



Deep Learning assists detection of mussel reefs in Roskilde Fjord

Liu, Xinyu; Ness, Lydia; Melin, Michelle; Svendsen, Jon C.

Published in:
Habitat

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Liu, X., Ness, L., Melin, M., & Svendsen, J. C. (2023). Deep Learning assists detection of mussel reefs in Roskilde Fjord. *Habitat*, 26, 100-107. https://issuu.com/dzs-habitat/docs/habitat_26_fw_sps/100

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

habitat



#26

for en vild verden

Dansk Zoologisk Selskabs magasin



Tema: Havet



Deep Learning assists detection of mussel reefs in Roskilde Fjord

We combine underwater video recordings with deep learning techniques to assist the detection of potential blue mussel reefs in Roskilde Fjord.

By
Xinyu Liu, Lydia Ness, Michelle Melin, Jon C. Svendsen, DTU Aqua

Mussel reefs often filter the water for organic contents and provide various habitats for a range of species.”

PROTECTION OF BLUE MUSSEL REEFS, TERMED BIOGENIC REEFS, OFTEN REQUIRES DETECTING AND MAPPING THE REEFS

Blue mussel (*Mytilus edulis*, henceforth called mussel) is a species of bivalve and has a two-part hinged shell with a soft-bodied inside. Reefs consisting of mussels are listed as “biogenic reefs” in the Habitat Directive of the European Union (EU). Studies have indicated that mussel reefs may improve the water quality and protect shorelines (Commito et al. 2008, Nielsen et al. 2019, Heckwolf et al. 2020, Lefcheck et al. 2019). Additionally, mussel reefs may function as habitats for a range of invertebrates and fish (Koivisto & Wester bom 2010, Commito et al. 2018, Lefcheck et al. 2019, Schwartzbach et al. 2020). However, mussel reefs are among some of the most threatened marine habitats, largely due to climate change and prolonged human activities (Airolidi et al. 2008). To protect existing mussel reefs, it

is necessary to firstly detect mussel areas, and secondly map the mussel areas, to confirm that they form a mussel reef.

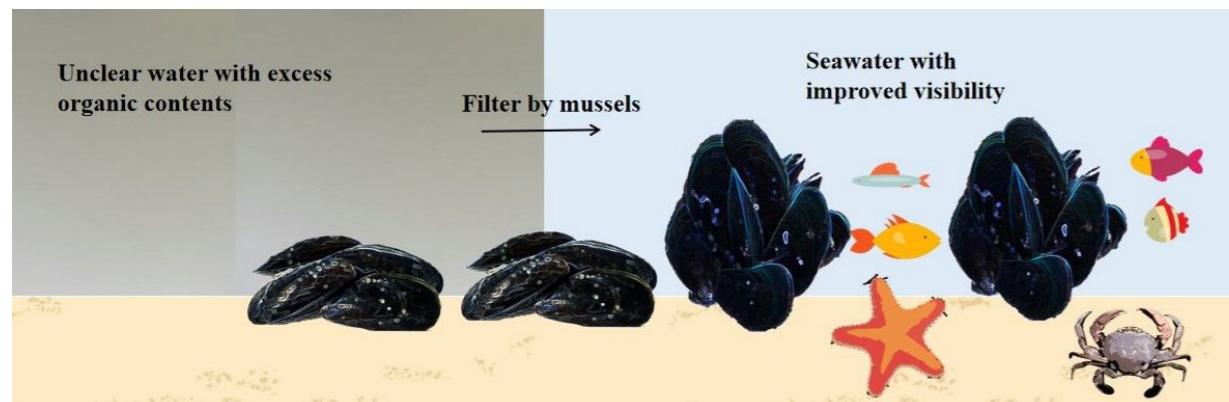
FINDING MUSSEL REEFS IN ROSKILDE FJORD

Roskilde Fjord extends about 40 km into the Sjælland landscape from the narrow outlet and is home to rich flora and fauna.

