

Changing Marine Exploitation During Late Pleistocene in Northern Wallacea: Shell Remains from Leang Sarru Rockshelter in Talaud Islands



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INTRODUCTION

THE COLONIZATION OF AUSTRALIA IS NOW WIDELY VIEWED as the earliest evidence for planned maritime voyaging in human history (e.g., Bailey 2004; Bailey and Flemming 2008; Erlandson and Fitzpatrick 2006), possibly dated back older than 45,000 B.P. (Mulvaney and Kamminga 1999; O'Connor and Chappell 2003; Turney et al. 2001). The colonization of islands east of New Guinea requiring farther water-crossings were also first settled by at least 40,000 B.P. (e.g., Allen et al. 1988; Groube et al. 1986; Leavesley and Chappell 2004; Specht 2005; Torrence et al. 2004; Wickler and Spriggs 1988). Regardless of the route chosen, colonization of New Guinea and Australia from the Asian mainland required several separate sea crossings, including voyages of at least 80 km (Clark 1991; Irwin 1992). While the colonization of Australia and New Guinea represents the earliest evidence of intentional and relatively long-distance (>50–80 km) seafaring in the world, there is relatively little known about the antiquity and nature of seafaring and coastal occupation in Wallacea, the nursery grounds for these early seafarers.

Recent excavations at late Pleistocene sites in south and eastern Wallacea provide evidence of early aquatic culture and marine exploitation. For instance, excavations in the Maluku Islands, Aru Islands, and East Timor (e.g., Bellwood et al. 1998; Glover 1986; Irwin et al. 1999; O'Connor 2002, 2006, 2007; O'Connor et al. 2002, 2005; Szabó et al. 2007) have uncovered evidence of human colonization dating as early as 30,000–40,000 B.P. On the other hand, aside from southern Sulawesi where there are dates of around 30,000 B.P. (e.g., Bulbeck et al. 2004; Glover 1981), there has been little archaeological evidence for early human presence in the northern part of Wallacea (e.g., Ono 2006; Tanudirjo 2001, 2005).

Unlike the Pleistocene coast of Sunda Shelf which is submerged, most islands in Wallacea have deeply shelving coastlines. Early sites along their coastlines may

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provide evidence for the Pleistocene coastal adaptation. In East Timor, for instance, several late Pleistocene sites have revealed considerable quantities of marine fauna, including shell, fish, and turtle remains (e.g., O'Connor 2007; O'Connor et al. 2002). Future analyses of these materials are expected to contribute to our understanding of the structure and strategies of past marine exploitation in Wallacea during the late Pleistocene to the early Holocene, especially in the Last Glacial Maximum (LGM).

The peak of LGM is estimated approximately 25,000 to 19,000 B.P. (e.g., Bird et al. 2005; Lambeck and Chappell 2001; Yokoyama et al. 2000). Glacio-eustatic lowering of sea level by ~130 m at the LGM fully exposed the Sunda Shelf, joining mainland Southeast Asia to Sumatra, Java, Borneo, and possibly Palawan (Bird et al. 2005 : 2229),¹ while the Wallacea region remained as an archipelago.

Although less is known about the impact of the last glacial phase of climate on the tropical equatorial realms, it is now clear that these regions also were affected (O'Connor and Aplin 2007 : 86). Lowland tropical regions are poorly represented in terms of palaeoecological proxies during this period; however, available evidence suggests that the magnitude and direction of change was regionally variable. Lowland locations close to sea level on small islands may have experienced reduction in temperature in the range of 2–4 °C (van der Kaars 1991).

Recent archaeological studies in East Timor (O'Connor 2002, 2006, 2007) and Aru Islands (O'Connor et al. 2005) demonstrate that while overall temperature reduction in lowland areas and on small islands may have been less than 2° C, the impact on faunal distributions and environmental productivity may in some cases have been dramatic (O'Connor and Aplin 2007 : 84). Overall, the regional lowland records for the Indonesian archipelago, particularly the Wallacea region, provide consistent indications of a reduction in overall precipitation and, in some areas, greater interannual variability in rainfall. If so they you need to move it after precipitation in the late Pleistocene (Hope 2001 : 143).

All of this evidence and discussion clearly indicates the importance of regional sampling across a variety of altitudes and environments to obtain long local sequences. This article explores the evidence of late Pleistocene to Holocene colonization and marine resource exploitation for the remote islands in the northern part of Wallacea from finds from our excavation at Leang Sarru in the Talaud Islands (Fig. 1). In this paper we summarize the excavation results, explore their implications for reconstructing marine exploitation, and compare relevant archaeological sites in west and southern Wallacea and adjacent regions of Sundaland and Sahul during the late Pleistocene to Holocene.

Talaud Islands and the Excavation of Leang Sarru in 2004

The Talaud Islands form part of the small island group of the Sangihe and Talaud chain, which extends from near the tip of northern Sulawesi toward the southern tip of Mindanao (Fig. 1). The Talaud group is located northeast of the Sangihe group (about 100 km in distance), and is basically composed of three large islands, including Karakelong (976 km²), Salibabu (about 95 km²), and Kabarau (about 90 km²), along with eight small (about 10–18 km² each) uplifted coral islands called the Nanusa Islands group. The three major islands are low-lying (the summit of Mt. Manuk in Karakelong is the highest point as 648 m) and non-volcanic

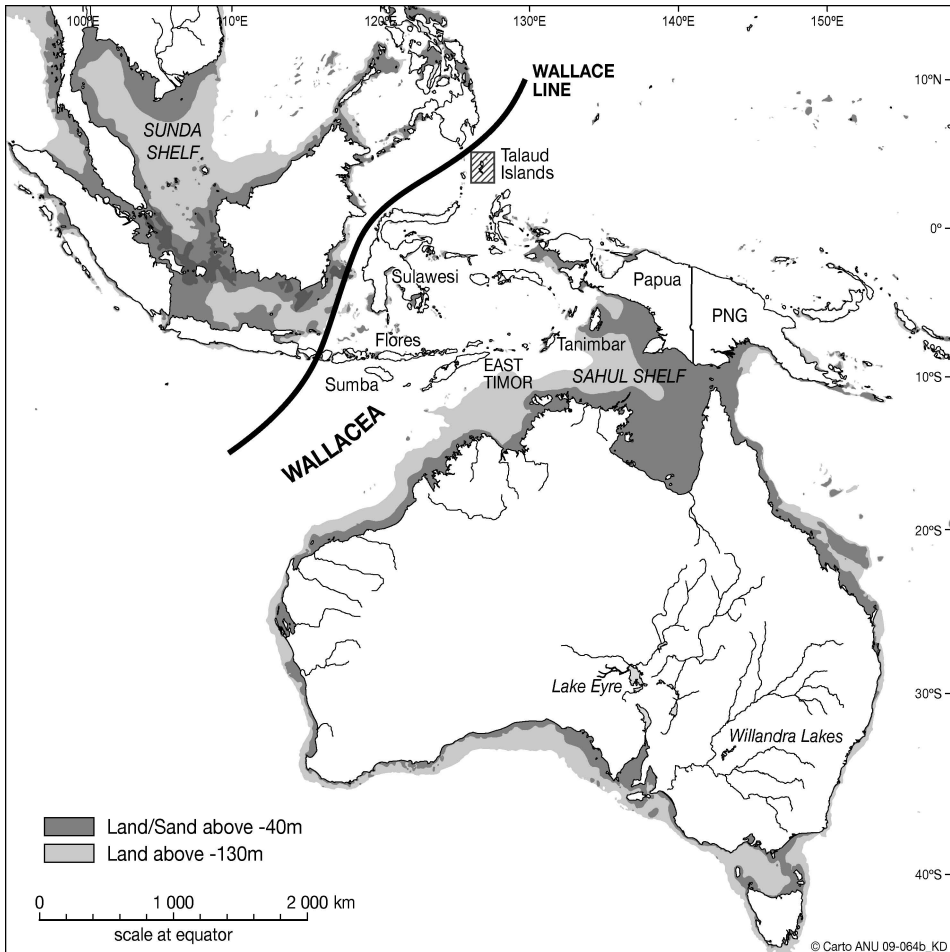


Fig. 1. Map showing Sunda Shelf, Wallacea, and Sahul Shelf and the Talaud Islands.

with extensive natural forest (see also Riley 2002), while the Sangihe group has fertile soil and a steep topography as a result of its volcanic origin, with some high volcanic mountains including Mt. Awu (1340 m) and Mt. Sahendaruman (1031 m).

