A HANDHELD RANGEFINDER FOR SEABIRD SURVEYS IN CONFINED CHANNELS

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SUMMARY

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To determine strip boundaries for ship-based surveys, seabird biologists commonly use the handheld rangefinder developed by Heinemann (1981). However, this tool's reliance upon the horizon as a plane of reference limits its use in confined channels or similarly enclosed areas. We have developed a rangefinder that uses a level, bubble-sight hole combination to establish a horizontal plane at the observer's eye level, from which range lines can be measured on the tool. Here we present its design and best practices to minimize bias and variance. Sensitivity analysis demonstrated that, of all variables tested, error in holding angle contributes most to error in strip width determination, followed in distant second by error in arm length. The performance of this rangefinder will be limited by the combination of platform height and target strip width. Our design, simulations and trials of the rangefinder allow us to predict error in strip width (e.g. coefficient of variation of 0.22 is expected for target strip width of 150 m from a platform height of 10 m), which can then be incorporated into strip-transect analyses to produce more transparent results. We propose the concept of a "zone of uncertainty" around target strip widths for propagating rangefinder performance metrics into the overall variance of a density estimate. For best performance, we recommend the use of 3D printing in rangefinder construction, extreme care in marking range lines on the tool, and field training and calibration sessions before use during formal surveys.

Key words: rangefinder, Heinemann, Bangarang, coastal seabird surveys, strip-transect sampling, sensitivity analysis

INTRODUCTION

The accuracy of density estimates from strip-transect surveys hinges upon correct field determination of the strip width (Buckland *et al.* 2001). Otherwise, biases and random error may go unnoticed in reported density and its uncertainty. To guard against this, Heinemann (1981) developed a handheld rangefinder that used the horizon as a reference point. He used platform height and observer arm length to measure lines on the tool that indicated survey strip boundaries when it was held against the horizon. A second version allowed the observer to measure the distance to individual seabirds. His tool is intuitive, simple to make and easy to use in the field. In the decades since Heinemann's publication, his design has become a staple of seabird fieldwork (Tasker *et al*. 1984, Spear *et al*. 1995, Spear *et al*. 2004, Ballance 2010, and many others; a Google Scholar search in March 2015 reported 125 citing publications). To our knowledge, no modification or improvement to Heinemann's design has been published.

The Heinemann rangefinder works well in pelagic surveys offshore, but its need for a horizon limits its usefulness in coastal areas, especially those confined to channels (e.g. rivers, fjords and other estuaries), or distant fog. To determine strip width for a survey during such conditions, we developed a rangefinder that instead establishes a *horizontal* as the reference for its range lines. Here we present this new design, detail its appropriate use and analyze the sensitivity of its design components to overall performance in terms of both bias and precision.

METHODS

Design

Like the Heinemann rangefinder, ours is held at arm's length in front of the observer, positioned relative to one's eyes according to a reference point (in our case, a horizontal plane). Once in place, a line on the rangefinder indicates where the survey strip boundary would appear on the water from the observer's point of view. Each observer's rangefinder is customized to the research platform's height above water and to his or her unique combination of height and arm length.

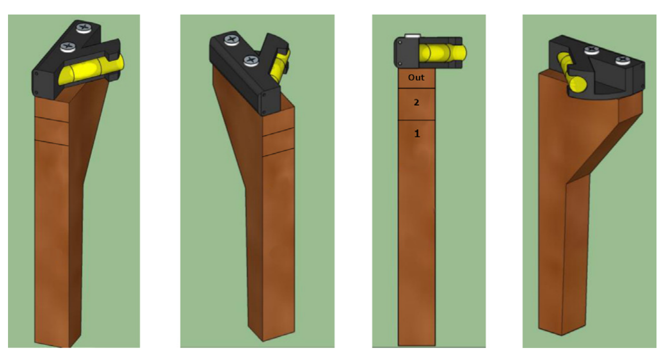

Fig. 1. The design of this study's handheld rangefinder, here with range lines for a bifurcated strip-width survey scenario. The black piece on top of the wooden handle is the 3D printed crown.

In our design, named the *Bangarang* rangefinder after the survey ship on which it was first used, the horizontal is found using a combination of a bubble level and sight tunnel built into the tool's crown, a precision piece crafted using 3D printing (Fig. 1), that can be mounted to any reasonably straight wooden handle. The design for this printed crown uses standard bubble levels readily available from retail stores. The level is horizontally rotated 30°, which allows the observer to see the bubble when the tool is held in front. We printed these crown pieces locally with a 3D printer at a cost of US$10 per unit (printer file provided in Appendix 1, available on the website). The bubble level indicates when the rangefinder is held vertically. Light is visible through the sight when the eye and the sight are coplanar. Both conditions must be met in order for the rangefinder to function — it will not function correctly if the rangefinder is held vertically but not at the same level as the eye, or if light is visible through the sight but the eye and the rangefinder together are not held at the correct angle. When both conditions are met, a truly horizontal plane is thereby established between the observer's eye and the sight. Some distance below this reference, a horizontal line can then be drawn on the tool that demarcates where the strip boundary falls on the water from the observer's perspective. Fig. 2 demonstrates a dual-strip scenario of 75 m and 150 m, in which everything seen below the bottom line is within Zone 1 (0–75 m), everything between the two lines is within Zone 2 (75–150 m), and everything seen above and beyond the top line is "Out." The placement of the drawn range line is observer- and platform-specific, calculated with Eq. 1, below.