From February to April 2022, we used ROV (Remotely Operated Vehicle) techniques to film the seabed to locate and possibly map potential mussel reefs in Roskilde Fjord. The project benefited greatly from assistance by local volunteer fishermen. During the fieldwork, a total of 61 videos of the seabed were collected in the Roskilde Fjord.

The videos were used to start investigating if mussel reefs are present in the Roskilde Fjord, according to the blue mussel reef identification criteria (Dahl & Petersen, 2018). Identification criteria include the following:

Figure 1: Conceptual figure showing that mussel reefs often filter the water for organic contents and provide various habitats for a range of species. Picture: Xinyu Liu.



The seabed coverage by mussels is at least 30 %, and the area of the seabed with mussels covers at least 2500 m². Reef identification may be considered repetitive and time-consuming, and we, therefore, wondered if deep learning techniques may be used to improve efficiency.

ARTIFICIAL NEURAL NETWORK AND YOLO (YOU ONLY LOOK ONCE) ALGORITHM

In deep learning, artificial neural networks are usually trained to solve problems with algorithms. To automatically detect mussels from the available video, an artificial neural network and YOLO algorithm may be applied (Redmon et al. 2016).

The artificial neural network generates a probability to distinguish categories of images. For example, the input could be a picture of an animal which may be a wolf or a dog. When using the artificial neural network, it may calculate that the probabilities of the animal being a wolf or a dog are 30 % and 70 %, respectively. Therefore, the most likely result is a dog, and the network outputs that “The picture shows a dog.”

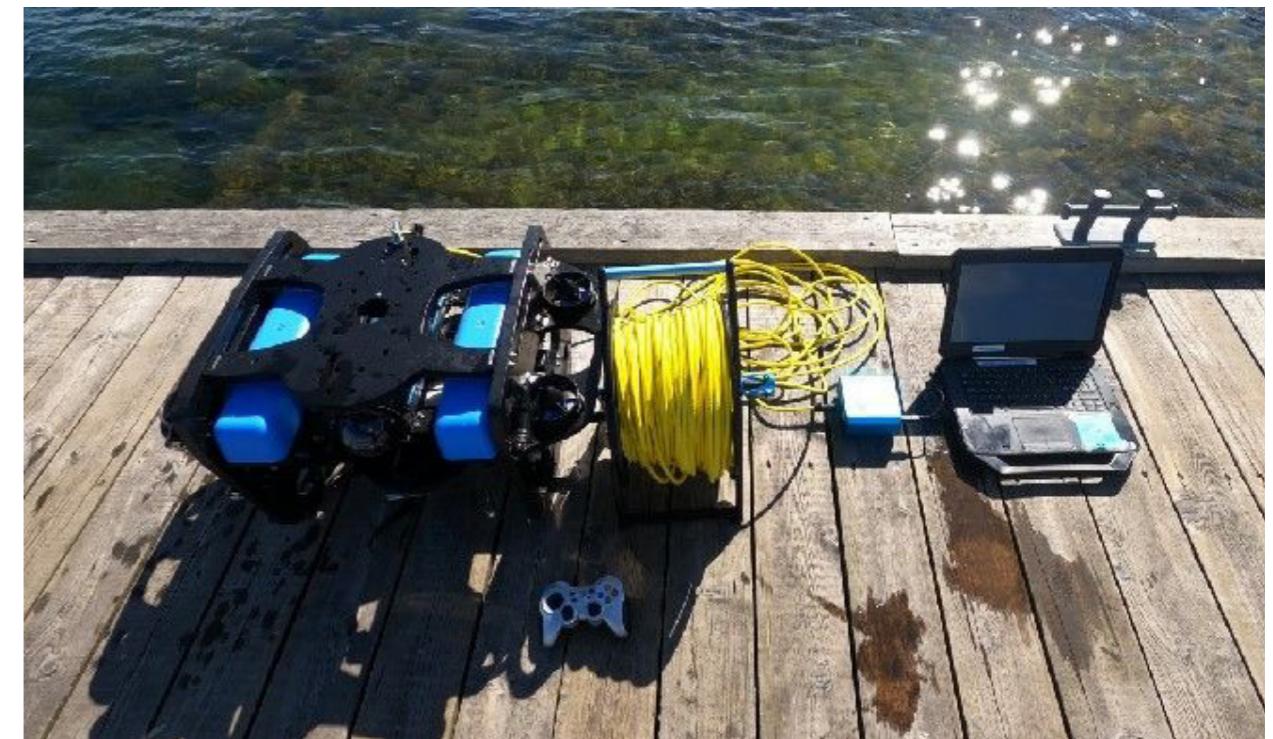
When there are multi-objects in a single picture, including for example mussels and star-



