





# 荷兰马肯湖 - 瓦登海项目： 探索自然的建造

## MARKER WADDEN, THE NETHERLANDS: A BUILDING-WITH-NATURE EXPLORATION

熊亮\*, 瑞克·德·菲索 / Liang XIONG, Rik de VISSER

\*Department of Urbanism, Delft University of Technology, Julianalaan 134, 2628 BL Delft, the Netherlands  
L.Xiong@tudelft.nl

### 1 引言

在过去的一千年里，自然进程和人类活动共同塑造了荷兰的国土形态。荷兰25%的国土位于平均海平面以下，65%的国土如果失去堤坝将遭受洪水侵袭。鉴于这一严峻现实，荷兰逐渐形成了一套切实可行的治理和设计方法。“圩田模式”是从水资源管理实践中形成的共识式决策治理模式，其建立在对经济和社会政策的长期审视和讨论之上<sup>[1]</sup>。同时，自20世纪70年代起，完全依从人类社会需求而应用水文工程技术塑造三角洲景观的传统也被重新审视<sup>[2]</sup>。马肯湖 - 瓦登海项目就是近年来探索在三角洲地区复杂环境下，用以塑造景观的新方法的大型项目之一。

### 2 马肯湖

#### 2.1 南海填海造地工程（1891~2006）

马肯湖是南海工程的意外产物。1891年，荷兰土木工程师及政府部长科内利斯·莱利决定将南海海湾与瓦登海相隔离，以围垦形成4块圩田并用于预防洪水。1932年，阿夫鲁戴克大坝的建成使南海成为了一片封闭的湖区，该湖区又于1976年被豪垂布大坝分割为马肯湖和艾瑟尔湖。如今，原计划中的三块圩田已经建造完毕，而最后一块马肯

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#### 摘要

荷兰马肯湖 - 瓦登海项目实现了传统智慧与前沿技术之间的平衡。一方面，基于圩田模式这一荷兰传统的共识式决策模式，多个公共和私营部门联合制定出了马肯湖 - 瓦登海项目计划；另一方面，该项目在设计思想及技术方面进行了大胆探索，并利用创新技术和自然进程建造出了新的自然。马肯湖 - 瓦登海项目在这个气候急剧变化的时代具有重要意义，其湿地设计与建造将有助于可持续水资源管理，改善当地生态系统，并增强处于暴雨和洪水威胁中的河流三角洲地区的韧性。

#### 关键词

马肯湖；圩田模式；淤泥；群岛；自然建造；栖息地修复；研究型设计

#### ABSTRACT

The Marker Wadden finds a good balance between traditional wisdom and technology advance. On the one hand, based on the polder model, a traditional consensus way of planning and decision-making in the Netherlands, the Marker Wadden project is created by an alliance of both public and private bodies sitting together and their opinions acknowledged. On the other hand, it boldly explores in both philosophy and technique, and a new nature has been achieved by using innovative techniques and natural processes. Marker Wadden will be of great importance in a time of climate change. Wetland design and construction can contribute to sustainable water management, improve local ecosystems, and provide greater resilience of river deltas in storms and floods.

#### KEY WORDS

The Markermeer; Polder Model; Silt; Archipelago; Building with Nature; Habitat Restoration; Design by Research

整理 田晓劫

译 孙一鹤 田晓劫

EDITED BY Xiaojie TIAN

TRANSLATED BY Robin SUN Xiaojie TIAN

1. 鸟瞰建造中的马肯湖 - 瓦登海项目（摄于2018年4月）

1. Bird view of Marker Wadden under construction (April 2018)

© John Gumlach - Flying Holland

**项目地址：**

荷兰马肯湖

**项目面积：**含浅滩景观约为1 000hm<sup>2</sup>  
(2021年远期目标为10 000hm<sup>2</sup>)**项目委托：**

荷兰自然遗产保护协会、荷兰基础设施和水管理部

**主管团队：**

Boskalis海事公司

**项目团队：**

Boskalis海事公司、Arcadis设计咨询公司、Witteveen+Bos工程咨询公司、Vista景观设计与城市规划事务所

**首席景观设计师：**

Rik de Visser

**设计时间：**

2014-2018年

**一期工程第一阶段建造时间：**

2016年3月-2018年8月

**建成时间：**

2021年1月

**LOCATION:**

Markermeer, the Netherlands

**AREA (SIZE):**Around 1,000 hm<sup>2</sup> including shallow water landscape  
(2021 long-term plan is aiming on 10,000 hm<sup>2</sup>)**CLIENTS:**

Natuurmonumenten, Ministry of Infrastructure and Water Management

**PROJECT LEADER:**

Boskalis

**PROJECT TEAM:**

Boskalis, Arcadis, Witteveen + Bos, Vista Landscape Architecture and Urban Planning

**CHIEF LANDSCAPE ARCHITECT:**

Rik de Visser

**DESIGN PERIOD:**

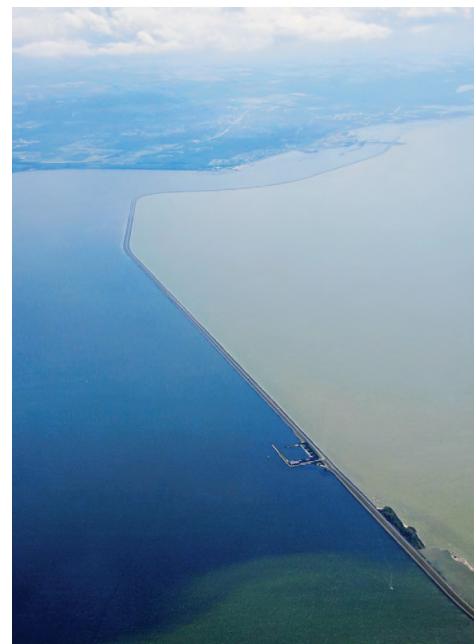
2014 - 2018

**CONSTRUCTION PERIOD OF STAGE ONE, THE FIRST PHASE:**

March 2016 - August 2018

**COMPLETION TIME:**

January 2021



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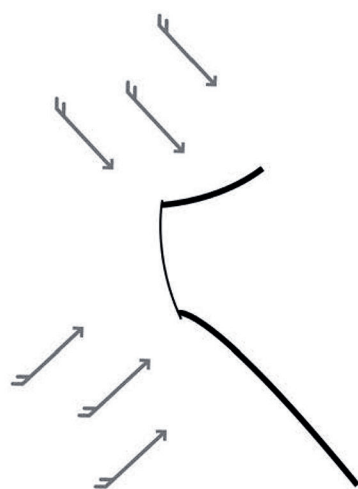
湖圩田则于2006年被撤消建造。截至当时，由于豪垂布大坝的阻隔，马肯湖与艾瑟尔湖已分离超过30年之久。

长期的隔离使得马肯湖的水质和生态系统均受到损害。由于水流无法将马肯湖内细小的沉积物冲刷至艾瑟尔湖，导致大量淤泥覆盖在马肯湖的湖床之上（图2）。此外，即使是在低风速下，风浪依旧不断侵蚀该浅水湖（2~4m深）的软泥层，导致沉淀在湖底

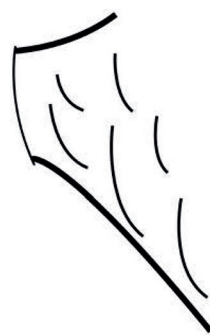
的泥沙再度悬浮起来。这些悬浮颗粒聚集在一起阻挡了阳光的射入。不仅如此，这里的生物多样性也由于海水转变为淡水而受到损害。在过去20年间，这片水域的生态系统急剧恶化。浑浊的悬浮泥沙使得藻类和水体的初级生产量大幅减少，进一步加剧了湖泊生态系统的退化。此外，由于湖体的自然海岸和滨海浅滩也几乎消失<sup>[3]</sup>，许多水生植物、鱼类以及斑马贝等贝类都濒临灭绝<sup>[4]</sup>。而湖体

