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（SHENGTAI XUEBAO）

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封面图说：岸边的小白鹭——鹭科白鹭属共有 13 种，其中有大白鹭、中白鹭、白鹭（小白鹭）、黄嘴白鹭等，体羽皆是全白，世通称白鹭。夏季的白鹭成鸟繁殖时枕部着生两条狭长而软的矛状羽，状若双辫，肩和胸着生蓑羽，冬季时蓑羽常全部脱落，白鹭虹膜黄色，嘴黑色，脚部黑色，趾呈黄绿色。小白鹭常常栖息于稻田、沼泽、池塘水边，以及海岸浅滩的红树林里。白天觅食，好食小鱼、蛙、虾及昆虫等。繁殖期 3—7 月。繁殖时成群，常和其他鹭类在一起，雌雄均参加营巢，次年常到旧巢处重新修葺使用。

彩图提供：陈建伟教授　北京林业大学　E-mail：cites.chenjw@163.com

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潘金华,江鑫,赛珊,周文江,吴家奇,李晓捷,杨官品.海草场生态系统及其修复研究进展.生态学报,2012,32(19):6223-6232.
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海草场生态系统及其修复研究进展

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摘要:海草场能够提供重要的生态系统服务。自 20 世纪末以来,由于人类活动和自然灾害的影响,全球范围内的海草场出现了急剧衰退,由此也促进了海草场生态系统的研究以及海草场人工修复技术的发展。近年来,针对海草场生境流失的现状,中国也开始开展海草场修复工作。从以下方面进行论述:(1)海草的种类、分布,海草场生态系统功能及其生态系统服务:与陆地系统相比,全球海草物种多样性较低,了解海草的分布特征有助于通过了解海草如何适应当地环境压力,以揭示海草适应环境的能力;海草场提供重要而广泛的自然生态系统服务,特别是在维护近岸生态系统健康和满足人类需求过程中起到重要的作用;(2)海草场的衰退及其原因:认识并缓解人类压力对海草场的危害是促进海草场生态系统可持续发展的重要一环;(3)国内外海草场修复现状:以此阐明海草场修复原理,为海草场修复提供科学的方法;(4)总结与讨论:基于科学研究背景,为中国海草场生态系统保护和修复提出建议。海草场的修复和保护应当相辅相成,并与我国海岸长远规划相结合,以此推动我国海草场生态系统服务的可持续发展。

关键词:海草场;生态系统功能;生态系统服务;衰退;修复

Seagrass meadow ecosystem and its restoration: a review

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Abstract: Seagrass meadows have long been recognized for the important ecosystem services they provide. Seagrass meadows not only play critical roles in near shore primary production and nutrient cycling, but also provide feeding, refuge and nursery habitat for a diverse array of marine organisms, and increase the stability of the seafloor. However, seagrass meadows have suffered great declines in the last century from anthropogenic effects, which in turn stimulated studies of seagrass ecosystems as well as development of restoration techniques. More recently, China has initiated restoration work on seagrass ecosystems in direct response to observed and anticipated loss of seagrass habitat. Here, four topics are reviewed that form the basis of the Chinese restoration effort: (1) Seagrass meadow ecosystem analysis, (2) Declines of seagrass meadows and its reasons, (3) Progress of seagrass restoration techniques abroad and in China, and (4) Actionable guidance. Under (1), seagrass species and their distribution, functions and ecosystem services will be inventoried. Although seagrasses globally have comparatively (to terrestrial systems) low taxonomic diversity they still have discernible niches whose ecological limits must be understood in order to forecast their response and resiliency when faced with local stressors. Because seagrasses have successfully colonized all but the most polar seas and thus have occupied wider latitudinal ranges as compared with the other major coastal marine habitats (mangroves and coral reefs in tropical regions,

