

COMMON MERGANSERS *MERGUS MERGANSE* USE WINGS TO PURSUE A FISH UNDERWATER

ANTHONY B. LAPSANSKY¹ & ROBERT H. ARMSTRONG²

¹Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada (lapsansky@zoology.ubc.ca)

²Nature Alaska, Juneau, Alaska, USA

Received 11 January 2022, accepted 15 March 2022

ABSTRACT

LAPSANSKY, A.B. & ARMSTRONG, R.H. 2022. Common Mergansers *Mergus merganser* use wings to pursue a fish underwater. *Marine Ornithology* 50: 111–114.

Common Mergansers *Mergus merganser* dive into lakes, rivers, and coastal waters to feed on fish and other aquatic prey. This species and others in the genus *Mergus* are traditionally classified as foot-propelled divers. When submerged, mergansers are expected to swim by kicking their feet, holding their wings close to their bodies. Here, we report, with video evidence, an event in which four mergansers used their wings underwater to chase down and capture a large fish. Documentation of wing use by this classically defined “foot-propelled diver” illustrates the gaps in our understanding of avian diving physiology, hydrodynamics, and behavior.

Key words: diving, foot-propelled, *Mergus merganser*, wing-propelled, swimming

This paper is the first to report wing-propelled submerged swimming in Common Mergansers *Mergus merganser* under natural conditions (Fig. 1). Our observations occurred at the outlet of the Peterson Creek Salt Chuck in Juneau, Alaska, USA, on 26 October 2016. The video was taken using a remote camera setup designed by one of us (RHA) and consisting of a GoPro Hero 3+ Black (GoPro, Inc., San Mateo, California, USA) anchored by a dive weight and powered by a rechargeable lithium-ion battery (Digipower, San Francisco, California, USA). The camera was anchored on the open beach at low tide and recorded continuously for approximately nine hours as the camera submerged with the rising tide. The complete setup was retrieved the following day. In the recovered video (see Video 1 in Supplemental Material, linked below), a fish appears from the left, followed by seven Common Mergansers. Four birds use their wings in addition to their feet for propulsion, while the others give chase using their feet alone, in the manner typically ascribed to the genus *Mergus*.

Mergansers, along with grebes, coots, loons, cormorants, anhingas, and a portion of other genera in the Anseriformes (e.g., *Aythya*, *Netta*, and *Dendrocygna*), are traditionally considered exclusive foot-propelled divers, meaning that they use only their feet for submerged swimming. Exclusive wing-propelled divers include alcids, penguins, and dippers. Eiders *Somateria* spp., certain scoters *Melanitta* spp., Long-tailed Ducks *Clangula hyemalis*, steamer ducks *Tachyeres* spp., and divers in the Procellariiformes (except *Pelecanoides*) are thought to use both their feet and wings to accomplish steady, submerged swimming (Ashmole 1971, Lovvorn 1991, Wilson *et al.* 1992). Still, the aquatic habits of birds continue to be an active topic of discussion.

Uncertainty among researchers derives from the fact that submerged animals are difficult to observe. As a result, most early records of aquatic locomotor behavior are of injured or cornered animals (discussed by Townsend 1924) or of animals in small tanks (discussed by Forbush 1922), which may behave abnormally. As

well, species that typically rely on only one pair of appendages for steady-state locomotion may use the other pair to change direction (Spring 1971, Hui 1985, Clifton & Biewener 2018). In this case, however, mergansers used both their feet and wings to swim under natural conditions and without substantial changes in direction (prior to prey capture, at least).