初级生产量的减少以及无脊椎动物和鱼类种群数量的下降又导致了水鸟的食物短缺。最终，马肯湖变成了一个700km<sup>2</sup>的水中荒漠。

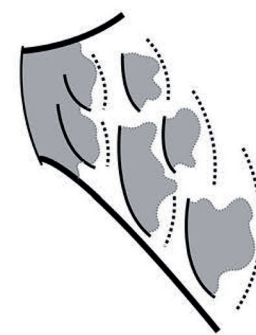
马肯湖存在的问题只是上世纪大规模工程干预所导致的负面环境后果之一。荷兰两个主要的防洪工程——三角洲工程和南海工程——均依靠大坝保护大面积低地免受海水侵袭。水环境的改变已经引发了水体本身和周边地区的生态危机。现在，设计师们致力于



Primary sandy dunes and stone dams  
主要沙丘和石坝



Secondary dams  
次级水坝



Compartment dams and marshland development in the Marker Wadden archipelago  
马肯湖-瓦登海群岛中的间隔式水坝和沼泽地

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2. 航空照片展现了相比艾瑟尔湖（左侧），马肯湖（右侧）充满淤泥的生态匮乏状态。
3. 马肯湖-瓦登海项目设计理念
4. 马肯湖-瓦登海项目总平面图

2. The aerial photo shows the extremely silty and ecologically poor and uniform situation in Markermeer (right) compared with the IJsselmeer (left).
3. Design concept of Marker Wadden
4. Master plan of Marker Wadden

## Legend 图例

### Edges creating shelter 边缘营造出庇护所

- Stone dam 石坝
- Stone dam harbor 石坝海湾
- Stone dam overwash 石坝上的溢浪口
- Sand dam above summer water level +0.20 NAP  
沙坝，高于阿姆斯特丹水平面夏季水位0.20m
- Secondary sand dam 次级沙坝
- Compartment sand dam above summer water level +0.20 NAP  
间隔式沙坝，高出阿姆斯特丹水平面夏季水位0.20m
- Compartment sand dam above winter water level -0.40 NAP  
间隔式沙坝，低于阿姆斯特丹水平面冬季水位0.40m
- Sand dam underwater threshold at -0.90 NAP  
沙坝水下阈值低于阿姆斯特丹水平面0.90m
- Poles with a distance of every 3 m on sand dam break waves entering compartment D1.  
沙坝上间距3m的立柱对进入D1间隔区的波浪进行消能。
- Poles with a distance of every 4 m on sand dam break waves entering compartment D3.  
沙坝上间距4m的立柱对进入D3间隔区的波浪进行消能。
- Small dunes in front 前方小沙丘

### Habitat type 栖息地类型

- Marshland 0.00 to -0.20 NAP  
低于阿姆斯特丹水平面0.00-0.20m的沼泽地
- Marshland -0.20 to -0.40 NAP  
低于阿姆斯特丹水平面0.20-0.40m的沼泽地
- Mud plain -0.20 to -0.40 NAP  
低于阿姆斯特丹水平面0.20-0.40m的泥浆平原
- Sheltered shallow water -0.40 to -1.00 NAP  
低于阿姆斯特丹水平面0.40-1.00m的受庇护的浅滩
- Sheltered shallow water -1.00 to -2.00 NAP  
低于阿姆斯特丹水平面1.00-2.00m的受庇护的浅滩
- Sheltered overflow area 0 to -2.00 NAP  
低于阿姆斯特丹水平面0.00-0.20m的受庇护的溢流区

### Facility elements 设施

- Visitor center and other facilities 游客中心和其他设施
- Harbor 海湾
- Beach 沙滩
- Path 小径
- pcfs Pilot consolidation of fine silt 巩固细泥的试点
- Water tower "Steltloper" 水塔“高台”观鸟点
- Bird watch hut "Lepelaar" “白琵鹭”视角观鸟点
- Bird watch hut "Duikeend" “潜鸭”视角观鸟点
- Bird watch hut "Aalscholver" “鸬鹚”视角观鸟点
- Nature [idem with recreational facilities allowed]  
未经开发的自然区域（可设置游憩设施的范围）
- Nature [according to municipal land use plan]  
未经开发的自然区域（根据城市土地使用规划划定的范围）

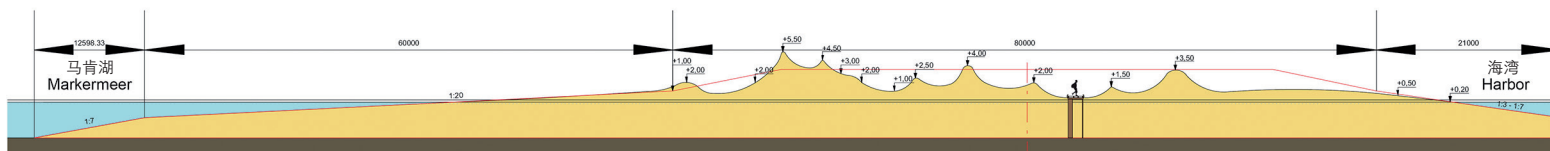


在不降低防洪安全的前提下恢复水生态安全。

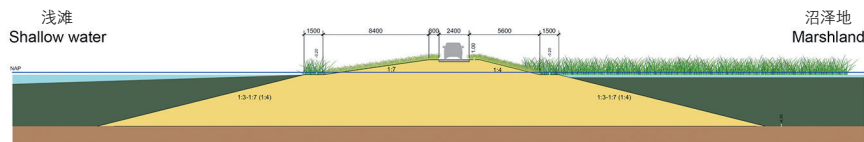
## 2.2 圩田模式塑造的艾湖 - 马肯湖区域 (2004~2013)

圩田模式这一传统的共识式决策模式是在维持荷兰由三万个圩田和运河网络组成的庞大系统的过程中发展起来的。自中世纪以来，处于同一圩田的不同族群就需要共同管

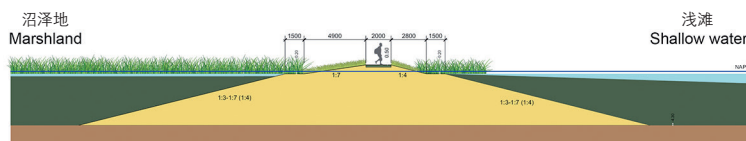
理堤坝及泵站，否则圩田一旦被淹没，将无人幸免。在当下的空间干预中依然可见这一传统的延续。艾湖是一处位于马肯湖南部的湖区。鉴于艾湖周边大规模的城市发展将会影响艾湖 - 马肯湖区域的生态和环境质量，7个公民及社会组织于2004年制定了一项针对艾湖的联合规划。这一团体包括非政府组织、省市政府，以及作为顾问的荷兰公共工



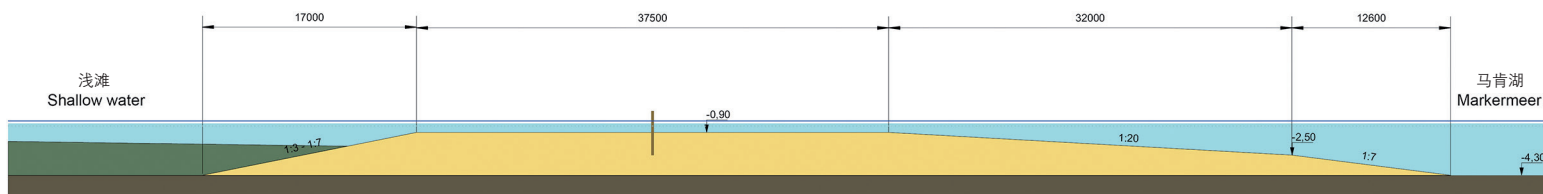
Primary sandy dune section  
主沙丘剖面图



Secondary dam section  
次级水坝剖面图



Compartment dam section  
间隔式水坝剖面图



Compartment dam opening up section  
间隔式水坝展开剖面图

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程与水管理局<sup>①</sup>。此后，该团队进行了一系列区域开发。由于采用了圩田模式，艾湖 - 马肯湖项目成为了首个成功的联合规划项目，该项目的成功经验也为之后更大尺度的马肯湖 - 瓦登海项目铺平了道路。