Figure 2: The location of Roskilde Fjord, situated in Northern Sjælland in Denmark. Picture: Xinyu Liu.

fishes, with the YOLO algorithm, the network partitions the 2D image into small squares and uses bounding box to cover some squares. Then the network assesses whether the squares in one bounding box contain part of a mussel or a starfish. Finally, it keeps the bounding box covering the object in the image. However, it is hard for the network to mark complete objects precisely. The reason is that the features of objects in some squares are not obvious for the network to identify, and the boundaries of objects may be complex curves which are difficult to divide by straight lines.

Figure 3: Picture of ROV (Remotely Operated Vehicle) used for filming the seabed in the Roskilde Fjord. Photo: Michelle Melin.



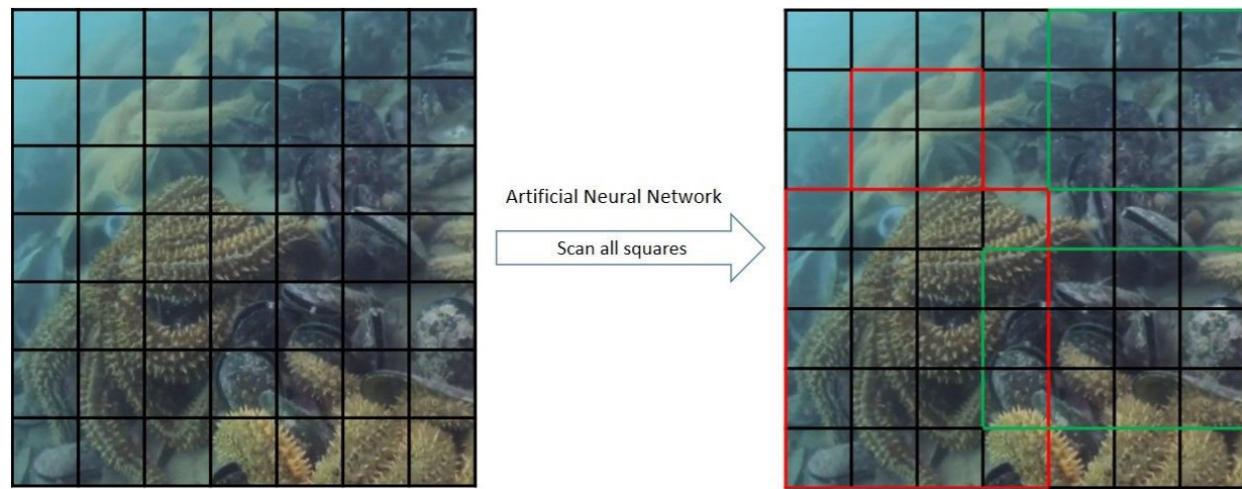


Figure 4: Multi objects classification by YOLO algorithm. Mussels and starfishes are distinguished as much as possible by green and red rectangles, respectively. Picture: Xinyu Liu.

”

We used ROV (Remotely Operated Vehicle) techniques to film the seabed to locate and possibly map potential mussel reefs in Roskilde Fjord.”