Leang Sarru is a small limestone rockshelter located about 400 m from the eastern coast of Salibabu Island in the Talaud group (Fig. 2). It is situated in an uplifted coral limestone block about 15 m above sea level in the middle of a clove plantation (see also Tanudirjo 2005:15). The shelter faces northeast and is about five by 3 m in area. It has a curving ceiling about 2.5 m high at the dripline. The floor is dry and flat in the sheltered area, but slopes down slightly toward from the dripline.

The site was previously excavated by Tanudirjo (2001, 2005) in 1995, and he dug two 1-m² pits in 10 cm spits to a depth of about 80–90 cm below ground surface. This excavation revealed four sedimentary layers and unearthed thousands

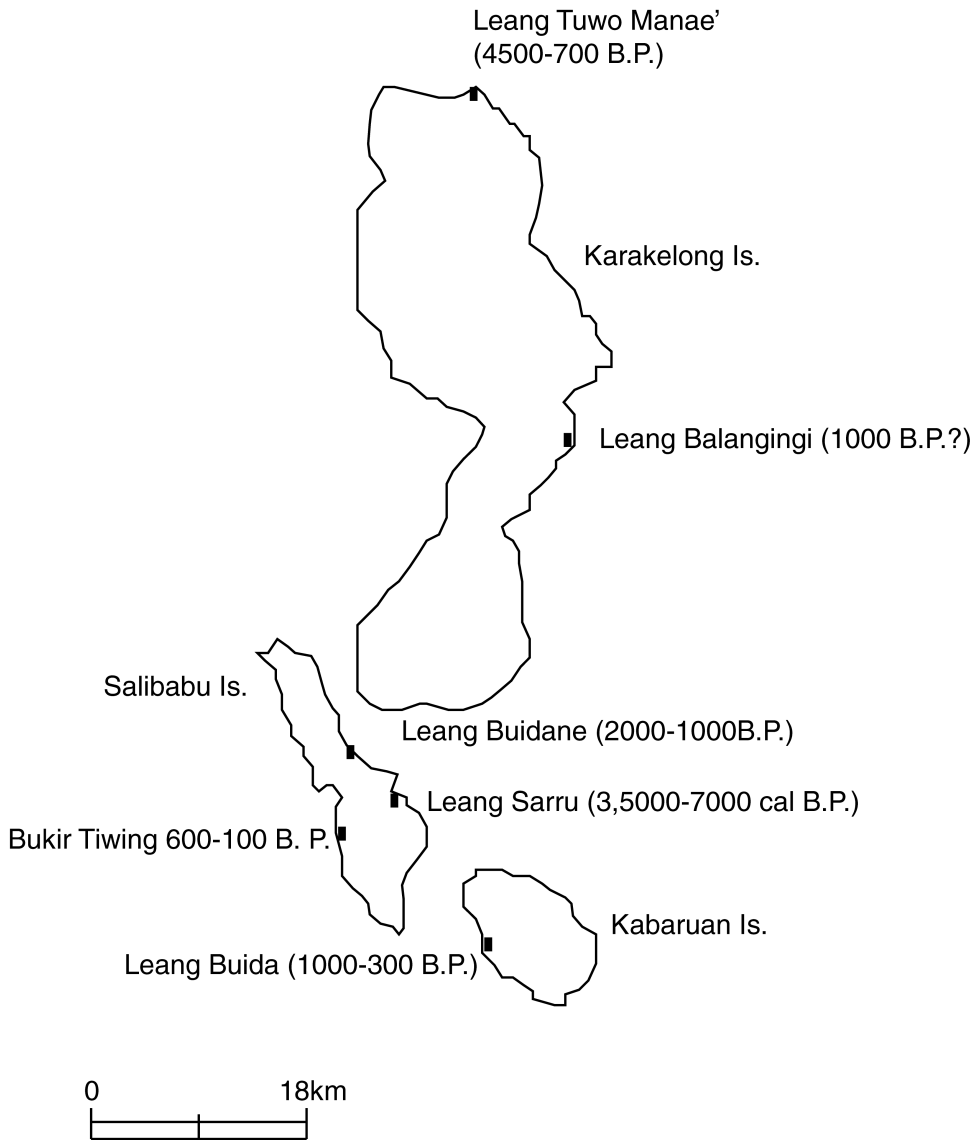


Fig. 2. Map showing Leang Sarru and other archaeological sites in the Talud Islands.

of chert artifacts and shell remains but no animal or fish bones. This excavation was relatively small, about 2 m^2 (1.8 m^3), and the front area of the shelter was not examined.

For this reason and to collect further archaeological data, Leang Sarru was re-excavated by Balai Arkeologi Manado (Institute for Archaeological Research in Manado) and Ono in August 2004 (Ono and Soegondho 2004; Soegondho 2004). This excavation uncovered a further area of about 6 m^2 (3.6 m^3) and comprised areas both inside and outside the shelter. We excavated six $1 \times 1 \text{ m}$ units, D2, D3, C3, C4, C5, and C6 (Fig. 3). The numbers of grid squares, size of each