This observation highlights gaps in our current understanding of avian diving physiology and hydrodynamics. The predominant explanation for the diverse kinematic strategies of diving birds infers that wing propulsion is primarily lift-based and that foot propulsion is primarily drag-based (Vogel 1994, Johansson & Norberg 2000). Lift-based locomotion is more efficient than drag-based locomotion from both theoretical and empirical perspectives (Jackson *et al.* 1992, Fish 1996). However, lift requires circulation around a foil and, therefore, is only effective for hydrodynamic propulsion at relatively high speeds. At low speeds, drag can generate greater thrust than can lift (Vogel 1994, Walker & Westneat 2000) and can therefore aid animals to accelerate from rest, perform powerful maneuvers, and hold station under external forces (Godoy-Diana & Thiria 2018, Chin & Lentink 2019). Consistent with this view, sea ducks frequently employ their wings during long descents, and alcids frequently employ their feet while hovering to feed on benthic food sources. However, recent studies have revealed lift-based thrust in diverse foot-propelled birds (Johansson & Norberg 2000, Johansson & Norberg 2001, Johansson & Norberg 2003, Ribak *et al.* 2004, Clifton & Biewener 2018) and the role of wing-drag in bird flight (Chin & Lentink 2019). In addition, whether a bird uses its wings, feet, or wings + feet may be influenced by the prevalence of submerged vegetation (Storer 1960, Richman & Lovvorn 2008), the costs of unsteadiness (Heath *et al.* 2006), and/or the contribution of maintaining thermal balance to overall dive costs (Richman & Lovvorn 2008).

In any case, documentation of wing-propelled submerged swimming in Common Mergansers indicates that this species—and perhaps



Fig. 1. Common Mergansers *Mergus merganser* pursue a large fish underwater, with multiple individuals using their wings for propulsion. Video recorded by Robert H. Armstrong on 26 October 2016, Juneau, Alaska, USA.

other foot-propelled divers—are capable of using their wings for hydrodynamic propulsion. If widespread, this behavior would further complicate the already challenging task of modeling foraging costs for foot-propelled divers (e.g., Lovvorn & Brooks 2021), as it would compel researchers to also estimate the costs of submerged swimming with the wings and the rate of wing use. Heath *et al.* (2006) report that Common Eiders *Somateria mollissima* time the power phase of their feet to occur while the wings transition from upstroke to downstroke (i.e., while the wings are providing little thrust). This is thought to help maintain a consistent speed and reduce the cost of swimming. Similarly, Richman & Lovvorn (2008) found that White-winged Scoters *Melanitta fusca* descend faster and more efficiently when swimming with their wings + feet than with their feet alone. If foot-propelled divers can and will

use their wings underwater, as we have shown here, and if wing propulsion increases dive speed and efficiency, it is unclear why wing use is not observed more frequently.

Given the context of our observation (prey pursuit), we hypothesized that Common Mergansers used their wings to increase their swimming speed. To test this idea, we estimated the velocity of four individual mergansers in the video, two swimming with wings + feet and two with feet alone, as they passed approximately perpendicular to the camera view while chasing fish. We digitized the tip of the beak and tail for each bird in MATLAB (MathWorks, Natick, Massachusetts, USA) using the DLTdv8 toolbox (Hedrick 2008) and calculated velocity by converting the pixel displacement between each time step to units of body length using a custom

script. All materials necessary to replicate these analyses are included in Supplemental Material. Mean velocities of birds swimming by wings + feet were 4.5 and 4.1 body lengths·s⁻¹ versus 3.9 and 3.3 body lengths·s⁻¹ for birds swimming with their feet alone. Thus, assuming these animals have similar body lengths, the use of the wings appears to confer a modest speed benefit that could be important to outcompete conspecifics for limited resources (in this case, a large fish).

The wingbeat frequencies exhibited by the four wings + feet-propelled individuals ($n = 22$ total wingbeats) were substantially lower than would be expected during aerial flight (mean: 4.6 Hz, range: 4.4–4.9 Hz versus ~8 Hz in flight), consistent with the kinematic patterns in alcids (Kikuchi *et al.* 2015, Lapsansky *et al.* 2020). However, unlike eiders, mergansers did not seem to coordinate their stroke patterns to maximize hydrodynamic efficiency (Heath *et al.* 2006). Instead, the power phases of the wings and feet in these mergansers appear to have occurred simultaneously.