In the present study, YOLO is modified to not just recognize the mussels from an image containing various objects but also roughly estimate the seabed coverage by mussels in images. As shown in figure 5, potential mussel regions are labelled with yellow rectangles. The value in the yellow background is the probability that the objects in yellow rectangles are mussels. The white value is the seabed coverage by the mussels in this image.



MUSSEL DETECTION IN ROV VIDEOS

One ROV video is composed of many frames. One frame is one image. The network detected mussels and estimated the seabed coverage in the frames, one by one. Finally, the network outputs a graph showing the seabed coverage by mussels across time when the frame includes mussels. This is expected to support future mapping projects by uncovering the distribution of the mussels on the seabed according to the recorded frames.

Figure 6 shows an example output from one video. The graph illustrates the seabed coverage by mussels in each minute. It can be seen from Figure 6 that the mussels concentrate from minute 5 to minute 17 in the video, and the mean seabed coverage often exceeds 30 % mussel. The findings indicate that

Figure 5: The mussels are labelled with yellow rectangles in the picture. Mussels' coverage in the yellow rectangle is estimated to be approximately 92 % of the seabed. Picture: Xinyu Liu.

”
Although method improvements are warranted, we believe our method may enable faster mussel detection and possible identification of mussel reefs.”

during this particular recording period, the ROV may have been filming parts of a mussel reef. Our study explores a mussel reef identification method based on deep learning using numerous underwater videos. Currently, it remains challenging to precisely detect all mussels in a complex seabed setting. The network's accuracy is around 60 % which may be improved by future research. Nevertheless, the method is now providing estimated recording periods when mussel reefs may exist. Moreover, the method enables filtering of videos without mussels. Although method improvements are warranted, we believe our method may enable faster mussel detection and possible identification of mussel reefs.

ACKNOWLEDGEMENTS

The authors thank Kim L. Jørgensen and Jønn Poulsen from the association “Foreningen til Ophøjlpning af Fiskeriet i Roskilde Fjord”, and Leif Henriksen, Arthur Sørensen, Niels Winther and Jesper Simonsen from Gershøj Fiskerforening. This study is funded by the Danish Rod and Net Fish License Funds and the EU Interreg project MarGen.

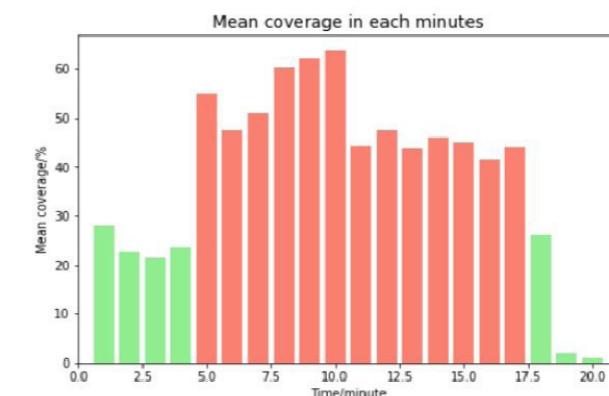


Figure 6: The output of an ROV video analyzed using deep learning. In the graph, the X-axis indicates minutes, and the Y-axis represents the mean mussel coverage on the recorded seabed. Each bar (green or red) represents a period of one minute, covering a total of approximately 2000 included frames from the ROV recordings. Picture: Xinyu Liu.



REFERENCES:

- Airoldi L, Balata D, Beck MW (2008). The gray zone: relationships between habitat loss and marine diversity and their applications in conservation. *Journal of Experimental Marine Biology and Ecology* 366: 8-15.
- Commito JA, Como S, Grupe BM, Dow WE (2008). Species diversity in the soft-bottom intertidal zone: biogenic structure, sediment, and macrofauna across mussel bed spatial scales. *Journal of Experimental Marine Biology and Ecology* 366: 70-81.
- Commito JA, Jones BR, Jones MA, Winders SE, Como S (2018). What happens after mussels die? Biogenic legacy effects on community structure and ecosystem processes. *Journal of Experimental Marine Biology and Ecology* 506: 30-41.
- Dahl, K., & Petersen, J. K. (2018). Definition af biogene rev: Miljøprojekt nr. 1992.
- Heckwolf MJ, Peterson A, Jänes H, Horne P, Künne J, Liversage K, Sajeva M, Reusch TB, Kotta J (2020). From ecosystems to socio-economic benefits: A systematic review of coastal ecosystem services in the Baltic Sea. *Science of the Total Environment*. 142565.
- Koivisto ME, Westerbom M (2010). Habitat structure and complexity as determinants of biodiversity in blue mussel beds on sublittoral rocky shores. *Marine Biology* 157: 1463-1474.
- Lefcheck JS, ..., Williams BL, Beck MW, Orth RJ(2019). Are coastal habitats important nurseries? A meta-analysis. *Conservation Letters* 12: e12645.
- Nielsen NRI, Skindhøj NL, Nielsen P, Svendsen JC (2019). Blåmuslingens evne som vandrenser, fødekilde og habitat: Kan gøre samfundet mere bæredygtigt. *Habitat #20*: 62-73.
- Redmon, J., Divvala, S., Girshick, R., & Farhadi, A. (2016). You only look once: Unified, real-time object detection. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 779-788).
- Schwartzbach A., Munk P., Sparholt H., Christoffersen M. (2020). Marine mussel beds as attractive habitats for juvenile European eel (*Anguilla anguill*); A study of bottom habitat and cavity size preferences. *Estuarine, Coastal and Shelf Science* 246: 107042.

SÅDAN BLIVER DU MEDLIEM

DANSK ZOOLOGISK SELSKAB

Er du ikke allerede medlem af Dansk Zoologisk Selskab, så er det meget let at blive det.

Og så koster det blot 100 kr om året i kontingent! Med et medlemskab støtter du aktivt op om foreningens arbejde for et stærkt dansk engagement i bevarelsen af vilde dyr og deres levesteder.



FAGMEDLEM ELLER STØTTEMEDLEM?

Du kan vælge mellem vores to typer medlemskab: fagmedlem eller støtte-medlem. Fagmedlem er dig, som har en baggrund eller viden inden for vilde dyr, biodiversitet og/eller naturbevarelse, hvor støttemedlem er dig, der blot ønsker at støtte op om vores arbejde.

Derudover har du valget mellem at betale et årligt kontigent på 100 kr for et almindelig kontigent eller 250 kr (eller valgfrit derover) for et PLUS kontigent. For studerende er kontigentet kun 50 kr.

Som medlem kan du være med til at forme foreningens arbejde. Du er altid velkommen til at deltage i vores møder, bidrage med kompetencer inden for fundraising, regnskab, IT eller hvad du nu er god til, komme med gode idéer til arrangementer og bistå i planlægningen heraf, og skrive indlæg og artikler til hjemmesiden, vores Facebook-gruppe og ikke mindst Habitat.

Send os en mail til info@dzs.dk, hvis du ønsker at deltage mere aktivt i vores arbejde. Vi hører meget gerne fra dig! Også hvis du har ris og ros.

Med et medlemskab vil du være den første til at modtage Habitat i din indbakke, når det udkommer (to gange årligt). Desuden bliver du inviteret til vores arrangementer til fordelagtige priser. Ikke mindst, så vil du som medlem bakke op om et arbejde, som vi i Dansk Zoologisk Selskab mener er helt essentielt - bevarelsen af en vild natur og dens dyr. Jo flere vi er, jo stærkere står vi også, når vi søger fonde om midler til vores projekter.

SÅDAN GØR DU

- 1) Gå ind på www.dzs.dk/medlem
- 2) Indbetal det årlige kontigent, vælg mellem MobilePay (19303) eller overførsel til vores konto Danske Bank (0260 - 3123241312)
- 3) Udfyld medlemsformularen med dine oplysninger (email, navn, adresse, medlemstype mm.)

