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MIST NETTING TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES: THE INFLUENCE OF SPATIAL AND TEMPORAL VARIABILITY ON CAPTURE DATA

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Abstract. We used constant effort mist netting during spring migration to sample populations of trans-Gulf migrants at two coastal study sites from 1987 to 1992. Approximately 2,500 individuals of 70 species were netted each season with approximately 5,000 net-hours of effort. Although captures per net hour and total species captured were fairly consistent each year, the seasonal patterns of capture, arrival condition, stopover duration, diversity of species, and number of individuals showed considerable variation from year to year. Differences in seasonal and annual weather patterns, the arrival condition of migrants, and habitat quality at stopover sites all influenced the probability of capturing birds with mist nets at our coastal stopover sites. Mist-net capture rates from coastal stopover sites, migratory activity indicated by radar echoes, and counts of migrants from censuses at mainland sites were correlated within a geographic radius of 100–150 km.

Key Words: capture variability, migration, mist netting, stopover, trans-Gulf migrants.

Over 80% of North American birds are migratory to some extent, and about half of those species cross the Gulf of Mexico during migration (Lowery 1946, Rappole and Warner 1976, Moore and Kerlinger 1987). The trans-Gulf flight is a dangerous, energetically expensive phase of the annual cycle. A typical migrant like an Ovenbird (scientific names in Table 1) deposits 40–50% of its body weight in fat each spring before departing on a 15–20 h non-stop flight en route from its tropical wintering grounds to the breeding grounds in North America. Crossing a large ecological barrier like the Gulf of Mexico is a risky endeavor for migrants, exposing them to the unpredictable forces of spring cold fronts and thunderstorms (Buskirk 1980). For migrants, this unpredictability often means that they have little control over their precise migratory trajectories (Gauthreaux 1971, Rappole et al. 1979, Moore and Kerlinger 1991). The inherently unpredictable nature of migration may make it a limiting factor for some populations. The variability in migratory patterns that emerge each year have important implications for the interpretation of mist-netting data from migratory stopover sites along the northern Gulf coast.

The objectives of this paper are to examine how variability in seasonal patterns of capture, arrival condition, and stopover duration at stopover sites may confound estimates of larger scale population trends, and to compare mist-net capture data with indices of activity derived simultaneously from mainland censuses and weather surveillance radar.

METHODS

We worked at two study sites along the northern Gulf Coast from 1987 to 1992 (Fig. 1). Peveto Beach is a coastal woodland in southwestern Louisiana. East Ship and Horn islands are barrier islands in Mississippi Sound. The two stations are approximately 400 km apart. The vegetation and field methods have been described in detail elsewhere (Loria and Moore 1990, Moore and Kerlinger 1987, Moore et al. 1990, Kuenzi et al. 1991). Approximately 20, 12-m nets were run daily at each station from dawn to 1100 hours and from 1400 to 1800 hours. The field season ran from late March to early May each spring. Standard measurements were taken on all birds captured before they were banded and released. Levels of body fat were estimated according to the ordinal scale developed by Helms and Drury (1960). In 1992 we conducted 1-km strip transect censuses (Emlen 1977) in pine (N = 63) and deciduous forest (N = 63) habitats in coastal Mississippi (Simons et al. 2000). In that same year, we also analyzed the archived film record of the WSR-57 radar at Slidell, Louisiana from 23 March to 27 May (Gauthreaux 1971, 1992). To quantify the radar images we used a calibration curve that related the spatial extent of the migration echoes on the radar image (measured as the maximum radius in nautical miles) to the mean number of birds in the volume defined by the 1.75° conical radar beam (elevated 2.5°) sweeping 20° of azimuth at a range of 46.3 km (Gauthreaux 1994).

RESULTS

Trans-Gulf migration occurs in spring from mid-March to late May, although the peak of activity is concentrated in April. Approximately 70 species