Assuming a body length of 0.6 m (Pearce *et al.* 2020), our analysis indicated that these Common Mergansers swam at 2.0–2.7 m·s⁻¹. This is fast relative to the sustained swim speeds of similarly sized wing-propelled divers (1.3–1.9 m·s⁻¹) (Watanuki *et al.* 2006, Heath & Gilchrist 2010), but it is comparable to the maximum speeds measured for the Common Murre *Uria aalge* (2.6 m·s⁻¹, Swennen & Duiven 1991) and less than the burst speeds of the Great Cormorant *Phalacrocorax carbo* (4 m·s⁻¹, Ropert-Coudert *et al.* 2006). The wingbeat frequencies of the mergansers that we observed were approximately double of those expected for similarly sized wing-propelled divers (Heath & Gilchrist 2010, Kikuchi *et al.* 2015, Lapsansky *et al.* 2020). Together with the context of our observation, these data suggest that we observed animals engaged in a burst of high-speed swimming, potentially explaining their inefficient stroke timing.

Videos of diving birds underwater behaving naturally are rare. Hopefully, new technologies, including improvements to remote and animal-borne cameras, will help elucidate the behavior of these animals. In the meantime, it may be illustrative to review accelerometry data from foot-propelled species to search for similar bouts of wing-propelled submerged swimming, especially surrounding prey capture.

ACKNOWLEDGEMENTS

We thank Gus van Vliet for helping with species identification, as well as the reviewers, whose suggested edits greatly improved our paper.

SUPPLEMENTARY MATERIAL

https://github.com/alapsansky/Lapsansky_Armstrong_2022

REFERENCES

- ASHMOLE, N.P. 1971. Sea Bird Ecology and the Marine Environment. In: FARNER, D.S. & KING, J.R. (Eds.) *Avian Biology*. New York, USA: Academic Press.
- CHIN, D.D. & LENTINK, D. 2019. Birds repurpose the role of drag and lift to take off and land. *Nature Communications* 10: 5354. doi:10.1038/s41467-019-13347-3
- CLIFTON, G.T. & BIEWENER, A.A. 2018. Foot-propelled swimming kinematics and turning strategies in Common Loons. *Journal of Experimental Biology* 221: jeb168831. doi:10.1242/jeb.168831
- FISH, F.E. 1996. Transitions from drag-based to lift-based propulsion in mammalian swimming. *American Zoologist* 36: 628–641. doi:10.1093/icb/36.6.628
- FORBUSH, E.H. 1922. *Some Under-water Activities of Certain Waterfowl*. Department of Agriculture Departmental Bulletin No. 8. Boston, USA: Division of Information, Commonwealth of Massachusetts.
- GODOY-DIANA, R. & THIRIA, B. 2018. On the diverse roles of fluid dynamic drag in animal swimming and flying. *Journal of the Royal Society Interface* 15: 20170715. doi:10.1098/rsif.2017.0715
- HEATH, J.P. & GILCHRIST, H.G. 2010. When foraging becomes unprofitable: energetics of diving in tidal currents by Common Eiders wintering in the Arctic. *Marine Ecology Progress Series* 403: 279–290. doi:10.3354/meps08482
- HEATH, J.P., GILCHRIST, H.G. & YDENBERG, R.C. 2006. Regulation of stroke pattern and swim speed across a range of current velocities: diving by Common Eiders wintering in polynyas in the Canadian Arctic. *Journal of Experimental Biology* 209: 3974–3983. doi:10.1242/jeb.02482
- HEDRICK, T.L. 2008. Software techniques for two- and three-dimensional kinematic measurements of biological and biomimetic systems. *Bioinspiration & Biomimetics* 3: 034001. doi:10.1088/1748-3182/3/3/034001
- HUI, C.A. 1985. Maneuverability of the Humboldt Penguin (*Spheniscus humboldti*) during swimming. *Canadian Journal of Zoology* 63: 2165–2167. doi:10.1139/z85-318
- JACKSON, P.S., LOCKE, N. & BROWN, P. 1992. *The Hydrodynamics of Paddle Propulsion*. 11th Australasian Fluid Mechanics Conference. Hobart, Australia: University of Tasmania.
- JOHANSSON, L.C. & NORBERG, R.Å. 2003. Delta-wing function of webbed feet gives hydrodynamic lift for swimming propulsion in birds. *Nature* 424: 65–68. doi:10.1038/nature01695
- JOHANSSON, L.C. & NORBERG, U.M.L. 2000. Asymmetric toes aid underwater swimming. *Nature* 407: 582–583. doi:10.1038/35036689
- JOHANSSON, L.C. & NORBERG, U.M.L. 2001. Lift-based paddling in diving grebe. *Journal of Experimental Biology* 204: 1687–1696. doi:10.1242/jeb.204.10.1687
- KIKUCHI, D.M., WATANUKI, Y., SATO, N., HOSHINA, K., TAKAHASHI, A. & WATANABE, Y.Y. 2015. Strouhal number for flying and swimming in Rhinoceros Auklets *Cerorhinca monocerata*. *Journal of Avian Biology* 46: 406–411. doi:10.1111/jav.00642
- LAPSANSKY, A.B., ZATZ, D. & TOBALSKE, B.W. 2020. Alcids ‘fly’ at efficient Strouhal numbers in both air and water but vary stroke velocity and angle. *eLife* 9: e55774. doi:10.7554/eLife.55774
- LOVVORN, J.R. 1991. Mechanics of Underwater Swimming in Foot-Propelled Diving Birds. *Acta XX Congressus Internationalis Ornithologici* III: 1868–1874.
- LOVVORN, J.R. & BROOKS, M.L. 2021. Feeding on epibenthic zooplankton by Long-tailed Ducks: patch structure, profitability, and food web implications. *Ecosphere* 12: e03780. doi:10.1002/ecs2.3780
- PEARCE, J., MALLORY, M.L. & METZ, K. 2020. Common Merganser (*Mergus merganser*), version 1.0. In: BILLERMAN, S.M. (Ed.) *Birds of the World*. Ithaca, USA: Cornell Lab of Ornithology. doi:10.2173/bow.commer.01