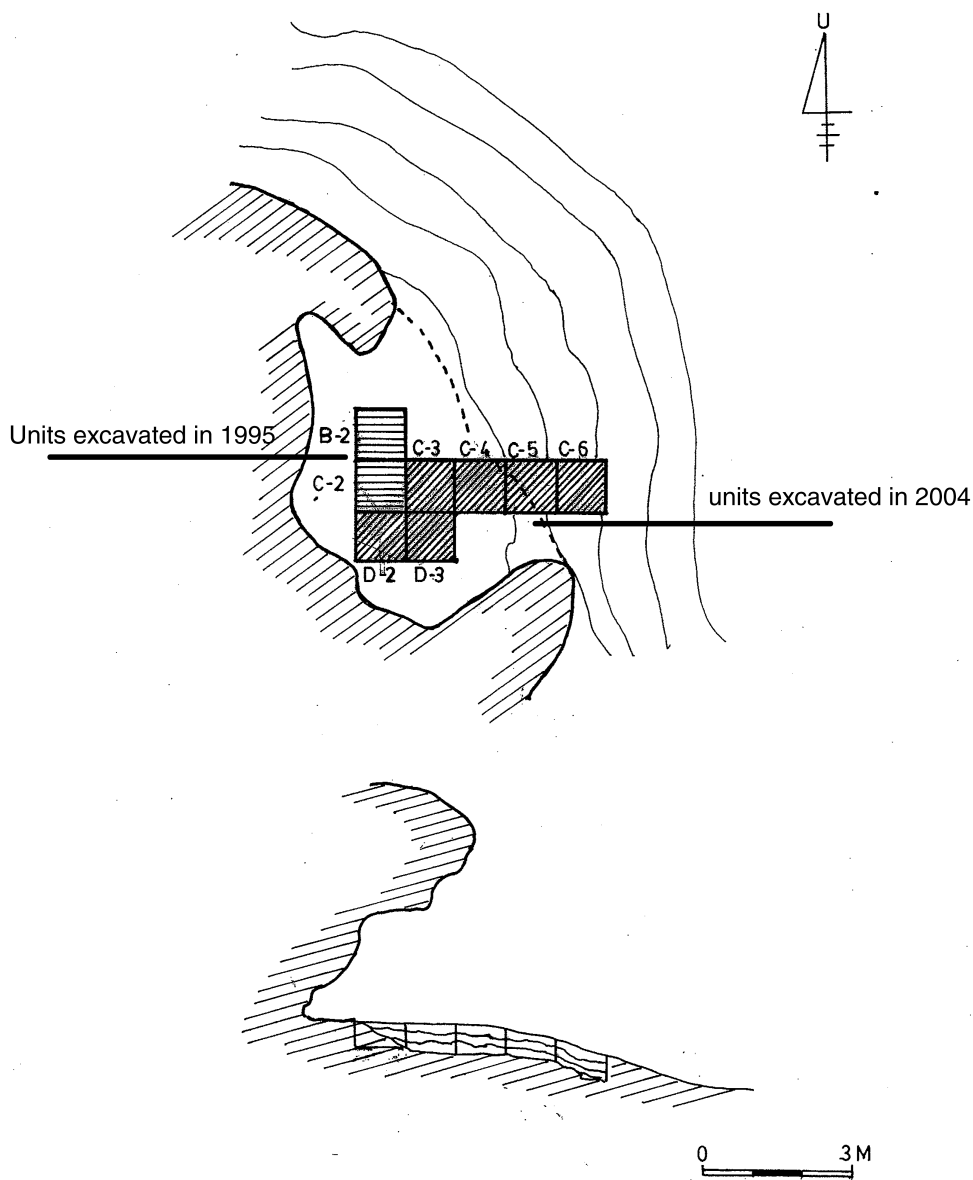


Fig. 3. Plan and section of excavation units in 1995 and 2004.

unit and spit depth (10 cm each) were consistent with the excavation in 1994. The excavated sediment was dry screened with 3 mm and 5 mm mesh.

Our excavation encountered only three cultural layers (corresponding to Tanudirjo's Layers 1 to 3) before reaching the hard calcareous deposit (corresponding to Tanudirjo's Layer 4), and we inferred that the hard deposit shelved downward toward the back wall of the shelter where Tanudirjo had excavated. Of these six excavated units, four units are located inside the shelter (C3, C4,

D2, D3), down to 60–70 cm depth to bedrock, with the other two units outside the shelter (C5, C6), down to 50–60 cm.

In total, 9465 stone artifacts, including flake tools, flakes, cores, chips, chunks, and hammerstones, together with 3371 NISP (Number of Identified Specimen) of marine shell, land mollusk (mainly snail), crustacean, and sea urchin, and 580 earthenware sherds were retrieved. This range of cultural materials was generally similar to those from the 1995 excavation, with no fish or animal bones. The lack of animal bones possibly indicates that edible animals were scarce in the Talaud Islands.

In fact, the Talaud Islands in modern times have no land mammals other than about 14 species of bat, 5 species of rat, 4 species of flying fox (*Pteropus* spp.), and 2 species of cuscus (*Ailurops ursinus* and *Strigocuscus celebensis*). Some introduced animals include chicken, dog, cattle (*Bos javanicus*), and pig (*Sus celebensis*) (see Riley 2002). There is no archaeological evidence for the existence of large or mid-sized animals.

The reasons for the total lack of fish bones are not clear, but fragility of fish bones might be one of the possible explanations. Interestingly, the past excavations at Leang Tuwo Mana'e on the northern coast of Kalakeran Island (Fig. 2), which provided an age range of about 6000–1000 B.P., reveal a similar situation with abundant shell remains but absence of fish and animal bones (Bellwood 1976; Tanudirjo 2001). In view of this further evidence, limited exploitation of fish, particularly inshore species, might be another possible reason. In fact, there is little shallow reef formation around the coasts of the Talaud Islands. Such coast and marine environments may have limited the inhabitants' access to inshore fish resources.

Results of ^{14}C dating

Conventional radiocarbon ages (CRA) were calibrated by using CalPal2007_Hulu data based on Greenland ice cores, coral cores, and speleothems from Hulu Cave, China (Weninger and Jöris 2008). First, the marine reservoir effect on marine shells was corrected by subtracting 400 ^{14}C years from CRA. The corrected data was then calibrated by the online version of the CalPal calibration program (<http://www.calpal-online.de/index.html>). Younger determinations generally agree with those arrived at by using another calibration, Marine04 (Hughen et al. 2004).

Samples of organic matter, including some marine shells (opercula of *Turbo marmoratus*) and pieces of microscopic charcoal or black organic matter, were selected for radiocarbon dating and submitted to both the laboratories at Waikato University (New Zealand) and National Institute for Environmental Studies (Japan)² for conventional radiocarbon and AMS dating. The dating of marine shells (*Turbo* spp.) from the basal layer was consistent with Tanudirjo's basal dates,³ which were newly calibrated by us as around 35,000 to 32,000 B.P. (see Table 1 for details). Tanudirjo (2001) obtained a total of seven conventional ^{14}C dates for opercula of *Turbo marmoratus* to provide dates for the lower layers (Layers 3, 4) of about 30,000 B.P. (by CALIB 3,0) or 35,000 to 32,000 B.P. (by Marine04); his dates for the middle layer (Layer 2) were around 21,000 B.P. to 17,000 B.P. (lower part) and 10,000 to 8000 B.P. (upper part).

TABLE 1. RADIOCARBON DETERMINATIONS FROM LEANG SARRU*

ACCEPTED LAB. CODE	SAMPLE	LOCATION	DEPTH	AGE (B.P.)	CALIBRATED ¹⁴ C	CALIBRATED ¹⁴ C
					AGE (B.P.)	AGE (B.P.)
					1ST RANGE WITH	1ST RANGE WITH
					CALPAL_HULU	MARINE04
TERRA- 070407a05	<i>Turbo</i> sp.	D3/Layer2	-30 cm	7660 ± 40	8033-8144	8050-8170
ANU-10203*	<i>Turbo</i> sp.	B2/Layer2	-30 cm	9750 ± 90	10,372-10,139	10,500-10,740
ANU-10810*	<i>Turbo</i> sp.	B2/Layer2	-40 cm	14,820 ± 80	17,346-17,099	17,070-17,560
ANU-10960*	<i>Turbo</i> sp.	C2/Layer2	-50 cm	18,880 ± 140	21,763-21,275	21,850-22,270
ANU-10499*	<i>Turbo</i> sp.	B2/Layer3	-50 cm	30,850 ± 340	34,988-35,033	out of range
TERRA- 070407a04	<i>Turbo</i> sp.	C3/Layer3	-50 cm	28,460 ± 150	32,223-32,832	out of range
TERRA- 070407a03	<i>Turbo</i> sp.	D3/Layer3	-60 cm	28,760 ± 150	32,426-33,079	out of range
ANU-10498*	<i>Turbo</i> sp.	B2/Layer4	-70 cm	29,590 ± 630	32,898-34,087	out of range
ANU-10204*	<i>Turbo</i> sp.	B2/Layer4	-80 cm	29,760 ± 650	33,031-34,201	out of range
REJECTED						
LAB. CODE	MATERIAL	LOCATION	DEPTH	AGE (B.P.)		
TERRA- 070407a01	BOM**	C3/Layer1	-20 cm	modern		
TERRA- 070407a02	BOM**	D2/Layer3	-50 cm	modern		
WK-15378	BOM**	C3/Layer3	-60 cm	modern		

* All the ¹⁴C dates with ANU lab code were collected and reported by Tanudirjo (2001) and re-calibrated by us by using CalPal2007_Hulu data and Marine04.