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salt marshes in temperate regions), defining their ecological limits is a significant challenge. Moreover, although seagrasses indisputably provide important and extensive natural resource services, specifically identifying those services in the context of the near shore ecology and human needs are fundamental to establishing effective protection. Under (2), identification and mitigation of human stressors that impair or eliminate seagrasses in coastal waters is a fundamental step to creating a sustainable resource base. The impact of local, anthropogenic stressors (eutrophication, dredging and near shore engineering) needs also to be separated from far-field effects such as global warming, sea level change, natural diseases, and disturbance events such as typhoons in order to understand that which is manageable and that which is natural or beyond local boundaries and thus not practicable for intervention. Under (3), seagrass restoration has been practiced for decades, with the first documented attempt at seagrass restoration being carried out in the USA in 1947. However, it was not until the mid-1970s that development of seagrass restoration techniques began to move beyond the experimental stage. In the past 40 years there has been considerable development of restoration methodologies and techniques, and a significant increase in the number of locations and species involved. Nonetheless, because seagrass restoration typically takes place in open (uncontrolled or non-engineered) settings, the restoration process is widely recognized as being complex and expensive. The most common method has involved the transplantation of adult plants, because they result in an immediate presence of the seagrass community. Some of these methods have involved transplantation of seagrass and associated sediments, whilst with other methods only the seagrass plant is utilized. But in recent years, new seeding techniques for a few species have been developed and successfully employed. Regardless of the method, the general success of previous restoration attempts have been variable and unfortunately in many cases, have resulted in limited survival and coverage (average success has been 50%). In most cases the transplantation of seagrasses relies on harvest from otherwise healthy meadows, which for some species (but not many in China) have extremely slow recovery rates, making donor bed impacts a concern for those species. Nonetheless, there remains an urgent need for better understanding of the limiting factors for seagrass in a restoration context and to employ new advances in applied research and methodology to conduct seagrass restoration in a cost-effective manner over large spatial extents. Finally, under (4) we propose to provide actionable guidance for seagrass conservation and restoration efforts in China. China covers two geographic bioregions and has a vast (but poorly inventoried) expanse of seagrass meadows along its coast. But China has not yet developed a comprehensive study of seagrass meadow ecosystems and applied practices in restoration. As a consequence of limited studies and popular understanding of the importance of seagrass resources, seagrass meadows in China are widely vulnerable and threatened. Consequently, seagrass meadows in China have, like many other under-managed seagrass ecosystems worldwide, suffered great declines from excessive emission of nutrients and pollution of coastal waters. Although there have been some limited studies that have been highly focused on seagrass restoration, China's ability to incorporate restoration into a management strategy has been severely limited by knowledge gaps identified in the four topic areas defined here. Without a balance of studies involving inventories, functions and services, population ecology and disturbance responses in which to place seagrass restoration in context, it is likely that (as occurred in the U.S. during the 1960's and 1970's) seagrass restoration could be perceived as an inappropriate solution to many coastal development problems, resulting in failed projects and continued seagrass losses. We conclude that conservation and restoration of seagrass meadows should be integrated with coastal planning in China for sustainable seagrass ecosystem services.

Key Words: seagrass meadow; ecological functions; ecosystem services; decline; restoration

海草场与珊瑚礁、红树林是三大典型海洋生态系统[1],可以稳定底质,缓解海浪对沿岸侵蚀,改善水质,提供重要初级生产力,为次级消费者提供食物网支撑,为经济水产动物提供栖息地和保障沿海旅游业健康发展[2],对维护近岸海洋生态系统健康、保护沿海渔业资源具有重要作用[3]。全球气候变化和海洋过度开发导

致的包括海草场生态系统在内的海洋生态环境恶化和局部海洋生态失衡,已在全球范围内越来越多地引起各国政府、研究机构和科研院校的关注[4]。进行海草场生态修复对缓解近海生态健康压力,改善近海水质环境具有重要意义。资料记载的第一次人工海草场修复始于 1947 年[5],此后,世界范围内(主要在发达国家)的海洋学者相继开展海草场生态系统研究和修复工作[6],积累了较为丰富的实践经验。本文总结了世界主要海草场生态研究成果和海草场修复技术发展,对海草场生态修复存在的问题进行了阐述,并在一定层面提出了相关解决问题的策略,以引起海洋研究领域对海草场生态系统的重视,为我国起步较晚的海草场生态系统的保护和修复提供一定的指导。

1　海草场生态系统

海草大面积聚集生长在海岸潮下带,浅滩,泻湖,河口等[3],最大可形成面积数百万英亩的海草场[7],构成一个庞大的海草场生态系统。

1.1　海草场的分布

海草是海洋单子叶被子植物,全世界海草分 6 科 14 属,共 66 种[2],已知中国海区有 10 属 20 种[8-9]。海草分布面积占全球海洋面积的 0.1%—0.2%[10],在热带、温带和北极圈地区均有海草生长[11]。Short 等[12]依据气候带等因素影响将全球海草划分为 6 大区系,分别为 4 个温带区系:温带北大西洋区系、温带北太平洋区系、温带地中海区系、温带南洋区系(新西兰、澳洲南海岸、非洲南海岸和南美海岸)和 2 个热带区系:热带大西洋区系和热带印度洋-太平洋区系。不同区系海草多样性差异较大,印度洋-太平洋区系物种多样性最高,有多达 12 种。海带场和盐沼生境主要分布在温带地区,珊瑚礁系统与红树林系统则只分布在热带海区[4]。与其它主要海岸生态系统相比,海草场生态系统分布更广泛,海草生长在中潮带至潮下带,绝大部分生长在海平面以下 25 m 深度以内[11]。目前报道的分布深度最深的海草是印度洋卡拉若斯群岛的毛叶盐藻(*Halophila decipiens*),最深深度达 86 m[13]。

