44	3.21	156.14	56.56
Gracilaria lemaneiformis	30.99	90775	51562	379566	3260	9.58	5.44	40.08	12.52	4.54
Eucheuma	33.93	1483	842	6201	1497	4.40	2.50	18.40	27.27	9.88
S. fusifarme	28.95	5714	3245	23891	1546	4.55	2.58	19.01	26.41	9.57
U. prolifera	41.13	78	44	327	699	2.06	1.17	8.60	58.37	21.14
Total		605193	343766	2530558						

[a]mean values of the data in Table S1. [b]Required area to achieve carbon neutrality based on carbon sequestration capacity. [c]Required area to achieve carbon neutrality based on carbon sequestration + removal capacity.

marine area of China is ~3 × 10^8 ha

Increase DO in aquaculture waters (3 m in depth) by 21% daily if the current DO is 8.16 mg/L.

a suitable cultivation area is 3.94 × 10^7 ha (20km*19.7 × 10^3 km)

Table 2 Nitrogen and phosphorus removal of seven cultivated seaweeds and required areas to bioremdiate fish aquaculture

Species	N content[a] (%)	P content[b] (%)	N removal (tonne yr^{-1})	P removal (tonne yr^{-1})	N removal capacity (tonne ha^{-1} yr^{-1})	P removal capacity (tonne ha^{-1} yr^{-1})	Required area[c] (10^3 ha)	Required area[d] (10^3 ha)
Saccharina japonica	3.07	0.43	44469	6229	1.02	0.14	132	178
Undaria pinnatifida	3.80	0.26	6768	463	0.95	0.07	142	392
Pyropia	4.66	0.69	6900	1022	0.10	0.01	1409	1794
Gracilaria lemaneiformis	4.04	0.29	11833	849	1.25	0.09	108	285
Eucheuma	0.66	0.31	29	14	0.09	0.04	1583	636
S. fusifarme	1.51	0.21	298	41	0.24	0.03	572	775
U. prolifera	3.35	0.58	6	1	0.17	0.03	809	881
Total			70304	8619				

[a]mean values of the data in Table S2. [b]mean values of the data in Table S3. [c]Required area to remove N (135,509 tonnes) released by fish mariculture per year. [d]Required area to remove P (25,553 tonnes) released by fish mariculture per year.

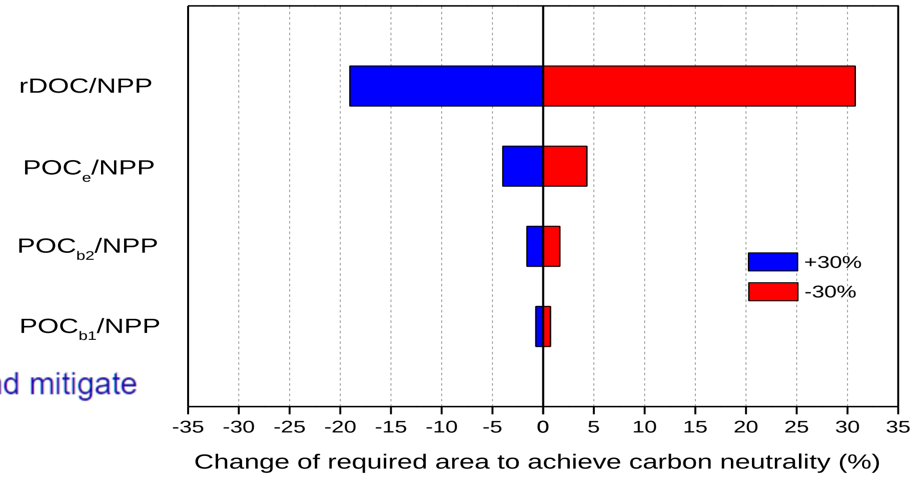
Two times and three times higher production of seaweeds than the current one are required, respectively

→

G. lemaneiformis had the highest N removal capacity
S. japonica heads the list for P removal capacity

- The change of rDOC/NPP has the largest influence on the required cultivation area,
- A 30% decrease in rDOC/NPP can lead to a 31% increase
- The same decrease in POC_{b1}/NPP results in only a 0.7% increase in the required cultivation area.

The potential of seaweed cultivation to achieve carbon neutrality and mitigate deoxygenation and eutrophication
G Gao, L Gao, M Jiang, A Jian, L He
Environmental Research Letters 17 (1), 014018