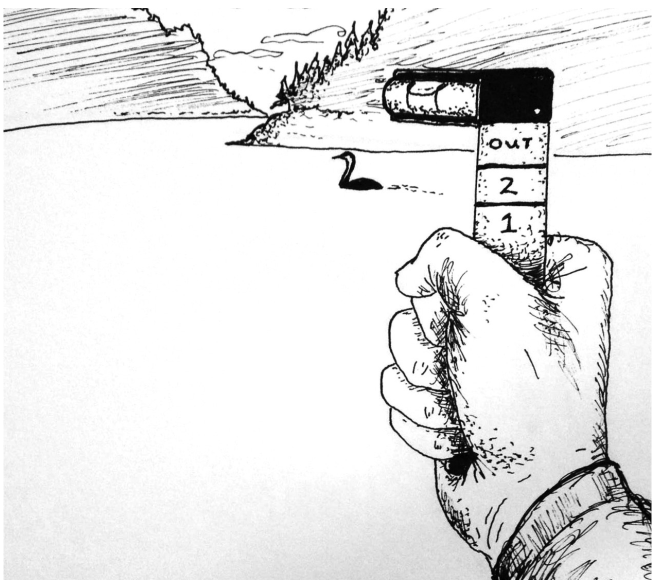

Fig. 2. A first-person view of a western grebe (*Aechmophorus occidentalis*) occurring within zone 2, between 75 m and 150 m. See text for explanation.

Rangefinder equation

The simple trigonometry behind this rangefinder design is demonstrated in Fig. 3. The distance, r, from the rangefinder's sight to a drawn range line can be calculated as follows.

$$r = \frac{d}{D}(h + b) \tag{1}$$

where

r = distance from sight hole down to range mark on rangefinder,
d = distance from observer's eyes to properly held rangefinder,
h = height of observer's eyes above the survey platform,
b = height of survey platform above water, and
D = target strip width.

Distance variables must be in the same units. For each observer, only two measurements are needed: standing eye height and arm length (distance from the near edge of the rangefinder to the back of the eye with shoulders square).

Sources of error

A rangefinder works when it can provide an observer with a sufficiently accurate reference to target strip-width, and it must do so quickly and consistently throughout a survey. To determine

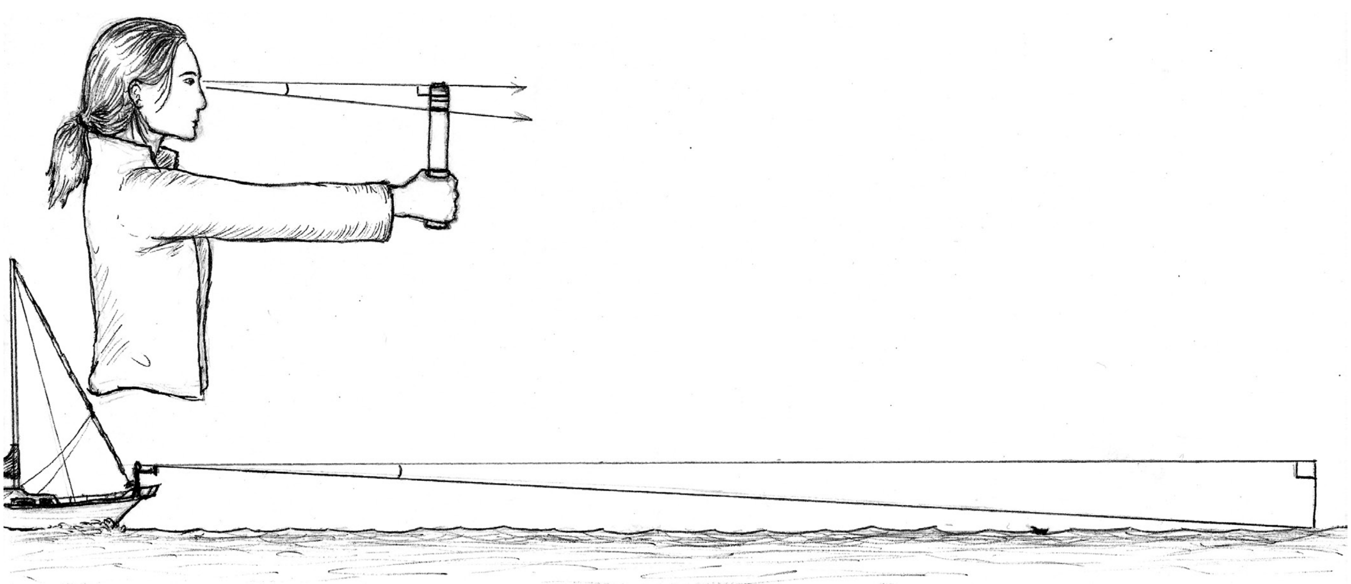

Fig. 3. The triangles involved in the design of the *Bangarang* rangefinder.

the apparent strip width provided by a rangefinder, Eq. 1 must be re-arranged as follows:

$$D = \frac{d\,(h + b)}{r}\,. \tag{2}$$

From this equation, we can intuit how errors in variable measurements can yield errors in strip width determination (Table 1). Systematic error (bias) is introduced by measurement errors for the variables on the right side of Eq. 2, as well as by consistently incorrect use. Random error (low precision) can be introduced by inconsistent use (e.g. bending knees, inconsistent shoulder extension when holding out the rangefinder, incomplete locking of elbow, etc.) and adverse field conditions.