TABLE 1. MEAN ANNUAL CAPTURES AT EAST SHIP ISLAND, 1987–1991

Species	Captures/1,000 net-h	CV
Yellow-billed Cuckoo (*Coccyzus americanus*)	2.33	1.42
EasternWood-Pewee (*Contopus virens*)	5.22	0.62
Yellow-bellied Flycatcher (*Empidonax flaviventris*)	1.05	1.16
Acadian Flycatcher (*E. virescens*)	4.76	0.23
Least Flycatcher (*E. minimus*)	0.57	0.93
Eastern Phoebe (*Sayornis phoebe*)	0.25	1.47
Great Crested Flycatcher (*Myiarchus crinitus*)	2.42	0.49
Eastern Kingbird (*Tyrannus tyrannus*)	1.26	0.76
White-eyed Vireo (*Vireo griseus*)	62.67	0.74
Yellow-throated Vireo (*V. flavifrons*)	10.48	0.35
Blue-headed Vireo (*V. solitarius*)	0.40	0.97
Warbling Vireo (*V. gilvus*)	0.07	2.24
Philadelphia Vireo (*V. philadelphicus*)	1.47	0.70
Red-eyed Vireo (*V. olivaceus*)	127.39	0.44
Black-whiskered Vireo (*V. altiloquus*)	0.12	1.38
Barn Swallow (*Hirundo rustica*)	0.13	2.24
Red-breasted Nuthatch (*Sitta canadensis*)	0.27	2.24
House Wren (*Troglodytes aedon*)	1.55	0.94
Ruby-crowned Kinglet (*Regulus calendula*)	1.44	1.40
Blue-gray Gnatcatcher (*Polioptila caerulea*)	0.69	1.43
Veery (*Catharus fuscescens*)	13.07	0.70
Gray-cheeked Thrush (*C. minimus*)	8.02	0.76
Swainson's Thrush (*C. ustulatus*)	12.24	0.93
Hermit Thrush (*C. guttatus*)	0.11	2.24
Wood Thrush (*Hylocichla mustelina*)	13.10	0.67
Cedar Waxwing (*Bombycilla cedrorum*)	0.07	2.24
Blue-winged Warbler (*Vermivora pinus*)	3.61	0.62
Golden-winged Warbler (*V. chrysoptera*)	0.42	0.90
Tennessee Warbler (*V. peregrina*)	9.31	0.55
Orange-crowned Warbler (*V. celata*)	0.07	2.24
Northern Parula (*Parula americana*)	4.39	0.39
Yellow Warbler (*Dendroica petechia*)	15.03	0.59
Magnolia Warbler (*D. magnolia*)	9.35	0.54
Cape May Warbler (*D. tigrina*)	4.79	1.40
Black-throated Blue Warbler (*D. caerulescens*)	1.16	0.68
Yellow-rumped Warbler (*D. coronata*)	2.25	1.60
Black-throated Green Warbler (*D. virens*)	2.95	0.79
Blackburnian Warbler (*D. fusca*)	1.31	0.92
Yellow-throated Warbler (*D. dominica*)	0.90	0.95
Prairie Warbler (*D. discolor*)	2.00	1.17
Palm Warbler (*D. palmarum*)	0.84	0.86
Bay-breasted Warbler (*D. castanea*)	4.84	0.67
Blackpoll Warbler (*D. striata*)	12.34	0.86
Cerulean Warbler (*D. cerulea*)	0.98	0.36
Black-and-white Warbler (*Mniotilta varia*)	16.17	0.27
American Redstart (*Setophaga ruticilla*)	8.50	0.34
Prothonotary Warbler (*Protonotaria citrea*)	9.41	0.67
Worm-eating Warbler (*Helmitheros vermivorus*)	9.64	0.53
Swainson's Warbler (*Limnothlypis swainsonii*)	1.13	0.92
Ovenbird (*Seiurus aurocapilla*)	13.53	0.66
Northern Waterthrush (*S. noveboracensis*)	6.75	0.56
Louisiana Waterthrush (*S. motacilla*)	0.56	0.77
Kentucky Warbler (*Oporornis formosus*)	8.15	0.74
Connecticut Warbler (*O. agilis*)	0.11	1.42
Common Yellowthroat (*Geothlypis trichas*)	14.29	0.66

TABLE 1. CONTINUED

Species	Captures/1,000 net-h	CV
Hooded Warbler (*Wilsonia citrina*)	27.97	0.65
Wilson's Warbler (*W. pusilla*)	0.05	2.24
Yellow-breasted Chat (*Icteria virens*)	3.45	0.72
Chestnut-sided Warbler (*D. pensylvanica*)	2.41	0.67
Summer Tanager (*Piranga rubra*)	20.20	0.20
Scarlet Tanager (*P. olivacea*)	13.16	0.60
Dark-eyed Junco (*Junco hyemalis*)	0.05	2.24
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	18.47	0.68
Blue Grosbeak (*Guiraca caerulea*)	4.15	0.42
Indigo Bunting (*Passerina cyanea*)	43.85	0.54
Painted Bunting (*P. ciris*)	7.33	0.83
Dickcissel (*Spiza americana*)	0.38	1.56
Bobolink (*Dolichonyx oryzivorus*)	0.13	2.24
Orchard Oriole (*Icterus spurius*)	26.92	0.41
Baltimore Oriole (*I. galbula*)	4.49	0.49

were netted at each of our stations each year. Daily patterns of arrival at stopover sites varied considerably from year to year, as illustrated by five years of capture data from East Ship Island (Fig. 2). Numbers of individual birds captured/recaptured on East Ship Island each year were: 873/70 (1987), 2,327/385 (1988), 3,080/306 (1989), 2,585/437 (1990), and 2,151/240 (1991); and on Horn Island 2,022/419 (1992). The annual percent of birds recaptured one or more times ranged from 8.0–20.7% (mean = 13.05 ± 4.36%). Annual spring capture rates, first captures, and recaptures combined for all species, ranged from 0.35 to 0.70 birds per net hour.