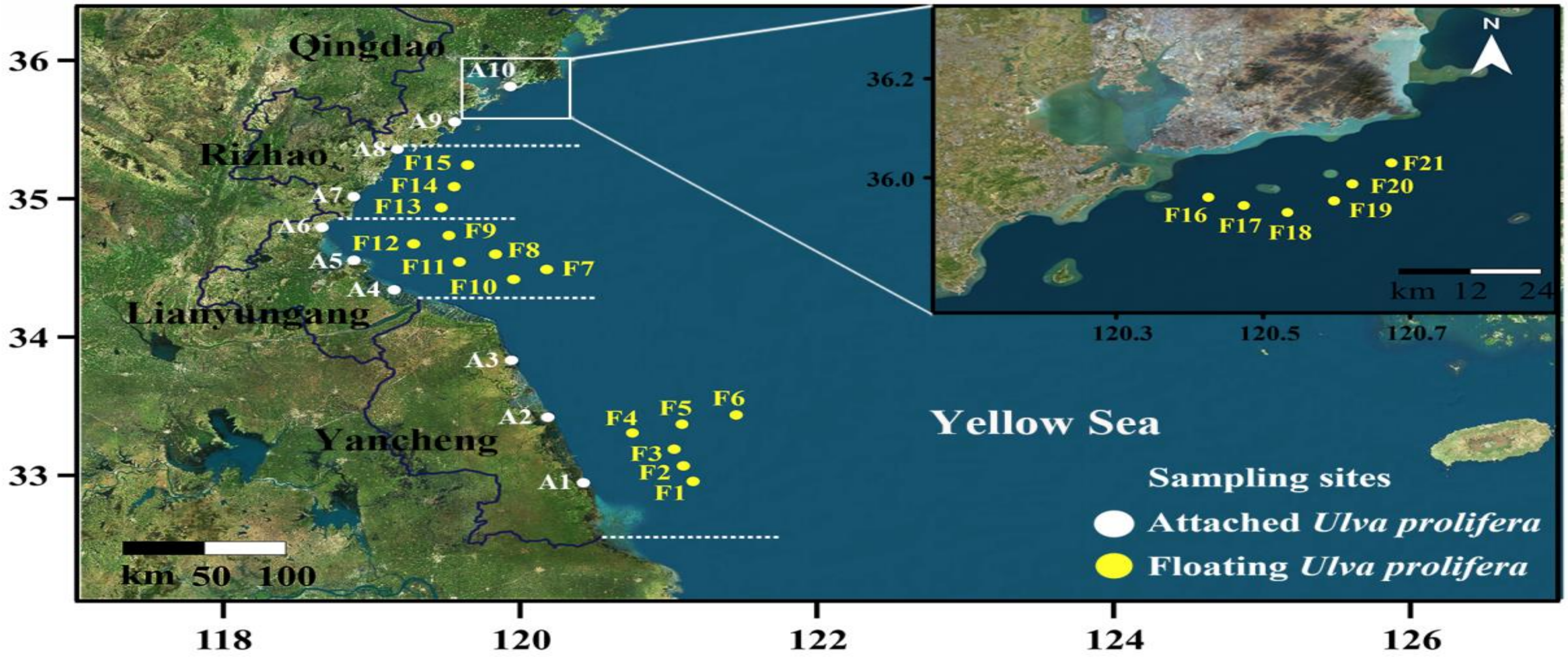


Sensitivity analysis

Conclusions

- Offshore seaweed cultivation could play an important role in achieving carbon neutrality target of China, although other carbon negative technologies must be employed at the same time.
- Seaweed cultivation has shown its potential in mitigating deoxygenation and eutrophication.
- Offshore cultivation techniques need to be improved in China, as well as in other areas in the world, and meanwhile species selection, environmental constraints and cultivation costs must be carefully assessed.

Macroalgae serve as an efficient bio-concentrator for microplastics: characteristics, mechanisms and impacts