1.2　海草场生态系统服务

生态系统功能是指生态系统的生境、生物或系统属性或过程,生态系统产品(例如食物)和服务(例如废弃物吸收)是指人类直接或间接地从生态系统功能中获得的收益,为简便起见,生态系统产品和服务统称为生态系统服务[14]。海草场在海洋生态系统特别是近岸生态系统中扮演着许多重要角色,提供了大量的不可取代的生态系统服务:(1)海草场能够减缓海浪对海岸的侵蚀、稳定底质[15-16]从而保护海岸环境;(2)能吸收营养盐和重金属,净化和改善水质[17-18];(3)作为重要的初级生产者,是地球碳循环和氮循环的重要一环[19];(4)是许多浮游生物、底栖生物和附着生物赖以生存的场所[20],同时也为许多重要经济鱼类提供产卵场和孵幼场所[18],海草场还是儒艮、海龟和海牛等珍贵保护动物的生存栖地并直接为其提供食物[12],对维护地球生物多样性具有重要意义。

此外,热带地区的海草场生态系统在与红树林生态系统和珊瑚礁生态系统的交互作用中扮演着至关重要的角色[3],海草场系统作为典型海洋三大生态系统中的重要一员,在保障另外两个海洋生态系统理化因素和生物因素双方面的基础稳定性当中提供了重要的支撑服务[21-22]。据统计估计,每公顷海草场每年在海洋环境中营养循环及直接产品的产出价值高达 USD 19,004,全球每年海草-海藻场生态系统服务价值总流量达 USD 3.801×10^{12} [14]。

2　海草场生态系统的衰退

受自然因素和人类活动干扰的影响[1],不论是在发达国家还是发展中国家海草场都在迅速缩减[23]。据 2003 年联合国环境规划署(UNEP)出版的《世界海草地图集》报道,全球海草场生长环境日益恶化,全球仅有的 17.7 万 km^2 的海草场在 1993—2003 的 10a 间锐减 2.6 万 km^2,缩减约 15%,并威胁到了其它海洋生物的生存[3]。

2.1　影响海草场生态系统衰退的自然因素

来自自然因素扰动的影响:(1)首要罪魁祸首就是全球气候变化的威胁——全球变暖、海平面上升[4, 24]。

全球变暖导致海水温度升高,直接导致了某些海草场由于不适应升高的海水温度而大量衰退[25],并且海水温度上升直接危害到海草新陈代谢和碳平衡[26]。海平面上升直接导致了海草场生境水深的变化,降低了光照辐射,影响海草光合作用而导致海草死亡[27-28];(2)台风的频繁侵扰亦会对海草场产生较大的影响[29],特别是在海草有性繁殖季节,台风会将海草繁殖枝破坏并吹到岸上或其它不适区域导致海草场种子库的种子流失[30]。然而,海草种子在多年生海草场剧烈衰退之后的自然种群恢复[31-33]和维持 1 年生海草场的可持续重建[34]中发挥着无可替代的关键作用,台风造成的种子库流失严重影响海草场的自我修复功能;(3)火山喷发、地震[35]以及疾病的爆发[36]也会引起海草场急剧衰退;(4)食海草动物的大量摄食也会对海草场生态系统造成一定的负面影响[37-38]。

2.2 影响海草场生态系统衰退的人类因素

沿海地区人口压力导致环境的剧烈变化给海草场生态系统造成了巨大的威胁[4],海草场的生长环境——海岸带注定了海草场必然受到人类活动的干扰[39]。由于人类原因导致的环境压力如污染物、沉积物、化肥过量使用和有毒化合物向海洋无限制的排放等,三大典型海洋生态系统都在呈加速度的退化趋势[40]。