Holding the rangefinder's sighting hole-bubble level complex at an angle from the true horizontal (θ, in degrees from 0) can also introduce error. Non-zero θ can result from poor design (e.g. the central axis of the sighting hole is not formed exactly parallel to that of the bubble level, leading to systematic error) and poor use (systematic and/or random error). Design problems are eliminated by the 3D-printed sight-bubble crown design. User error alters the position of the drawn range line in relation to the horizontal plane at the observer's eyes, causing range line error (ε). In this paper, a negative ε (down-tilted rangefinder) leads to underestimation of strip width, while a positive ε (up-tilt) leads to overestimation. The error is calculated as follows:

$$D = \frac{d\,(h + b)}{r - \varepsilon}\,. \tag{3}$$

Users can introduce θ in two horizontal axes by holding the tool at a slight offset while (1) light is still visible through the sight (θ_s), (2) the bubble appears level but in fact is not (θ_b), and/or (3) the user thinks the tool is held vertically but in fact is rotated slightly to the left or right (θ_r).

Rotational error confounds in/out calls because apparent r will be shorter on one side of the tool, and longer on the other. Note that the influence of θ_r is a function of the vertical length of the rangefinder; a taller tool rotated about its base (where it is gripped) will yield greater offsets at its radius (near the range lines and sight). The turned bubble level in our design responds to both vertical and rotational offset. That is, θ_r would manifest itself in θ_b. Given that rotation should be relatively easy to detect and correct by eye from the observer's point of view, we do not expect θ_r to contribute significantly to overall θ. For these reasons, we wrap θ_r into θ_b for the remainder of this paper, as follows:

$$\theta = \theta_s + \theta_b\,. \tag{4}$$

When the rangefinder is held at θ from the horizontal plane, an isosceles triangle with long sides equal to arm length (d) can be visualized. The remaining angles (ϕ) are also equal, thus:

$$\phi = \frac{180 - |\theta|}{2}\,. \tag{5}$$

TABLE 1
Variables in the design and use of the *Bangarang* rangefinder, potential sources of error and parameters used to model error in the sensitivity analyses

	Error potential			Simulated parameter / error				
Variable	**Type**	**Causes**	**Symbol**	**Units**	**Mean**	**SD**	**Min.**	**Max.**
Range line			r	cm				
	Systematic	Misplacement						
		Off-axis bubble/sight complex		cm	–	–	-0.5	0.5
	Random	Sight error	θ_s	°	0	0.1942	-0.5	0.5
		Bubble error	θ_b	°	0	0.1942	-0.5	0.5
		Rotational offset	θ_r	°				
Eye height			h	cm	–	–	135	200
	Systematic	Mismeasurement						
		Incorrect form						
	Random	Inconsistent form (e.g. bent knees)						
Arm length			d	cm	–	–	40	75
	Systematic	Mismeasurement						
		Incorrect form						
	Random	Inconsistent form (e.g. unsquare shoulders)		cm	0	3.0	-	-
Platform height			b	cm	–	–	25	2000
	Systematic	Mismeasurement		cm	0	0.01b	–	–
	Random	Pitch and roll		cm	0	0.025b	–	–

The distant, minute side of this triangle (c) can be calculated using the law of cosines:

$$c = \sqrt{2d^2 - 2d^2 \cos \theta}\,. \tag{6}$$

Side c is the hypotenuse of a right triangle with an opposite face that is the true offset (ε) in r. Therefore:

$$\varepsilon = | c \cdot \sin \phi | \,. \tag{7}$$

Sensitivity analyses

Variance

To evaluate the sensitivity of rangefinder performance to its design components at various combinations of target strip-width and platform height, a Monte Carlo error-introduction simulation was run for each design variable individually, then for all variables at once. For each strip width-platform combination in these analyses, a generated dataset of 1 000 likely eye height and arm length combinations ("observer scenarios," explained below) was used to compute the expected variability in estimation of strip width when random error was applied to the variable(s) in question. This expected variability, expressed as the coefficient of variation (CV), was used as the metric of the rangefinder's sensitivity to error.

The 20 target strip width distances we tested were spaced equally from 25 to 500 m. The 20 platform heights were spaced equally from 0.25 to 20 m. For all 400 combinations of these measures, for every observer scenario, error was introduced to one of the design variables. To introduce error, new values were randomly drawn from a normal distribution defined using the variable's original value as the mean and an estimate of its standard deviation (Table 1, explained below). Strip width was then recalculated using the "errored" values (D_e). The CV of all D_e in a simulation was the metric of sensitivity at that strip-platform combination.