### 2.3 荷兰自然遗产保护协会启动计划 (2012~2015)

成立于1905年的荷兰自然遗产保护协会是荷兰最大的私营自然保护组织之一。截至2010年，由该协会购买、保护和管理的355个自然保护区总面积达1 029.51km<sup>2</sup>，其中包括马肯湖周边的几个自然保护区。作为荷兰生态主干结构和水系轴线的一部分，马肯湖在自然保护和开发中起着至关重要的作用<sup>⑤</sup>。

2012年，荷兰自然遗产保护协会提出建设马肯湖 - 瓦登海项目，以提升马肯湖的生态价值。2013年，经过与国家政府及周边省政府的协商，该协会完成了土地利用计划草案，并于同年筹得1 500万欧元进行项目开发。截至目前，荷兰自然遗产保护协会、荷兰国家邮编彩票中心、荷兰经济部、荷兰基础设施与环境部<sup>②</sup>，以及弗莱福兰省共募集资金6 000万欧元。这一规划将拦截淤泥，并建造出一片自然的湖岸<sup>⑥</sup>。

### 2.4 设计研究与设计竞赛 (2014)

在2014年鹿特丹国际建筑双年展上，荷兰政府针对若干个具有深远空间影响的大型复杂长期项目进行了一系列的研究、公众讨

论，以及展览。针对马肯湖 - 瓦登海的设计研究也在双年展中得以展示。该项目由代尔夫特理工大学范·伊斯特伦教授和政府顾问委员会一同提出，并由此次双年展策展人德克·赛蒙兹进行审核<sup>⑦</sup>。荷兰基础设施与环境部以及经济部委托Vista景观设计与城市规划事务所和Svasek水利公司共同“探索将马肯湖 - 瓦登海建造为一处具有空间和生态价值，同时集体验性与游憩性于一体的区域，并着眼于未来发展与更广泛的环境议题，包括马肯湖和艾瑟尔湖的关系，水质和淡水贮存问题，豪垂布大坝在水安全和基础设施建设方面的发展，以及欧洲自然保护协议的建立”。<sup>⑦</sup>

这一设计研究提供了4个各有侧重的设计方案：三角洲方案重在最大限度地聚集

① 荷兰公共工程与水管理局隶属于荷兰基础设施与水管理部。

② 2017年，荷兰基础设施与环境部更名为荷兰基础设施与水管理部。

环流，泄湖方案重在最大限度地利用由风力作用产生的水位变化，环礁方案和群岛方案则分别重在最高效地处理淤泥，以及形成沼泽、湿地和浅滩。包括政府机构、非政府环保组织、非政府文娱组织、科研院所、工程公司和设计公司在内的17个利益相关方对这些方案进行了讨论。

2014年下半年，荷兰自然遗产保护协会与荷兰公共工程与水管理局针对马肯湖-瓦登海发起了设计竞赛。2015年，由Boskalis海事公司、Arcadis设计咨询公司、Witteveen+Bos工程咨询公司，以及Vista景观设计与城市规划事务所组成的团队赢得了该项竞赛。随后，工程正式开始。

### 3 马肯湖-瓦登海项目：建在淤泥上的鸟类天堂

在谷歌地图上，你可以很快看出浑浊的马肯湖与清澈的艾瑟尔湖之间的差别。马肯湖-瓦登海项目将通过清理淤泥，并利用这些淤泥建造沼泽和浅滩的方法来改变这一现状。这一过程仅需很少的投入即可形成独特的湿地和鸟类天堂（图1）。未来的马肯湖将拥有更清澈的湖水和宝贵的自然环境。同时，这也是世界上前所未有的水利工程创举。我们疏浚全新世地质时代的沉积物，将其堆在沙坝上并使其高出水面，随后分阶段自然固结紧实。通过将沉积物与水体相混合，陆地面积在土石方平衡的基础上实现了增长。这是一种可以创造新自然的经济型填海方式。在这里，鸟类处于生态系统的中心位置，它们推动着自然的持续演进。

#### 3.1 群岛

马肯湖-瓦登海项目得名于瓦登海这一荷兰首屈一指的自然之境。在瓦登海群岛，位于西南和西北面的沙滩和沙丘保护着岛屿免受海浪侵袭，其背风面则由泥滩和沟谷组成。马肯湖-瓦登海项目的设计就是受到瓦登海群岛的启发。在设计中，我们在稳固的沙丘景观后方建造了多泥的软质景观（图3）。人造沙丘为马肯湖提供了免受海



6-1 © Vista Landscape Architecture and Urban Planning



6-2 © Vista Landscape Architecture and Urban Planning

浪侵袭的庇护所。在受到最强烈海浪冲击的西岸，我们采用石坝连接两处沙丘景观以建造出受庇护的湖面，使这里可以逐渐形成遍布湿地的岛屿。

马肯湖-瓦登海项目被设计为一组群岛（图4）。同时，我们希望为马肯湖和马肯湖-瓦登海项目间的交互创造条件。此外，设计实现了边界长度和坡度的最大化。在这些岛屿上广阔交织的沟谷间，遍布着沼泽植被、泥滩、独立的淡水湖泊、溪流，以及受庇护的水洼（图5）。一些明显的“填海造陆语汇”——如迎着盛行风向的大坝以及其后开阔软质的腹地则成为了该项目的标志。

5. 马肯湖-瓦登海项目坝体主要剖面图
- 6-1. 从西南方鸟瞰马肯湖-瓦登海项目
- 6-2. 从西北方鸟瞰马肯湖-瓦登海项目
5. Principle sections of Marker Wadden dams
- 6-1. Bird view of Marker Wadden from southwest
- 6-2. Bird view of Marker Wadden from northwest

马肯湖 - 瓦登海项目的设计避免了增加硬质边缘。其中软质的人造沙坝和沙丘参照了被隔断前海湾内的自然沙丘、恩克赫伊曾滩的潮间带，以及东部和南部的更新世海岸。本地黏土和沙土的使用增强了系统养分，亦保持了原有南海潮汐盆地的特征。

### 3.2 自然建造——波浪、水流和倾斜度带来的自然动力

在对现有生态系统进行最大程度整合的基础上，我们制定出马肯湖 - 瓦登海项目的建造策略。在完成土壤固结和植被演替之后，我们意在促使该项目与马肯湖进行最大程度的交互。群岛、小溪和沼泽以最优方式被组织到整个水系之中。那些原本被视为阻力的自然动态过程（风、波浪、水流、水位和冰面倾斜）在项目中则成为助力。位于西南（图6-1）和西北（图6-2）的沙丘成为抵挡盛行风的主要屏障。次级水坝为内部湿地提供额外保护。间隔式水坝的高度保持在阿姆斯特丹水平面（荷兰平均海平面，NAP）以上1.00m的位置。处于背风面的间隔式水坝则与水平面齐平。