Du vil snarest herefter modtage en velkomst-pakke med nogle af vores flotte gadgets

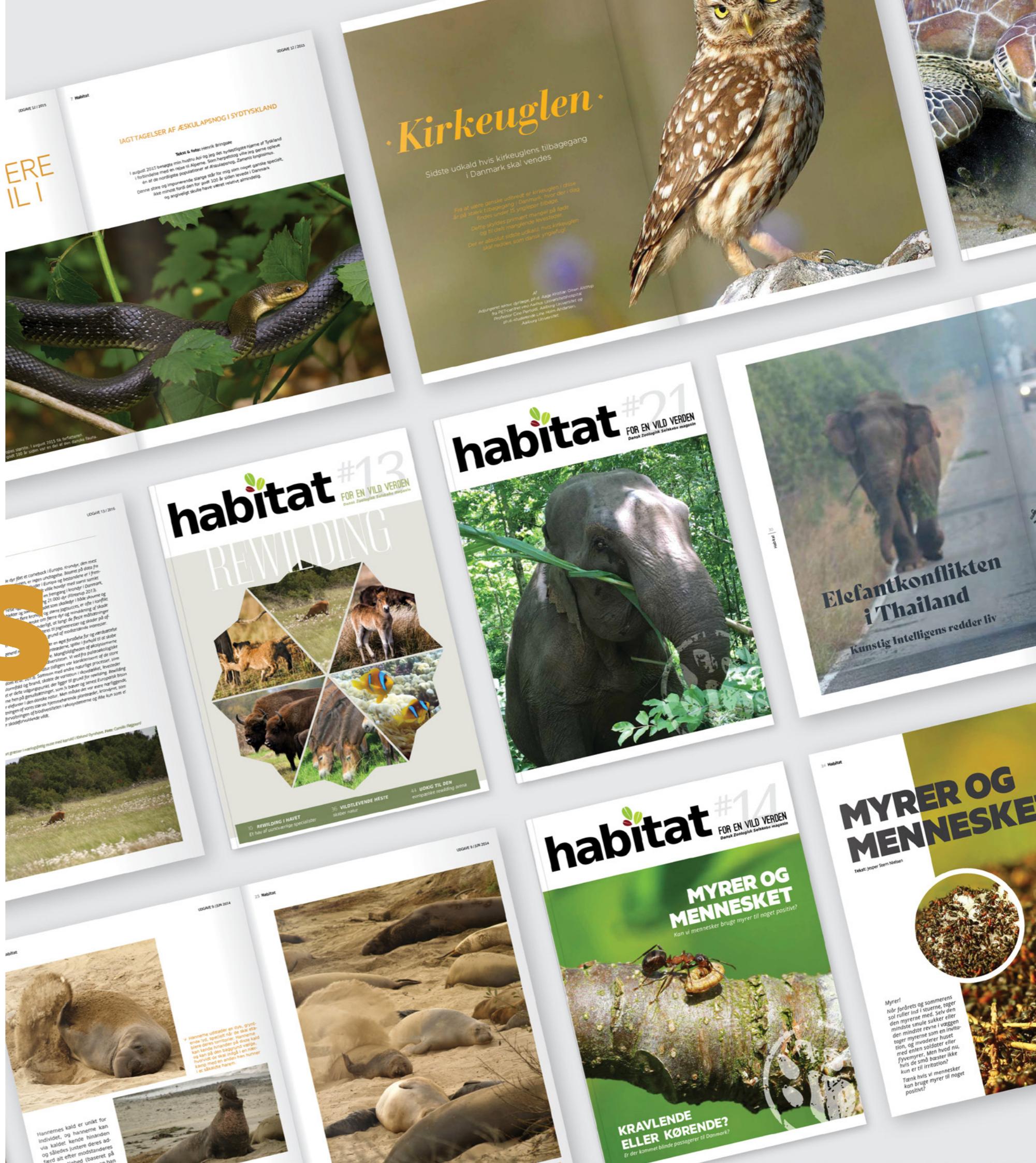
LÆS ELLER GENLÆS

Af Lotte Endsleff

Igennem alle de år, vi har udgivet Habitat, har vi skrevet om en lang række dyr og naturområder fra store dele af verden samt forskellige temaer. På vores hjemmeside **dzs.dk** finder du alle numrene af Habitat (<https://dzs.dk/category/habitat/>).