To generate the dataset of observer scenarios, random values for eye height (h) were drawn from a bounded uniform distribution to represent all possible observer scenarios (Table 1). Eye-height values were then assigned plausible corresponding arm lengths (d), since eye height and arm length are correlated. To relate the two variables, we took the measurements of 12 observers from the *Bangarang* field team and used the mean ratio of these measurements (2.87) as a conversion factor and its standard deviation (0.181) to build a normal distribution of ratios of eye height to arm length.

Variance estimates of each variable were required to generate simulated errors. To be conservative, chosen variances were larger than those observed in the field (Table 1). All distributions were assumed to be Gaussian (Fig. 4).

Eye and platform height

Variance of eye height was considered constant, but the variance of platform height (b) was a function of its estimate, since higher

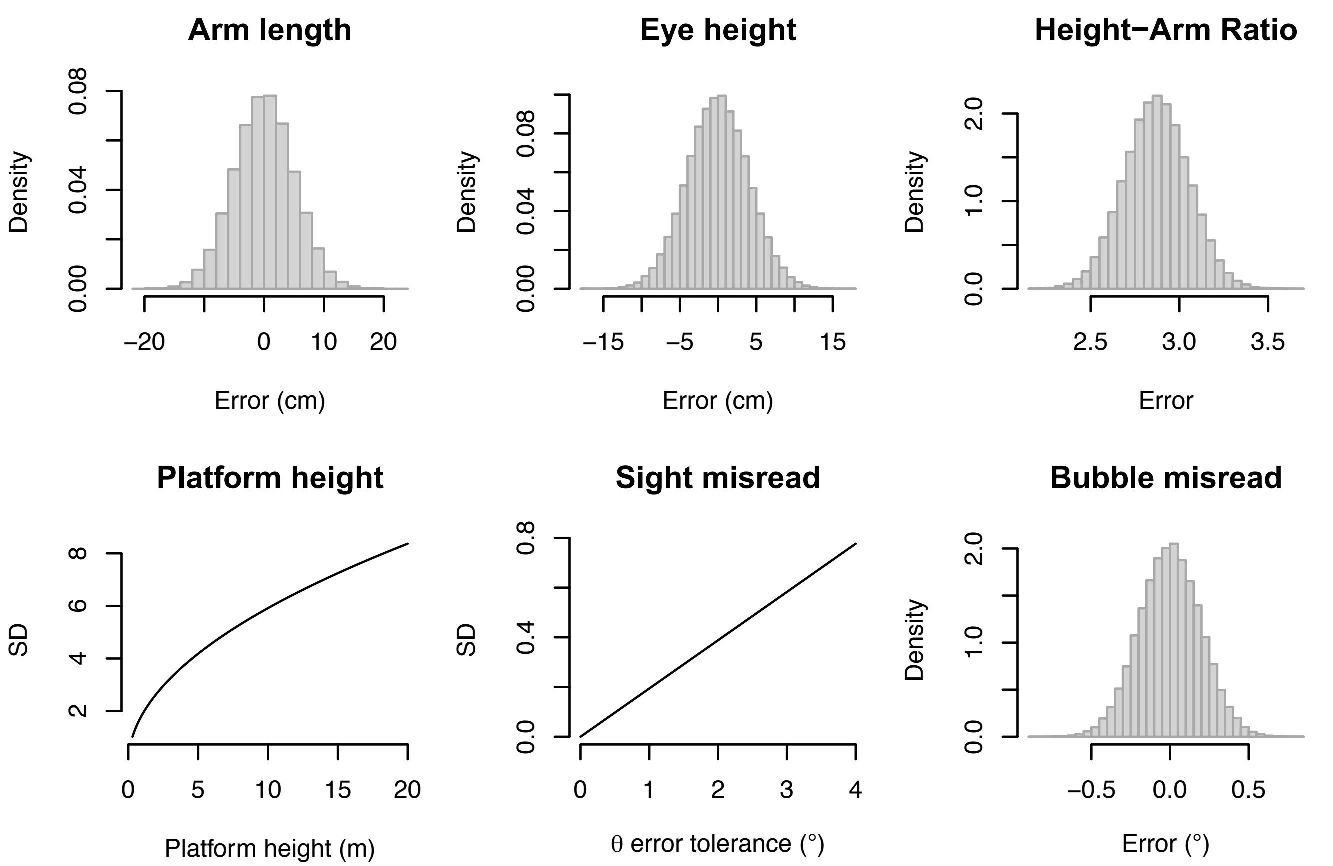

Fig. 4. Simulated distributions of random error for each variable, defined by the parameter values in Table 1, used in the sensitivity analysis. Standard deviation of platform height (bottom left) is expected to scale with platform height. Error tolerance in design of the sight hole (bottom middle) determines its expected contribution to the standard deviation of angle offset.

platforms are subject to larger error in both measurement (m) and pitching at sea (p). Therefore, $\sigma_b = (m + p) \cdot b$, and p is expected to vary greatly according to vessel design and sea state. Our choice of p error corresponds to fair weather conditions (Beaufort sea state 2 or less; Bowditch 1966).