Feng et al., 2021 J HAZARD MATER

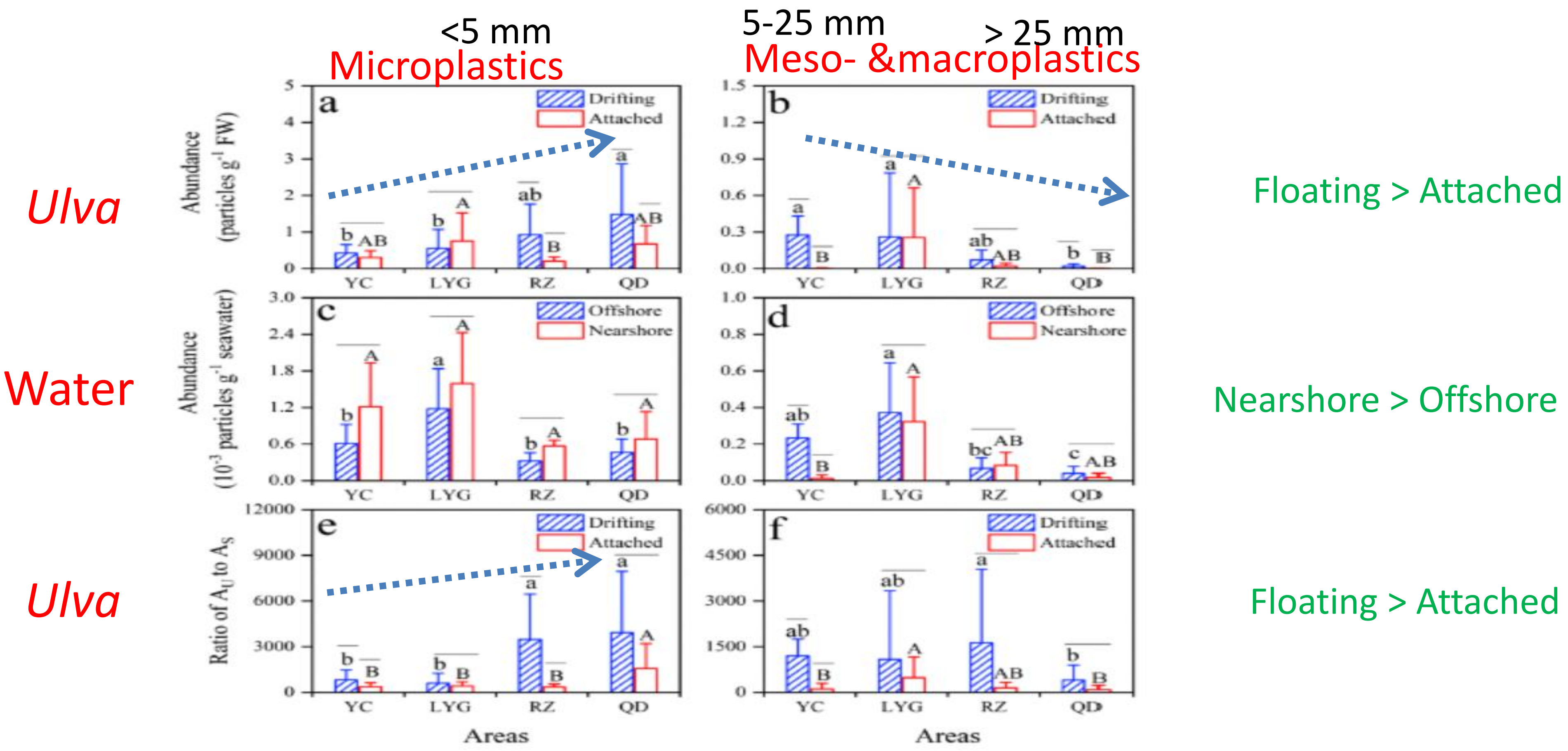
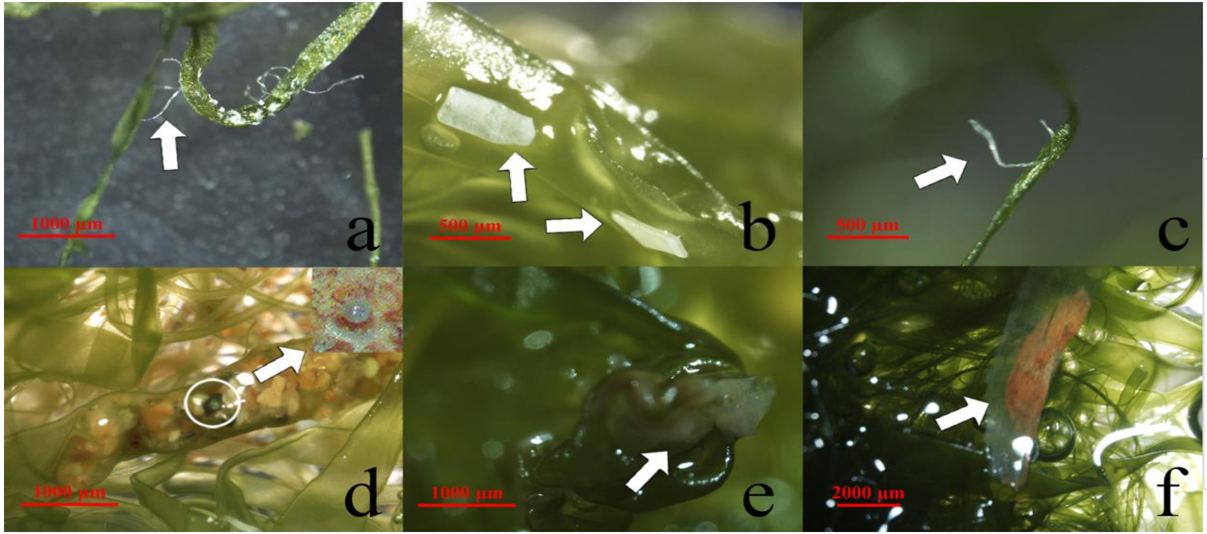


Fig. 2 Abundance of microplastics (a, c, e) and meso- & macroplactics (b, d, f) in floating and attached *U. prolifera* (a, b), and in seawater (c, d) and bioconcentration factor (e, f) in different areas

Table 2. Microplastics abundance in seawater and organisms in the seas of China

Area	Type of mediums	Total species	MPs abundance (items/g)	References
Yellow Sea	Seawater	/	$(0.13 \pm 0.20) \times 10^{-6}$	Sun et al. (2018)
Yellow Sea	Zooplankton	11	$(12.24 \pm 25.70) \times 10^{-6}$	Sun et al. (2018)
East China Sea, South China Sea	Pelagic fish	5	0.02-0.13	Jabeen et al. (2017)
East China Sea, South China Sea	Bethopelagic fish	4	0.02-0.06	Jabeen et al. (2017)
East China Sea, South China Sea	Demersal fish	11	0.02-0.25	Jabeen et al. (2017)
Yellow Sea	Floating *U. prolifera*	1	0.83 ± 0.95	This study
Yellow Sea	Attached *U. prolifera*	1	0.49 ± 0.53	This study

[a]The data were recalculated based on the fresh weight of the whole individual.



Microplastics

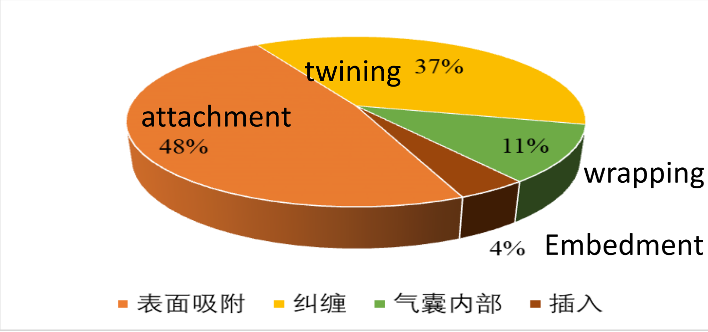
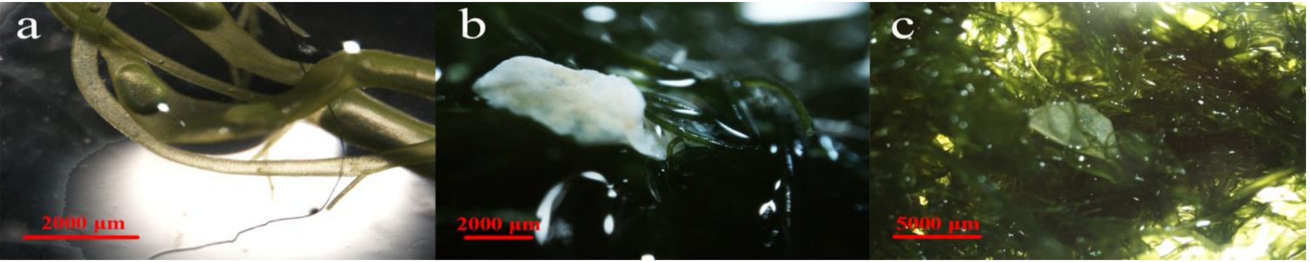