** BOM = Black Organic Matter or microscopic charcoal

For our 2004 excavation a total of three conventional radiocarbon dates from opercula of *Turbo marmoratus* shells and three AMS dates from the microscopic charcoal or black organic matter were obtained. Among these, two *Turbo* samples excavated from Layer 3 dated to about 33,000 to 32,000 B.P., while another *Turbo* sample from the upper part of Layer 2 dated to around 8000 B.P. (see Table 1). All the ¹⁴C determinations from marine shell samples are in good sequence. In contrast, all three samples of microscopic charcoal or black organic matter are dated as modern. It was suspected that the unidentified matter had been inadvertently introduced by disturbance or transport from upper layers into deeper levels by insects or tree roots. Such natural disturbance or transport might frequently happen at the site, as its deposit is relatively shallow at 60-70 cm, and the site is surrounded by secondary forest. We have therefore rejected this second series of dates.

The radiocarbon determinations on marine shell indicate that Layer 3 (and Layer 4 in Tanudirjo's excavation) accumulated during the late Pleistocene, possibly between 35,000 to 32,000 B.P., and the lower part of Layer 2 accumulated during the final stage of the LGM around 21,000 to 18,000 B.P. (see also Tanudirjo 2001). The upper part of Layer 2 and possibly the lower part of Layer 1 formed during the early Holocene, around 10,000 to 8000 B.P. There were no

conventional ^{14}C or AMS determinations for the periods between 27,000 to 21,000 B.P. and 17,000 to 10,000 B.P., and it is possible that the shelter may not have been inhabited during these periods, other than perhaps very occasionally with little or no cultural discard.

We infer that the shelter had been occupied during at least three different periods in the late Pleistocene and early Holocene, an interpretation consistent with the tentative conclusion reached by Tanudirjo (2005). While no ^{14}C dates were determined for the topsoil of Layer 1, it contained sherds similar to the early Metal Phase jars from Leang Buiduane Cave (Bellwood 1976) about 20 km north of Leang Sarru on Salibabu Island. This evidence indicates that the site was probably used for burials around 2000 to 1000 B.P. (see also Tanudirjo 2005: 18–19).

Production of Stone Artifacts

Stone artifacts were the most abundant find, numbering 9465 pieces weighing about 36 kg. Adding the 5060 stone artifacts Tanudirjo retrieved in 1995 provides a grand total of 14,525 stone artifacts from an excavated area of 5.4 m³ (2689 artifacts per m³). The density of stone artifacts increased dramatically in Layer 2 in all the units excavated in both 1995 and 2004. Red and pink chert flaking débitage was the dominant component of the stone assemblage in all layers. While Tanudirjo (2001) classified stone material into five categories: débitage, utilized flake, blade-like flake, core, and hammer, we classified the assemblage into six major categories: retouched flake (Fig. 4), core, flake, chip, chunk, and hammer. Size, weight, and edge angle of whole flakes and tools were analyzed further.

The detailed analysis of the flakes and retouched flake tools is not complete, but our impression is that the stone tools and flakes in Leang Sarru represent a reduction of chert pebbles procured from watercourses (e.g., Bellwood 1997). Reduction of waterworn stone is one of the basic forms of lithic technology in Island Southeast Asia, and is evident at cave and rockshelter sites in the Philippines and neighboring island groups dating to late Pleistocene and Holocene times. Another general attribute of flaked stone artifacts in the region is small size; the size of the flakes from Leang Sarru is similarly small (average mean length of whole flakes is 25 mm and width is 10 mm). The most likely reason for this general size restriction is the nature of the source material. Our field survey found no chert procurement locality or quarry, but only small waterworn igneous stones along the island's watercourses and beaches.

Result of Shell Analysis

Shell remains are the second most common cultural material from the excavation. Identification was mainly conducted by Ono who supplemented earlier reference works by Abbott (1991) and Habe and Kosuge (1996) with the project's modern reference collection of Talaud Island shells. Some archaeological shell specimens that could not be identified by these sources were further examined by Dr. Osamu Kataoka at Kansai Gaidai University in Japan.

A total NISP of 3281 marine shell and land mollusk (26 kg) recovered from the excavation were sorted into 53 taxa: 23 of these taxa were identified to species level, and the remainder to genus and family levels. Ono identified and

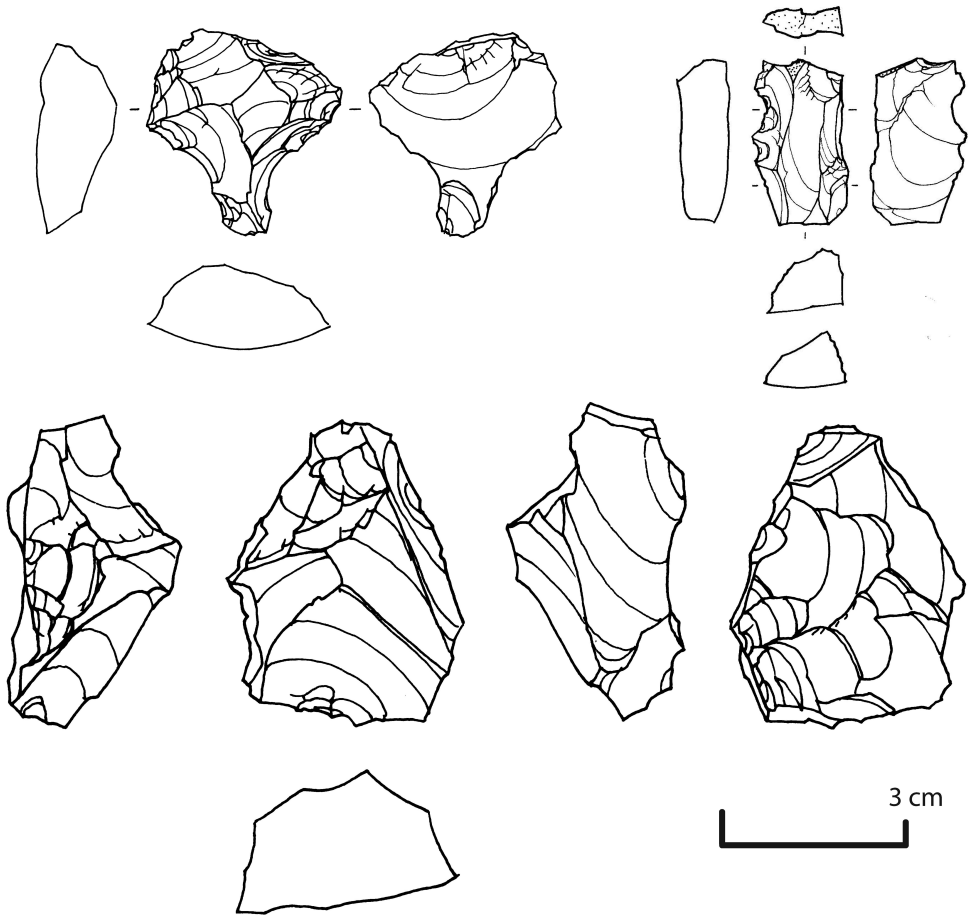


Fig. 4. Retouched flakes excavated from Leang Sarru in 2004.

counted the number of shells that were at least 60 percent complete, arriving at an NISP figure for major shell species (mainly Gastropoda shell species) that is likely to be close to the actual MNI. Shells that were no more than 40 percent complete were classified as “shell fragment.”