Sight misread (θ_s)

θ_s is a function of the combination of crown length L and sight hole diameter s (Fig. 5). Assuming that the user does not allow light through the sight to be more than 50% obscured, the maximum expected sight misread error (in degrees offset) can be calculated as follows:

$$\theta_s = \tan^{-1} \frac{s}{2L} . \tag{8}$$

The *Bangarang* rangefinder uses a sight hole of 2.38 mm diameter, which through trial and error was found to be optimal for 3D printing and use in the field. To perform within a 1° offset range, the sight must have a length of 68.20 mm (Fig. 5). A larger hole would have to be longer to achieve the same error distribution. Beyond a certain L, perspective limits the apparent light through the sight and the tool becomes unwieldy.

Assuming angle offset is normally distributed about a mean of 0°, the user could hold the tool between -0.5θ and +0.5θ before noticing partial obstruction of light in the sight hole. Those bounds can be treated as the 99% confidence intervals for the θ_s distribution:

$$99\%\ UCI = \tfrac{1}{2}\,\theta = z \cdot \sigma . \tag{9}$$

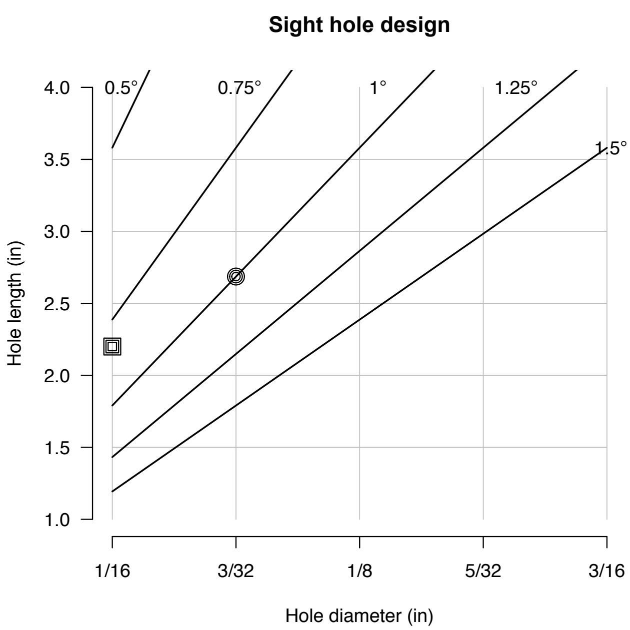

Fig. 5. Sight hole design at various tolerance levels of angle offset due to sight misread. Sight misread can occur because the rangefinder can be held at a slightly imperfect angle while light is still visible at the end of the sight. See text for details. Square mark denotes the design configuration trialed for this paper; circular mark denotes the revised design as a result of those field trials.

For a 99% confidence interval z = 2.575, Eq. 9 is rearranged as follows:

$$\sigma = \frac{\theta}{5.15} . \tag{10}$$

Assuming θ_s = 1°, the standard deviation of the user offset error distribution is 0.194°.

Bubble misread (θ_b)

For simplicity, we assumed that bubble misreads also result in maximum error offset of 1.0°, yielding an error distribution for θ_b with a standard deviation of 0.194°.

Rotational offset (θ_r)

In our design, the horizontally rotated bubble level responds to both vertical and rotational offset. That is, as previously mentioned, θ_r would manifest itself in θ_b. Because rotation should be easy to detect and correct by eye from the observer's point of view, we did not expect θ_r to contribute significantly to vertical angle offset. For these reasons, we did not include θ_r as a discrete variable in the sensitivity analysis. Note that the influence of this error variable depends on the vertical length of the rangefinder; a taller tool rotated about its base (where it is gripped) will yield greater offsets at its radius (near the range lines and sight).

Ground-truthing of angular error (θ)

To confirm that actual variance in θ resembled these predicted values, we conducted trials in a classroom at Scripps Institution of Oceanography (SIO) with an early version of the design concept (L = 55.88 mm, s = 1.59 mm). According to our parameterization, θ_s for this design could be as high as 0.814°, which would cause the design to be used with an overall θ that is normally distributed about 0° with standard deviation 0.246°. For the trial, a laser was attached to the rangefinder, and an observer (EMK) aimed it at a chalkboard from 5.74 m across the room. A second observer marked the laser dot on the chalkboard and measured the mark's height from the floor. This was repeated 40 times. Each reading was made within 3 s of raising the rangefinder. The marks' associated angles of offset spanned 1.09° (σ = 0.249°), which was acceptably close to predicted values.

Bias due to rangefinder construction

Incorrect measurements will introduce bias, not random error, into strip-width determination. Severity of bias introduced by error in line placement on the rangefinder, which determines the estimated strip width D_e, will depend on the combination of platform height and target strip width. To explore that relationship, we calculated bias (as a proportion of the target strip width D, Eq. 11) resulting from a variety of measurement errors at all combinations of strip width and platform height. During this exercise no error was introduced to other variables. The same analysis was run for measurement error of arm length:

$$Bias_D = \frac{D - D_\varepsilon}{D} . \tag{11}$$

Field trial

A field trial of the 55.88 mm long, 1.59 mm sight design was conducted on a pier at the SIO, chosen for its length, reliably horizontal surface, and structures at the end of the pier that obscure the horizon from the observer. This land-based trial was taken as a simulation of non-swell conditions in Beaufort sea states 0 to 2, which is not uncommon in confined channels such as rivers and fjord systems. Two target strip widths were tested: 75 m and 150 m. An observer (EMK) used a ladder to attain a platform height of 1.17 m, an uncommonly low platform height for seabird surveys. A meter tape was used to mark 58 distances from the ladder discretely on the pier pavement. Marked distances were concentrated near the strip boundaries to test the tool where errors are most likely to occur: every other meter in the ranges 60–70 m, 80–90 m and 130–180 m, and at every meter from 70–80 m. These marks were visited once each in random order by an assistant. Upon reaching a mark, the assistant would whistle, at which point EMK opened his eyes and called out which zone the person was in (“Zone 1” = 0–75 m, “Zone 2” = 75–150 m, and “Zone 3”= beyond 150 m) and his confidence level (2 levels: certain/uncertain) within 3 s. Performance at each strip boundary was evaluated using (1) error radius, half the range of distances in which incorrect calls were made; (2) uncertainty radius, half the distance range of uncertain calls; (3) success rates within these windows and within a radius of 10% of the strip width; and (4) the mean distance of incorrect calls (an indicator of bias).

RESULTS

As expected, the effects of error in arm length, eye height and platform height on strip-width CV were all minor relative to the overwhelming influence of angle offset error θ (Fig. 6). None of these minor effects was a joint function of strip width and platform height, unlike θ, which showed strong interaction effects. Arm length error, which was the second-most influential design variable, showed no platform- or strip-dependent effects. Effect of eye height error increased with decreasing platform height.

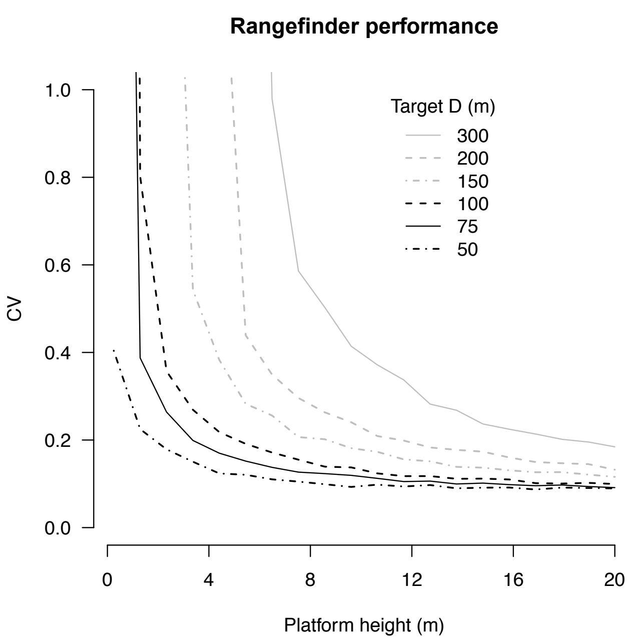

Fig. 6. Expected CV of estimations of strip width using the *Bangarang* rangefinder, when all error is introduced to all parameters simultaneously.

Of all the design components tested, angle offset had by far the strongest influence on rangefinder performance (Fig. 6). Its effect was a function of both platform height and target strip width, such that their combination resulted in low and stable CV estimates above a certain threshold. Such a pattern was also clear in results of the combined sensitivity analysis, in which all variables were subjected to error at the same time (Fig. 7). This combined analysis revealed that expected CV for a given target strip width escalates dramatically below a certain platform height, showing that only certain combinations of target strip width and platform height are appropriate for this rangefinder design (which is probably the case for all handheld rangefinding tools). Lower platforms generally require a narrower survey strip in order to locate the strip boundary at low and stable error rates. The combined analysis is a “worst-case” scenario, in which observers are not using any spatial sense whatsoever to correct their use of the rangefinder.

The bias sensitivity analysis (Fig. 8) demonstrated the importance of accurately drawn range lines and revealed that a misplaced range line results in proportionately greater bias (1) at greater target strip widths and (2) in the case of negative errors (where the range line is drawn too high on the rangefinder). Arm length bias was negligible relative to angle offset and did not scale with platform height or target strip width.

The SIO pier trial demonstrated high performance at a low platform height of 1.17 m (Fig. 9) and in the absence of any effect of seas, such as pitch and roll. About the D = 75 m strip boundary, incorrect calls occurred within a 3.5 m error radius (71–78 m, 4.7% of D).