岛屿的建造（图7，8）从使用沙子作

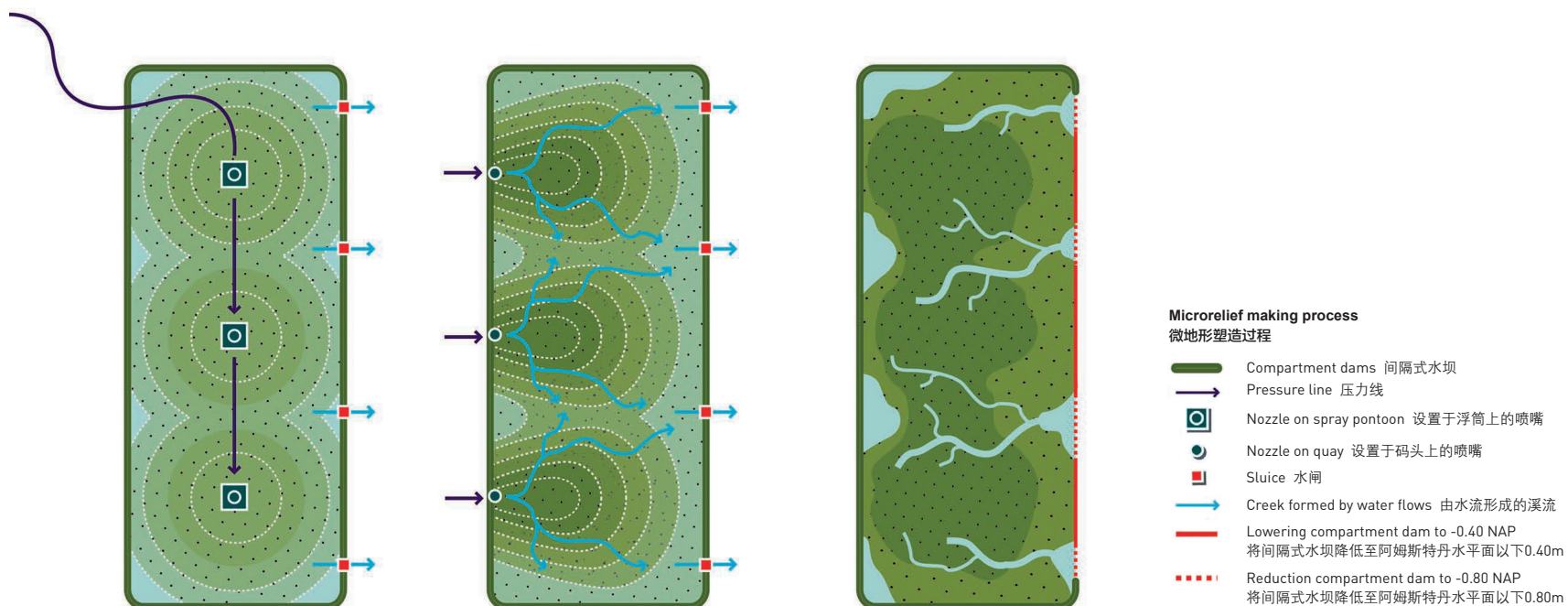
为填海框架筑造水坝开始，随后再分步骤利用淤泥填充这一框架。随着淤泥被不断固结紧实，渗出的水分通过坝体上的闸口排出，之后再在框架上填充新的淤泥。借助疏浚技术，我们可以通过自然方式形成差别化的沼泽地。最后，淤泥将达到预期设计高度。当水从最后一层被释放出来，流出的水会形成溪流。当植被充分演替后，背风面水坝可以降低至马肯湖的水位以进行最适宜的水交换。




岛屿的东北和东南侧非常开阔，可以与马肯湖实现交互。马肯湖的弱环流可以从各个方向流向岛屿，使得淤泥沉积物进入水坝。马肯湖没有潮汐，但风力很强，因此迎风面的水位会升高。刮强风时，沼泽地的水面会产生高潮或低潮。如同瓦登海的情况一样，水位变化会使额外的水流进入沼泽地，从而促进侵蚀和沉积等自然过程的发生，由此进一步塑造当地景观。

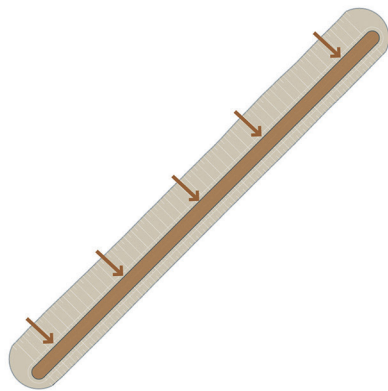
### 3.3 栖息地多样性




马肯湖 - 瓦登海鸟类天堂处于一个独特的生态系统之中：马肯湖是一个大面积淡水低地泥湖。由于湖床的全新世层被侵蚀，大部分湖体非常浑浊，这导致很多动植物在这

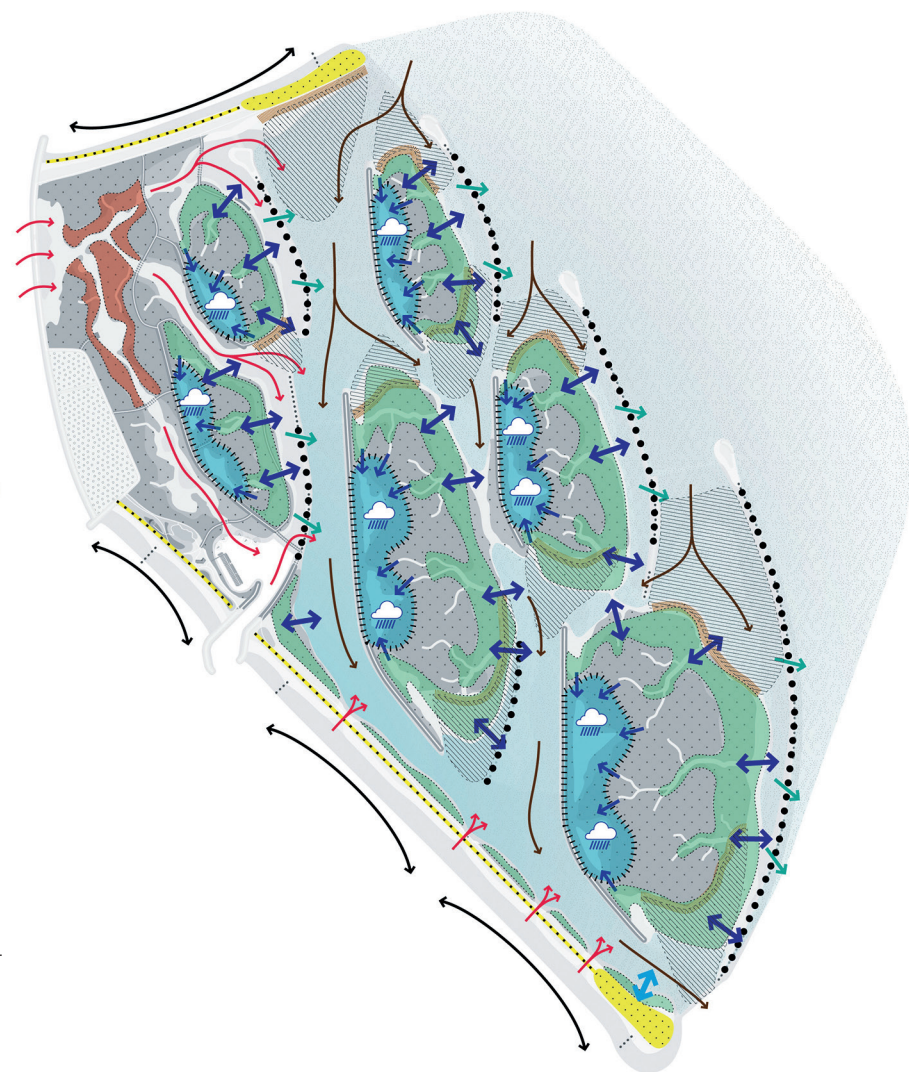
7. 马肯湖 - 瓦登海项目微地形塑造过程
  8. 马肯湖 - 瓦登海项目的生态理念及启动过程
7. Marker Wadden microrelief making process
  8. The ecological concept and initiated processes of Marker Wadden



- 
 Maintain stable open sandy coast by profile, sand buffers, transverse dams, and ice rink. Wash overs and sedimentation gradients due to reductions in sand dam.  
 通过边界、沙缓冲带、横坝和冬季冰面维持稳定开放的沙质海岸。由于沙坝的削弱效应，溢浪和沉积物能形成有梯度的冲刷和堆积。
- 
 Water, backwater, and run-off through wave overtopping by lowering of stone quay.  
 通过石质驳岸的凹口产生的越波，能够形成入水、回水和径流。
- 
 Maximum land-water interaction by shifting and digging deeper quays.  
 通过调整和深挖驳岸，充分实现水陆交互。
- 
 Temporary water reservation from precipitation and slant by realizing central subtle watersheds.  
 经过巧妙设计的中央分水岭可以使降水经斜坡汇聚，形成临时蓄水。
- 
 Collection and distribution of silt water and silt sedimentation by configuration in islands.  
 通过在岛屿上进行布局，对泥水和淤泥沉积进行收集和分配。



- 
 Additional filtering by developing mussel beds on pile reefs.  
 通过培育暗礁上的贝壳层实现进一步过滤。
- 
 Keeping sweet swallowing open by creating space for secondary wave build-up.  
 通过为次级波累积创造空间保持淡水吞吐通畅。
- 
 Collection of silt in underwater ditch.  
 在水下沟渠中收集淤泥。