One species each of crustacean (*Brachyura*) and sea urchin (*Heterocentrotus mammillatus*) were also identified as marine resources. With only minor differences, the shell density demonstrates a consistent pattern. When the 4135 in NISP and 15.2 kg/1.8 m³ of shell remains from the previous excavation (identified as 40 taxa; see Tanudirjo 2001) are added, a grand total of 7416 (NISP) shell and land mollusk remains and 42.1 kg/5.4 m³ was retrieved from Leang Sarru.

The distribution of shell remains within the excavation revealed that the number and density of shell remains were larger inside the rockshelter than outside it. A total NISP of 1827 shell and land mollusk remains were recovered from Unit C3 (13.5 kg), which is located in the middle of the shelter, followed numerically by Unit D2 as 343 (2.1 kg), Unit D3 as 471 (4.6 kg), and Unit C4 as 326 (2.3 kg),

which are also located within the shelter. Unit C5 and Unit C6, which are located outside of the shelter, produced only 182 (2.5 kg) and 187 (1.8 kg) shell remains, respectively.

Table 2 shows the results of the identification of shell, land mollusk, crustacean (Brachyura), and sea urchin (*Heterocentrotus mammillatus*) from our 2004 excavations. In general, our analysis of the shell and other faunal remains confirmed that *Turbo* spp. (e.g., *Turbo marmoratus*, *Turbo setosus*), *Nerita* spp. (e.g., *Nerita balteata*, *Nerita undata*), and *Trochus* spp. (e.g., *Trochus maculatus*, *Trochus niloticus*) were the predominant faunal species at Leang Sarru. Among them, the *Turbo* spp. and *Nerita* spp. were the most abundant in number, though in terms of size and actual meat value, *Turbo* spp. and *Trochus* spp., much larger than *Nerita* spp., were more important in terms of food and protein sources.

In terms of temporal change of excavated shell and land mollusk, 33 species of marine shell and land mollusk, with one species each of crustacean (Brachyura) and sea urchin (*Heterocentrotus mammillatus*) excavated from Layer 3 dated between 35,000 and 32,000 B.P. The intertidal to subtidal rocky shore species such as Neritidae (*Nerita balteata*), Patellidae, Muricidae, Haliotidae, and Chitonidae were dominant, while *Turbo* spp., a subtidal species, were also exploited. The number of land mollusk such as Ellobiidae (*Pythia pantherina*) was also predominantly exploited during this period. However, the total amount of marine shell and land mollusk are small in number (NISP = 859) during this early period.

In Layer 2B, dated between 21,000 and 17,000 B.P., the total number and variety of species dramatically increased (NISP = 1456; 42 species), as did crustacean (Brachyura) and sea urchin (*Heterocentrotus mammillatus*) (NISP = 56, compared with NISP = 12 in the earlier period). For instance, the major marine shell species such as *Nerita* spp. and *Turbo* spp. greatly increased in number and species variety, while the number of intertidal shell species such as *Haliotis varia* and land mollusk such as *Pythia* spp. slightly decreased. For *Nerita* spp., the number of *Nerita balteata*, *Nerita undata*, and *Nerita albicilla* dramatically increased, and for *Turbo* spp., the large to mid-size species such as *Turbo setosus* and *Turbo marmoratus* also increased. For other species, shell belonging to Trochidae (particularly *Trochus maculatus*) and Fascioliariidae also dramatically increased. The increase in the total amount of shell remains in Layer 2B indicates more active exploitation of shell resources during the LGM. The exact reasons for such an increase is not completely clear, though one of the crucial factors may have been a decline in the available food resources in the vicinity of the rockshelter during the LGM; alternatively the site might have been more intensively used during this period.

However, the total amount of shell remains dramatically decreased in Layer 2A (NISP = 516), which dated around 8000 to 10,000 B.P., and in Layer 1 (NISP = 450), while some subtidal and coral rubble-dwelling species belong to Fascioliariidae (*Latirus nagasakiensis*) and Tridacnidae (*Tridacna maxima*, *Tridacna crocea*) increased. If the radiocarbon determinations reliably date the shell remains in Layer 2A and Layer 1 the increase of such coral rubble-dwelling species possibly indicates warming of sea and air temperatures and renewed growth of coastal corals.

In contrast, the major subtidal species such as *Turbo* spp. and *Trochus* spp., as well as major intertidal species such as *Nerita* spp., *Cellana* spp., and Chiton dra-

TABLE 2. IDENTIFIED SHELL (NISP) AND TEMPORAL DISTRIBUTION

A: GASTROPODA

	FAMILY	SPECIES	HABITAT	8000	10,000	21,000	35,000	NISP
				B.P.	B.P.	B.P.	B.P.	
				L1	L2A	L2B	L3	
1	Neritidae		Intertidal to subtidal	94	85	466	239	884
		<i>Nerita balteata</i>	Rocky shore	34	44	304	203	585
		<i>Nerita undata</i>		30	23	87	18	158
		<i>Nerita albicilla</i>		13	11	62	11	97
		<i>Nerita plicata</i>		11	6	13	5	35
		<i>Nerita squamulata</i>		0	1	0	0	1
		<i>Neritopsis radula</i>		6	0	0	2	8
2	Turbinidae		Intertidal to subtidal shore	125	193	366	209	893
		<i>Turbo</i> spp. (operculum)		104	128	312	185	729
		<i>Turbo cinereus?</i>		13	52	4	2	71
		<i>Turbo setosus</i>		4	8	20	10	42
		<i>Turbo marmoratus</i>		0	0	19	6	25
		<i>Turbo chrysostomus</i>		0	1	7	4	12
		<i>Turbo petholatus</i>		4	2	1	2	9
		Unidentified		0	2	3	0	5
3	Trochidae		Subtidal shore	20	39	168	23	250
		<i>Trochus maculatus</i>		8	14	157	21	200
		<i>Trochus niloticus</i>		4	24	10	2	40
		<i>Tectus pyramis</i>		8	1	1	0	10
4	Patellidae		Intertidal to subtidal	7	3	108	109	227
		<i>Cellana</i> spp.		5	3	105	109	222
		<i>Patelloida</i> spp.		2	0	3	0	5
5	Chitonidae		Intertidal rocky shore					
		<i>Acanthopleura/Lioloiphura</i>		12	11	114	81	218
6	Fascioliariidae		Subtidal shore	19	68	49	4	140
		<i>Latirus nagasakiensis</i>		18	68	38	1	125
		<i>Fusinus undatus</i>		1	0	3	2	6
		Unidentified		0	0	8	1	9
7	Ellobiidae (Mollusk)		Mangrove, supratidal					
		<i>Pythia</i> spp.		74	19	10	24	127
8	Muricidae		Subtidal	13	18	41	12	84
		Unidentified		8	16	25	10	59
		<i>Thais armigera</i>	Coral reef < 20 m	5	2	16	2	25
9	Zonitidae (Mollusk)		Land					
		Unidentified		16	11	17	15	59

(Continued)

TABLE 2 (Continued)