Her er en oversigt over artikler om hav-emner i tidligere numre af Habitat - i alt 57 artikler.

Fortsat god læselyst!





HABITAT #25 (DZS.DK/HABITAT-25/)

- s. 06 Strandede læderskildpadder i Danmark
- s. 62 Using trapezoid concrete reef elements to build artificial reefs



HABITAT #20 (DZS.DK/HABITAT-20/)

- s. 34 Ørreder med hedeslag i Roskilde Fjord
- s. 62 Blåmuslingens evne som vandrenser, fødekode og habitat
- s. 96 Nyttig viden om havskildpadder



HABITAT #24 (DZS.DK/HABITAT-24/)

- s. 06 3 arter af næbhvaler strandet i Danmark
- s. 32 Restoring marine landscape and its wildlife back to how H.C. Andersen knew it



HABITAT #19 (DZS.DK/HABITAT-19/)

- s. 40 Miljøfremmede stoffer truer tandhvalernes overlevelse



HABITAT #23 (DZS.DK/HABITAT-23/)

- s. 06 Et årti med strandede hvaler 2010-2020
- s. 20 Underwater plant that is more important and more threatened than coral reefs: eelgrass



HABITAT #17 (DZS.DK/HABITAT-17/)

- s. 07 Village based marine reserves in Fiji: A viable management tool for edible snails?
- s. 24 Knowledge for conservation of green turtles from citizen science efforts
- s. 52 Marine beskyttede områder - Filippinerne som eksempel



HABITAT #22 (DZS.DK/HABITAT-22/)

- s. 48 En oase i Limfjorden – et stenrevs evolution
- s. 58 The unique history of two recaptured brown trout in Roskilde Fjord
- s. 70 Camouflagens mester



HABITAT #16 (DZS.DK/HABITAT-16/)

- s. 06 Gamle biologiske samlingers betydning – et eksotisk, zoologisk eksempel (om Neptunbægeret)
- s. 20 Det pelagiske dyb hav – unikke og ekstreme selvlysende tilpasninger i verdens største habitat
- s. 30 Muligheder ved ændret mindstemål og indførelse af vinduesmål for pighvarre
- s. 38 Livet i det kolde mørke (om ishavet)
- s. 50 Dokumentation af marin biodiversitet i tropiske Cambodia
- s. 62 Dykning ud for Hurghada har det hele: skibsvrag fra 2. Verdenskrig, smukke revdyk og fantastisk dyreliv



HABITAT #21 (DZS.DK/HABITAT-21/)

- s. 06 Havlampretten – en underlig fisk



HABITAT #15 (DZS.DK/HABITAT-15/)

- s. 06 Sortmundet kutling – spredet sig på bekostning af hjemmehørende danske arter
- s. 20 Havskildpadder – alle kan bidrage til viden
- s. 36 Havet – kort om det store blå



HABITAT #10 (DZS.DK/HABITAT-10/)

- s. 58 Hajen og mennesket, mennesket eller hajen



HABITAT #14 (DZS.DK/HABITAT-14/)

- s. 32 Snæblens tilbagegang i Anthropocæn – hvordan redder vi danmarks eneste endemiske vertebrat?



HABITAT #9 (DZS.DK/HABITAT-9/)

- s. 08 Conservation med succes – søelefant
- s. 23 Narhval – Enhjørningens hemmelighed
- s. 68 Skifter fisk farve?