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里难以生存，甚至完全无法存活。这里还存在着水陆过渡介面过硬、生物栖息地受限和反常水位等不利因素。为了营造一个自然而健康的生态系统，将马肯湖 - 瓦登海项目与马肯湖融为一体非常重要。具体措施包括实现水体深度和透明度的动态渐变、增强连通性，以及改善水陆过渡介面等。这些措施将增加栖息地和物种多样性。

我们认为鸟类是这一生态系统中种类最丰富且最具吸引力的种群。它们处于食物链顶端，反映着水体中生物的质量。因此，我们选择鸟类这一最具系统性的群体作为切入点。在当前阶段，我们首要关注与特定鸟类

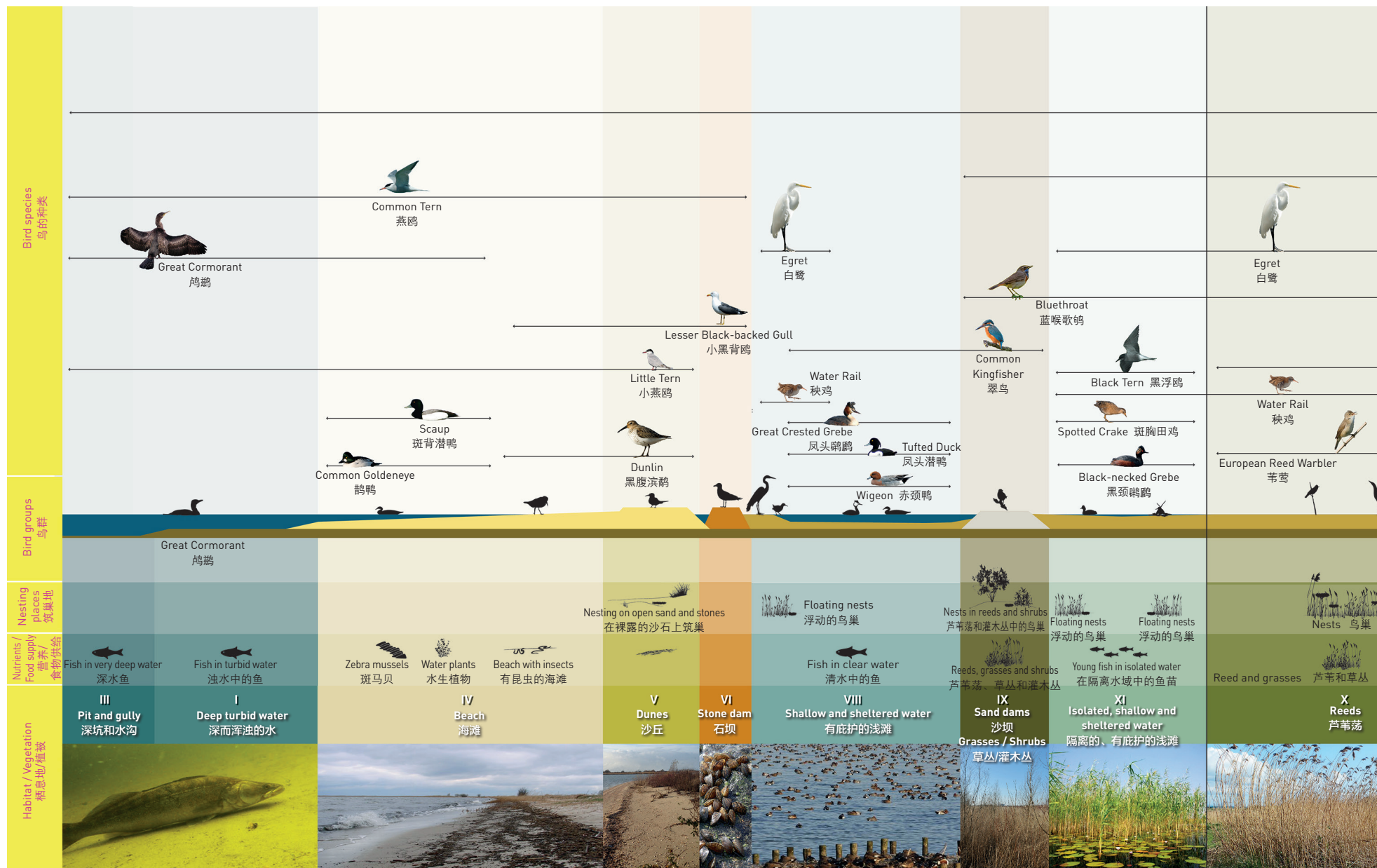
相关的淡水原始沼泽、黏土，以及富含营养的栖息地。为打造鸟类天堂，我们为鸟类提供了三个必要的生存条件：食物供给、休憩场所和繁殖机会（图9）。

大量的食物供给从利用富含营养的全新世黏土和淤泥开始。但是这些营养仍未被充分释放。鉴于土壤熟化能够改变这一现状，我们通过对土壤进行干燥以及引入芦苇来加速土壤的熟化过程（图10，11）。休憩区对鸟类而言必不可少。新设计的水坝和岛屿结构为鸟类提供了大量不同尺度的庇护所和浅水区。最后，繁殖活动是马肯湖 - 瓦登海鸟类数量持续增长的关键所在。而这

些孤立的岛屿则可以最大限度地发挥“岛屿效应”——狐狸和鼬类等地面捕食者无法登岛，这意味着更多物种如琵鹭和鸬鹚等可以毫无顾虑地在芦苇和其他水草中进行繁殖活动。由于没有地面捕食者，沙坝也能最大限度为地面繁殖种群提供筑巢机会。此外，通过在港湾区附近划定人类活动区域，可以避免游客对鸟类的打扰。

### 3.4 自然与休闲娱乐功能的完美结合

我们希望马肯湖 - 瓦登海成为大自然和景观爱好者的旅行目的地之一。鸟类和沼泽在这处绝佳的独立区域内占据主导地位。受



到重重庇护的海港和游客接待区构成了马肯湖 - 瓦登海的中心点。通过沙丘顶上引人注目的瞭望塔，人们从远处就可以识别出这个地方。通往沼泽区的步道和木板桥沿途串联起不同种类的观景屋以及各种寓教于乐的设施。

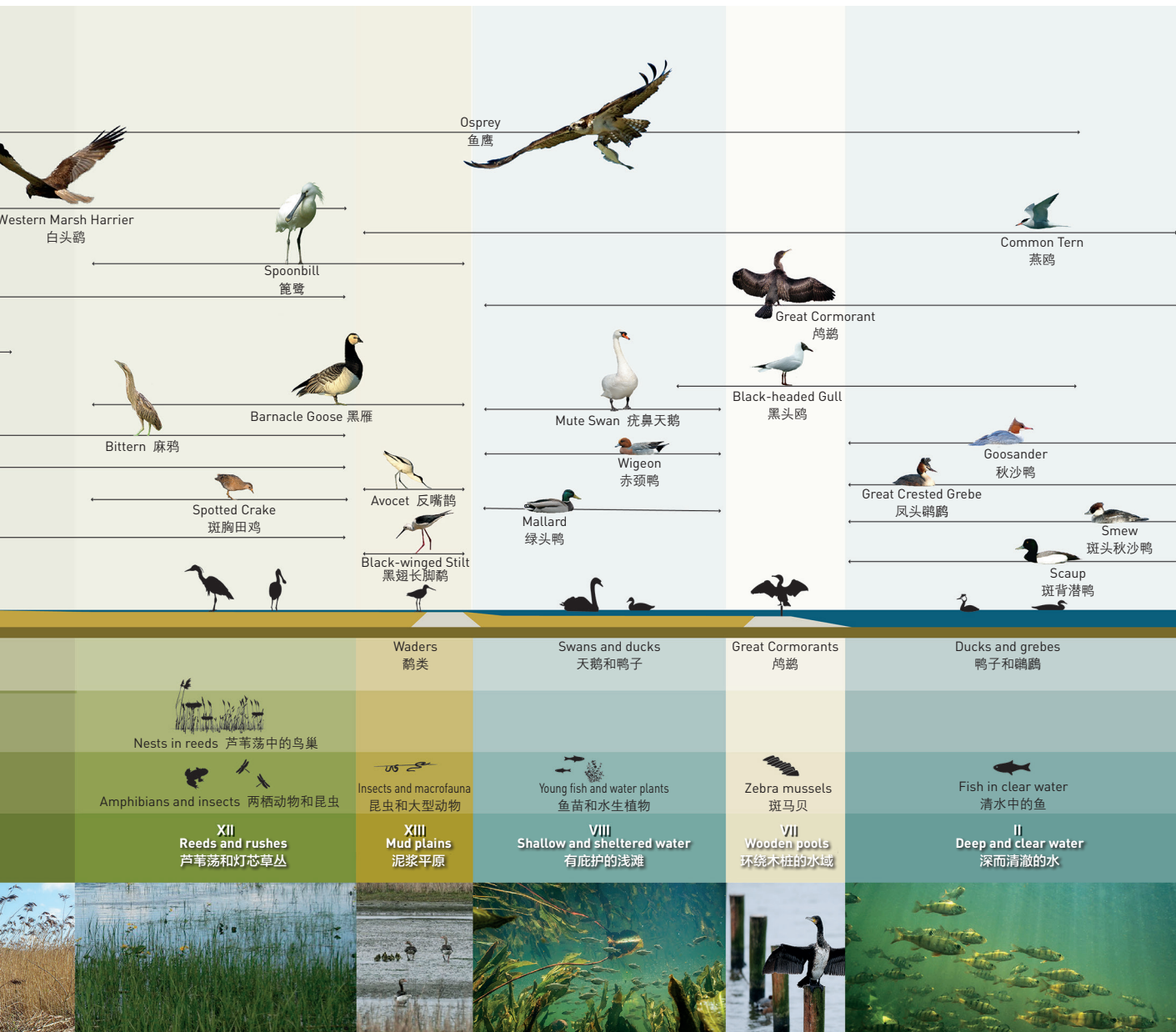
港湾是一处富有吸引力的航行目的地，这里有可供游人休憩的场地及游客中心。首批参观者因鸟类天堂而来。但同样重要的是，马肯湖 - 瓦登海项目赋予了马肯湖新的