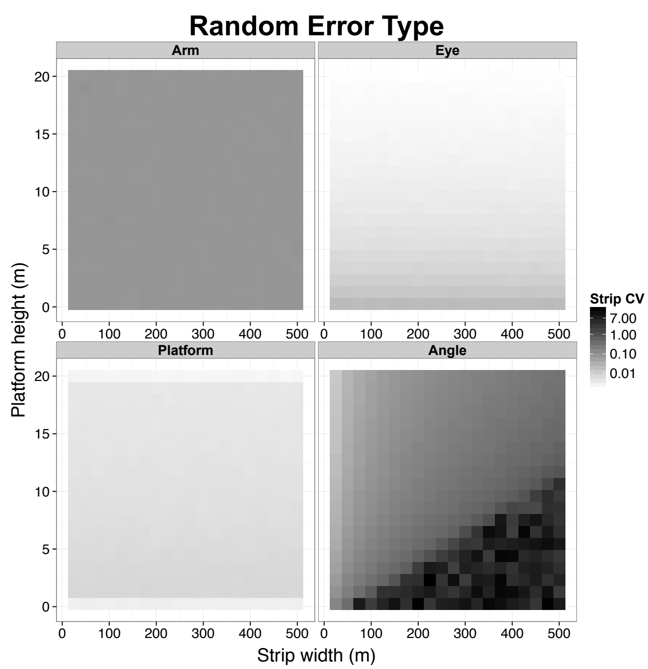

Fig. 7. Sensitivity of strip-boundary determinations to feasible random error in each design variable, at all combinations of platform height and target strip width. Metric of sensitivity is expected CV of estimations of strip width (grey scale, note log scale). Error in arm length is not a strong function of platform height or strip width, while errors in eye and platform height are a function of platform height. Angle offset is a function of both axes, and contributes much greater variability than the other error types.

Success rates within this and the 0.1 D radius were 68.8% (n = 16) and 79.1% (n = 24), respectively. The mean distance of incorrect calls was 74 m, suggesting minor negative bias. Removing a 60 m outlier, uncertainty radius was also 3.5 m (66–73 m, mean 70 m, 70% success rate, n = 10). At D = 150 m, error radius was 10 m (136–156 m, 6.7% of D, mean 145 m). Success rates within this and the 0.1 D radius were 66.7% (n = 12) and 80% (n = 20), respectively. Uncertainty window was 22 m (136–158 m, 7.3% of D, mean 147 m, 69.2% success rate, n = 13).

DISCUSSION

We have presented a rangefinder design that is inspired by Heinemann's (1981) but is not limited to pelagic habitats with unobstructed horizons. The design is affordable, increasingly easy to make, given the proliferation of 3D printing, and rugged enough for most field conditions. While we consider our design to be an improvement upon Heinemann's rangefinder for strip boundary delineation, it cannot replace his design that measures the distance to individual seabirds. Our simulations and trials suggest high performance for appropriate combinations of platform height and strip width, although we caution users to refer to our figures before committing to this design for their surveys (Fig. 7). The field trial on the SIO pier was encouraging; even at low platform heights, the *Bangarang* rangefinder performed better than predicted by our simulations, perhaps because the observer's own spatial sense counters the more extreme errors that are possible based solely on the tool's design. Results of the pier trial indicated that large CV values introduce error only in the few meters before and after the target strip (see "Implications").

The pier trial also revealed slight bias at target strip widths of both 75 m and 150 m. This may have been due to error in range line placement, error in other measurements or consistently improper form, but it is possible that the observer was subconsciously compensating (holding the tool at a negative offset, slightly downward) to avoid overestimation of strip boundaries. The mind may be aware that it is better to err towards a negative angle offset than a positive, since perspective distorts greater distances (a pattern demonstrated in the bias analysis; Fig. 8). To minimize error and ensure consistency among all observers in a field effort, we recommend the following best practices.

Best practices

- Before a survey, orient observers to the theory behind this rangefinder design and train them in its appropriate use.

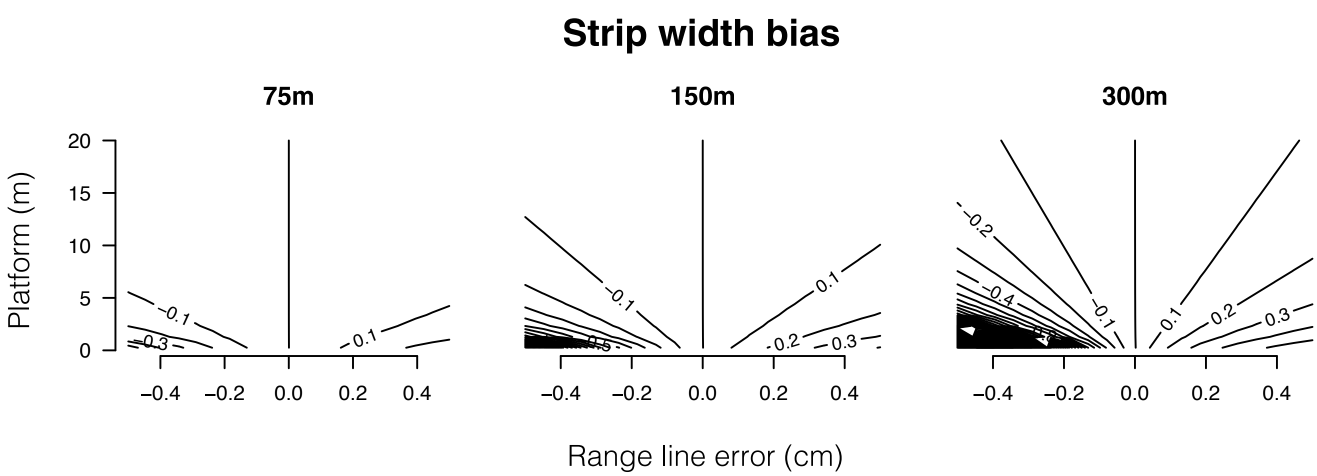

Fig. 8. Bias (contour lines, as a proportion of the target strip width) that would be introduced by error in range line measurements at three common strip widths.