The mean number of birds netted annually/1,000 net-h varied considerably within species (Table 1). Coefficients of variation (CV; Zar 1984) for annual mean rates from 1987 to 1991 on East Ship Island provide an index of annual within-station capture rate variability. For example, over all years, approximately 63 White-eyed Vireos were captured/1,000 net-h, but annual capture rates were highly variable (CV = 74%). In contrast, Black-and-white Warblers were caught less often (16/1,000 net-h), but annual capture rates were much less variable (CV = 27%).

Most of the birds captured at our study sites had low fat reserves. Overall, slightly over 50% were scored "0 fat," although there was some variation in the average condition of birds from year to year (Fig. 3).

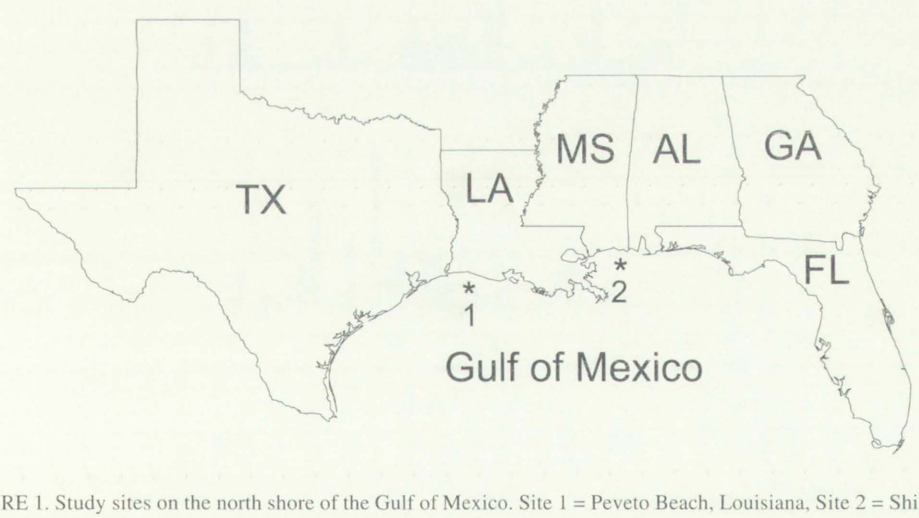

FIGURE 1. Study sites on the north shore of the Gulf of Mexico. Site 1 = Peveto Beach, Louisiana, Site 2 = Ship and Horn Islands, Mississippi.