HABITAT #13 (DZS.DK/HABITAT-13/)

- s. 10 Et hav af uundværlige specialister



HABITAT #8 (DZS.DK/HABITAT-8/)

- s. 19 The value of nature – coral reefs in the Red Sea
- s. 26 Flydende affaldsøer i verdenshavene
- s. 32 Gråsælen – en solstrålehistorie i en kold tid
- s. 40 Phi Phi – Paradis i frit fald
- s. 50 Mangfoldigt liv – Monterey Bay, Californien



HABITAT #12 (DZS.DK/HABITAT-12/)

- s. 24 Arbejdet med truede havskildpadder i Costa Rica
- s. 30 Spøgelseskoraller



HABITAT #7 (DZS.DK/HABITAT-7/)

- s. 32 Symbiosis – a fundamental element in marine life on coral reefs
- s. 44 Forældreløs rethvalunge får lov til at die hos fremmede hunner
- s. 46 Hvalros



HABITAT #11 (DZS.DK/HABITAT-11/)

- s. 20 Tilbage fra de uddøde – Verdens mest sjældne havfugl i fremgang
- s. 24 Fra havfrue til truet dyreart (om søkøer)
- s. 30 Lungefisken og andre luftåndende fisk
- s. 34 Dansk ekspedition undersøger verdenshavene for plastik



HABITAT #6 (DZS.DK/HABITAT-6/)

- s. 38 Sipadan – skildpaddernes hovedstad



HABITAT #5 (DZS.DK/HABITAT-5/)

- s. 05 Wings over icy waters
- Seabirds in the arctic
- s. 11 Big Brother i hvalernes verden -
narhvalernes vandring i Østgrønland
- s. 48 Balancegangen mellem turisme og
naturbevarelse - om tropiske havgræs-
områder, havskildpadder og søkører



HABITAT #4 (DZS.DK/HABITAT-4/)

- s. 29 Hajen og mennesket, mennesket eller hajen
- s. 35 Gigantene under overfladen
- s. 58 Havets planter - forudsætningen for
livet i havet



HABITAT #2 (DZS.DK/HABITAT-2/)

- s. 32 To sælarter fredet i Grønland
- s. 34 Hajen slår til igen
- s. 38 Goplerne kommer...! - om vandmænd,
dræbergopler og andre gele-dyr



HABITAT #1 (DZS.DK/HABITAT-1/)

- s. 12 Rødehavets unikke dyreliv

The collage includes several pages from the Habitat magazine series:

- #0:** A page titled "ACTION MED SUCCES ELEFANT" (Action with success Elephant) showing an elephant's trunk.
- #1:** A page titled "HØSTEN" (Autumn) showing a group of bison.
- #2:** A page titled "ERE VILDT" (Wildlife) showing a landscape with a cow.
- #3:** A page titled "VILDT" (Wild) showing a landscape with a cow.
- #4:** A page titled "REWILDING" showing a collage of animals including a bison, a horse, and a clownfish.
- #5:** A page titled "KÆMPEN VI IKKE LÆNGERE HAR PLADS TIL I DANMARK" (The giant we no longer have room for in Denmark) showing a snake.
- #6:** A page titled "VAGTTAGELSER AF JÆSKU" (Surveillance of Jæsku) showing a close-up of a snake.
- #7:** A page titled "TAKET & FÆRER VÆRK BRINGES" (The roof and the workbench are brought) showing a snake.
- #8:** A page titled "REGNSKOVENS RIGDOMME FRA ORANGUTANGER TIL OLIEPALMER" (The richness of the rainforest from orangutans to oil palms) showing an orangutan.
- #9:** A page titled "TOPPREDATORER" (Top predators) showing a gorilla.
- #10:** A page titled "REVIVING" showing a landscape with a cow.
- #11:** A page titled "VILDTLEVNE HESTE" (Wildliving horse) showing a horse.
- #12:** A page titled "VILDT" (Wild) showing a landscape with a cow.
- #13:** A page titled "VILDT" (Wild) showing a landscape with a cow.

 habitat