FAMILY	SPECIES	HABITAT	8000	10,000	21,000	35,000	NISP
			B.P.	B.P.	B.P.	B.P.	
			L1	L2A	L2B	L3	
10	Strombidae	Subtidal	7	14	26	12	59
	<i>Strombus gibberulus</i>		6	14	25	10	55
	<i>Strombus</i> spp.		1	0	0	0	1
	<i>Strombus</i> spp.		0	0	1	0	1
	<i>Strombus</i> spp.		0	0	0	2	2
11	Haliotidae	Intertidal to subtidal					
	<i>Haliotis varia</i>		4	0	10	30	44
12	Tridacnidae	Subtidal, coral shore	15	15	8	4	42
	<i>Tridacna maxima</i>		8	2	6	0	16
	<i>Tridacna crocea</i>		7	12	1	1	21
	<i>Hippopus hippopus</i>		0	1	1	3	5
13	Cypraeidae	Subtidal, coral shore	3	14	14	6	37
	<i>Cypraea caputserpentis</i>		1	8	3	3	15
	<i>Cypraea tigris</i>		1	5	5	2	13
	<i>Cypraea nucleus</i>		0	0	4	0	4
	<i>Cypraea mauritania</i>		0	1	2	1	4
	<i>Cypraea lynx</i>		1	0	0	0	1
14	Helicarionidae (Mollusk)	Land					
	Unidentified		19	3	2	11	35
15	Conidae	Subtidal, coral to sandy shore					
	<i>Conus</i> spp.		3	5	11	1	20
16	Terebridae	Subtidal, sandy shore					
	<i>Terebra</i> spp.		10	2	0	3	15
17	Mitridae	Subtidal, coral to sandy shore					
	<i>Mitra</i> spp.		1	0	1	0	2
18	Cerithidae	Subtidal, coral to sandy shore					
	<i>Cerithium nodulosum</i>		0	0	1	0	1
19	Cymatiidae	Subtidal to deep sea (-300 m)					
	Unidentified		0	1	0	0	1
	Total (NISP)		442	501	1412	783	3138
	Number of species		34	30	37	31	

(Continued)

TABLE 2 (Continued)

B: BIVALVIA

RANK	BIVALVIA	SPECIES	HABITAT	L1	L2A	L2B	L3	NISP
1	Unidentified	Unidentified		3	0	30	72	105
2	Psammobiidae	<i>Asaphis violascens</i>	Intertidal sandy beach	2	8	6	0	16
3	Unidentified			0	5	2	0	7
4	Veneridae		Littoral/mangrove					
		Unidentified		0	2	3	2	7
		Unidentified		1	0	2	0	3
5	Mactridae		Intertidal sandy beach					
		<i>Sposila</i> spp.		1	0	1	2	4
6	Ostreidae		Intertidal					
		Unidentified		1	0	0	0	1
		Total (NISP)		8	15	44	76	143
		Number of species		5	3	5	2	

C: OTHERS

RANK	TAXON	SPECIES	HABITAT	L1	L2A	L2B	L3	NISP
1	Echinodermata							
		<i>Heterocentrotus mammillatus</i>	Subtidal rocky shore	5	14	22	4	45
2	Brachyura							
		Unidentified		0	3	34	8	45
		Total (NISP)		5	17	56	12	90
		Number of species		1	2	2	2	

matically decreased during this early Holocene stage, although *Turbo* spp. were still dominant even in this stage. Crustacean (Brachyura) and sea urchin (*Heterocentrotus mammillatus*) also slightly decreased from Layer 2A (NISP = 17) to Layer 1 (NISP = 5). In terms of land mollusk, Ellobidae (*Pythia* spp.) and other land snails (Zonitidae and Helicarionidae) increased, particularly in Layer 1, though it is unclear whether these were collected by humans or naturally accumulated in the sediments.

Late Pleistocene Marine Exploitations in Wallacea and Adjacent Regions

Previously excavated Pleistocene sites (Fig. 5) at the present coast of the former Sunda Shelf region reveal very little or no evidence for human use of marine resources during the late Pleistocene, as all of these sites were located a considerable distance from the coast at that time. For instance, Lang Rogrien rockshelter, which is currently located in the western coast of southern Thailand, but was about 75 to 140 km from the coast during the late Pleistocene (Anderson 1997), produced no marine faunal remains other than a single fish bone identified as a probable marine species (Muder and Anderson 2007).

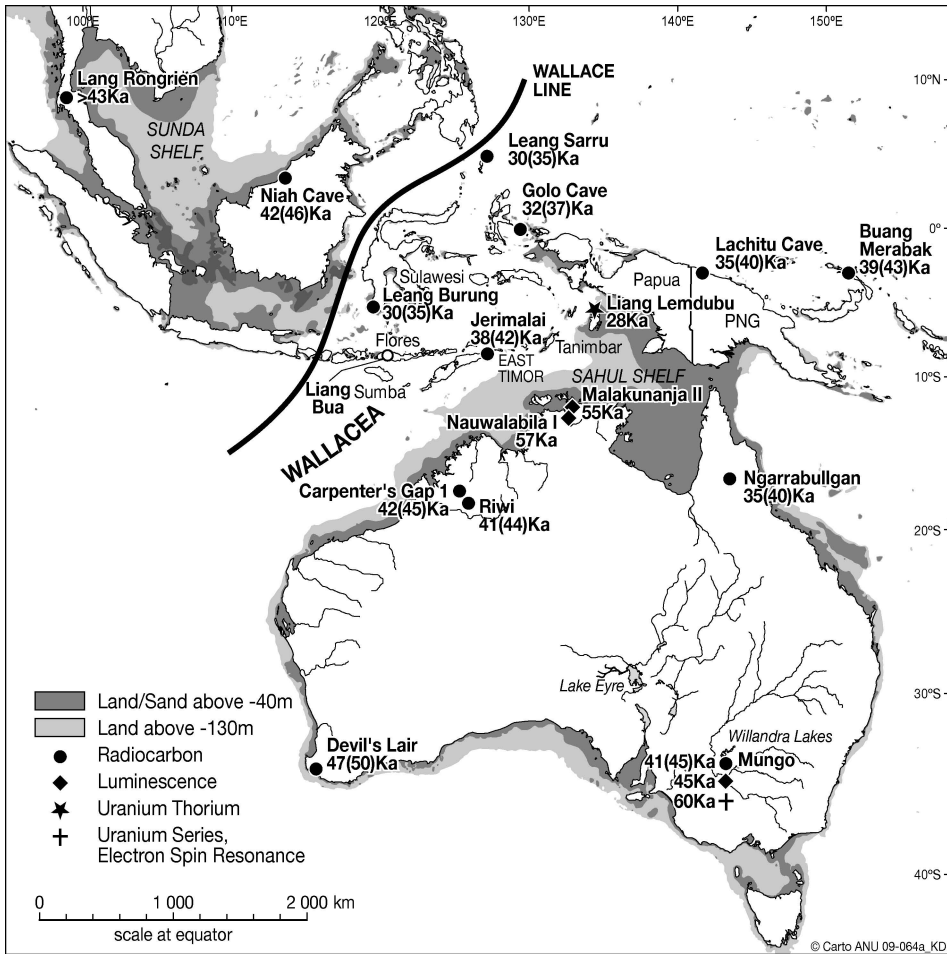


Fig. 5. Map showing Sunda Shelf, Wallacea, and Sahul Shelf and sites, with associated chronometric ages.

Similarly, there are very little or no marine shell and fish remains in the cave sites of Niah (e.g., Barker 2005; Zuraina 1982), Leang Burung 2 (Glover 1981), and Tabon in west coast of Palawan Island (Fox 1970), or from the open-air site of Tingkayu in north-eastern part of Borneo Island (Bellwood 1988), all of which were a distance of 30 to 400 km⁴ from the coast during the late Pleistocene; in general, these sites do have remains of freshwater mollusk and fish along with a variety of terrestrial animals (e.g., Cranbrook 2000; Fox 1970; Medway 1977). Such archaeological results demonstrate the difficulty of investigating Pleistocene marine exploitation and adaption in the Sunda Shelf region where former coastal sites are now submerged on the sea bed.