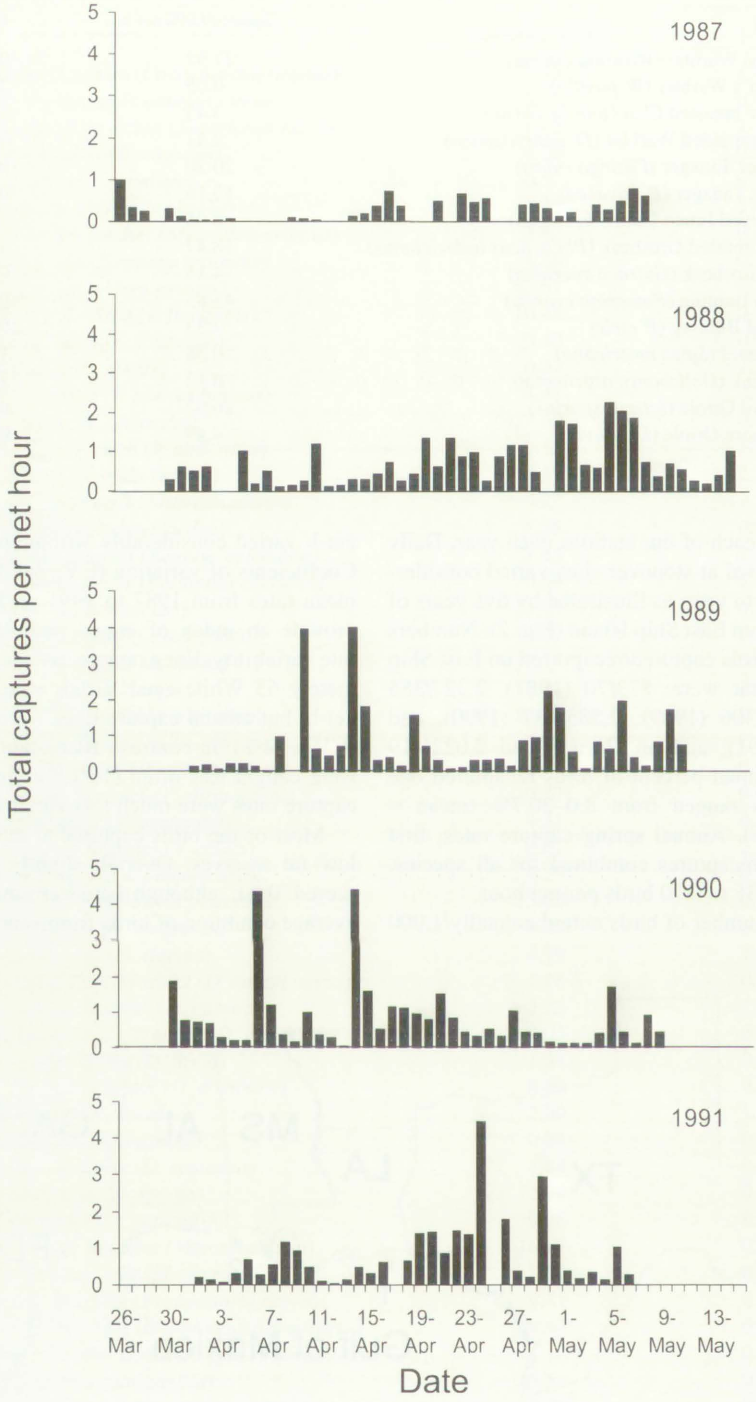

FIGURE 2. Capture rates of trans-Gulf migrants on East Ship Island, 1987–1991.

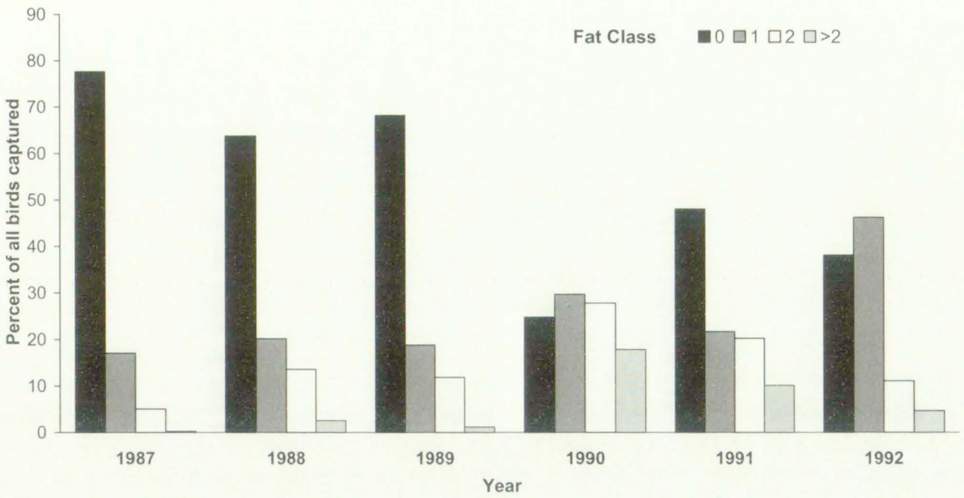

FIGURE 3. Distribution of arrival fat scores of trans-Gulf migrants netted at East Ship Island (1987–1991) and Horn Island (1992), Mississippi.

Birds with no fat reserves were more likely to remain at stopover sites and be recaptured than were birds with higher levels of body fat (Fig. 4). Examination of arrival weight and stopover length for six common species illustrates the pattern. In general, birds arrived at Peveto Beach in better condition (Table 2) and tended to depart sooner (Table 3) than birds at East Ship island. We previously found evidence of differences in habitat quality related to prey availability at the two stations (Moore and Simons 1992, Simons et al. 2000), which may explain why birds at Peveto Beach tended to gain weight more quickly than birds stopping over on East Ship Island (Table 4). Thus, the capture probabilities for individual birds at these two stopover sites appeared to be a function both of the bird's arrival condition and the availability of food at the stopover sites.