吸引力，在这里，水上运动爱好者不仅能放松自我，还能体验到水上运动的价值。在马肯湖 - 瓦登海的横向景观上，港湾和游客中心位于西南向的沙丘景观之中。从远处眺望，可以看到帆船桅杆。由于石坝为帆船提供了有效的庇护（图12），且港湾的边缘被芦苇所覆盖，港湾在各种天气条件下均可使用。

港口周围集中了这一区域最重要的功能。各种观鸟设施为游客观察沼泽中的鸟类

9. 由马肯湖 - 瓦登海项目形成的栖息地以及预期会出现的鸟类

9. Habitats created by Marker Wadden and expected bird species



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## 4 结论

2016年3月，一期工程的第一阶段正式开始。5个岛屿和淤泥通道预计将于2018年年中完成，并面向公众开放（图17~20）。待到2021年1月，群岛中将再增加三组岛屿。荷兰自然遗产保护协会致力于在未来建造更多群岛。为保障这一长期工程的顺利进行，这里还规划了两项主要干预措施：隶属于莱利斯塔德城的半岛将提供水上运动沙滩，以为游客提供可以放风筝和冲浪的空间；而面积270hm<sup>2</sup>的具有固沙作用的里恩泰尔滩则能够巩固豪垂布大坝，并创造新的自然（图21）。这两个长期规划项目的完成时间尚未确定。

马肯湖-瓦登海项目实现了传统智慧与前沿技术之间的平衡。一方面，荷兰多个公共和私营部门秉承着对传统规划流程的尊重联合起来并肩协作、共同商议，制定出了马肯湖-瓦登海项目计划；另一方面，该项目在设计思想及技术方面进行了大胆探索。马肯湖-瓦登海项目是展示荷兰水利工程产业的国际化窗口。当世界上大部分地区还在强调保护自然的时候，该项目已经关注于如何建造新的自然。通过利用创新技术（如利用稀释的全新世物质进行建造）和自然进程（如自重固结和干燥板结），这一目标已经达成。设计、管理和科技在这片曾经废弃的生态荒漠中被很好地结合在一起。这种意在形成新自然的结合从未在如此广博的尺度上实现。研究人员分析了设计中的生态恢复情况和管理风险，这些科学知识和经验将有助于今后国内外项目的实施。马肯湖-瓦登海项目在这个气候急剧变化的时代具有重要意义，特别是对于人口密集的河流三角洲地区。湿地设计与建造将有助于可持续水资源管理，改善当地生态系统，并增强处于暴雨和洪水威胁中的河流三角洲地区的韧性。LAF

### 致谢

感谢Vista景观设计与城市规划事务所邵珊女士对本文的帮助。

提供了不同的观察途径和观景视角：

- 1) 水塔“高台”（12m）：鸟瞰群岛全景（图13-1,13-2）；
- 2) “白琵鹭”视角（3.5m）：俯视小溪和芦苇（图14）；
- 3) “鸬鹚”视角（2m）：平视主要溪流和沙地（图15）；
- 4) “潜鸭”视角（0m）：观察小屋（青蛙视角和 underwater 观察窗）（图16）。

这些设计使人们能够从不同角度体验马

肯湖-瓦登海：从位于沼泽之内靠近鸟类的低视角，到沼泽之上远离鸟类的高视角。这里提供了完全不同于以往的深入而全面的观察体验方式。这些设施位于徒步小径和木质步道的分支上。在这里，你可以在不打扰鸟类的情况下接近它们。观察设施被置于靠近浅滩开阔水面的芦苇地边缘，在这里可以观察到大部分鸟类。在一些观察点，我们将木杆插入水中，以便鸬鹚能够在太阳下晾晒翅膀。

## 1 Introduction

Over the last thousand years, the Dutch territory has been shaped by both natural processes and human activities. Being 25% of its surface below mean sea level and 65% of the surface flooded without dikes, the Dutch developed a practical way of governing and design. With a reference to the water management, the “polder model” has been known as a traditional consensus way of governing based on long and careful deliberation on the economic and social policies<sup>[1]</sup>. Meanwhile, the tradition of utilizing the hydrologic engineering techniques to shape the delta landscape completely to the needs of human society, has been reconsidered since the 1970s<sup>[2]</sup>. The Marker Wadden project is one of the latest large-scale projects that explore new approaches in the complex condition of delta landscape.

## 2 The Markermeer

### 2.1 The Land Reclamation in Zuiderzee (1891 ~ 2006)

The Markermeer (Marker Lake) is an unexpected product of the Zuiderzee Works. In 1891, Cornelis Lely, a Dutch civil engineer and government minister, designed to close off the Zuiderzee, a marine bay, from the Waddenzee to create four polders and

prevent flood. The closure of the Zuiderzee was realized in 1932 by the Afsluitdijk (Enclosure Dam). Then, the Zuiderzee became a lake district, which then was divided into Markermeer and IJsselmeer by Houtribdijk (Houtrib Dam) in 1976. Nowadays, three polders have been realized while the last one, the Markermeer, was canceled in 2006. By then, the Markermeer had been cut off by the Houtrib Dam from the IJsselmeer for over thirty years.

The water quality and ecology of Markermeer suffered from the disconnection. Fine sediments could not be flushed out to the IJsselmeer by currents. Instead, a suffocating blanket of silt has dominated the lake bed (Fig. 2). Moreover, even at low wind speeds, wind-induced waves cause erosion and resuspension of the soft mud layer in this shallow lake (2 ~ 4 m deep). Suspended particles concentrated and inhibited light penetration. The biodiversity also suffered from the change of the water from salt to fresh. During the last twenty years, the ecosystem has deteriorated dramatically. Turbidity from suspended sediments has greatly reduced primary production by algae and water, resulting in the lake ecosystem deterioration. Furthermore, the lake has barely any natural shores or shallow littoral zones<sup>[3]</sup>. Thus, many water plants, fish and mussels such as the zebra mussel are struggling to survive<sup>[4]</sup>.

The decrease in primary production and reduced invertebrate and fish populations in the Markermeer have led to a food shortage for many water birds. As a result, the Markermeer functioned as a big aquatic desert of 700 km<sup>2</sup>.