(1)人类活动导致海区透明度的降低　相对于浮游植物而言海草对光线具有更高的要求[41-42],海草场全球范围内的衰退往往主要来自光照条件压力的增加[43],因人类生产生活引起的营养盐过度排放[44],水体富营养化、附生生物、浮游植物和浊度的升高以及赤潮的频繁爆发导致海草场接受光线严重不足而大量衰退[33, 45-46]。沿海水产养殖业的大力发展很大程度上促进了沿海海域的富营养化和大量沉积物产生[47-48];

(2)机械损坏　船用螺旋桨[49-50]、渔业拖网和船锚[51-53]的直接机械损害;

(3)城市化扩展速度加剧,填海造地,采挖滩涂和浅海底生物资源、生物入侵[54]以及海上油田、轮船溢油[55]等都会对海草场生态系统造成毁灭性的灾难。

导致海草场衰退的因素是复杂的,人类因素和自然因素之间又存在相互影响相互促进的关系。某些自然因素对海草场生态系统的影响可能是间接受到人类活动的影响导致的,如全球变暖[4]。人类对环境无休止的开发和破坏导致了自然环境的恶化和海洋生态失衡,从而加剧了海草场的衰退。因此,在把影响海草场衰退的因素一部分推脱归咎于大自然的同时,不得不对人类自己活动对海草场生态系统的影响进行深刻的反省。

3 海草场生态系统修复研究进展

3.1 国外海草场修复研究进展

越来越多的文献报道世界各地海草场退化或消失的严峻形势下[56],对以海草场生态系统为主的海岸带生态系统未来发展趋势的预测是非常不乐观的[4]。资料记载的第一次人工海草场生态修复始于 1947 年[5]。历经半个多世纪的时间,直到 20 世纪末, 海草场生态修复才在世界范围内(主要在发达国家)相继开展[6]。其中规模最大、影响范围最广的当属美国国家海洋与大气管理局(NOAA, National Oceanic and Atmospheric Administration)管理下的美国切萨皮克湾(Chesapeake Bay)海草场大规模修复计划(Chesapeake Bay Program, 切萨皮克湾计划)[30]。切萨皮克湾是世界上最大的河口湾之一,该计划自 2003 年开始启动以来至 2008 年,构建海草场的速率约为 13. 4hm^2/a,并且本计划大大促进了海草场人工修复新技术和新设备的开发和应用[57]。

3.1.1 海草成体移栽技术进展

最初的海草场修复主要是通过移植成体的海草[16]。成体海草植株移栽方法有(1)插管法[58]:利用岩芯取样管将海草先装进管子,然后再转移进移栽目标区挖的洞内,此法比较费时费力,因此移植成本很高;(2)枚钉法[59]:从移植地将海草附着的泥去掉,用 U 形钉子直接插入海底以固定,此法比插管法节省时间,简单易行且成活率高;(3)草皮法和泥盆法[58]:此方法类似于陆地上带土栽培技术,即把海草成块铲起,装入托盘或类似于花盆的容器内,然后在目标海区挖同等大小的坑,将整个“草皮”埋入坑内。此外,还有一些其它方法如把海草一簇一簇夹在绳索上,然后把整条绳索用 U 形钉固定在海底[16]。上述方法的优点是成活率较高,能

达到 80% 左右,但缺点是都需要潜水作业,大大提高了劳动强度和成本。Lee 和 Park[60] 开发了一种利用牡蛎壳将植株沉入海底的移栽方法,省去水下种植劳动,降低移栽成本,但此方法仅在水流平静的泥底质海区适用,在水流较强的沙底质海区,移栽成活率仅为 5% 左右。Fishman[61] 等尝试一种机械海草移植船舶但未达到预期效果而未获成功。

3.1.2　海草种子播种技术进展

移栽成体海草来进行海草场生态修复,普遍存在劳动强度大和成本高等问题[16, 61]。上世纪末本世纪初,人们开始开发海草种子播种技术来代替高成本的海草成体移栽进行海草场生态修复[62-63]。海草种子具有体积小易于运输,而且对于成体移栽而言,收集种子对原海草场造成的危害较小等优点[64],利用种子进行海草场修复逐步发展成为大规模海草场生态修复的主要手段[65-66],并且促进了海草种子基础生物学的广泛而深入的研究[64]。最初的种子采集是通过潜水员在水下人工收集种子,综合效率大约是每名经验丰富的潜水员每小时 1.6 万粒,后来又发明了海草繁殖枝采集机械船,大大提高了种子收集效率,平均每人每小时可收集种子高达 13.2 万粒,但并非所有的地方都可以采用繁殖枝采集机械船,要考虑海草场繁殖枝的密度以及可供采集繁殖枝的海草场面积的大小,太低的密度和太小的面积都不能真正发挥繁殖枝采集机械船的优势。由于不同海草场种子产量不同,同一个海草场不同年份的种子产量也会有较大差异,因此每年收集种子的数量并非恒定[67]。