Fig. 3 Mechanisms of *U. prolifera* as a plastic concentrator. (a) twining, (b) attachment, (c) embedment, and (d, e, f) wrapping. Different plastic were wrapped in the tubular air sac of *U. prolifera*, including microbead (d), foam (e) and film (f).



Meso- & macroplastics

Twining 100%

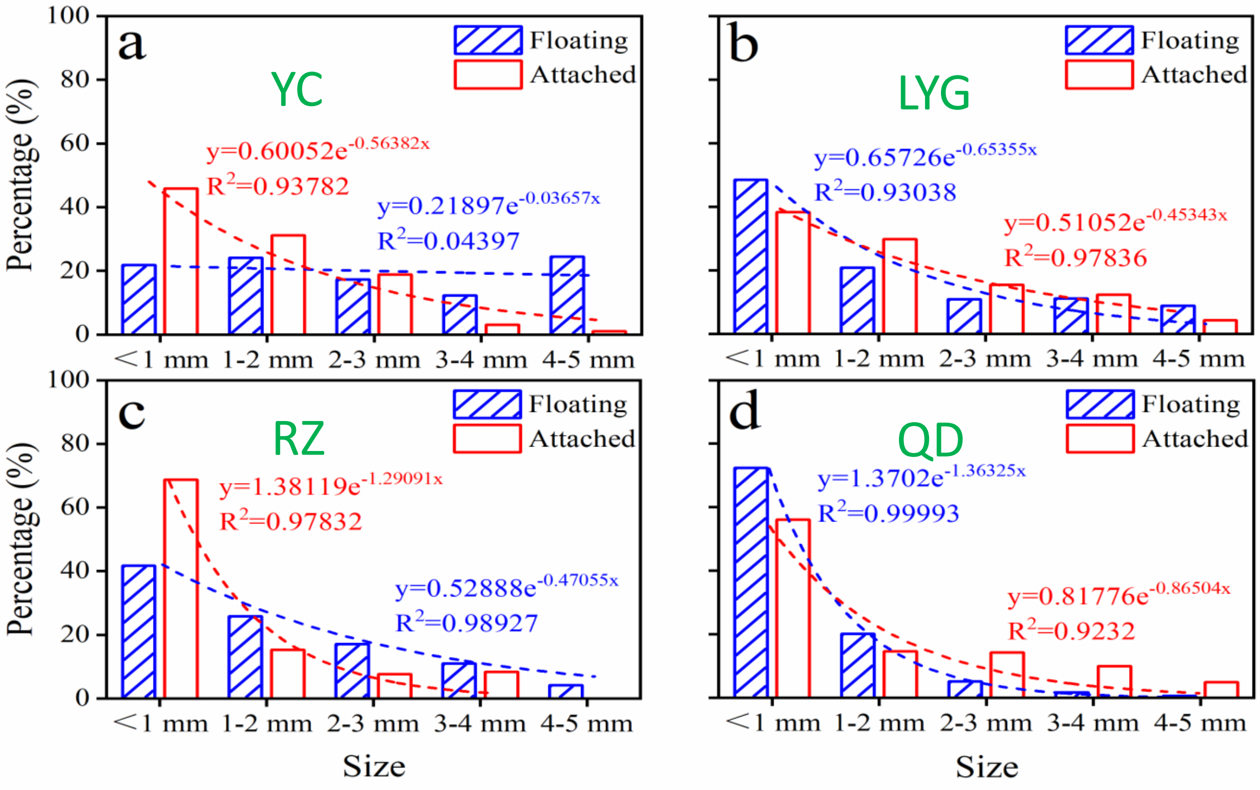


Fig. 4 Size distribution of MPs in floating and attached *U. prolifera* in YC (a), LYG (b), RZ (c) and QD (d). YC, Yancheng; LYG, Lianyungang; RZ, Rizhao; QD, Qingdao.