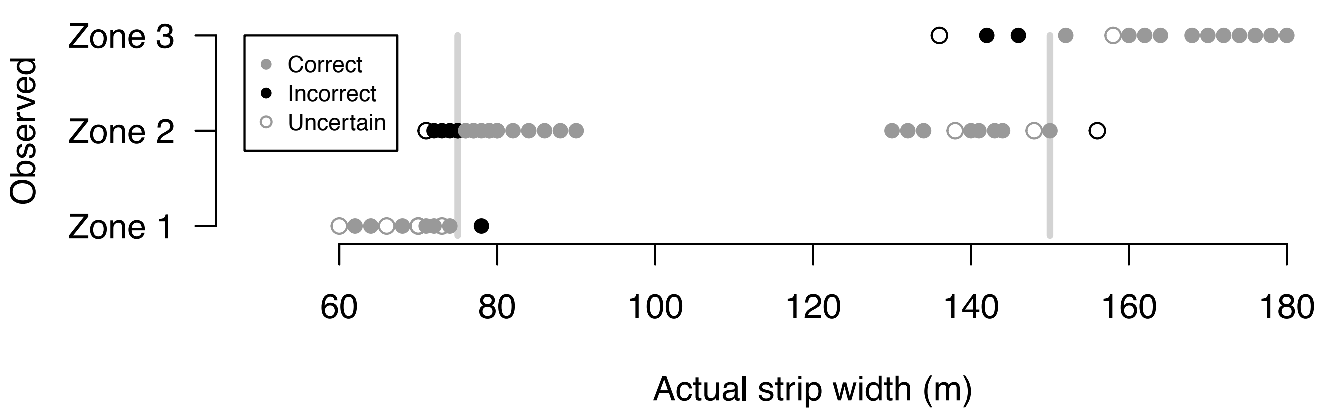

Fig. 9. Results of performance trial conducted on the pier of the Scripps Institution of Oceanography. Gray lines demarcate strip width zones (75 m and 150 m) that the observer used a *Bangarang* rangefinder to discern. Black dots are incorrect strip determinations; open dots are low-confidence determinations.

- Make all measurements with great care; have multiple people take measurements of each observer, the platform height, and the drawn range lines.
- Mark range lines on the rangefinder with a sharp, fine-point pencil. Ensure that the line is orthogonal to the vertical plane of the rangefinder. Then create an extremely fine, permanent, indented line with a hot blade.
- During observer training, emphasize the importance of consistent and proper form in the use of the rangefinder: i.e. shoulders squared to the sighting and not hyperextended as the tool is held up to the horizontal, elbows and knees locked, strip determination in 3 s or less, etc.
- Conduct extensive practice and calibration sessions with observers before rangefinders are used in surveys that "count." After Heinemann (1981), we recommend towing a buoy behind the survey vessel at various known distances so that observers can calibrate spatial sense and form.
- These training sessions can also be used to assess bias. If a laser rangefinder is available, we recommend making several passes of a large floating object (e.g. a buoy) and having observers use their rangefinders to estimate the moment the object passes into the survey strip. In this trial, a crewmember can be laser-ranging to the object simultaneously, so that determination errors can be estimated and then mitigated (Michael Force, pers. comm.).
- Repeat these calibration sessions regularly throughout periods of fieldwork.

Implications for survey results

Conventional strip-transect analysis treats survey strip width as a constant with no associated uncertainty. This assumption simplifies density computations but can produce falsely precise estimates. Our design and testing of this new rangefinder has allowed for the quantification of strip-width uncertainty in various survey scenarios. Uncertainties can and should be incorporated into strip-transect density estimations.

Rangefinder uncertainty should affect only birds occurring near the strip boundary, which requires the delineation of a zone of uncertainty about the target strip width, within which all incorrect calls and nearly all uncertain in/out calls should fall. Determining the breadth of this zone should be a subjective choice that takes into consideration the experience of the research team and the seabird community of the study area. It could conceivably be observer-specific. As a rule of thumb, we suggest that the radius for a zone of uncertainty be 10% of target strip width D. Error in our pier trial fell well within this range.

As with the Heinemann rangefinder, our design's performance is expected to decline dramatically in heavy seas, especially on ships with dramatic pitch. Because our CV predictions were based on calm seas (for these purposes, 0 to 2 on the Beaufort scale), we suggest scaling the predictions from our rangefinder simulations by sea state. Until proper field trials are conducted, we propose the following interim transformation, which assumes that sea state does not influence variance at or below Beaufort 2:

$$\text{If } BFT \leq 2 \qquad CV_{tot} = CV_{pred} \tag{12}$$

$$\text{If } BFT > 2 \qquad CV_{tot} = CV_{pred} \cdot 0.5BFT \tag{13}$$

where BFT is Beaufort scale.

CONCLUSIONS

We suggest that the *Bangarang* rangefinder be used whenever possible for strip-transect studies in all study area types, confined or otherwise, so that (1) effort is comparable regardless of habitat types and sighting conditions (i.e. distant fog) throughout a survey, and (2) strip-width uncertainty can be quantified, reported and incorporated into survey results. We stress the general value of the use of rangefinders like this one for cost-effective but rigorous survey methods (Heinemann 1981, Tasker *et al*. 1984), and we encourage further efforts to quantify the uncertainties inherent in strip-transect methodologies.

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