最佳播种时机一般是在水温降至 15 ℃以下时[68]。主要播种技术有将带有成熟种子的繁殖装入网袋而后固定漂浮在播种海区的"漂浮播种法"[69],利用硅胶介质包裹种子的"机械播种器"[70]和利用抽水泵固定在船上喷洒种子的播种船[67]。此外亦有学者提出利用地上室内育成的海草苗,然后在合适时机将人工培育的一定大小海草移栽到需要修复的海草场[53]并取得一定成功[71]。这些新技术的应用在一定程度上提高了海草场生态系统的修复效率。

3.2　中国海草场研究进展

我国同时处于温带北太平洋和热带印度洋-太平洋两大海草地理区系,海草品种多达 20 种,海草场面积十分广阔,仅南海海草场面积达就达 2400 hm^2[72]。但是我国海草场生态系统的相关研究起步较晚[73-76],对于海草种子相关生物学的研究鲜有所见[53],且我国东部沿海和黄、渤海区域海草基本状况基础研究资料比较匮乏[9, 77],但这并不说明我国的海草场生态系统相安无事,人们对近岸环境的不合理利用导致中国华南地区海草场日趋退化,仅广西合浦海草场 1980—2005 年间由于人类活动造成的直接和间接导致其生态服务价值损失达 7.38 亿元人民币[78]。因此,我国海洋学者应加强我国海草场的生态研究,对全国范围内的海草场进行大规模生态普查,对我国特定近岸海洋环境下海草场生态功能、影响海草场生态环境因素进行深入研究并形成全面而系统的分析、评价机制,为建立我国海草场生态系统信息库和进行海草场保护以及海草场生态系统的人工生态修复提供依据。

3.3　海草场生态系统人工修复面临的困境

大规模的海草场修复计划在改善局部生态健康,提高生态系统功能水平和增加重要渔业资源生境的保有量中起到了重要的作用[30]。但目前来说依然面临着较大的困难。

3.3.1　成本高

海草场生态系统修复是一项费时、费力和高成本的综合工程[39, 61]。海草成体移栽的综合成本高达 USD 91300/hm^2[65]。即使后来采用种子进行海草场修复,根据播种密度和播种方法的不同,包括种子采集、处理、保存等环节,综合修复成本也高达 USD 6674—165699/hm^2,平均每播种 1 粒种子的成本高达 USD 0.17,这还没有包括一次性设备购买的投入与损耗、修复工程之前与之后的监测及其它一些费用[79]。尽管人们的海草场生态系统方面的知识日益丰富,技术研究与应用不断取得新进展,海草场生态系统人工修复的成本已呈下降趋势[57],但切萨皮克湾海草场生态系统修复工程每年耗费资金仍达数百万美元,如此高昂的代价或许是发展中国家较少开展海草场生态修复的原因之一。

3.3.2 效率低

成体移栽法虽然具有较高的成活率[80]，但是因其破坏原海草场严重及劳动强度大成本高等原因，目前学者今本不推荐再采用成体移栽的方法进行海草场人工修复。但是以种子播种为手段进行海草场修复也存在诸多问题。Pickerell 等[69]报道的"浮漂播种法"成苗率在6.9%，切萨皮克湾成修复计划当中苗率在0.6%—39.8%范围内，且普遍较低[81]，罗德岛（Rhode Island）播种成苗率在5%—15%之间[65]。大规模海草场修复工程中，像地上农业一样把种子直接埋入底质是一件非常困难的事情，需要大量潜水员长时间高强度地水下作业才能完成，目前还没有其它更好的行之有效的技术可供应用，而要想得到很高的成苗率，种子的埋藏最佳深度是在1—2 cm，深度大于2 cm会显著降低成苗率[82]。如此苛刻的种子埋藏深度要求也成为阻碍播种技术研发的一大障碍。虽然应用新技术使得切萨皮克湾海草场修复计划速度在一定程度上大大提高，但当初计划于2010年完成185000英亩的恢复计划至今完成不足0.2%[30]，远未完成既定目标。虽然实验室内种子成苗率可达80%以上[53]，但是人工育苗成幼苗之后依然面临着转移至自然海区的困难，成本依然很高[71]。但实际海草场生态修复实践中，世界范围内的播撒种子成苗率普遍在1%—10%之间，海区播种后低成苗率已成为制约海草场生态系统修复工程的一大瓶颈[83]。