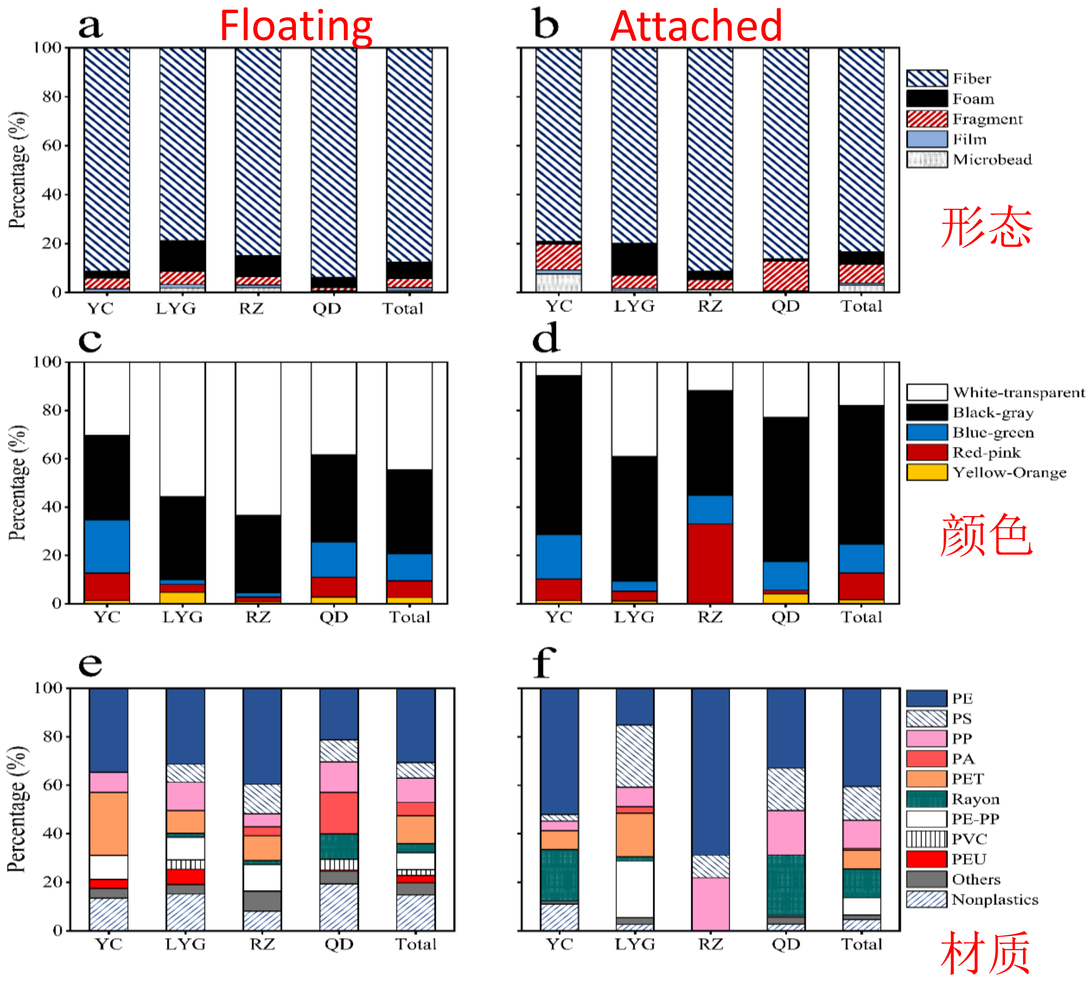
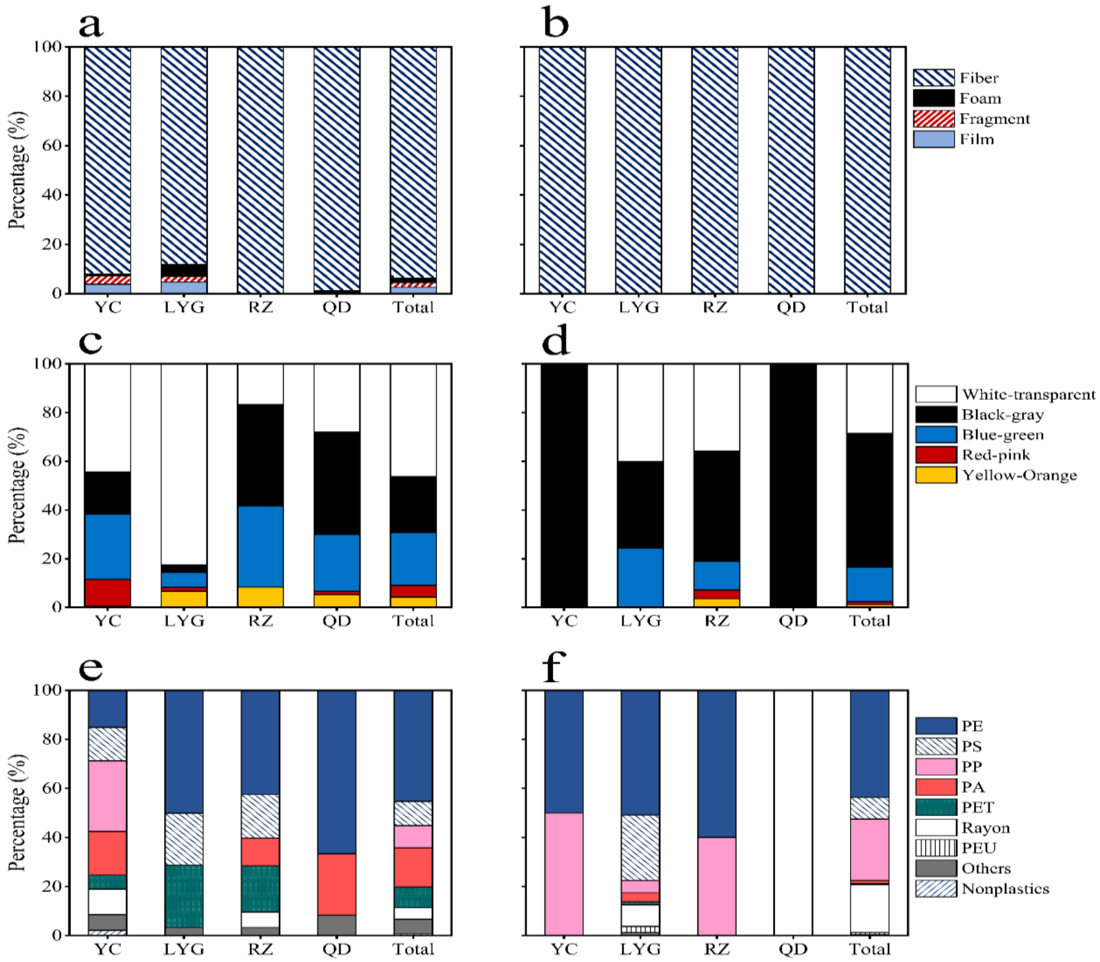