The Markermeer is merely one of the negative environmental outcomes from the large-scale engineering interventions in the last-century. The two major flood defense projects, the Delta Works and the Zuiderzee Works, both relied on dams to protect large area of lowlands from the sea. The changing water environment has caused ecological hazards in the water bodies and surrounding regions. Nowadays, designers strive to restore the ecological safety without reducing the flood control safety.

### 2.2 The Polder Model Shaping the IJmeer-Markermeer region (2004 ~ 2013)

The polder model is a traditional Dutch consensus decision-making process that developed when maintaining the extensive system of 30,000 polders and the web of canals. Since the Middle Ages, different societies in the same polder were forced to manage the dikes and pumping stations together, otherwise the polders were flooded and nobody was safe. Such tradition remains in the spatial interventions. In 2004, seven civic and public organizations developed a joint plan for the IJmeer, a

10. 2017年8月，一辆橙色气垫船在马肯湖 - 瓦登海项目中一个堤坝内的湿泥上播种芦苇。
11. 芦苇在堤坝内生长，并促进土壤熟化（摄于2017年10月）。
12. 设有石坝的港湾于2017年10月竣工。港湾的边缘将被芦苇覆盖。
10. An orange hovercraft was sowing the reed on the soggy mud inside one of the dams of the Marker Wadden in August 2017.
11. The reed was growing to help the soil ripening within the dam (October 2017).
12. Harbor with stone dams was finished in October 2017. The edges of the harbor will be covered with reeds.



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10



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11



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12

lake in the south of the Markermeer, where major urban developments would impact the ecological and environmental quality of the IJmeer-Markermeer region. This group includes NGOs, the municipalities, and the provinces with Rijkswaterstaat (Bureau of Public Works and Water Management)<sup>①</sup> as advisor. The group has formed a series of regional development since then. Based on the polder model, IJmeer-Markermeer becomes the first successful joint planning project, the experience of which paves the way for the later Marker Wadden on a larger scale.

### 2.3 Natuurmonumenten's Initiation Plan (2012 ~ 2015)

Founded in 1905, Natuurmonumenten (Society for preservation of nature monuments in the Netherlands), one of the largest Dutch private nature conservation

organizations, buys, protects, and manages 355 nature reserves of 1,029.51 km<sup>2</sup> by 2010. It owns several nature reserves around the Markermeer. Being part of the Dutch ecological main structure (EHS) and Water Axis (Natte As), the Markermeer is essential for preserving and developing nature<sup>[5]</sup>. In 2012, the Marker Wadden project was proposed to improve the Markermeer's ecological value by the Natuurmonumenten. In 2013, it negotiated between the national and provincial governments, proposing a draft land-use plan, and then it received EUR 15 million to develop this plan. So far, EUR 60 million has been raised by Natuurmonumenten, the Dutch National Postcode Lottery, the Ministry of Economic Affairs, the Ministry of Infrastructure and Environment<sup>②</sup> and the province of Flevoland. In this plan, a natural shore would be built, and silt would be trapped<sup>[6]</sup>.

### 2.4 The Design Research and Design Competition (2014)

A design research on the Marker Wadden was held at the International Architecture Biennale in Rotterdam (IABR) 2014, where the government brought complex, extensive, and long-term projects with large spatial issue for research, public debates, and exhibitions. It was put on the agenda by Van Eesteren Chair at Delft University of Technology with the Board of Government Advisors, and the IABR curator Dirk Sijmons as audit<sup>[7]</sup>. The Ministry of Infrastructure and the Environment and the Ministry of Economic Affairs commissioned the design research to Vista landscape architecture and urban planning in collaboration with Svasek Hydraulics for "exploring the opportunities for the development of Marker Wadden to an area with spatial and ecological quality to be experienced and recreationally used. With a

① Rijkswaterstaat (Bureau of Public Works and Water Management) is a branch of the Ministry of Infrastructure and Water Management.

② The Ministry of Infrastructure and Environment was renamed the Ministry of Infrastructure and Water Management in 2017.



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13-1



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13-2

view to future developments and to the wider environment, including the relationship between Markermeer and IJsselmeer, water quality and fresh water storage, the developments concerning the Houtribdijk for water safety and infrastructure, and European agreements with respect to nature.”<sup>[7]</sup>

The design research delivered four alternatives with different focuses: the Delta focused on maximum concentration of circular current, the Lagoon focused on maximum use of water level fluctuations by wind action, the Atoll and the Archipelago focused on maximum efficiency for processing silt and the realization of marshes, wetlands and shallow water respectively. The debate was organized among 17 stakeholders from governments, environmental NGOs, recreational

NGOs, research institutes, engineering companies, and design firms.

Later in 2014, Natuurmonumenten and Rijkswaterstaat issued a design competition about Marker Wadden. It was won in 2015 by a team from Boskalis with Arcadis, Witteveen + Bos and Vista landscape architecture and urban planning. Then the work started.

### 3 Marker Wadden: A Bird Paradise Built on Silt

On the Google Earth, you can immediately notice the difference between the turbid Markermeer and the clear IJsselmeer. Marker Wadden will change that by achieving a unique dual-purpose: tackling the silt problem and then creating marshlands and shallow water by taking

use of the silt. This process will result in a unique wetland and bird paradise at a very low cost (Fig. 1). It allows us to create a future for the Markermeer with clearer water and valuable nature. At the same time, it gives the Netherlands a hydraulic engineering innovation which has never shown before in the world. We dredge Holocene material, bring it up above the water level within sand dams, and let it be consolidated in phases. By mixing Holocene material and water, the volume of the land increases on balance. We see this as a very economical manner of land reclamation for new nature. Birds take a central position in the ecosystem and stimulate the nature to get going.

#### 3.1 Archipelago

We associate the term of Marker Wadden

- 13-1. 通过小径前往“高台”
- 13-2. 从“高台”(12m)往外看: 总览群岛
- 14. “白琵鹭”(3.5m)视框: 俯瞰溪流和芦苇荡
- 15. “鸬鹚”视角(2m)观鸟点
- 16. “潜鸭”视角(0m)观鸟点

- 13-1. On the path towards "Steltloper"
- 13-2. View from the "Steltloper" (12 m): an overview on the archipelago
- 14. "Lepelaar (Eurasian spoonbill)" (3.5 m) view frame: overlooking the creeks and reeds
- 15. Perspective view of "Aalscholver (Great cormorant)" (2 m) bird-watching hut
- 16. Perspective view of "Duikeend (Diving duck)" (0 m) bird-watching hut

with the Wadden Sea, the number one of the Dutch nature. On the Wadden Islands, sandy beaches and dunes on the southwestern and northwestern sides protect the land from the waves. The lee side consists of mudflats and gullies. The design of Marker Wadden is inspired by the Wadden Islands. Behind a stable sandy dune landscape, we create a soft and muddy landscape (Fig. 3). In the plan, created dunes provide shelter to prevent the waves on the Markermeer. We connect two dune landscapes with a stone dam all along the western side where it will receive the strongest attack from the waves. In this way, we create a sheltered part of the lake where we are able to develop islands with wetlands.

Marker Wadden is designed as an archipelago (Fig. 4). Herewith, we want to

create conditions for optimal interaction between Markermeer and Marker Wadden. We realize maximum length of the edges and its gradients. The islands contain marsh vegetations, mudflats, shallow (isolated) lakes, creeks, and sheltered and shallow water in between the broad interweaving gullies (Fig. 5). Marker Wadden can be identified by a recognizable "reclamation narrative" with dams oriented to the prevailing wind direction and soft open backsides.

The design of Marker Wadden emphatically adds as few new hard edges as possible. The soft sandy dams and dunes in Marker Wadden refer to the dunes of the former Zuiderzee, the tidal threshold of Enkhuizerzand, and the Pleistocene coasts in the east and south. The choice to use



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the local clay and sand also strengthens the nutritious part of the system, which is characteristic of the former Zuiderzee as a tidal basin.