We compared mist-netting data from Horn Island in Mississippi Sound with data collected simultaneously from a coastal weather radar site, and from field censuses on mainland habitats (Fig. 5), to evaluate the stopover habitat requirements of trans-Gulf migrants at broader geographic scales. Results provide some indication of the extent to which mist-net data from a single station reflect conditions at a broader scale (Fig. 6). Over the course of the entire

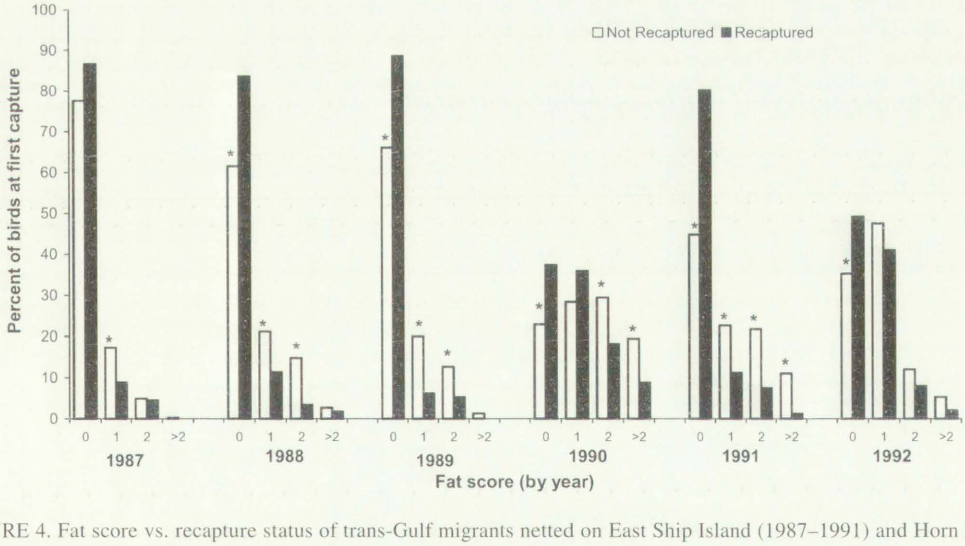

FIGURE 4. Fat score vs. recapture status of trans-Gulf migrants netted on East Ship Island (1987–1991) and Horn Island (1992), Mississippi. * indicates difference between percents (t-test, $P < 0.05$).

TABLE 2. AVERAGE ARRIVAL WEIGHT (GRAMS) OF TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES

Species	Site	1987	1988	1990	1991
Hooded Warbler	PEV	9.67 ± 0.86 (273) *	9.57 ± 0.90 (288)	9.84 ± 0.85 (134) **	9.62 ± 0.88 (58)
	ESI	9.40 ± 0.90 (31)	9.80 ± 0.90 (32)	9.30 ± 1.10 (152)	9.70 ± 1.00 (94)
Red-eyed Vireo	PEV	15.65 ± 0.16 (199) **	15.79 ± 1.59 (574) **	15.82 ± 1.53 (80)	16.26 ± 2.10 (25)
	ESI	15.00 ± 1.70 (170)	15.5 ± 1.60 (883)	15.70 ± 1.70 (280)	16.40 ± 1.90 (370)
Indigo Bunting	PEV	12.25 (1)	12.80 ± 1.38 (372) **	12.88 ± 1.21 (49)	13.08 ± 1.43 (85)
	ESI	12.70 ± 1.50 (50)	13.60 ± 1.80 (360)	12.80 ± 1.70 (101)	12.80 ± 1.40 (105)
Black-and-white Warbler	PEV	9.53 ± 0.89 (33)	9.56 ± 0.90 (147) **	9.62 ± 1.15 (31) **	9.30 ± 0.75 (27)
	ESI	9.30 ± 0.80 (29)	8.80 ± 1.00 (65)	8.60 ± 0.80 (62)	9.20 ± 0.90 (62)
Summer Tanager	PEV	27.17 ± 2.38 (56) *	27.63 ± 2.47 (154) **	28.60 ± 3.50 (73) *	27.77 ± 2.81 (37)
	ESI	26.10 ± 2.30 (45)	26.30 ± 2.30 (93)	27.30 ± 3.30 (73)	28.80 ± 3.10 (43)
White-eyed Vireo	PEV	11.15 ± 0.92 (41) **	11.42 ± 1.12 (138) **	11.27 ± 1.22 (81) **	11.27 ± 1.05 (17)
	ESI	10.60 ± 1.00 (73)	10.60 ± 0.90 (91)	10.60 ± 1.00 (536)	11.00 ± 1.20 (228)

Notes: PEV = Peveto Beach, Louisiana, ESI = East Ship Island, Mississippi. Data are reported as mean ± one SE (N). Two sample t-test for differences between sites, one-tailed P values reported as * ($0.01 < P < 0.05$), ** ($P < 0.01$).