Fig. 5 The shape (a, b), colour (c, d) and material type (e, f) of microplastics in floating (a, c, e) and attached (b, d, f) *U. prolifera* in each location. YC, Yancheng; LYG, Lianyungang; RZ, Rizhao; QD, Qingdao.



Less diversity compared to MPs

Fig. 6 The shape (a, b), colour (c, d) and material type (e, f) of meso- & macroplactics in floating (a, c, e) and attached (b, d, f) *U. prolifera* in each location. YC, Yancheng; LYG, Lianyungang; RZ, Rizhao; QD, Qingdao.

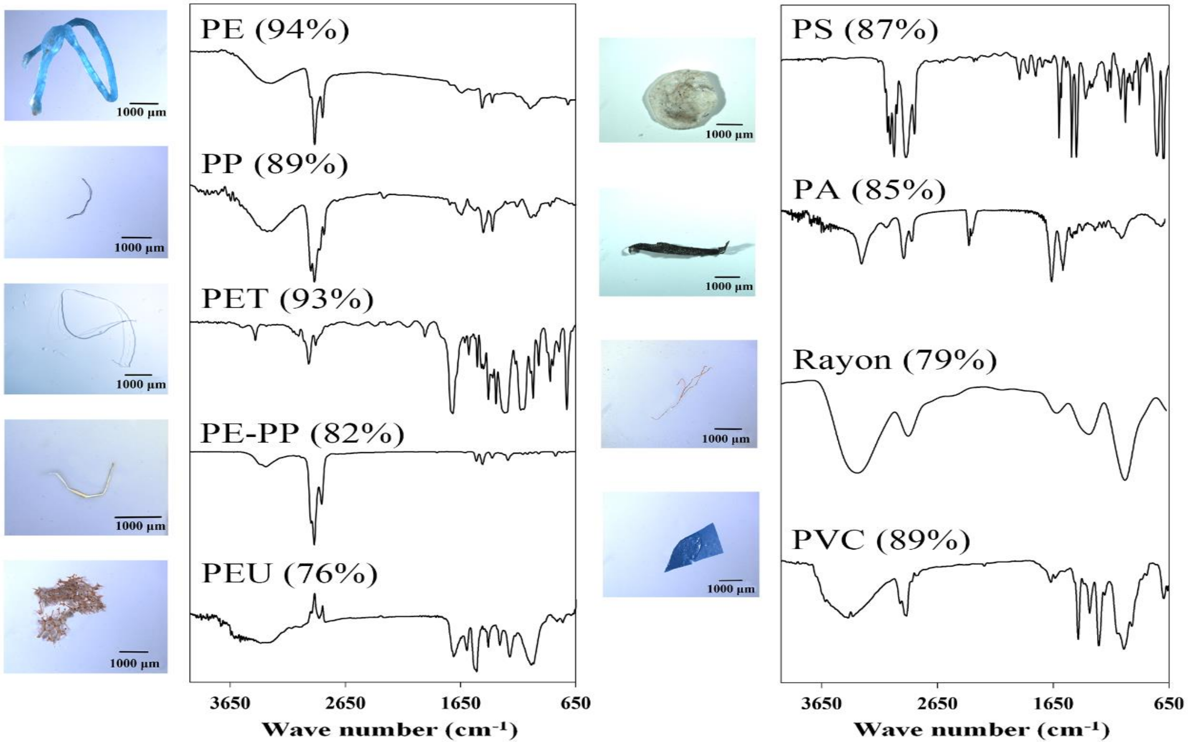


Fig. 7 Analysis of microplactics with micro-FI-IR. PE, polyethylene; PS, polystyrene; PP, polypropylene; PA, polyamide; PET, polyethylene terephthalate; Rayon; PE-PP, poly (ethylene: propylene); PVC, polyvinyl chloride; PEU, polyether polyurethane.