- RIBAK, G., WEIHS, D. & ARAD, Z. 2004. How do cormorants counter buoyancy during submerged swimming? *Journal of Experimental Biology* 207: 2101–2114. doi:10.1242/jeb.00997
- RICHMAN, S.E. & LOVVORN, J.R. 2008. Costs of diving by wing and foot propulsion in a sea duck, the White-winged Scoter. *Journal of Comparative Physiology B* 178: 321–332. doi:10.1007/s00360-007-0225-9
- ROPERT-COUDERT, Y., GRÉMILLET, D. & KATO, A. 2006. Swim speeds of free-ranging Great Cormorants. *Marine Biology* 149: 415–422. doi:10.1007/s00227-005-0242-8
- SPRING, L. 1971. A comparison of functional and morphological adaptations in the Common Murre (*Uria aalge*) and Thick-Billed Murre (*Uria lomvia*). *The Condor* 73: 1–27. doi:10.2307/1366120
- STORER, R.W. 1960. Evolution in the diving birds. In: BERGMAN, G., DONNER, K.O. & HAARTMAN, L.V. (Eds.) *Proceedings of the XII International Ornithological Congress*. Helsinki, Finland: Tilgmannin Kirjapaino.
- SWENNEN, C. & DUIVEN, P. 1991. Diving speed and food-size selection in Common Guillemots, *Uria aalge*. *Netherlands Journal of Sea Research* 27: 191–196. doi:10.1016/0077-7579(91)90012-P
- TOWNSEND, C.W. 1924. Diving of grebes and loons. *The Auk* 41: 29–41. doi:10.2307/4074084
- VOGEL, S. 1994. *Life in Moving Fluids: The Physical Biology of Flow, 2nd Edition*. Princeton, USA: Princeton University Press.
- WALKER, J.A. & WESTNEAT, M.W. 2000. Mechanical performance of aquatic rowing and flying. *Proceedings of the Royal Society B* 267: 1875–1881. doi:10.1098/rspb.2000.1224
- WATANUKI, Y., WANLESS, S., HARRIS, M. ET AL. 2006. Swim speeds and stroke patterns in wing-propelled divers: a comparison among alcids and a penguin. *Journal of Experimental Biology* 209: 1217–1230. doi:10.1242/jeb.02128
- WILSON, R.P., WILSON, M.-P. & NOLDEKE, E.C. 1992. Pre-dive leaps in diving birds: Why do kickers sometime jump? *Marine Ornithology* 20: 7–16.
-