### 3.2 Building with Nature — Natural Dynamics due to Waves, Currents and Tilt

Our construction strategy of Marker Wadden is based on maximum integration with the existing ecosystem. After establishing soil consolidation and vegetation development, we aim for maximum interaction with the Markermeer. The islands, creeks, swamp areas are optimally connected to the total water system. We consider the natural dynamics (wind and waves, currents, tilting of the water level and ice) first as a foe then a friend. The sandy dunes to the southwest (Fig. 6-1) and the northwest face (Fig. 6-2) provide the main shelter from prevailing wind directions. Secondary dams provide extra shelter for the wetlands. We keep the compartment dams at a height of + 1.00 m NAP (=average water level). The compartment dams in the leeward side lie at the water level.

The island construction (Fig. 7, 8) starts from building a dam using sand as a reclamation frame. Subsequently the frame is filled with silt in multiple steps. Silt consolidates, then the remaining water is released from the compartment and new silt is added. With dredging techniques, it is possible to define differences in the relief of the marshland in a natural way. Finally, the silt will reach the required level. When the water is released from the last layer, the outflowing water forms creeks. When vegetations are sufficiently developed, dams can be lowered at the leeside up to the level of the Markermeer for optimal exchange of water.

On northeast and southeast, the area is very open and interacts with the Markermeer. The weak circular flow in the Markermeer can enter here from all sides, where the silt sediments go inside the dams.



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There is no tide in the Markermeer, but the wind can blow hard here. Then the water level rises in the direction of the wind. In case of strong wind, a higher or lower level can temporarily occur in the marshland. These level changes provide extra water flows, just like that in the Wadden Sea, to enter the marshland, thereby stimulating the natural processes such as erosion and

sedimentation, thus further shaping the landscape in details.

### 3.3 Habitat Diversity

Marker Wadden bird paradise is located in a particular ecosystem: the Markermeer is a large fresh water lowland clay lake. A large area of the lake is turbid due to the erosion of the Holocene layer on the lake

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| <p>17. 2016年6月，鸟类在第一座建成岛屿上漫步，其后方正在进行施工作业。</p> <p>18. 2016年9月的岛屿建造情况</p> <p>19. 2017年4月，在经过一个冬季之后，第二个和第三个岛屿的建造工作继续进行。一圈水下潜坝建成后，其高度被提升两倍。</p> <p>20. 2018年2月，建造过程中的第二个冬季，距离工程完工并面向公众开放还有7个月。</p> | <p>17. In June 2016, birds wandered in the first visible island with construction as background.</p> <p>18. The islands in September 2016</p> <p>19. In April 2017, after the winter break, the construction of the second and third islands resumed. An underwater dam was built and then raised twice of its height.</p> <p>20. In February 2018, the second winter break of the construction, there were 7 months before its completion and open to the public.</p> |
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bed. This makes many plants and animals difficult or even impossible to survive. There are other negative factors, such as hard land-water transitions, limited habitat diversity and an unnatural water level. To achieve a natural and healthy ecosystem, it is important that the Marker Wadden will become an integral part of the Markermeer. The measures are to realize the dynamic gradients in water depth and transparency, connectivity, and better development of land-water transitions. This will increase the diversity of habitats and species.

We regard birds as the most species-rich and most appealing group of this ecosystem. At the top of the food chains, they reflect life and quality in and under water. We see and choose birds as the most systemic group as the starting point. In the current phase, we focus primarily on fresh water primal marshland, clay, and nutrient-rich habitats with the associated bird species. For the bird paradise, we provide three important conditions: food supply, resting place, and reproduction opportunity (Fig. 9).

A large food supply starts with using nutrient-rich Holocene clay and silt. However, these nutrients are locked in the

system. This can be changed by ripening the soil. We accelerate the ripening process by dehydration and further by actively introducing reed development (Fig. 10, 11). Rest area is essential for the birds. The design of dams and island structures provide abundant sheltered and shallow water zones in different sizes. Finally, breeding is an essential aspect of a sustainable and permanently bird-populated Marker Wadden. Because of the isolated location, the “island effect” will play maximally here. Ground predators such as fox and mustelids will not be able to reach the islands. This means that many more species dare to breed in the reeds and rush vegetations, such as spoonbill and cormorant. The sandy dams also offer maximum nesting opportunities for ground breeders due to no ground predators. Besides, the design prevent disturbance from visitors through zoning of human activities around the harbor area.

### 3.4 Optimal Integration of Nature and Recreation

We stimulate Marker Wadden into a major tourist destination for nature and landscape lovers. Birds and marshlands dominate in



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this splendid isolated area. The harbor with its sheltered location and the reception area form the central point in the Marker Wadden. It is recognizable afar through the striking lookout tower on the top of the dunes. Walking routes and plank bridges provide access to the marshland area, connecting various types of viewing cabins and playful and educational facilities along the way.

The harbor is an attractive sailing destination with a little settlement and visitor center. First visitors come here for the bird paradise. But it is equally important that water sports enthusiasts also feel at home and experience the water sport value that the Marker Wadden has added to the Markermeer. In the horizontal landscape of Marker Wadden, the harbor and visitor center is located in the southwest orientated dune landscape. From afar you can see the masts of the moored sailing boats. Stone dams create sufficient shelter for the sailing boats (Fig. 12). Covered with reeds along its edges, the harbor can be used in all weather conditions.

Around the port, most important functions are concentrated. The birdwatching shelters and facilities provide different ways and points of view to observe birds in the marshland:

- 1) "Steltloper" (12 m): creating an all over bird view on the archipelago (Fig. 13-1, 13-2);
- 2) "Lepelaar" (3.5 m): overlooking the creeks and reeds (Fig. 14);
- 3) "Aalscholver" (2 m): eye level perspective on a major creek and sandy plate (Fig. 15);
- 4) "Duikeend" (0 m): viewing hut (frog perspective and window showing under water) (Fig. 16).

The design allows people to experience the Marker Wadden from different perspectives: low in the marshland close to the birds and spectacularly high above the marshland far from the birds. This gives totally different experiences and ways of looking: insight and overview. These facilities

are on side branches of the hiking trails and wooden paths. Here you can get close to the birds without disturbing them. The viewing facilities are situated at the edge of the reed near the shallow open water, and most birds can be seen. At the viewing points, we place poles in the water, on which cormorants can dry their wings in the sun.

#### 4 Conclusion

In March 2016, stage one of the first phase started. The five islands and the silt channel are expected to be completed and open to public by mid-2018 (Fig. 17 ~ 20). Three more islands would be added to this archipelago by January 2021. Natuurmonumenten emphasizes to build more archipelagos. In the long term vision, two major interventions are planned. A peninsula attached to Lelystad provides a water sports beach, space for kite flying and wind surfing, and Trintelzand, a 270-hectare sandy reinforcement strengthens the Houtribdijk and creates new nature (Fig. 21). The completion of the long term plan has not been decided yet.

The Marker Wadden finds a good balance between traditional wisdom and technology advance. On the one hand, with respecting its traditional planning process, the Marker Wadden project is created by an alliance of both public and private bodies sitting together and their opinions acknowledged. On the other hand, it boldly explores in both philosophy and technique. Marker Wadden is an international showcase for the Dutch hydraulic engineering industry. Where in large parts of the world the emphasis is mainly on protecting nature, Marker Wadden shows building new nature. This aim has been achieved by using innovative techniques (such as building with diluted Holocene material) and natural processes (such as self-weight consolidation and crusting by drying). Design, governance, and science have been well combined in this once abandoned ecological desert. Such

21. 马肯湖-瓦登海和里恩泰尔滩项目长期规划。在这一规划中,更多的岛屿会被增加到群岛的东边及东南方向。而新的里恩泰尔滩项目则能够通过营造水下沙环境来巩固豪垂布大坝(西北方向)。

21. Long term plan of Marker Wadden and Trintelzand. In this plan, more islands are added into the archipelago in the east and southeast. A new project Trintelzand will reinforce the Houtribdijk by creating the underwater sandy environment (northwest).



combination aiming a new nature has never been done before on this scale. Researchers study both the ecological restoration and risk in the governance of this design. The scientific knowledge and experience gained in this project would contribute to the future national and international cases. Marker Wadden will be of great importance in a time of climate change, especially meaningful for densely populated river deltas. Wetland design and construction can contribute to sustainable water management, improve local ecosystems, and provide greater resilience for river deltas in storms and floods. **LAF**

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