TABLE 3. AVERAGE DAYS OF STOPOVER BY TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES (MOORE AND KERLINGER 1987)

Species	Site	1987	1988	1990	1991
Hooded Warbler	PEV	1.43 ± 0.74 (41)	3.15 ± 2.67 (106)	1.85 ± 1.66 (33) *	2.61 ± 1.75 (23)
	ESI	4.50 ± 4.95 (2)	1.00 (1)	2.97 ± 2.37 (30)	2.20 ± 1.48 (9)
Red-eyed Vireo	PEV	2.00 ± 1.00 (4)	2.00 ± 1.80 (36)	2.92 ± 2.23 (12)	2.00 (1)
	ESI	2.33 ± 1.53 (3)	1.97 ± 1.90 (29)	2.57 ± 1.90 (7)	1.80 ± 1.30 (5)
Indigo Bunting	PEV	–	3.10 ± 4.36 (11)	–	2.00 ± 2.00 (2)
	ESI	2.00 ± 1.00 (3)	3.52 ± 3.67 (31)	7.18 ± 9.81 (17)	2.20 ± 1.10 (5)
Black-and-white Warbler	PEV	1.33 ± 0.58 (3)	2.50 ± 2.00 (19) **	2.50 ± 2.12 (2)	2.00 ± 1.00 (3)
	ESI	1.50 ± 0.71 (2)	1.50 ± 0.65 (14)	3.41 ± 2.69 (17)	2.60 ± 3.72 (10)
Summer Tanager	PEV	1.75 ± 0.95 (4)	1.80 ± 0.87 (19)	2.22 ± 1.72 (9)	13.00 (1)
	ESI	3.00 ± 2.83 (2)	1.75 ± 1.49 (8)	3.80 ± 4.09 (5)	3.67 ± 3.06 (3)
White-eyed Vireo	PEV	1.83 ± 1.17 (6)	3.40 ± 3.45 (33)	2.18 ± 1.47 (11) **	2.00 ± 1.73 (3) **
	ESI	2.67 ± 1.63 (6)	2.90 ± 2.71 (30)	5.11 ± 5.71 (75)	4.84 ± 5.62 (37)

Notes: PEV = Peveto Beach, Louisiana, ESI = East Ship Island, Mississippi. Data are reported as mean ± one SE (N). Two sample t-test for differences between sites, one-tailed P values reported as * ($0.01 < P < 0.05$), ** ($P < 0.01$).

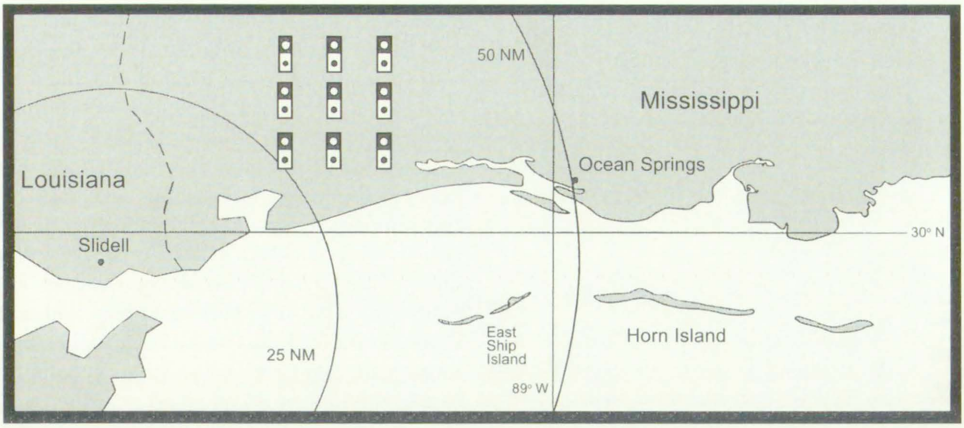

FIGURE 5. Study sites used for comparison of data on migratory bird activity collected using mist nets (Horn Island, Mississippi), field censuses (9 paired study sites in pine uplands and riparian habitats, coastal Mississippi; shown by paired squares with circles in them), and radar imagery (WSR-57 weather radar, Slidell, Louisiana).

season, mist-net capture rates, migratory activity indicated by radar echoes, and the number of migrants detected on field censuses were correlated within a geographic radius of 100 km. Peaks in coastal migratory bird activity evident in mist-net and radar data around 30 March, 7 April, 20 April, and 1 May were generally followed by peaks in number of passage migrants detected by field censuses on the mainland (Fig 6; Kendall's rank correlation analysis, $W = 0.643$, $\chi^2 = 32.793$, $0.01 < P < 0.025$).