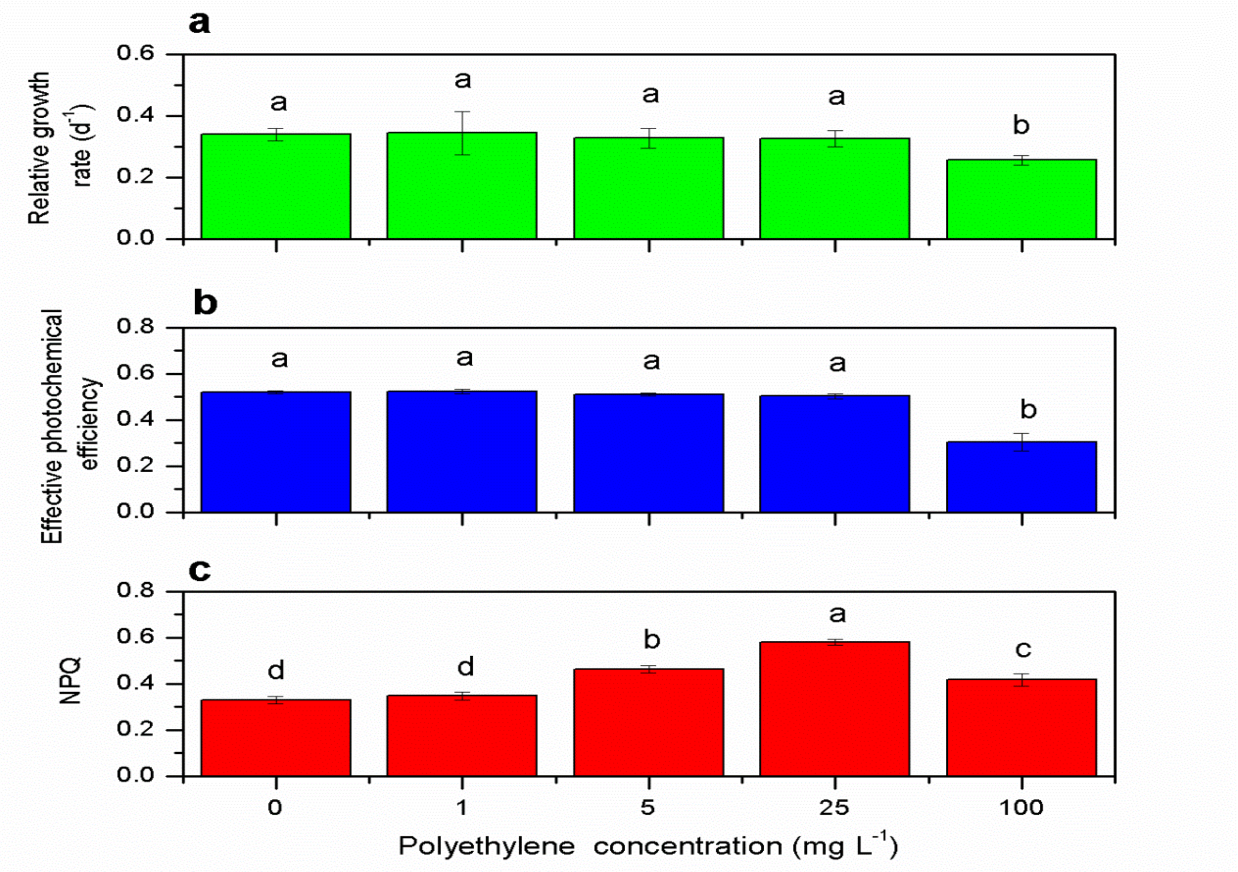


Fig. 8 Effects of polyethylene on relative growth rate (a), effective photochemical efficiency (b) and nonphotochemical quenching (NPQ) of *U. prolifera* (c).