4 总结与讨论

海草场生态系统以其独特的生态特征和独具魅力的生态服务功能为数亿人和无数的水生动、植物直接或间接地提供了无可替代的巨大的生态系统服务[14]。2008年8月世界海草协会全球海草监测网将一套全球标准化海草监测工具赠予广西红树林研究中心，标志着中国首个全球海草科学监测站的正式建立[84]。对于我国海草场生态系统的研究和修复工作，笔者做出如下建议：

（1）加强海草及海草场生态系统基础生物学领域的研究，为开发低成本、高效率的海草场生态修复技术提供基础知识指导。我们对大多数地区的许多海草的种群动态知识的了解仍旧是相对贫乏的[85]，海草场衰退背后的机制以及由此产生的对近岸生物地球化学的效应仍然是未来海草研究一大趋势。进一步对分布于我国的各种海草的繁殖生物学及种群动态进行基础领域的研究，对我国海草场生态系统的保护和修复具有重要意义。

（2）开发利用种子播种技术进行海草场修复的关键技术，提高成苗率，以提高修复效率，降低修复成本。不论采用何种方式移栽成体海草进行海草场修复都是一个耗时耗力的过程，而且存在对原有海草场的直接破坏。而利用海草种子进行室内人工育苗再进行移栽，虽然具有较高的萌发率和成苗率[53]，但是育苗过程中的水、电、人工费也是一个巨大的经济开支，且育成幼苗之后依然面临着巨大的移栽成本，因此室内育苗再移栽的方法并非是一个经济高效的方法[71]。因地制宜，针对不同海区和海草种类，研究最佳播种时机以提高成活率，开发更加简单易行的新型播种方法，是提高生态修复效率，有效利用种子进行海草场修复的关键节点之一。

（3）加强海草场知识的科普教育，提高海草公众关注度，增加科研投入。利用媒体和先进网络平台技术，增加海草场生态系统公众关注度，吸引广泛的群众积极参与到海草场生态系统保护和生态修复活动中来。尽管海草科学迅速成长起来，与海草有关的科技论文迅速增加，但是海草与公众视线之间的距离与其它海岸带生态系统（如珊瑚礁和红树林）相比还有很大的差距。红树林生态系统和珊瑚礁生态系统受到媒体的关注程度分别是海草场生态系统的3倍和100倍，然而海草-海藻场生态系统所产生的生态服务价值却是红树林-盐沼生态系统的2倍之多[14]。媒体关注度的差别部分地反映出科研投入不均衡，单从发表的科技论文数量上看，海草方面论文数量也远低于盐沼、红树林和珊瑚礁[4]，种种证据表明与其它近岸生态系统相比，海草场生态系统距公众视线所关注相距甚远。为提高海草场在媒体和公众当中的关注度，需要政府政策引导和科研基金的支持，加大对公众进行海草知识科普教育，并且吸引志愿者[30]参与到海草场生态系统保护和人工修复活动中来，这也是降低生态修复成本的一个重要途径。

（4）学习发达国家海草场修复先进经验，寻求国际援助，少走弯路，减少不必要的重复投入以降低成本。

发展中国家在海草场生态系统保护和修复过程中应当得到来自发达国家的支持。发达国家比发展中国家在先进技术和资金方面都占有绝对优势,然而发展中国家的生物多样性及其潜力却高于发达国家[86],发达国家对发展中国家在海草场保护及海草场生态系统人工修复方面的援助有利于全球生物多样性的保护和整个海洋生态系统的平衡与健康发展,可以从根本上改善发达国家近岸沿海生态环境健康,也有利于推进海草场生态系统全球化监测网络的建设,有利于减少发展中国家在海草场生态修复过程中为开发修复技术而进行的重复投入,节约成本,提高效率。

(5)坚持海草场保护和修复相结合,以保护为主,以修复为辅,促进海草场生态系统自然恢复和可持续发展。加强监管,对我国现有自然海草场进行监测和保护,促进海草场自然恢复进程。推进和健全相关法律法规的形成与实施,加强政府政策引导,严格监管,大力推进海草场生态系统保护,走生态保护和生态修复相结合的可持续发展之路,才能实现海草场生态系统健康发展,造福人类。

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