DISCUSSION

Data collected by netting birds at coastal stopover sites are useful for answering a variety of questions related to the ecology and habitat requirements of

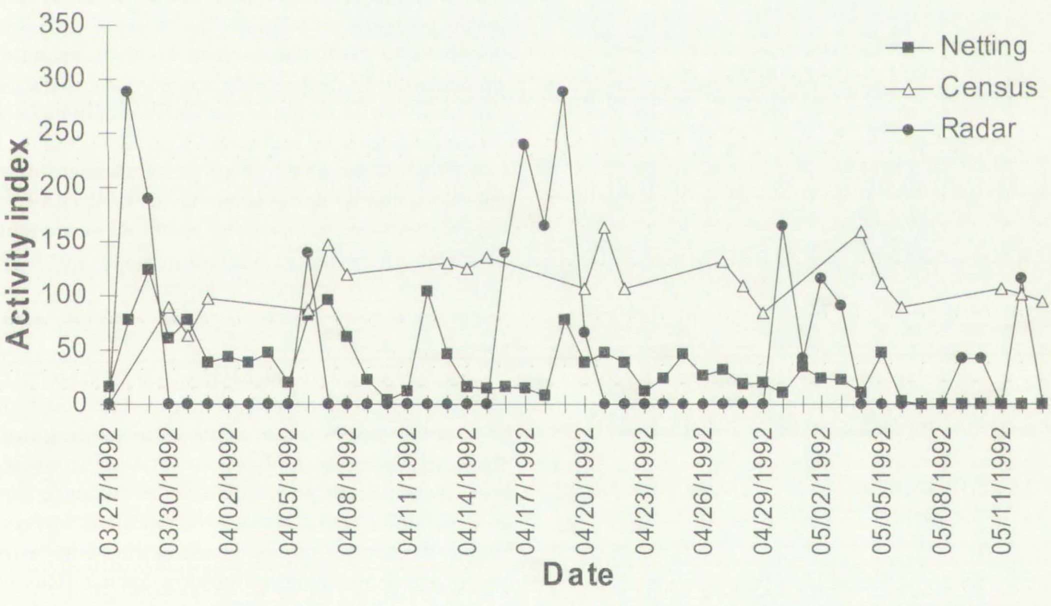

FIGURE 6. Comparison of migratory bird activity based on data from mist netting, field censuses, and WSR-57 radar imagery. Netting data (dark squares) are reported as number of birds captured/50 net-h. Census data (white triangles) are reported as total number of migrants counted in morning censuses. Radar data (dark circles) are reported as the mean number of flocks per 20° sector of the WSR-57 radar image (Gauthreaux 1994).

TABLE 4. AVERAGE MASS CHANGE (G/D, SEE KUENZI ET AL. 1991) OF TRANS-GULF MIGRANTS AT COASTAL STOPOVER SITES

Species	Site	1987	1988	1990	1991
Hooded Warbler	PEV	0.16 ± 0.69 (41)	0.18 ± 0.39 (106)	0.003 ± 0.43 (33)	0.22 ± 0.25 (23)
	ESI	0.38 ± 1.59 (2)	–	-0.42 ± 1.78 (30)	-0.25 ± 0.95 (9)
Red-eyed Vireo	PEV	0.10 ± 0.56 (11)	-0.19 ± 0.78 (36) **	0.18 ± 0.40 (12) **	0.18 (1)
	ESI	–	-1.25 ± 0.73 (29)	-1.23 ± 1.13 (7)	-0.23 ± 0.91 (5)
Indigo Bunting	PEV	–	0.12 ± 0.47 (29)	−0.21 ± 0.10 (2)	
	ESI	-0.17 ± 0.63 (3)	0.03 ± 0.95 (31)	0.48 ± 1.00 (17)	0.09 ± 0.65 (5)
Black-and-white Warbler	PEV	0.34 ± 0.26 (3)	0.15 ± 0.42 (33) *	0.19 ± 0.01 (2)	0.14 ± 0.60 (3)
	ESI	-0.50 ± 0.71 (2)	0.09 ± 1.24 (14)	0.21 ± 0.84 (17)	0.54 ± 0.71 (110)
Summer Tanager	PEV	0.60 ± 0.55 (4)	0.22 ± 2.27 (19) *	0.33 ± 1.00 (9) **	0.47 (1)
	ESI	1.25 ± 1.41 (2)	-1.64 ± 1.54 (8)	2.83 ± 1.47 (5)	0.72 ± 1.41 (3)
White-eyed Vireo	PEV	0.20 ± 0.65 (6)	0.33 ± 0.47 (33) *	0.16 ± 0.32 (11) **	0.27 ± 0.25 (3)
	ESI	-0.17 ± 0.70 (6)	0.08 ± 0.84 (30)	-0.43 ± 1.01 (75)	-0.07 ± 0.79 (37)

Notes: PEV = Peveto Beach, Louisiana, ESI = East Ship Island, Mississippi. Data are reported as mean ± one SE (N). Two sample t-test for differences between sites, one-tailed P values reported as * ($0.01 < P < 0.05$), ** ($P < 0.01$).

migratory birds. However, population indices, such as mist-net captures from stopover sites along the Gulf Coast, may not provide data suitable for monitoring population levels if capture probabilities vary over time or space (Pollock et al. 2002).