On the other hand, island coasts in the Wallacea region were far less affected by the rapid rise in sea level since the late Pleistocene, because they shelve steeply into deep water. For this reason coastal sites in Wallacea provide good potential for identifying human exploitation of marine resources during the late Pleisto-

cene. For instance, Golo Cave, located 60 m inland from the northwestern coast of Gebe Island in the Maluku Islands, produced shell tools and a variety (47 species) of marine shell that mainly inhabit rocky subtidal zones (Szabó et al. 2007:703–704). Similarly, in East Timor, Lene Hara Cave and Matja Kuru 2 Cave located less than 10 km from the coast during the LGM, produced a larger amount of marine shell (O'Connor et al. 2002; Veth et al. 2005), while Jerimalai Cave, dating back to 42,000 B.P. and located only a few kilometers from the shore, produced numbers of *Nerita* spp., *Strombus* spp., *Trochus* spp., *Turbo* sp., and *Chiton* sp. as well as a large amount of fish remains including tuna and a variety of inshore fishes (O'Connor 2007:530).

Matenkupkum and Buang Merabak on New Ireland in the Bismarck Archipelago also produced amounts of marine shell, mainly rocky platform species such as *Strombus luhuanus*, *Trochus niloticus*, *Lambis lambis*, *Turbo* spp., *Nerita* spp., and *Chiton* (Gosden and Robertson 1991; Leavesley and Allen 1998; Specht 2005; Swadling 1994). Wickler (1995) notes a similar pattern at Kilu on Buka Island, in which *Chitons* comprised a relatively common component of the shell assemblages until the early Holocene.

Although evidence for intensive marine exploitation in Australia during the late Pleistocene is lacking, several sites in Western Australia have produced limited amounts of marine shell from strata dated between about 20,000 and 36,000 B.P. (e.g., Bowdler 1990; Morse 1988; O'Connor 1989; Veth 1993). For instance, at Mandu Mandu Creek rockshelter, located only about 4–5 km from the coast just prior to the LGM, a low-density midden deposit includes the remains of shell, crab, fish, and terrestrial fauna (Bowdler 1990; Morse 1988). These sites could be interpreted as evidence for limited Pleistocene use of marine resources, but sea level and shoreline reconstructions show a strong correlation between the presence and density of marine resources and the variable distance of each site from the sea (Erlandson 2001:316).

These results tentatively indicate that coastal people in the Wallacea and Sahul regions (and probably in the Sunda Shelf region as well) actively exploited marine resources, especially shell, during the late Pleistocene. The most important shell species exploited at these sites during the late Pleistocene were *Turbo* spp., *Nerita* spp., *Trochus* spp., *Strombus* spp., and *Chiton*. In terms of actual meat value, *Turbo* spp. might have been the most important, followed by *Trochus* spp., and *Strombus* spp.

After 30,000 B.P., the total volume and number of shell from Matja Kuru 2 Cave in East Timor dramatically decreased (Veth et al. 2005). In contrast, the amount and variety of marine shell resources at Leang Sarru dramatically increased, especially during the LGM. These differences between the two sites may possibly relate to their distances from the coast. The distance to the coast from each site was greater during the LGM. Even so, Leang Sarru was located within 2.5 km of the nearest coast (see also Tanudirjo 2001:264), while Matja Kuru 2 was over 10 km distant. Similarly, a heavy reliance on marine shell and other marine resources continued at Jerimalai, which was located within 5 km of the coast during the late Pleistocene (O'Connor 2007:530). The dramatic decrease in number and volume of marine shell in Matja Kuru 2 during the LGM, suggests the possible movement of the inhabitants to other locations closer to the coast or to other areas of the island.

In Sundaland, Niah and Tabon caves had been continually used, though their distances from the coast increased during the LGM, and very little or no marine shells were brought to these sites. Similarly, all other inland sites, such as Hagop Bilo Cave (17,000–12,000 B.P.) in northern Borneo and Ulu Leang Cave in southern Sulawesi, produce very little or no marine shell but instead freshwater and land mollusk species. Overall, it is plausible that the access to marine resources depended on distance from the coast (see also Erlandson 2001).

The fact that marine shell remains are abundant at Leang Sarru indicates that extensive marine exploitation was conducted by the people who lived close to the coast even during the LGM. Furthermore, the dramatic increase in volume and variety of shell species in Leang Sarru during the LGM strongly indicates that there was heavy reliance on marine and coastal resources particularly during cold conditions. It is possible that maritime and coastal adaptation in remote islands such as Talaud during the LGM was a consequence of very limited terrestrial resources.

Early Holocene Marine Exploitations in Wallacea and Adjacent Regions

After the LGM, the climate warmed and the sea level rose progressively until about 6500 B.P. The number of archaeological sites in Wallacea and adjacent regions postdating the early Holocene dramatically increased. In East Timor, human habitation of Matja Kuru 1 Cave (e.g., Veth et al. 2005) and Uai Bobo 2 Cave (Glover 1986) began at around 13,000 B.P. and there is evidence of increased human presence and activity from 8000 to 5000 B.P. During this latter period, human habitation of Bui Ceri Uato Cave in East Timor also commenced (Glover 1986). Matha Kuru 1 and Bui Ceri Uato caves, which are close to the coast, produced a variety of marine shell, while Uai Bobo 2, which is located in the inland hill country, has no marine shell.

In northern Borneo, Hagop Bilo Cave was abandoned about 10,000 B.P., while human activity at Madai caves is evident from 11,000 until 7000 B.P. (Bellwood 1988). Madai caves produced a variety of fresh and brackish water shell but no marine shell. The distance of these caves from the coast during the early Holocene was over 15 km, which, as for Uai Bobo 2 in East Timor, would explain why marine shell are absent. Other sites such as Niah, Lang Rogrien, and Leang Burung 2 were continually inhabited during the early Holocene, but no marine exploitation occurred there either.

On the other hand, some marine shell species increased in Leang Sarru during the early Holocene. This is especially the case for Tridacnidae and Fasciolaridae, which are subtidal or coral rubble-dwelling species. As noted above, the increase of coral rubble-dwelling species such as Tridacnidae, possibly relates to the rise in sea temperature and the growth of coral reefs.

The heavy reliance on marine resources, especially shell, was continually evident in Lene Hara (O'Connor and Veth 2005) and Bui Ceri Uato (Glover 1986) in East Timor. Similarly at Golo Cave in Maluku, the Holocene sediment prior to 3000 B.P. (Phase 3) contains a high density of shells (Szabó et al. 2007:704). In Buang Merabak on New Ireland, subtidal species such as *Trochus* spp. and Limpet suddenly increased after 10,000 B.P., while the coral rubble-dwelling species, such as *Cypraea* spp. and *Strombus* spp., increased around 5000 B.P. (Rosenfeld 1997; Swadling 1994).

All this evidence indicates that the possible change in target species corresponds to the development of early Holocene coastal environments, though shell continued to be one of the major marine resources exploited by humans in Talaud as well as in other island coasts in Wallacea and its adjacent regions.

DISCUSSION

Identifying evidence of early seafaring tradition can be difficult, yet evidence for the settlement of offshore inlands not connected to adjacent mainland tentatively indicates the use of watercraft by humans during the Pleistocene (Erlandson and Fitzpatrick 2006:12). Recent excavations at Leang Sarru have shown that humans colonized the Talaud Islands by sea crossing of over 100 km at least by around 35,000 B.P. (see also Tanudirjo 2001, 2005). Although the exact route of this migration to the islands is not known, it appears likely that many islands in Wallacea were already colonized by modern humans at the time the relatively remote islands of the Talaud group were settled. Correspondingly, voyages to the Bismarck Archipelago and Solomon Islands from Sahul occurred during 40,000 or 30,000 to 15,000 B.P. (e.g., Allen et al. 1989; Leavesley and Chappell 2004; Specht 2005; Torrence et al. 2004; Wickler and Spriggs 1988).

While the initial settlement of New Guinea, New Britain, and New Ireland required voyages of up to 100 km, colonization of Buka in the Solomon Islands at least 28,000 years ago required a minimum sea voyage of 140 km and possibly 175 km (Irwin 1992:20). By 15,000 years ago, Melanesian seafarers had reached Manus Island in the Admiralty group, which required an uninterrupted voyage of 200–220 km, 60–90 km of which would have been completely out of sight of land (Irwin 1992:21).