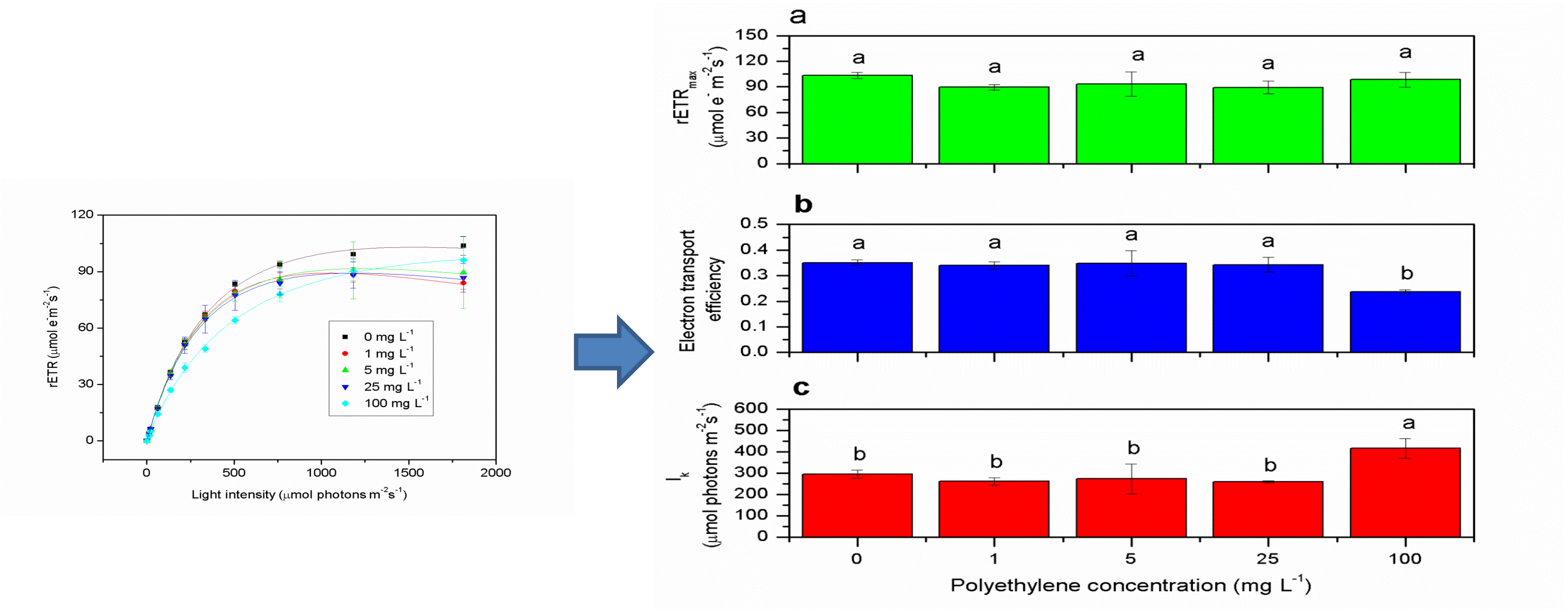
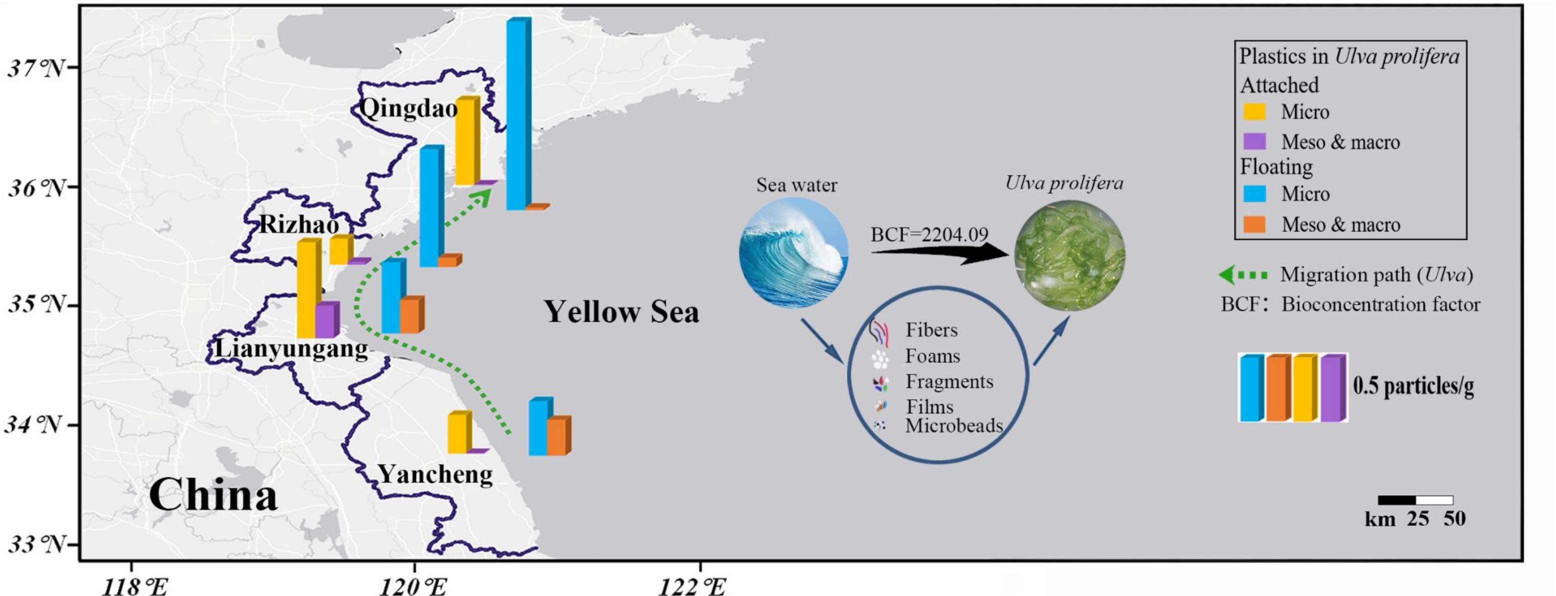


Fig. 9 Effects of polyethylene on electron transport efficiency (a), $rETR_{max}$ (b) and saturating irradiance (I_k, c) of *U. prolifera*.

Conclusion

- Both floating and attached *Ulva* species could accumulate a large amount of plastics via diverse approaches.
- The floating macroalgae can affect the spatiotemporal distribution of plastics in oceans.
- The strong bioconcentration capacity of MPs and high tolerance to MPs endow *Ulva* species an ideal material to remediate polluted seawaters.

6-65 million tons biomass
4.98–53.95 $*10^{12}$ particles
0.019-0.215 $*10^{6}$ tonnes
3-29% plastic into Chinese seas
（Bai et al., 2018）



Take home message

- Climate change and human activity are leading to macroalgal blooms that are affecting humans.
- We must have wisdom to switch them from trash to treasure.
- Seaweed cultivation has shown its potential in mitigating CO_2 emission, deoxygenation and eutrophication.

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RESEARCH INTERESTS

- Seaweed Physiology and Ecology
- Application of algae for CO_2 and eutrophication remediation

Ph.D. in Marine Biology (Newcastle University)
State Key Laboratory of Marine Environmental Science
Xiamen University
Tel: +86-0592-2187963
Email: guang.gao@xmu.edu.cn

- https://mel2.xmu.edu.cn/faculty/GuangGao/
- https://www.researchgate.net/profile/Guang-Gao-5

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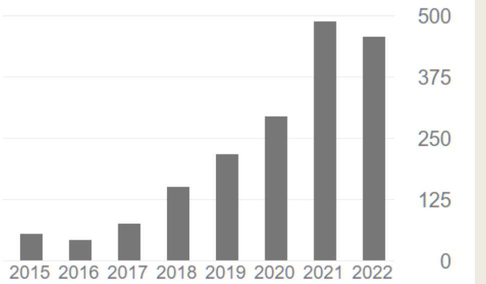

Thank You For Your Attention!