Analysis of the arrival condition of birds at stopover sites suggests that birds with sufficient energy reserves continue migration, or move to alternate habitats more quickly than lean birds, or that they may simply over-fly some coastal stopover sites entirely. Confirmation of this phenomena is provided during a typical bird "fallout," which occurs when birds encounter late cold fronts or local thunderstorms. Under these conditions, it is common to capture birds with large fat reserves that, under favorable weather conditions, would have simply over-flown these coastal sites (Moore et al. 1990). In 1990, when fallout conditions occurred on East Ship Island in early and mid-April (Fig. 2), birds were fatter on average than in years when fallout events were less common (Fig. 3).

Weather is clearly a dominant factor influencing the total number of birds captured per net-hour at an individual station (Buskirk 1980, Moore and Kerlinger 1987). Weather conditions favorable for migration will reduce the proportion of a population stopping at a migratory stopover site. Favorable weather also increases the likelihood that birds visiting stopover sites will be in better condition. We have shown that recapture rates are lower for migrants in better energetic condition. The average energetic condition of birds (determined by their condition on departure from the wintering grounds, distances flown, or wind conditions encountered enroute) will all influence capture probabilities at stopover sites. It is usually not possible to distinguish whether differences in capture rates at stopover sites reflect differences in the average energetic condition of migrants or actual differences in population levels. For long-term trends to be unbiased it has to be assumed that variation in mean annual energetic condition occurs randomly among years.

Finally, variability of habitat quality at stopover sites will also influence the likelihood and duration of stopover, and therefore capture probabilities. Both the yearly succession of vegetation and the temporary abundance of prey within years influence capture probabilities at stopover sites, which is why recommendations for migration monitoring emphasize the need for maintaining uniform habitat (Hussell and Ralph 1998). Thus, differences in seasonal and annual weather patterns, the arrival condition of migrants, and habitat quality at stopover sites all influence the probability of capturing birds with mist-nets at stopover sites along the northern Gulf coast.

Abundance estimates based on mist-net based count indices can be adjusted by modeling date, weather, moon phase and year as covariables (Dunn and Hussell 1995, Dunn et al. 1997, Hussell et al. 1992, Pyle et al. 1993). These approaches may be most suitable for inland sites adjacent to breeding areas where the energetic condition of migrants, habitat conditions, and migratory pathways are less variable. At sites with high daily turnover rates, modeling covariates may provide unbiased indices of population size if the assumption that only newly arrived birds are included in analyses can be met (Dunn and Hussell 1995). When recapture rates are low (<10%) this assumptions may be valid. Higher recapture rates (up to 20%) at our study sites along the Gulf Coast may make it difficult to meet the assumptions of this approach. Modeling covariables may not be sufficient to control for the variability in capture probabilities inherent to populations migrating across large ecological barriers such as the Gulf of Mexico.

Not surprisingly, differences in the factors affecting mist-net capture probabilities appear to increase with the distance between study sites. Differences in the arrival condition of birds at Peveto Beach and East Ship Island (400 km apart) suggest that these sites are sampling populations following different migratory routes. In contrast, local WSR 57 radar, field census results, and mist-net data were correlated on a scale of 50–100 km at our study sites in Mississippi. Williams et al. (2001) observed a similar local scale correspondence between observations of migrants in New Hampshire using portable marine radar, ceilometer, and ground census data.

Presumably, sampling at a fairly fine geographic scale across the northern Gulf would be necessary to understand population level patterns of trans-Gulf migration. Nevertheless, establishing a network of sampling sites along the Gulf Coast would probably prove to be an inefficient approach to population monitoring, because while migration can be viewed as a broad-front phenomena on decadal or longer time scales, annual patterns of arrival tend to be quite localized. In any single year only a small percentage of sites would be expected to collect data sufficient to assess population trends. Thus the sampling frame required to adequately track population trends would be very large and expensive.

Recent advances in the application of WSR-88D Doppler weather radar to bird migration hold the promise that it may one day be feasible to implement a sampling frame sufficient to monitor bird population trends through migration monitoring (Gauthreaux and Belser 1998, Gauthreaux and Russell 1998), although individual species can not be identified. On-going validation studies employing ground truthing of radar imagery with mist-net and census based field data will determine the potential of this new technology.

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