All of such evidence clearly indicates that by 30,000 years ago modern humans had the seafaring skills to make sea crossings to the islands of Wallacea and to Sahul. It has often been argued that initial colonization of the many islands of Wallacea and its adjacent regions must have been facilitated by a maritime adaptation, and that coastal lowland regions would therefore have been the logical focus of early settlement (Bulbeck 2003; Bulbeck et al. 2004). However, Leang Sarru was not continually used during the late Pleistocene, and it remains uncertain whether the early phase colonization of Talaud was successful or not. The ^{14}C dates indicate that initial occupation of the site was rather short, lasting only about 3000 years, from 35,000 to 32,000 B.P. It is not known why people stopped using Leang Sarru after 32,000 B.P. Did they move to other locations or islands to be close to better resources or did they just die out? Certainly terrestrial resources were very limited in the Talaud Islands as there were no land mammals except for a few species of bat and rat, possibly with cuscus and flying fox (e.g., Riley 2002). This paucity of terrestrial resources must be one of the major factors for the short occupation of Leang Sarru in the late Pleistocene.

The Leang Sarru case tentatively shows that modern humans in Wallacea might not have had the strategies and skills prior to the advent of agriculture to sustain continual colonization of remote islands such as Talaud, which had limited terrestrial resources during the late Pleistocene and Holocene. The difficulty of sustaining hunter-gathering subsistence in a remote island with limited natural resources has been discussed in relation to islands off the coast of southern Austra-

lia, such as Kangaroo Island (e.g., Draper 1988; Lampert 1981) and Hunter Island (Bowdler 1984), and Ryukyu (Okinawa) Islands (e.g., Takamiya 2006) in south Japan.

The excavations of Golo Cave on Gebe Island in Maluku (Bellwood et al. 1998; Szabó et al. 2007) and Jerimalai Cave (O'Connor 2007) in East Timor tentatively show that these sites also had not been used continually during the late Pleistocene to Holocene. Golo Cave, for instance, was only occupied intermittently during the late Pleistocene around 32,000 to 28,000 B.P., and 21,000 to 19,000 B.P., then later during the Holocene around 12,000 to 10,000 B.P., and possibly most recently during 7000 to 3000 B.P. (see Bellwood et al. 1998; Szabó et al. 2007:703). Similarly, Jerimalai Cave was occupied intermittently, during the late Pleistocene from about 40,000 to 38,000 B.P. and again around 14,000 B.P. and during the Holocene around 6000 to 4000 B.P. (see O'Connor 2007:528–529).

As with these sites, particularly Golo Cave in Maluku, the second occupation phase of Leang Sarru occurred during 21,000 to 18,000 B.P. corresponding to the LGM. Although it is unknown whether people voyaged from other islands in the Talaud Group or from adjacent regions such as the Sangihe Islands or Mindanao, it is clear that marine exploitation was practiced in the Talaud Islands during the LGM. The lower temperature and limited land resources may have forced people to rely more on shell and other marine resources such as crab and sea urchin. After 17,000 B.P., Leang Sarru was used only occasionally. The third period of occupation possibly occurred during the early Holocene around 10,000–7000 B.P. Again, it is not known where the inhabitants came from if indeed they were new settlers. As Leang Tahuna on Merampit Island, a remote island located in the northern part of Talaud Islands, was newly occupied and used during this phase (Tanudirjo 2001), it is possible that another human colonization occurred during the early Holocene from the north via Mindanao or the west via Sangihe Islands, or directly from northern Sulawesi. In any event, the analysis of shell remains from the site shows that the dominant and most important marine shell species for human use were still *Turbo* spp. and *Nerita* spp., while a variety of coral rubble-dwelling species such as *Tridacna* spp. and *Cypraea* spp. were newly exploited during this phase. Much warmer temperature and growth of coral reefs around the island's coasts were possibly the main factors for these changes.

After the early Holocene, Leang Sarru was again abandoned as a habitation site though it might have been re-used by the islanders as a ritual place until recent times (Tanudirjo 2001). Some pottery sherds from the top layer indicate that the site was used after the late Neolithic or during the Metal Age.

CONCLUSION

We conclude that Leang Sarru had been occupied or used intermittently, at least during four different times from the late Pleistocene to the Holocene. Analysis of shell remains reveals that marine exploitation dramatically changed and that these changes may relate to changes in climate and temperature, sea level, and surrounding environments. *Turbo* spp., *Nerita* spp., and *Trochus* spp. were dominant species, especially *Turbo* shells, which provided an important food resource.⁵ The migration of modern humans to remote islands like Talaud Islands and the inten-

sive exploitation of a variety of marine shell clearly indicate maritime adaptation in northern Wallacea similar to that of southern Wallacea, the Bismarck Archipelago, and Sahul during the late Pleistocene.

Yesner (1980, 1987) has proposed that marine adaptation was developed after the last glacial. In Wallacea and Oceania the great oceanic migrations of modern humans, including Austronesian-speaking people, were made possible by innovations in maritime technology during Neolithic to late Holocene times. However, maritime exploitations and adaptations appeared well before the Neolithic, and as early as the late Pleistocene, in Wallacea.

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ENDNOTES

1. This large continent had about double the current land area, but the coalescence of many islands into a single landmass reduced the length of coastline by about 50 percent (Dunn and Dunn 1977).
2. Where Yoneda was affiliated at the time of analysis.
3. These dates by Tanudirjo were calibrated by using CALIB 3.0 (Tanudirjo 2001:164) providing a general date of around 30,000 B.P., whereas our new calibrated dates based on the revised calibration curve are about 35,000 B.P.
4. Niah Cave about 400 km (Zuraina 1982), and Tabon, Leang Burung 2, and Tinkayu about 30 to 50 km distant from the past coasts (Bellwood 1988; Fox 1970; Glover 1976) during the LGM (see also Erlandson 2001).
5. In Golo Cave some worked shell tools made from operculum of *Turbo marmoratus* (Szabó et al. 2007), and other *Turbo* spp. shell might be important also for shell tools since the late Pleistocene.

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ABSTRACT

The previous excavation by Tanudirjo and our recent excavation at Leang Sarru in the Talaud Islands, located between northern Sulawesi and southern Mindanao, reveal intermittent human colonization and marine exploitation in these remote islands as early as 35,000 to 32,000 B.P. The evidence indicates that humans migrated and colonized the northern part of Wallacea by ocean crossings of over 100 km, equivalent to the human migrations from southern Wallacea to Sahul, and Sahul to the Bismarck Archipelago during the late Pleistocene. The ^{14}C dates obtained from the marine shell samples collected during our excavation and the earlier excavation by Tanudirjo, along with other archaeological evidence enable us to conclude that the site was occupied during at least four main periods: (1) the earliest phase during 35,000 to 30,000 B.P.; (2) the intensive occupation phase during 21,000 to 17,000 B.P., partly corresponding with Last Glacial Maximum (LGM); (3) the early Holocene during 10,000 to 8000 B.P.; and (4) during the “Metal Age” with some ceramic evidence not identified by ^{14}C dates. Such intermittent use of the site tentatively shows that humans in Wallacea might not have had the strategies and skills to sustain continuous colonization or habitation of remote islands like Talaud, having limited terrestrial resources during the late Pleistocene and even in the Holocene before the maturity of an agricultural system and knowledge as part of their subsistence strategies. We also discuss the past maritime exploitation and adaptation from the late Pleistocene to the early Holocene in the Talaud Islands. **KEYWORDS:** marine exploitation, shell, colonization, Last Glacial Maximum (LGM), Leang Sarru, Talaud.